24-hour Hazardous Waste Site Worker Participant Guide

Acknowledgments

The Midwest Consortium developed this course for Hazardous Waste Worker Training under cooperative agreement number U45 ES 06184 from the National Institute of Environmental Health Sciences.

We encourage you to comment on these materials. Please give any suggestions to your facilitator.

Warning

 The material was prepared for use by facilitators experienced in the training of persons who are or who anticipate being employed at a hazardous waste worksite. Authors of this material have prepared it for the training of this category of workers as of the date specified on the title page. Users are cautioned that the subject is constantly evolving. Therefore, the material may require additions, deletions, or modifications to incorporate the effects of that evolution occurring after the date of this material preparation.

Disclaimer

The Occupational Safety and Health Administration (OSHA) rule to help ensure worker health and safety at hazardous waste sites requires introductory, general training on basic hazard recognition, use of provided protective equipment, basic hazard control, decontamination procedures and other relevant standard operating guides, as well as training at each site. This program is intended to meet the requirements of the introductory, general training. It must be followed by on-site training, during which the specifics of the protective equipment, decontamination methods, and other procedures and information at the site are discussed and practiced. At that time, the elements of the site-specific standard operating guides are detailed.

Additional training is necessary to perform many activities. These activities include implementing the emergency response plan, identifying materials using monitoring instruments, selecting protective equipment, and performing advanced control containment or confinement. Additional site-specific training for emergency response must be provided so that you can recognize and respond to alarms at the site and can carry out any role which may be assigned during a response.

For information about this matter, consult the training facilitator, your company Safety and Health Program, or your company health and safety representative.

All web links are active as of February 28, 2023; if you find an error, please inform the facilitator so that it can be updated.

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Introduction

Welcome to the 24-hour HAZWOPER program. The acronym HAZWOPER stands for:

HAZ HAZardous

W Waste

OP OPerations and

E Emergency

R Response

This training is required for anyone who is going to work at a location that has been determined to meet the rules set by the US Environmental Protection Agency (EPA) for a hazardous waste site, or where state or local government or a contractor requires the training. National hazardous waste sites are also referred to as Superfund sites or National Priorities List (NPL) sites.

The overall goals of this training are for you to be better able to:

- Recognize hazards that may be present at hazardous waste sites
- Identify adverse health effects of those hazards
- Use work practices and protective equipment to reduce hazards
- Use written programs such as Standard Operating Guides (SOGs) to control hazards
- Identify federal regulations and agencies that protect your health and safety and that of your fellow employees in hazardous waste site work

This program is the first part of training before you start site work; it is followed by one day of on-site training with a supervisor, designed to familiarize you with site-specific plans, potential exposures and work practices. Participants who complete this 24-hour course may at a later date complete the remaining 16 hours needed for the full 40-hour Hazardous Waste Worker Course. The 24-hour training is required by OSHA for “occasional” site workers with limited potential for exposures while the 40-hour training is required for workers with more regular potential for exposures.

Using some basic information (such as chemical hazards, health effects, regulatory requirements and safety terms) you will be introduced to and work with:

- Respiratory protective equipment
- Chemical protective clothing
- Information resources
- Monitoring equipment

This program was developed by the Midwest Consortium for Hazardous Waste Worker Training, a group of trainers from nine states dedicated to interactive training to meet the needs of workers. The Consortium receives funding from the federal government (National Institute of Environmental Health Sciences, or NIEHS) to develop and present 'model' training programs. By this the government means that we have a certain number of facilitators, include hands-on activities, and include methods to document the value of the training to participants through your feedback. In addition, we are required to define "successful completion" for the participants. This program includes a combination of several measures to obtain successful completion: a knowledge test, exercises and attendance at all sessions. Pre- and post-tests are used to measure knowledge gain during the course.

Get the Most from Training

Ask questions

Participate in small group discussions

Put your hands on equipment and tools

Use resources

Learn from experiences of others

Introduction to HAZWOPER

Sites where cleanup is conducted vary greatly based on many factors including the wastes disposed of, surrounding buildings and roadways, climate, bodies of water, position of the water table and soil. As a first part of the training, pictures or video of some site activities will be reviewed; in addition we would like you to describe your previous work experience in various industries, as some of your observations and experiences will add to the training.

During this session, you will:

- Become familiar with some site activities
- Describe previous work experience
- Identify training requirements using the HAZWOPER standard
- Access information resources

Your job in hazardous waste site remediation builds on your previous work experience and health and safety training. Different jobs create different obstacles. Your experience is important and when shared will add value to everyone taking or teaching this course. By learning to use resources, you will be able to find answers to questions that arise after the training program ends.

The goal is to use safe work practices to minimize exposures to hazards.

Previous Experience You Bring to Training

- Participants are asked to share their expertise. Everyone should take time to outline their experiences related to HAZWOPER. Examples of the types of experiences are listed below. Experience with:
  - Construction
  - Chemicals
  - Hazards and hazardous situations
  - Use of respirators and protective clothing
  - Other kinds of remediation, such as lead or asbestos
- Your current employment, why you are taking the class, what you hope to learn during the class, and how you will use this training.
- Any specific chemicals/hazards of interest.

This information will be used to tailor the course to the needs and skills of participants. Your facilitator will note items you want to learn about and specific chemicals or hazards of interest and post the listings on the wall. The facilitator will refer back to these lists regularly.

The Requirements of HAZWOPER

The standard commonly called HAZWOPER, or 29 CFR 1910.120, is the major federal regulation designed to safeguard the safety and health of workers at hazardous waste sites. The standard is enforced by the Occupational Safety and Health Administration (OSHA).

Paragraphs in the standard are identified with numbers and letters to make it easier to locate the information, similar to how library books are numbered.

For example, the specific requirements for training of general site workers are found in section 29 CFR 1910.120(e)(3)(i). In the illustration below, see how to interpret the numbering of the paragraph.

Requirements for Hazardous Waste Site Workers

29 CFR 1910.120

29	=	OSHA regulations are located in Title 29.
CFR	=	*Code of Federal Regulations* is the title of the government publication.
1910	=	Part number 1910 covers General Industry.
.120	=	Section number 120 covers hazardous waste operations and emergency response.
(e)	=	The paragraph which describes a specific topic such as Training.

Exercise - Using HAZWOPER

In this exercise, you will use the HAZWOPER standard to look up the paragraph described above, and discover what training is required. (See Exercise Guide.)

Training Requirements of HAZWOPER

HAZWOPER requires that all employees working on the site where there are hazardous substances, health hazards, or safety hazards and their supervisors and management receive training before they are permitted to engage in operations that could expose them to hazardous substances, safety, or health hazards.

Topics covered in this training include:

- Use of personal protective equipment
- Work practices by which the employee can minimize risks from hazards
- Safe use of engineering controls and equipment on the site
- Medical surveillance requirements, including recognition of symptoms and signs which might indicate overexposure to hazards
- Decontamination procedures
- Emergency response plan
- Confined space entry procedures
- Spill containment program

Everyone is required to participate in one day of on-site training (after this 24-hour general program) that is specific to the programs and hazards at the site. On-site management and supervisors require at least 8 hours of additional training.

For more information, consult the HAZWOPER standard, your site management, or your health and safety committee representative.

Some Useful Resources

Both OSHA and the Environmental Protection Agency (EPA) are concerned with hazardous waste sites. You may find websites of these agencies to be useful sources of information:

- www.osha.gov
- www.epa.gov for general information

Other resources that may be useful:

- Emergency Response Guidebook (ERG) https://www.phmsa.dot.gov/hazmat/erg/emergency-response-guidebook-erg
- SDS Pocket dictionary or other dictionary of technical terms
- NIOSH (National Institute for Occupational Safety and Health) Pocket Guide to Chemical Hazards (NPG, available as a hard copy, on CD, or electronically at https://www.cdc.gov/niosh/npg/
- HAZWOPER standard, 29 CFR 1910.120 (electronically at https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.120)

Rights and Responsibilities

Workers and employers have rights and responsibilities in the workplace. While several government agencies have jurisdiction over various aspects of waste site work, the primary agency for most work is the Occupational Safety and Health Administration (OSHA). Guided by the Occupational Safety and Health Act (OSHAct), OSHA sets standards to limit exposure to hazardous materials and conditions. For site workers, the HAZWOPER standard is a key resource. This standard was developed following an update of the Superfund program by the Environmental Protection Agency (EPA).

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify major components of the Superfund Amendments and Reauthorization Act (SARA)
- Identify worker rights and responsibilities under the OSHAct
- Identify employer rights and responsibilities under the OSHAct
- Identify federal agencies that regulate the use and transportation of hazardous materials

Federal Regulations

Exercise – Rights and Responsibilities

What do you already know about worker and employer safety and health rights and responsibilities? See Exercise Guide.

SARA

The Superfund Amendments and Reauthorization Act (SARA) was passed by Congress in 1986 to improve the authority of the Environmental Protection Agency (EPA) to safeguard the health and safety of workers and the community at large. It is made up of three separate sections or “Titles”. Titles I and III deal with emergency response and planning, whereas Title II concerns a fund for hazardous waste clean-up. In brief, the Titles require the following:

Title I

- Protection of the health and safety of workers engaged in hazardous waste operations.
- Training of emergency response personnel and workers at hazardous waste operation sites (HAZWOPER).
- Preparation of a written emergency response plan (ERP) for companies where hazardous materials may be spilled or released.
- Proper procedures for handling emergency response operations.

Title II – Not applicable at this time

Title III (Community Right-to-Know)

- Development of comprehensive community emergency plans by Local Emergency Planning Committees (LEPCs).
- Reporting of certain chemical inventory and release information to fire departments, LEPCs, and the State Emergency Response Commission (SERC).

HAZWOPER - Hazardous Waste Operations and Emergency Response

SARA TITLE I required the Occupational Safety and Health Administration (OSHA) to develop a standard to protect hazardous waste operations and emergency response personnel. That standard is commonly called HAZWOPER (Hazardous Waste Operations and Emergency Response) or 29 CFR 1910.120. The HAZWOPER standard was covered in the beginning of this training course.

Case Study - A contaminated site is the result when training is not done and when waste handling is not done according to regulations.

Kaltech Industries was a sign manufacturer in New York City. On April 25, 2002, two employees were combining hazardous wastes from manufacturing into a 55-gallon plastic drum in the basement of a 10-story building. Shortly after the employees had finished transferring waste and walked away, the drum began to hiss and vent vigorously through the top bung opening. As employees started to run toward the exits, the drum exploded, blowing out windows up to the fifth floor. The street was showered with glass and debris, injuring at least 1 pedestrian. The stairway from the basement collapsed, slowing the rescue of those in the basement. Fortunately, the sprinkler system put out the fire that followed the

explosion. Thirty-one people were taken to hospitals, including four with critical injuries.

The Chemical Safety and Hazard Investigation Board (CSB) investigation of the accident revealed that the employees had combined concentrated nitric acid with lacquer thinner (primarily acetone and toluene) in the waste barrel, causing the explosion. The employees had no idea of the identity of the chemicals that they were combining.

Kaltech had no Hazard Communication program for employees and did not manage its hazardous waste in accordance with federal, state and local law. There was no list of the hazardous substances present in the facility and waste containers were unlabeled. If Material Safety Data Sheets (MSDSs, the standard format for information at that time) were received from vendors, they were filed by the purchasing manager or owners, and not shared with the employees. The employees received no formal training on the hazardous chemicals in the workplace. See: http://www.csb.gov/investigations/detail.aspx?SID=43

A photo showing the site following the explosion is shown:

Cleaning up the site represented hazards to workers. What hazards can you anticipate?

OSHAct

The Occupational Safety and Health Act (OSHAct) of 1970 is a major law concerned with worker health and safety. It was passed to prevent workers from being killed or seriously harmed at work. The law requires employers to provide their employees with working conditions that are free of known dangers. The Act created the Occupational Safety and Health Administration (OSHA), which sets and enforces protective workplace safety and health standards. OSHA also provides information, training and assistance to workers and employers. Regulations set by OSHA are published in Section 29 of the Federal Register, with Part 1915 reserved for maritime industries, Part 1910 for general Industry, and Part 1926 for the construction industry.

Most employees in the nation come under OSHA jurisdiction. OSHA covers private sector employers of all sizes in all 50 states, the District of Columbia, and other U.S. jurisdictions. Small employers (fewer than 10 employees) are exempted from some injury record-keeping requirements (29 CFR 1904). Laws are administered by federal OSHA or through an OSHA-approved state program. State-run health and safety programs must be at least as effective as the Federal OSHA program. To find the contact information for the OSHA Federal or State Program office nearest you, see the Regional and Area Offices map at http://www.osha.gov/html/RAmap.html.

Employees who work for state and local governments are not covered by Federal OSHA but have OSHAct protections if they work in a state that has an OSHA-approved state program. Four additional states and one U.S. territory have OSHA approved plans that cover public sector employees only. This includes Connecticut, Illinois, New Jersey, New York, and the Virgin Islands. Private sector workers in these four states and the Virgin Islands are covered by Federal OSHA.

Federal agencies must have a safety and health program that meet the same standards as private employers. Although OSHA does not fine federal agencies, it does monitor federal agencies and responds to workers' complaints.

Those not covered by the OSHAct include the self-employed, immediate family members of farm employers that do not employ outside employees, and workplace hazards regulated by another Federal agency (for example, the Mine Safety and Health Administration, the Federal Aviation Administration, the Coast Guard).

In addition to setting standards such as HAZWOPER and HazCom, OSHA is charged with:

- Inspecting workplaces to ensure standards are being met
- Issuing citations and fines to companies that do not meet the standards
- Overseeing state plans for safety and health
- Encouraging the development of training programs for workers, management, and health professionals

Rights and Responsibilities Under OSHA

Workers and employers have a number of rights and responsibilities under the Act.

Worker Rights and Responsibilities

Workers have a number of rights and responsibilities under the Act. Detail is shown at the OSHA website, www.osha.gov click on You have the Right to a Safe Workplace. See also Workers' Rights booklet at https://www.osha.gov/Publications/osha3021.pdf:

Image as of May 2020

A brief summary is provided here.

Worker Rights

Your Right to Have an Inspection of a Workplace

It is possible for a worker to file a complaint against the employer. A formal procedure is followed, including the completion and submission of the OSHA Notice of Alleged Safety or Health Hazards form as illustrated on the following two pages. Once a complaint is received at the OSHA Office, it will be assigned to one of their compliance officers. The inspection priority defined by OSHA is:

- Imminent danger
- Catastrophic (a fatality or three or more workers are hospitalized overnight as a result of an on-the-job exposure)
- Complaint inspection (as a result of a worker or union complaint)
- Scheduled inspection (general OSHA inspection not because of a complaint or catastrophe, but because injury statistics show that the employer has more injuries and illness than similar employers)
- General inspection or “pick of the hat.” (Previously inspected sites are pooled, and, through random selection, two sites are drawn and visited in a given year).

A worker or representative of workers can file a complaint. The form is shown on the next two pages. It can be anonymous and can be done online.

U.S. Department of Labor
Occupational Safety and Health Administration

Notice of Alleged Safety or Health Hazards

For the General Public:

This form is provided for the assistance of any complainant and is not intended to constitute the exclusive means by which a complaint may be registered with the U.S. Department of Labor.

Sec 8 (f) (1) of the Williams-Steiger Occupational Safety and Health Act, 29 U.S.C. 651, provides as follows: Any employees or representative of employees who believe that a violation of a safety or health standard exists that threatens physical harm, or that an imminent danger exists, may request an inspection by giving notice to the Secretary or his authorized representative of such violation or danger. Any such notice shall be reduced to writing, shall set forth with reasonable particularity the grounds for the notice, and shall be signed by the employee or representative of employees, and a copy shall be provided the employer or his agent no later than at the time of inspection, except that, upon request of the person giving such notice, his name and the names of individual employees referred to therein shall not appear in such copy or on any record published, released, or made available pursuant to subsection (g) of this section. If upon receipt of such notification the Secretary determines there are reasonable grounds to believe that such violation or danger exists, he shall make a special inspection in accordance with the provisions of this section as soon as practicable to determine if such violation or danger exists. If the Secretary determines there are no reasonable grounds to believe that a violation or danger exists, he shall notify the employees or representative of the employees in writing of such determination.

NOTE: Section 11(c) of the Act provides explicit protection for employees exercising their rights, including making safety and health complaints

For Federal Employees:

This report format is provided to assist Federal employees or authorized representatives in registering a report of unsafe or unhealthful working conditions with the U.S. Department of Labor.

The Secretary of Labor may conduct unannounced inspection of agency workplaces when deemed necessary if an agency does not have occupational safety and health committees establish in accordance with Subpart F, 29 CFR 1960; or in response to the reports of unsafe or unhealthful working conditions upon request of such agency committees under Sec. 1-3, Executive Order 12196; or in the case of a report of imminent danger when such a committee has not responded to the report as required in Sec. 1-201 (h).

INSTRUCTIONS:

Open the form and complete the front page as accurately and completely as possible. Describe each hazard you think exists in as much detail as you can. If the hazards described in your complaint are not all in the same area, please identify where each hazard can be found at the worksite. If there is any particular evidence that supports your suspicion that a hazard exists (for instance, a recent accident or physical symptoms of employees at your site) include the information in your description. If you need more space than is provided on the form, continue on any other sheet of paper.

After you have completed the form, return it to your local OSHA office.

NOTE: It is unlawful to make any false statement, representation or certification in any document filed pursuant to the Occupational Safety and Health Act of 1970. Violations can be punished by a fine of not more than $10,000 or by imprisonment of not more than six months, or by both. (Section 17(g)).

Public reporting burden for this voluntary collection of information is estimated to vary from 15 to 25 minutes per response with an average of 17 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An Agency may not conduct or sponsor, and persons are not required to respond to the collection of information unless it displays a valid OMB Control Number. Send comment regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to the Directorate of Enforcement Programs, Department of Labor, Room N-3119,200 Constitution Ave., NW, Washington, DC; 20210.

OMB Approval# 1218-0064; Expires 03-31-2011
Do not send the completed form to this Office.

U.S. Department of Labor
Occupational Safety and Health Administration

Notice of Alleged Safety or Health Hazards

		Complaint Number		
Establishment Name				
Site Address				
	Site Phone		Site FAX	
Mailing Address				
	Mail Phone		Mail FAX	
Management Official			Telephone	
Type of Business				
HAZARD DESCRIPTION/LOCATION. Describe briefly the hazard(s) which you believe exist. Include the appropriate number of employees exposed to or threatened by each hazard. Specify the particular building or worksite where the alleged violation exists.				
Has this condition been brought to the attention of?	☐ Employer ☐ Other Government Agency (specify)			
Please Indicate Your Desire:	☐ Do NOT reveal my name to my Employer ☐ My name may be revealed to the Employer			
The Undersigned believes that a violation of an Occupational Safety or Health Standard exists which is a job safety or health hazard at the establishment named on this form.	(Mark "X" in ONE box) ☐ Employee ☐ Federal Safety and Health Committee ☐ Representative ☐ Other (specify) of Employees			
Complainant Name			Telephone	
Address (Street, City, State, Zip)				
Signature			Date	
If you are an authorized representative of employees affected by this complaint, please state the name of the organization that you represent and your title:				
Organization Name: Your Title:				

Your Right to Participate in the OSHA Walk-Around Inspection:

Through an employee organization such as a union, an employee representative is designated to accompany the OSHA compliance officer in the walk-around inspection. It should be noted that OSHA regulations currently do not require the employer to pay the employee for time spent on the OSHA walk-around; however, some states with an OSHA plan require employees to be paid for the time spent during a walk-around. Walk-around activities include all opening and closing conferences related to the conduct of the inspection but do not include any post-citation appeal procedures.

Your Right to Be a Witness or to Give Information:

Every employee has the right to appear as a witness at an OSHA hearing. During the walk around inspection, or before or after the inspection for that matter, any employee has the right to provide OSHA with any information regarding possible safety and health hazards. This right is protected by law.

Your Right to Be Informed of Imminent Dangers:

All employees have the right to be informed by the OSHA compliance officer if it is determined that they are exposed to an imminent danger (one which could cause death or serious injury now or in the near future). The compliance officer will also ask the employer to stop the particular work process voluntarily and remove the employees. If the employer refuses to stop the work process upon the request of the compliance officer, a judge can force the employer to do so if necessary.

Your Right to Be Told About Citations:

Notices of OSHA citations must be posted in the workplace near the site where the violation occurred and must remain posted for three days or until the hazard is corrected, whichever is longer. Citations and penalty notification forms are, in general, available upon request from the OSHA Area Office. When an OSHA industrial hygiene inspection has taken place, the hygienist’s report, which includes substances collected, procedure used, and measurement results, may also be obtained by the employees, their representatives, or their union upon request.

Your Right to Appeal About OSHA Performance:

If OSHA fails to perform in a responsible and timely manner, the employees, employer, or union has the right to meet with the OSHA Area Director and the OSHA Regional Administrator. Any of the groups may ultimately appeal to the Secretary of Labor.

Your Right to Appeal Abatement Dates (When a Violation Must Be Fixed):

The findings of the OSHA officer may be appealed within 15 working days of the issuance of the citation to the employer. The right to contest the citation is limited only to the question of the reasonableness of the abatement period of the citation. Employees or their organization cannot contest the penalty amount or the citation itself.

Your Right to Have a Closing Conference After an Inspection:

Employees have the right to meet privately with the OSHA officer and discuss the results of the inspection. OSHA procedures state that the OSHA inspector shall inform the employers and employees that a generally responsive discussion covering general issues will be held.

Your Right to Know of Health Hazard Exposures:

Employees have the right to be notified if exposed to occupational health hazards and to be notified of the results of occupational health studies conducted by the employer or OSHA officers. The employees or their organization can and should ask for any and all instrument readings or levels of contaminants found. A copy of the lab report should also be requested from OSHA. These documents are normally available upon request but may also be obtained by any member of the public pursuant to the Freedom of Information Act.

Your Right to Have Access to OSHA Records:

Generally speaking, most OSHA records are available upon request. The employees, or their organization, should contact the OSHA Area Office where the plant is located.

Your Right to Participate in Development of New Standards:

Every employee has the right to participate in the development of new safety and health standards or modification of old codes through his or her employee organization. Individuals may also comment on proposed standards during open periods of comment.

Your Right to Review a Citation Procedure When a Citation Is Not Issued:

Every employee has the right to request an informal review of an OSHA officer's refusal to issue a citation or any other issue related to an inspection, citation, notice of proposed penalty, or notice of intention to contest a citation. A written statement as to why a citation was not issued in particular instances may be requested.

Your Right to File a Discrimination Complaint:

If an employee has been discriminated against as a result of exercising his or her rights under OSHA, that employee has the right to file a complaint with the OSHA Area Office within 30 days. This time limit is strictly enforced. Similar rights to file a complaint may exist with state and local anti-discrimination agencies, as well as the employee organization.

Worker Responsibilities

Your Responsibility to Abide by Established Safety Rules:

Workers cannot be cited or fined by OSHA, but employers can take disciplinary action for violation of established safety rules.

Your Responsibility to Wear and/or Use Required Safety Equipment:

Workers are responsible for wearing and/or using required safety equipment.

Your Responsibility to Seek Prompt Medical Treatment When Required:

Workers should seek medical treatment promptly when required. Depending on applicable state law, workers have a right to be treated by a physician of their own choice for work-related injuries. The key here is not to delay medical treatment when necessary.

Your Responsibility to Bring Safety and Health Concerns to the Attention of Management:

Workers should bring safety and health hazards or concerns to the attention of their supervisors or forepersons as soon as possible. If the workers are organized, then they may want to ask the representative to bring the issue to the attention of management.

Your Responsibility to Finance Gear That Can Be Worn Off the Job:

Workers will have to pay for ordinary safety-toed footwear, ordinary prescription safety eyewear, logging boots, and ordinary clothing and weather-related gear that can be worn off the job.

Employer Rights and Responsibilities

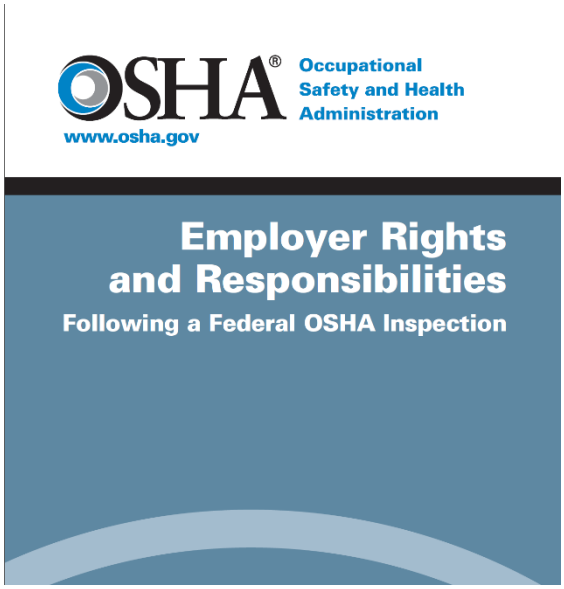

Image from May 2020 at: https://www.osha.gov/Publications/osha3000.pdf

Employer Rights

Employer Rights following an OSHA inspection

If a worksite inspection is conducted, the employer has rights to an informal conference to discuss the apparent violations, to contest the citation and to petition for a modification of abatement dates. See https://www.osha.gov/Publications/fedrites.html.

Employer Responsibilities

The OSHAct places important responsibilities on the employer. Understanding exactly what these responsibilities are is essential to maintaining a safe and healthful workplace and meeting other requirements of the law.

Employer Responsibility to Furnish a Safe and Healthy Job and Work Environment:

The employer must furnish each employee a job and a place of employment free from recognized hazards that are likely to cause death or serious physical harm. This responsibility is commonly referred to as the “general duty clause” of the Act. It describes the overall or general responsibility of the employer not to expose employees to harmful situations or chemicals.

Employer Responsibility to Pay for Personal Safety Equipment:

The employer must pay the full cost for almost all required personal protective equipment (PPE) used to comply with OSHA standards, with the exception of safety shoes and prescription safety eyewear, which are personal in nature and may be used off the jobsite.

Employer Responsibility to Comply with OSHA Standards:

Employers must comply with applicable parts of the OSHA General Industry Standard (1910) and the Construction Industry Standards (1926), including HAZWOPER (29 CFR 1910.120). HAZWOPER applies only to hazardous waste operations and emergency response. In the event of conflict between HAZWOPER and the general standard, the most protective is enforced.

The General Industry Standards (29 CFR 1910) cover most manufacturing industries. In addition to HAZWOPER, other OSHA standards are important to site workers. These include:

- 1910.38: Emergency Action Plans
- 1910.119: Process Safety Management of Highly Hazardous Chemicals
- 1910.132: Personal Protective Equipment
- 1910.134: Respiratory Protection
- 1910.146: Permit-Required Confined Space
- 1910.147: The Control of Hazardous Energy (Lock-Out/Tag-Out)
- 1910.156: Fire Brigades
- 1910.165: Employee Alarm Systems
- 1910.1000: Permissible Exposure Limits on Airborne Toxic Substances
- 1910.1020: Employee Access to Exposure and Medical Records
- 1910.1200: The Hazard Communication (Right-to-Know) Standard (See Appendix B.)
- 1910.1201: Retention of DOT Markings, Placards and Labels

Many of these are referenced in HAZWOPER.

The Construction Standards (29 CFR 1926) cover construction activities at remediation work sites. Specific parts of the Construction Standards that supplement HAAZWOPER at construction operations on sites include:

- 1926.55: Permissible Exposure Limits on Airborne Toxic Substances
- 1926.59: Right-to-Know (Hazard Communication) Standard

- 1926.102: Eye and Face Protection
- 1926.150: Fire Protection and Prevention
- 1926.300: Hand and Power Tool Safety
- 1926.651: Excavations

Employer Responsibility to Report Fatalities and Injuries:

Employers must inform OSHA of any fatality within 8 hours of the event. The employer must inform OSHA of any injury requiring inpatient hospitalization, an amputation, or any loss of an eye within 24 hours.

Employer Responsibility to Maintain Records of Injuries:

Under the OSHAct, all employers with more than 10 employees must maintain a log of injuries and make it available to OSHA compliance officers upon request. Each year the employer must post an annual summary of the injury log for the information of the employees. This form is called the OSHA 300A and must be displayed each year for the months of February, March, and April. A portion of the form is shown on the following two pages. The employer must also display the required OSHA poster, which outlines specifics of the OSHAct.

Employers are required to record information about specific occupational injuries and illnesses. Every occupational death and non-fatal illness must be recorded on the OSHA log. Other non-fatal injuries which must be recorded include loss of consciousness, restriction of work motion, transfer to another job, or medical treatment other than First Aid.

Contact your local OSHA office with questions about recordable illnesses and injuries.

OSHA's Form 300A

Summary of Work-Related Injuries and Illnesses

All establishments covered by Part 1904 must complete this Summary page, even if no work-related injuries or illnesses occurred during the year. Remember to review the Log to verify that the entries are complete and accurate before completing this summary.

Using the Log, count the individual entries you made for each category. Then write the totals below, making sure you've added the entries from every page of the Log. If you had no cases, write "0."

Employees, former employees, and their representatives have the right to review the OSHA Form 300 in its entirety. They also have limited access to the OSHA Form 301 or its equivalent. See 29 CFR 1904.35, in OSHA's recordkeeping rule, for further details on the access provisions for these forms.

Number of Cases			
Total number of deaths _____ (G)	Total number of cases with days away from work _____ (H)	Total number of cases with job transfer or restriction _____ (I)	Total number of other recordable cases _____ (J)
Number of Days			
Total number of days of job transfer or restriction _____ (K)		Total number of days away from work _____ (L)	
Injury and Illness Types			
Total number of . . . (M) (1) Injuries _____ (2) Skin disorders _____ (3) Respiratory conditions _____		(4) Poisonings _____ (5) All other illnesses _____	

Post this Summary page from February 1 to April 30 of the year following the year covered by the form.

Public reporting burden for this collection of information is estimated to average 50 minutes per response, including time to review the instruction, search and gather the data needed, and complete and review the collection of information. Persons are not required to respond to the collection of information unless it displays a currently valid OMB control number. If you have any comments about these estimates or any aspects of this data collection, contact: US Department of Labor, OSHA Office of Statistics, Room N-3644, 200 Constitution Ave., NW, Washington, DC 20210. Do not send the completed forms to this office.

OSHA's Form 300A

Summary of Work-Related Injuries and Illnesses

Establishment information

Your establishment name_____

Street

_____

City _____ State _____ Zip _____

Industry description (e.g., Manufacture of motor truck trailers)

_____

Standard Industrial Classification (SIC), if known (e.g., SIC 3715) ___ ___ ___ ___

Employment information *(If you don't have these figures, see the Worksheet on the back of this page to estimate.)*

Annual average number of employees _____

Total hours worked by all employees last year _____

Sign here

Knowingly falsifying this document may result in a fine.

I certify that I have examined this document and that to the best of my knowledge the entries are true, accurate, and complete.

_____

Company executive Title

(_____)_____

Phone Date

Employer Responsibility to Post Information

The official OSHA *Job Safety and Health – It's the Law* poster that describes rights and responsibilities must be posted prominently in the workplace at all times. Download it here: https://www.osha.gov/Publications/poster.html.

Any citation for apparent violations received from OSHA must be posted until the items are resolved where workers can see each page.

The annual summary of injury and illness data must be posted where workers can see the form during the months of February, March and April of each year.

Employer Responsibility to Not Retaliate

If a worker exercises rights under the law, including the right to report a work-related injury or illness, the employer must not retaliate.

See also https://www.osha.gov/as/opa/worker/employer-responsibility.html.

Other Agencies and Legislation

Agencies

Besides OSHA, four other governmental agencies are directly responsible for writing and enforcing regulations that concern hazardous materials handling.

Environmental Protection Agency (EPA)

The EPA is concerned with the quality of the environment including the air, land, and water (except for navigable waterways). The EPA published regulations to define hazardous waste. It created an identification system and a reporting system so that the government can track the quantities and types of hazardous waste being generated and to confirm that they are being properly handled. Regulations set by the EPA are published in Section 40 of the Code of Federal Regulations, beginning with Part 200.

The federal EPA has delegated the enforcement of its regulations to state EPA agencies. Some states don't call their agency EPA. Some call them DNR (Department of Natural Resources), DLNR (Department of Land and Natural

Resources), DPHE (Department of Public Health and Environment), DEQ (Department of Environmental Quality), DEM (Department of Environmental Management), etc. Some states have regulated other wastes in addition to EPA hazardous wastes, and they are called “special wastes.” Examples of special wastes that come under state-by-state rules are waste oils, asbestos abatement waste, and petroleum-contaminated soil.

In states where federal personnel enforce OSHA, they cannot apply the regulations to state and local government employees; the EPA has a regulation identical to HAZWOPER to protect the safety and health of these persons at waste sites.

Department of Transportation (DOT)

DOT is concerned with the transport of hazardous materials through interstate commerce. DOT publishes a manual used in interpreting labels it requires on containers, the Emergency Response Guide (ERG). Regulations set by the DOT are published in Section 49 of the Code of Federal Regulations, Parts 100 - 200.

DOT works jointly with the EPA-RCRA to regulate hazardous waste transportation. The transportation of these wastes and materials can be dangerous. The enforcement of the Hazardous Material Regulations is handled by a wide range of government organizations such as Federal Aviation Administration and the United States Coast Guard.

United States Coast Guard (USCG)

The USCG is responsible for monitoring the transportation of hazardous materials across navigable waterways and the preservation of our bodies of water. The USCG is involved in clean-up actions following oil spills.

Nuclear Regulatory Commission (NRC)

The NRC is responsible for community and worker protection from radiation hazards. The agency focuses its attention on: Radiation Protection; Reactor Safety; and the Regulation of Nuclear Materials. They also manage waste at both high- and low-levels.

Legislation

There is other Federal Government legislation which addresses issues of worker safety and health and/or hazardous substances.

National Oil and Hazardous Substances Pollution Contingency Plan, 40CFR300

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) was developed in 1968 to provide a coordinated approach to potential oil spills in US waters. It established a system of accident reporting, spill containment and cleanup; and set up the National Response Center and precursors to today's National Response Team and Regional Response Teams. There is a toll-free number where spills must be reported to the National Response Center, which is administered by the US Coast Guard.

Following the Clean Water Act of 1972, the NCP was revised to include hazardous substance spills. As part of Superfund legislation, the NCP was extended to cover releases at hazardous waste sites that require emergency removal actions. Responses to releases of hazardous substances depend on consideration of their threat to human or animal populations, drinking water supplies, sensitive ecosystems, high levels in soils, adverse weather conditions, threats of fire or explosions and other similar factors.

Paragraph 150(a) of the NCP requires response actions to comply with worker health and safety protections specified under HAZWOPER. The OSHAct must also be followed. OSHA is responsible for ensuring worker safety and site compliance with HAZWOPER. Post-emergency response actions, such as cleanup, must also conform to the HAZWOPER standard (29 CFR 1910(q)(11)).

Hazardous Materials Transportation Uniform Safety Act (HMTUSA)

The Hazardous Materials Transportation Act (1975) gave the Department of Transportation the authority to regulate the transportation of hazardous materials. It additionally set standards for packaging and labeling of those items. In 1990, this act was clarified, becoming the Hazardous Materials Transportation Uniform Safety Act (HMTUSA). HMTUSA's primary purpose is to help protect the health and safety of transporters, accident responders, the public, and property. HMTUSA standards apply to any person who transports hazardous materials. They also apply to any person or company, who manufactures, fabricates, marks, maintains, reconditions, repairs, or tests a package.

Toxic Substance Control Act (TSCA)

The TSCA (1976; updated 2016 as the Frank R. Lautenberg Chemical Safety for the 21st Century Act) requires evaluation of chemicals before they are sold. This act requires EPA to create a list of reviewed harmful substances that need precautions and safe work practices by the community as well as industry. This act gives the manufacturers, importers, and distributers of these goods the responsibility to report on and keep records related to those substances. Some substances have additional restrictions, while others are excluded from the requirement due to the nature of their use.

Resource Conservation and Recovery Act (RCRA)

RCRA (1976) was established to regulate the management and disposal of hazardous materials and wastes. RCRA started the manifest system of tracking a hazardous waste from generator through transportation, storage, and disposal. It is sometimes referred to as the “cradle-to-grave” liability tracking system. It also encourages hazardous waste recycling and minimization. RCRA gave EPA the jurisdiction and responsibility to create and enforce the regulations regarding the proper handling, labeling, storing, treating, and disposal of hazardous waste.

RCRA Amendments of 1984 strengthened the program to include underground storage tanks (USTs), to redefine small-quantity generator (SQG) to include more generators, and to restrict liquid and hazardous wastes from landfills.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA (1980), also known as Superfund, authorized government money for clean-up of abandoned hazardous waste sites, clean-up and emergency response to transportation incidents involving chemical releases, payment to injured or diseased citizens, etc. It was amended in 1986.

Exercise - Regulations and Agencies

You are a member of an employer-employee safety and health committee. The committee has decided to review all employer safety and health programs to make certain that they meet or exceed all existing safety and health regulations. You have made up a list of questions or concerns, and your job is now to check them out and report back to the entire committee. See Exercise Guide.

Summary – Rights and Responsibilities

OSHA is the federal government agency that has major responsibility for writing and enforcing safety and health rules in the workplace. The regulations are either enforced by the federal government or state employees; these state programs are known as 'state plans' and must be "at least as effective" as the federal program.

Two important programs bear directly on worker safety and health:

- SARA (EPA).
  - Continues "Superfund" for clean-up of hazardous waste sites
  - Mandates training of hazardous waste workers
  - Requires state and local emergency response plans and committees
- HAZWOPER (OSHA).
  - Worker training to reduce hazards

Employees and employers have rights and responsibilities established by the OSHAct. A major employer responsibility is to furnish a workplace free from recognized safety and health hazards likely to cause serious physical harm. A major employee responsibility is to follow reasonable employer safety rules and to wear personal protective equipment when required. Employers and employees have specific rights regarding OSHA enforcement, development of standards, and inspections.

The following additional governmental agencies may be involved in hazardous waste operations:

EPA (Environmental Protection Agency) – concerned with the protection of human and environmental health

DOT (Department of Transportation) – concerned with the transport of hazardous materials through interstate commerce

USCG (United States Coast Guard) – concerned with the transportation of hazardous material across navigable waterways and the preservation of our bodies of water

NRC (Nuclear Regulatory Commission) – responsible for community and worker protection from radiation hazards

The following additional regulations may have an impact on hazardous waste operations:

The Frank R. Lautenberg Chemical Safety for the 21st Century Act of 2016, an update to TSCA (Toxic Substance Control Act of 1976)

RCRA (Resource Conservation and Recovery Act) of 1976, amended 1984

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act) of 1980, amended 1986

HMTUSA (Hazardous Materials Transportation Uniform Safety Act) of 1990

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Chemical Properties

Many types of chemicals may be found at hazardous waste worksites. Workers who can recognize and describe the properties of chemicals are better able to reduce exposures and avoid injury or illness. Information on chemicals can be obtained from reference materials, safety data sheets (SDS) or other documents regarding materials at the site. Describing chemical properties is the focus of this chapter.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify properties of chemical, radiological and biological hazards that may be present at a hazardous waste site
- Use properties to evaluate risk to health
- Identify the factors needed for fire or explosion
- Demonstrate an ability to find properties of chemicals in resources

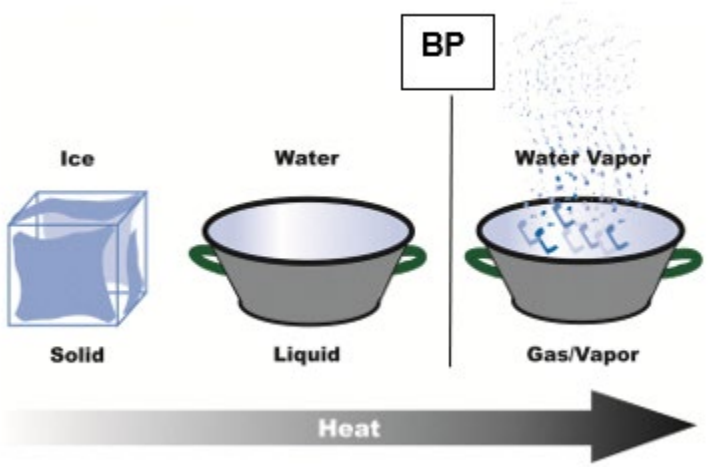
Introduction to Chemical Terms

Chemicals present a wide range of hazards, including the risk of fire or explosion and adverse health effects.

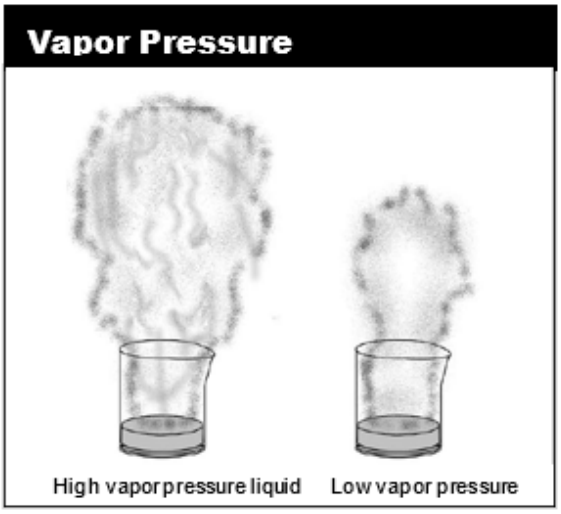
A list of chemicals found at EPA designated National Priority List hazardous waste sites is shown at http://www.atsdr.cdc.gov/SPL/index.html. This list has been prioritized by how frequently each is found at sites, toxicity, and potential for human exposure. The top five chemicals on the list are arsenic, lead, mercury, vinyl chloride and polychlorinated biphenyls (PCBs).

The following are some properties of chemicals that may be important on a hazardous waste site:

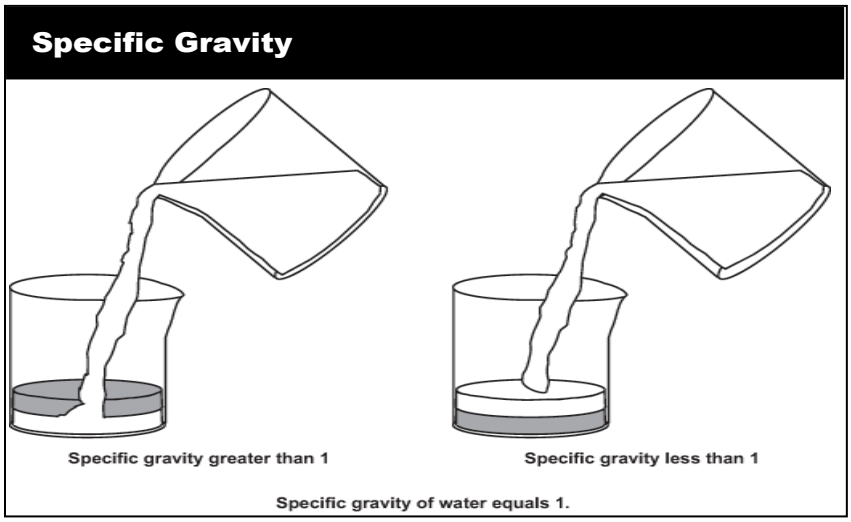
BP (Boiling Point). The temperature above which a liquid when heated to 'bubbling' at a specified pressure will evaporate rapidly. See the illustration showing ice changing to water (melting point) and to a vapor (boiling point); at sea level, water boils at 212°F.



VP (Vapor Pressure) in millimeters of mercury (mmHg). In a closed system, the pressure exerted by a vapor in equilibrium with the solid or liquid form. The vapor pressure increases with increasing temperature. VP is usually measured at 68°F at the reference pressure of 760 mmHg (1 atmosphere, 1atm). The higher the VP, the faster the chemical evaporates into space. See an illustration of vapor pressure on right for two chemicals at the same temperature

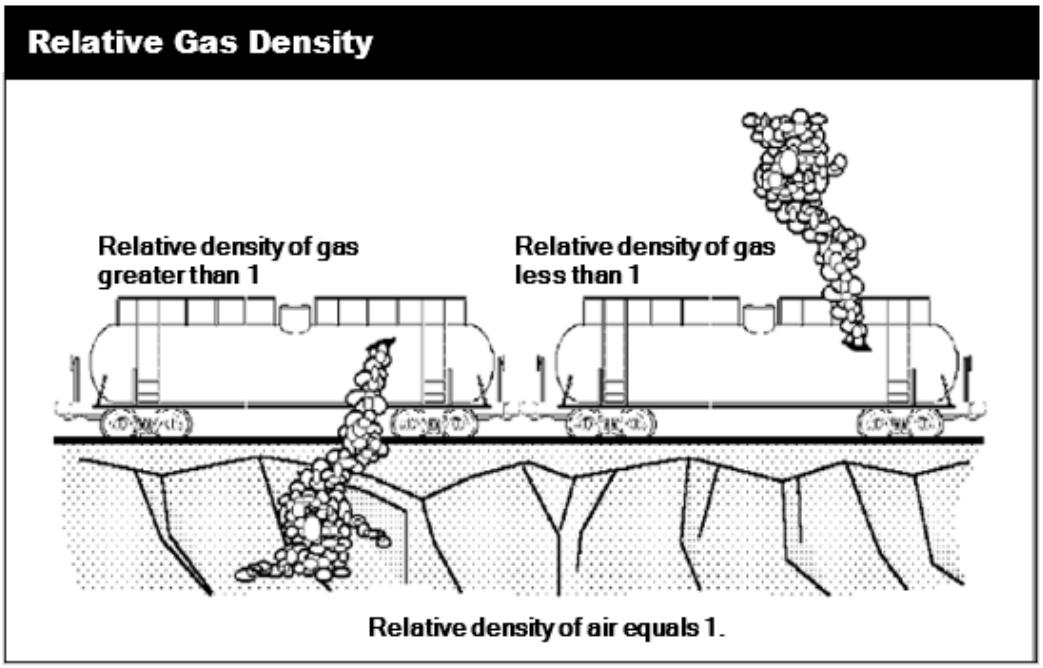


Sp.Gr. (Specific Gravity). As a ratio of density of equal volumes of one substance compared with density of another at a specified temperature, Sp.Gr. has no units. Usually water is the comparison and the measurement is made at 68°F. If a chemical has a higher density than the reference compound, it will sink (Sp. Gr. greater than 1). If a chemical is less dense than the reference (the Sp. Gr. is less than 1) it will rise when mixed with the reference compound.
See an illustration of specific gravity below.



Fl.P. (Flash Point). The temperature at or above which there is enough vapor of a liquid chemical to ignite if an ignition source is applied. The Fl.P. varies by test conditions and methods. If the open cup (oc or COC) method is used, a sample in an open cup is heated and a flame passed above the liquid surface at a specified height; the Fl.P. is identified when the vapor flashes. In the closed cup (cc) method, the ignition source is introduced into a closed container; the Fl.P. is determined when the vapors ignite. The cc Fl.P. is generally lower than the Fl.P. determined using the oc method.

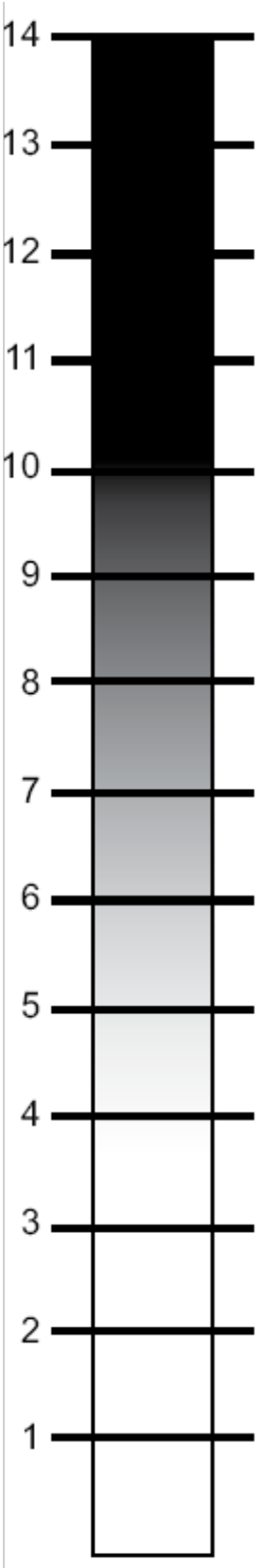
RGasD (Relative Gas Density of vapor compared to air=1). RGasD greater than 1 indicates the chemical is heavier than air; RGasD less than 1 indicates the chemical is lighter than air. If you know the molecular weight (MW) of the chemical, calculate the RGasD as MW/29. See an illustration of relative gas density below.



Acids and Bases

One property that the NPG does not show is whether a chemical is an acid or a base (also called an alkali, caustic or alkaline). Hydrogen ion concentration (measured as pH) is used to determine if a substance is an acid or a base.

A strong acid and a strong base are incompatible and must never be mixed. A dangerous reaction would occur with a lot of heat produced and possible splashing. If they are mixed in a closed container, an explosion could result.



liquid drain cleaner
caustic soda

bleach
oven cleaner

hair straighteners
(11.5 to 14.0)

soapy water

household ammonia
and cleaners

milk of magnesia,
mild detergent

toothpaste, hand
soap
perm solutions
baking soda, eggs,
seawater

shampoo (7 to 10)

“pure water”, blood

Urine, saliva, milk

Healthy skin, hair
and nails
Black coffee

Acid rain

Tomato juice, beer

Apples

Grapefruit and
orange juice

Lemon juice, vinegar

Stomach acid

Battery acid

pH

Definition Hydrogen ion concentration (pH) is used to determine if a substance is an acid or a base. A pH of 1 is very acidic; a pH of 14 is very alkaline. Because of the very large range in the values of pH, a special scale has been created. On it a change in pH of one unit (for example, from 3 to 4) represents a 10-fold change in acidity or alkalinity.

Example See scale.

Importance Compounds with high and low pH values will cause burns, irritate eyes, and irritate the nose and lungs. Substances with a pH less than or equal to 2 or greater than or equal to 12.5 are legally defined as hazardous waste. Materials with a pH less than 2.0 or greater than 11.5 will burn skin, eyes, and lungs.

Organic and Inorganic Chemicals

Organic chemicals, also known as hydrocarbons, all contain the element carbon, and generally come from living sources. Many organic chemicals are nearly insoluble in water and will form a separate layer when they are in the same container. Examples of organic chemicals found at hazardous waste sites include benzene, chloroform and coal tar.

A solvent is a chemical that is used to clean up or dissolve other substances. Many solvents are organic chemicals.

Inorganic chemicals are usually not from living sources, and include salts, metals and minerals. Inorganic chemicals that are found at hazardous waste sites include arsenic, lead, mercury and cadmium.

Incompatible Chemicals

Chemical combinations can be dangerous when the chemicals involved are incompatible, like strong acids and bases. Incompatible chemicals react violently when they come in contact with each other. They may become more volatile and react due to an environmental change such as a temperature increase.

Reactions of incompatible materials may result in heat, fire, explosion or a release of toxic gas. Chemicals such as chlorine and ammonia are incompatible and react when combined to produce a toxic gas. Acids added to cyanides produce hydrogen cyanide gas, which can cause death. Acids added to sulfides produce hydrogen sulfide gas, which can cause death. Incompatible chemicals must be stored away from each other and protected from coming into contact if the containers leak or rupture.

Many chemicals react with strong oxidizers. Oxidizers are chemicals that readily give off large amounts of oxygen or other oxidizing substances (such as bromine, chlorine or fluorine) when they react, and they react readily with other chemicals. The potential to react is increased at higher temperatures. See the NIOSH Pocket Guide to Chemical Hazards “Incompatibilities and Reactivities” section of each chemical listing to determine which other chemicals they are incompatible with.

Reactive Materials

Reactive materials are unstable and will decompose without reacting with any other compound if they are shaken, heated or compressed. They may also react with water or air. Heat or flammable gases may be generated, resulting in fire or explosion. Toxic gases may also result. Reactive materials pose additional problems for the site worker.

Examples:

Peroxides - Ethers stored for a long time react with the oxygen in the air to form peroxides. These peroxides are chemically unstable and shock-sensitive, and explosion may result from moving a container. Tetrahydrofuran and ethyl ethers are examples of ethers which form peroxides. They must be handled with extreme care.

Monomers - During polymerization, monomers (short chemicals) combine into long-chain compounds called polymers. In order to decrease the potential for explosion and fire during transit, these materials are usually mixed with a chemical inhibitor prior to shipping, to prevent polymerization. If the inhibitor becomes ineffective, runaway polymerization may cause an increase in pressure, rupturing containers or drums. Vinyl chloride and 1,3-butadiene are examples of monomers that may be found at hazardous waste sites.

Flammable, Combustible, Ignitable

The terms, “flammable, combustible and ignitable”, are commonly used to classify chemicals. In general, all three terms refer to chemicals that can catch fire easily. The lower the Flash Point (Fl.P.), the more flammable, combustible or ignitable a chemical is.

Explosive Limits

When the mixture of air and gasoline in an engine is too lean (not enough gas), the engine will not run. If the engine floods (too much gas or too rich), the car will not run. When the mixture is right and the spark plugs are working, the gas/air mixture burns and the engine fires.

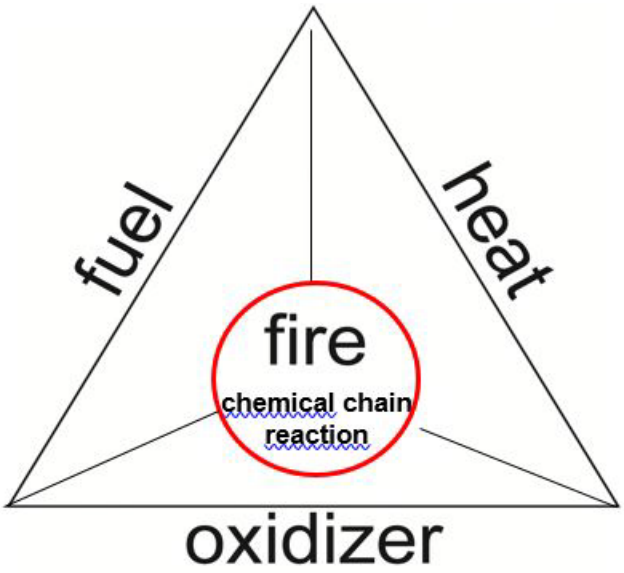
When there is just enough gas or vapor in the air to ignite, the concentration is at the Lower Explosive Limit (LEL, % in air). As the concentration of chemical in the air increases, it will reach a point where there is too much to produce a fire and

subsequent explosion. This concentration is called the Upper Explosive Limit (UEL, % in air). These limits may also be called the Lower Flammable Limit (LFL) and Upper Flammable Limit (UFL).

When concentrations in an area are higher than a certain percentage of the LEL (guideline may vary from employer to employer), the area must be evacuated.

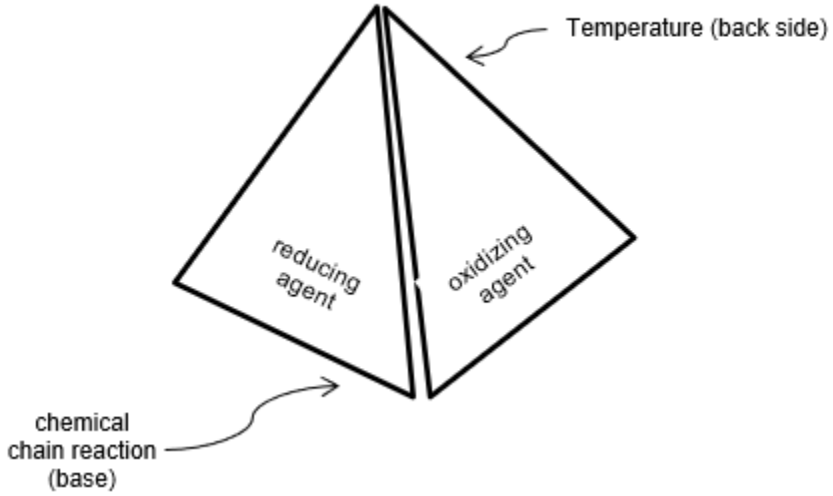
Fire Tetrahedron: Fuel, Oxygen/Oxidizing Agent, Heat, and Chemical Reaction

For a fire to burn, there must be four things: fuel (which may be a flammable vapor), oxygen from the air or other source (such as an oxidizer), heat (or source of flame or spark), and a self-sustaining chemical reaction. These four items make up the fire tetrahedron. The fire tetrahedron helps predict situations that may result in fire. To put out a fire, one or more of the four elements must be removed.



The addition of the chemical chain reaction allows for the conversion of the fire triangle to a four-sided pyramid-shaped figure known as a tetrahedron. See below for another figure:

The base of the pyramid is the chemical chain reaction that causes combustion. The sides of the pyramid—reducing agent, oxidizing agent and temperature—are the elements of the fire triangle (fire, oxygen and heat, respectively). The removal of one or more of the four sides will extinguish the fire.



Spontaneous Combustion

Some chemicals can catch on fire without a flame being introduced. This reaction is called spontaneous combustion. An example of spontaneous combustion is when oily rags, improperly stored in the equipment repair area of the site, spontaneously burst into flame.

Exercise – Using the NIOSH Pocket Guide to find Chemical Properties

In this exercise, you will use the NIOSH Pocket Guide to look up the properties of some chemicals found at hazardous waste sites. (See Exercise Guide)

Explosions

Explosions are violent reactions of solids or liquids, which produce a large amount of heat and usually gas. When the reaction between the ingredients of blasting powder is started with a spark or shock, a vigorous generation of heat and gas occurs that can shatter rocks or shell casings. In such a reaction, one compound that can burn reacts with an oxidizer, which takes the place of the

oxygen in the air. Nitrates, perchlorates, and peroxides are examples of oxidizers found in explosives. Some single compounds such as trinitrotoluene (TNT) contain all the ingredients necessary to create an explosion.

Combustible Dust Explosions

Explosions may be caused by an accumulation of dust inside a building, even when the material is considered to be safe. Fatal explosions have been caused by accumulations of dust from sugar, flour, grain, pharmaceuticals, paper, plastics, metal, insulation, wood and cloth, as well as many other materials. According to the US Chemical Safety and Hazard Investigation Board (CSB), 105 combustible dust incidents occurred between 2006 and 2017, resulting in 59 worker deaths. Conditions presenting a risk of dust explosion may be avoided by minimizing the buildup of dust, inspecting regularly for dust accumulation, and frequent cleaning, using methods that do not stir up clouds of dust. For more information, see http://www.osha.gov/dts/shib/shib073105.html

Radiation

When a material is radioactive, it gives off energy. There are four forms of ionizing radiation: Alpha, Beta, Gamma and Neutron. Radiation is colorless, odorless and tasteless, and is detected only by the use of special instruments. Radiation hazards are described further in later sections of the manual.

Biological Hazards

Biological hazards that may be encountered at a hazardous waste site include dangerous insects or animals, and toxic plants. Examples of dangerous insects:

Black widow spiders	Brown recluse spiders
Ticks	Scorpions
Bees	Yellow jackets
Wasps	Hornets
Stinging ants	Mosquitoes
Biting flies, midges and gnats	Fleas

These creatures can deliver a painful bite or sting, cause an allergic reaction or transmit disease. In extreme cases, severe illness or death can result. To avoid contact with these species:

- use an effective insect repellent
- wear light-colored clothing
- avoid wearing fragrances
- stay away from visible nests and webs
- wear long sleeves and long pants
- avoid reaching into places where you cannot see

Those who are allergic to bees and wasps may elect to carry an epinephrine auto injector after consulting a health care provider.

Contact with many different types of animals may be hazardous. Some examples of animals to be avoided at a hazardous waste site include:

Venomous snakes	Rodents
Birds	Raccoons
Skunks	Feral cats and dogs

These animals can inflict painful bites or scratches. Animals can carry disease, including serious diseases like rabies. In addition, approximately 5 people per year die from venomous snake bites. To avoid the potential of an animal bite or scratch, wear sturdy boots and long pants, wear leather gloves when handling brush and debris, and avoid likely areas where animals may take shelter, such as tall grass, or piles of leaves, rocks or wood.

Toxic plants may cause itchy rashes. Examples of such plants include poison ivy, oak, and sumac.

You should learn how to identify the most common types of these plants in your area. To minimize the hazard of exposure to the sap of these plants, wear long sleeves, long pants, boots and gloves when working outdoors. A barrier cream made specifically for the purpose may reduce the risk of developing a rash. Never burn any of these plants; exposure to the smoke may cause severe respiratory problems.

Never eat unknown plants, berries or mushrooms. Some varieties are extremely toxic.

Summary – Chemical Properties

Hazardous substance releases and reactions can cause harm to people and the environment.

Knowing the properties of chemicals helps to predict behavior in the environment: BP, VP, Sp. Gr., Fl.P., RGasD, pH

The fire tetrahedron shows the four elements necessary for a fire to burn:

- Fuel (can be solid, liquid, or a flammable vapor)
- Heat (spark or fire source)
- Oxygen from the air or an oxidizer
- Chemical reaction

The *NIOSH Pocket Guide to Chemical Hazards* is one reference used to identify chemical properties (water-reactive, oxidizer, and flammable) and incompatibilities.

Radiation is invisible and can seriously harm the body. It can only be detected with special instruments.

Biologic hazards at a hazardous waste site may include insects, spiders, animals and plants.

Toxicology and Health Effects

Toxicology is the study of physical and chemical agents that damage humans, animals, and/or the environment. Knowing some of the basic terms of toxicology is helpful in determining if and how exposure to a chemical can affect your health.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify several principles of toxicology
- Identify human responses to some chemical exposures
- Use resources to find occupational exposure limits
- List reasons why medical surveillance is important to waste site workers

Some Basic Principles of Toxicology

How does the body react to exposure?

Have you ever inhaled second-hand cigarette smoke? What reaction did you have: throat and airway irritation; nausea; dizziness? Did your eyes burn from being in a room filled with smoke?

Do you, or does someone you know, have a runny nose and red eyes during "pollen season?"

Have you ever consumed too much alcohol (ethanol or ethyl alcohol)? Did you experience slurred speech, dizziness, nausea, vomiting, "passing out," and hangover complete with headache?

These are examples of responses of your body to an exposure. The effect on your body was felt rapidly in each of these examples.

Exercise – Responses to Exposures

This exercise is a review of exposures that you may have experienced at work or at home. (See Exercise Guide)

Possible Health Effects

The health effects due to exposure to a hazardous substance can occur immediately or soon after (acute) or be delayed for months or years (chronic).

Acute Effects or Acute Toxicity

An acute health effect means that the body's response occurs at the time of exposure or within a few hours or days. Acute effects may result from exposure to high concentrations of a substance for a short period of time. Examples of acute health effects include:

- Choking or coughing
- Nausea
- Dizziness
- Burning eyes, throat, or skin

After recovery from an exposure you may have no evidence of damage or may have temporary or permanent damage.

You may recognize an exposure and remove yourself from the area if the chemical has a warning property. Warning properties may result in:

- Irritation to the skin, eyes, or lungs
- Bad/unpleasant smell (but don't depend on your nose to alert you)
- Dizziness

Warning properties cannot be relied upon to provide adequate protection from harm.

Chronic Effects or Chronic Toxicity

A chronic health effect is one that is recognized months or years after the exposure. Chronic effects generally involve repeated or prolonged exposure Examples of exposures and related chronic effects include:

Exposure	Effect (Disease)
Asbestos	Lung cancer
Carbon tetrachloride	Liver disease
Beryllium	Chronic beryllium disease
1,2-Dibromo-3-chloropropane (DBCP)	Male sterility

Some chemicals can cause both acute and chronic effects, depending on how long you were exposed and the chemical concentration. For example, high exposures to a solvent such as benzene may cause dizziness immediately; many years of exposure may result in cancer of the blood.

Routes of Entry

The way a harmful material enters the body is called the “route of entry.” The four routes of entry are skin absorption, inhalation, ingestion, and injection. Taking a toxic material into the body by these routes of entry can result in acute or chronic effects.

- Lungs (inhalation)
- Skin (skin absorption or skin or eye direct contact)
- Mouth (ingestion)
- Injection (skin puncture)

Inhalation

As we breathe, we take in whatever is in the air. If dusts, fibers, and chemicals are in the air, they may be deposited in the lungs or cross into the bloodstream.

Skin/Eye Absorption or Contact

The skin may be a major route of exposure, as many chemicals (such as solvents and liquid insecticides) cross through the skin and get into the bloodstream. Some chemicals (e.g., formaldehyde) penetrate the skin and cause an allergic reaction. If the skin is irritated, damaged, or punctured, absorption is increased. Human skin in different areas of the body lets chemicals through at different rates, called permeability. Some of the most-permeable areas of the body are the scrotum, scalp and forehead, as shown in the following table.

Area of body	Times Greater Than Absorption Through the Foot
Scalp and forehead	34–36
Arms	10–15
Hands	5–10
Scrotum	300

The skin and eyes may also be damaged by contact.

Ingestion

Chemicals can be ingested through the mouth and swallowed when eating, drinking, or using contaminated cigarettes or cosmetics. Don't eat, drink, smoke, or apply cosmetics in a contaminated area. Never carry cigarettes or cosmetics into contaminated areas.

Injection

A chemical can be accidentally injected into the body if you get injured by a tool, a compressed air/gas line, a fall, or a sharp object.

Multiple Routes of Entry

Some chemicals can enter the body in more than one way.

- Solvents: skin/eye contact and absorption, inhalation, ingestion, injection
- Metal fumes: skin contact can lead to ingestion or injection, inhalation
- Carbon monoxide: skin contact (if liquified), inhalation
- Metal particles: inhalation, ingestion, injection

Be alert for secondary sources of exposure

Hand contamination can contribute to ingestion and inhalation!

Example: Lead on your fingers/hand:

Transfer to a snack → ingestion

Transfer to a cigarette → inhaled when it burns

Example: Lead on your shirtsleeve or arm:

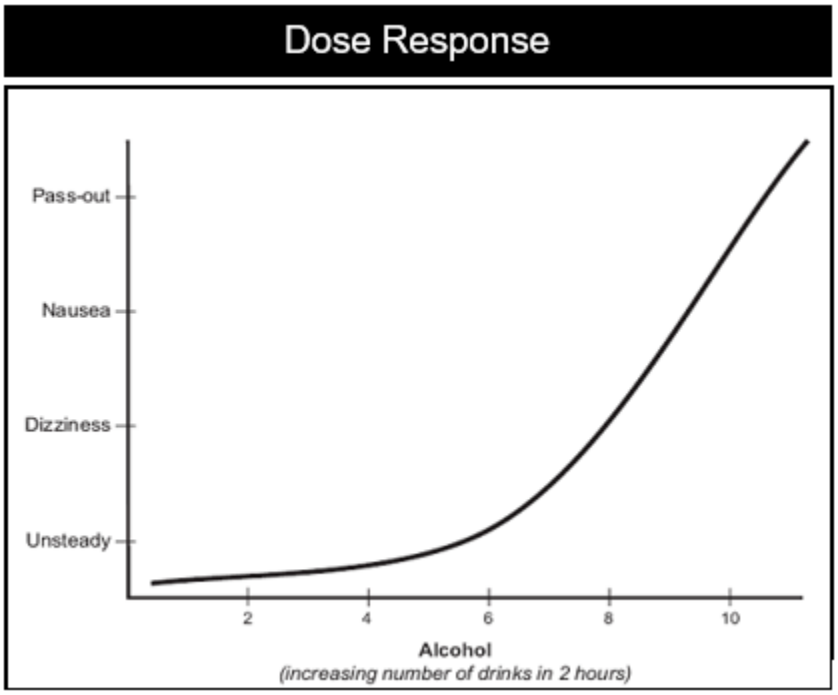
Transfer to face/lips when wiping sweat away→inhale or ingest

Example: Wash your hands and go to lunchroom; put hands on back of chair where someone with dusty shirt has been sitting

Transfer to your hands→ ingestion

Factors That Influence the Body's Response to Exposure

Different chemicals also can cause varying responses at different concentrations. This is known as a dose-response relationship. (See the illustration below).
A chemical is considered to be relatively nontoxic if a large amount of a chemical (dose) is needed to cause an adverse health effect. The chemical is considered to be highly toxic if a small amount causes an adverse health effect.



Importance: As the exposure increases, the body absorbs more (the dose increases) and the effect also increases.

Different individuals have different reactions to chemical exposure. There are a number of factors which seem to influence response. These include current health status, age, race, sex, allergy history, and previous chemical exposure.

Exposure or Dose? The concentration of a chemical in the air is Exposure. The concentration of the chemical or a metabolite in the body that does harm is Dose.

Other Terms to Describe Health Hazards

Several other important terms are described below:

A carcinogen is a chemical or physical agent that can cause cancer when a worker is exposed, generally over a long period of time. There may be no safe level of exposure to carcinogens.

A mutagen is a chemical or physical agent that changes the blueprint (DNA genetic code) of cells in your body. The effect is mutagenicity.

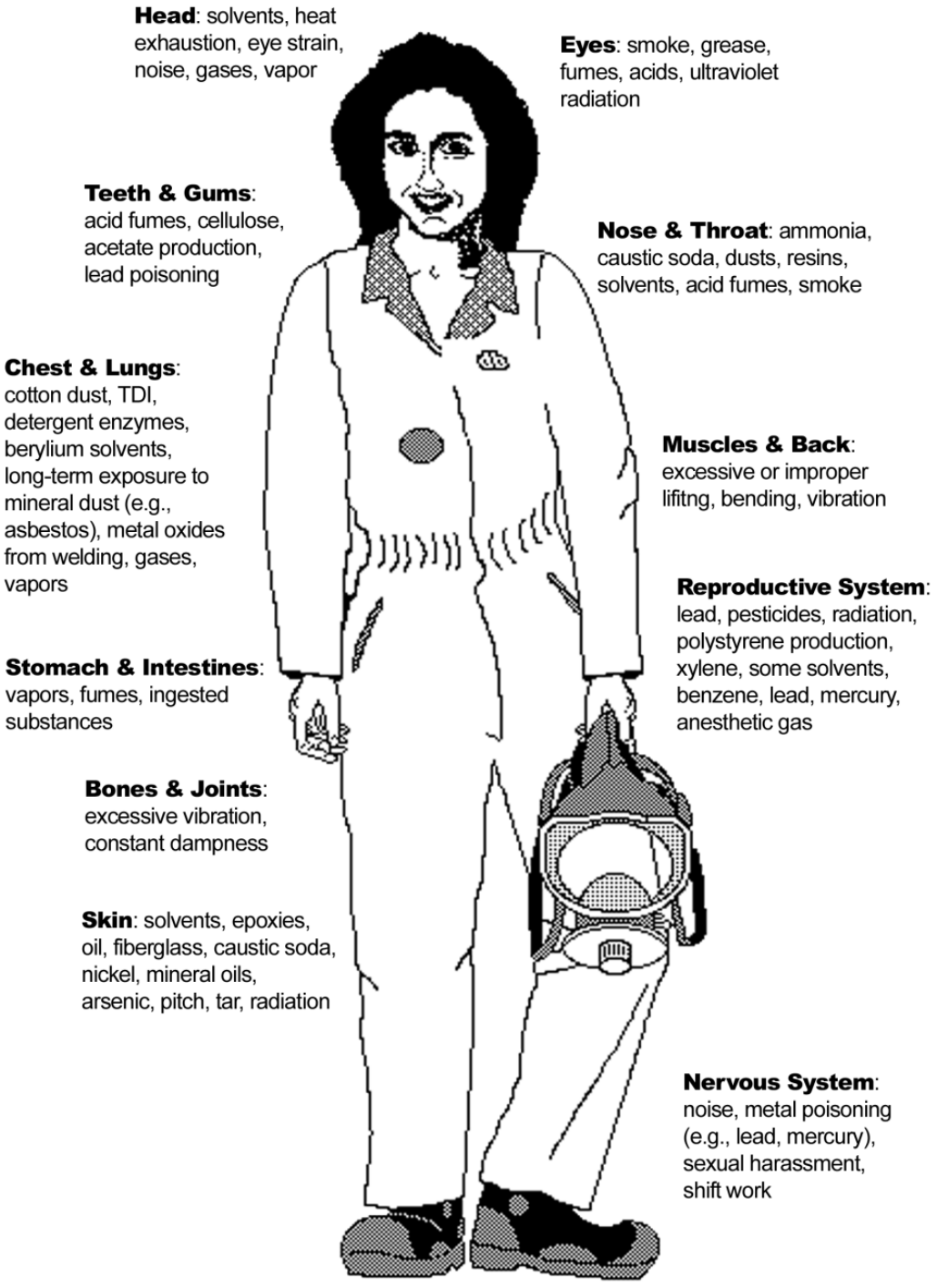
Aspiration is the entry of a liquid or solid chemical directly through the oral or nasal cavity (or indirectly during vomiting) into the trachea and lower respiratory system. Aspiration toxicity includes chemical pneumonia, other pulmonary injury or death. Petroleum distillates and chlorinated solvents have been shown to be aspiration toxins in humans

The illustrations on the next two pages describe harmful effects of chemicals and how different target organs may be affected.

Any time you suspect that signs or symptoms of illness are due to occupational exposure, consult an occupational healthcare provider.

Find an occupational healthcare provider: http://www.aoec.org/, a nationwide Association of Occupational and Environmental Clinics.

Health Effects: Where does the health effect occur (Target Organ) and What are potential causes (the Hazard)?



Adapted from the International Metal Worker's Union

Health Effects: How Does Your Body React (Acute/Chronic; Local/Systemic)?

Head: dizziness, headache

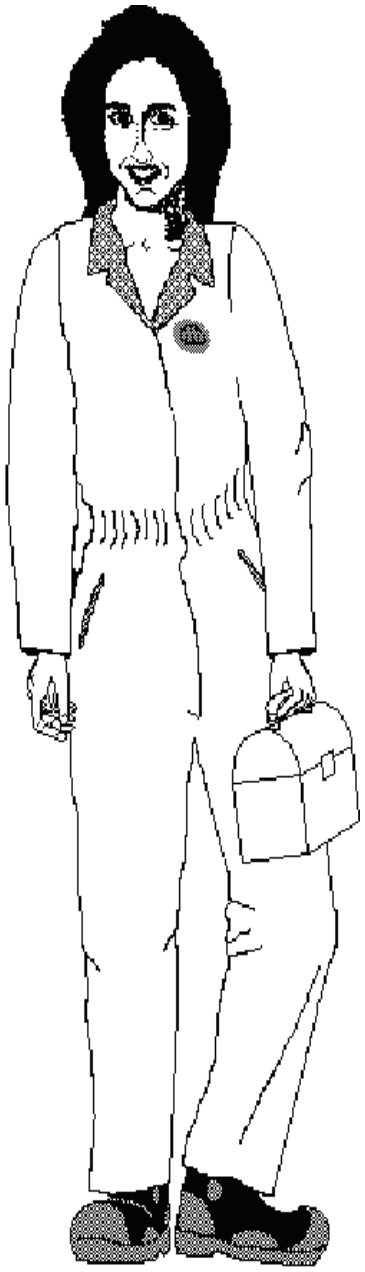
Teeth & Gums: corrosion of tooth enamel, blue gums

Chest & Lungs: wheezing, congestion, shortness of breath on mild exercise, flu-like symptoms (e.g., "metal fume fever")

Stomach & Intestines: Vomiting, diarrhea

Bones & Joints: arthritis.

Skin: redness, dryness, itching, ulcers, skin cancer.



Eyes: redness, irritation, watering, grainy feeling, "welder's flash"

Ears: ringing, temporary deafness, hearing loss

Nose & Throat: sneezing, coughing, sore throat, nasal cancer

Muscles & Back: soreness, strain

Reproductive System: miscarriage, irregularities in menstruation, damage to fetus or chromosomes, sterilization

Nervous System: stress, nervousness, irritability, sleeplessness, tremors, speech changes

Adapted from the International Metalworker's Union

Occupational Exposure Limits & Guidelines

OSHA sets and enforces airborne exposure limits. Generally, the enforced level is the Permissible Exposure Limit (PEL); however, OSHA inspectors can build a case to cite based on an exposure guideline if the PEL is considered 'old and outdated' or there is no PEL.

NIOSH and non-governmental agencies (such as ACGIH®) have also established exposure levels to protect health. These guidelines and recommendations are not legally enforceable. Some exposure levels have a "skin" designation to indicate that the material is readily absorbed through the skin.

All these organizations provide background on how the number was determined; however, it is notable that the numbers are often quite different. The process to set a standard through OSHA takes many years, and therefore most OSHA standards have not been changed since the agency was established in 1970. ACGIH® and NIOSH update values more often. All groups consider the need to limit exposure to preserve health when a new number is developed.

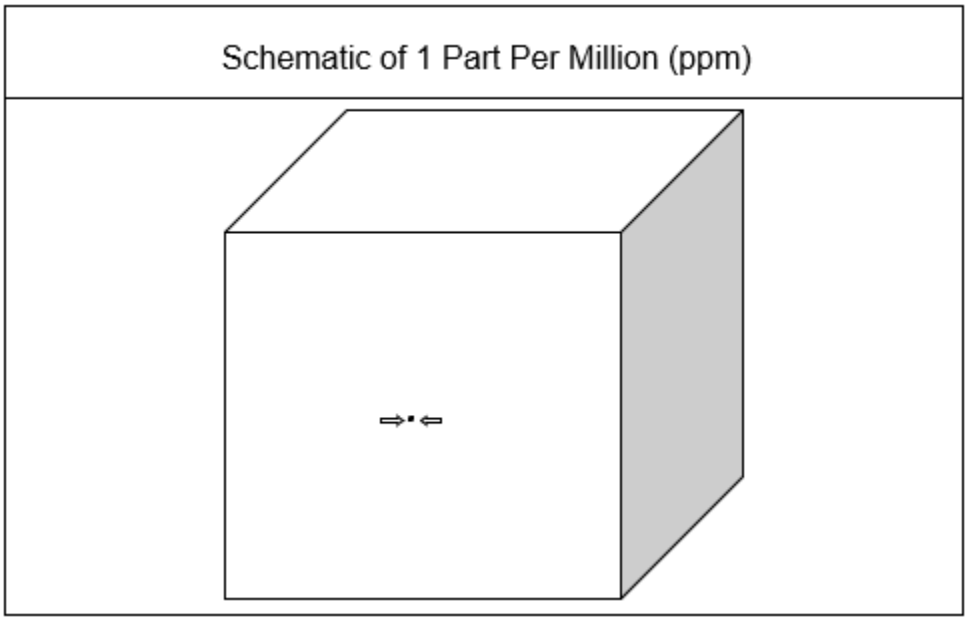
Some large companies provide Occupational Exposure Levels (OELs) that could be different and are generally lower than the PEL. Exposure standards as used in this training are enforceable by a government agency. You may see other sources of standards; for example, the American National Standards Institute (ANSI) develops consensus documents referred to as standards, but that are not enforced by ANSI.

Measures of Concentration

Exposure limits are expressed as an airborne concentration. Concentration is the amount of a substance contained in a certain volume of air. Concentrations of gases or vapors in air are usually measured in parts per million (ppm) or percent by volume of air:

1 ppm, 1 mg/m^3, or 1 f/cc are low concentrations. Some chemicals are hazardous even at these low concentrations.

Percentage is used for higher concentrations; a concentration of 1% is 10,000 ppm



Concentrations of particulates, dust, and mists are usually measured in milligrams per cubic meter of air (mg/m^3).

- There are about 400,000 milligrams in one pound.
- There are about 35 cubic feet in one cubic meter. (A meter is about 40 inches.)

Fiber concentrations are measured in fibers per cubic centimeter (f/cc). A cc is about the size of a sugar cube.

Immediately Dangerous to Life and Health (IDLH)

IDLH is a concentration or condition that poses an immediate threat to life or health or might prevent someone from escaping such an environment. IDLH conditions include situations where a chemical is present above the IDLH concentration, where oxygen concentration in the air is too low, or when there is risk of explosion.

Permissible Exposure Limits (PELs)

Permissible exposure limits (PELs) are legal exposure levels set by OSHA. Employers are required by law to keep exposures below the PELs. In most cases, the PELs have not been updated for many years.

Threshold Limit Values (TLVs)

Threshold limit values (TLVs) are recommendations for exposure limits which are prepared by the ACGIH, a private, non-governmental agency. TLVs, which are not legally enforceable, do include updates of some levels each year. They are usually more protective (lower) than PELs. TLVs are not listed in the NPG, and the full listing and basis for the concentration are not available for free. The TLV is listed in safety information from chemical suppliers.

Recommended Exposure Limits (RELs)

Recommended exposure limits (RELs) are set by NIOSH. RELs are not legally enforceable. Like TLVs, RELs are generally more protective than the enforceable PELs. See the NPG (NIOSH Pocket Guide, https://www.cdc.gov/niosh/npg/default.html).

Short-Term Exposure Limits (STELs)

These exposure limits are set by ACGIH, OSHA, and NIOSH. The STEL is a maximum average concentration a person may be exposed to over a short period of time, usually 15 minutes. It is legally enforceable if set by OSHA. STEL is sometimes abbreviated further to ST.

Ceiling Limits (C)

The ceiling limit (C) is an exposure level set by ACGIH, OSHA, and NIOSH that should not be exceeded at any time. It is legally enforceable if set by OSHA.

Time-Weighted Averages (TWAs)

Most PELs, TLVs, and RELs are 8-hour time-weighted average concentrations. The purpose of this type of average exposure is to characterize an 8-hour work shift. An example of how the TWA is calculated follows:

Time-Weighted Averages Calculated

An employee is exposed to acetone at 60 ppm for 6 hours and 12 ppm for 2 hours. What is the TWA?

$$TWA = \frac{(Exposure_1 \times Time_1) + (Exposure_2 \times Time_2) + \ldots}{(Time_1 + Time_2 + \ldots)}$$

$$TWA = \frac{(60 \text{ ppm} \times 6 \text{ hrs}) + (12 \text{ ppm} \times 2 \text{ hrs})}{(6\text{hrs} + 2 \text{ hrs})}$$

$$TWA = \frac{(360 + 24) \text{ ppm hrs}}{8 \text{ hrs}}$$

$$TWA = 48 \text{ ppm}$$

Compare this result with the current OSHA PEL for acetone of 1000 ppm.

- Has the PEL been exceeded?
- Was it exceeded for any portion of the time sampled?
- Is there a REL, ST or C designation in the *NIOSH Pocket Guide to Chemical Hazards*?

Biological Exposure Standards and Indices

Instead of measuring a concentration in the air, a person's exposure to some substances may be evaluated by measuring the concentration of the substance in the blood, urine, or exhaled breath. Examples include:

Substance	Measured in:
Lead	Blood
Carbon monoxide	Blood, breath
n-Hexane	Urine
Parathion (pesticide)	Urine
Trichloroethylene	Blood, urine, breath

Few OSHA standards include biological monitoring – the lead exposure standard is one example that does include biological monitoring.

For more information on biological exposure guidelines, see individual OSHA standards for enforceable limits and the section on Biological Exposure Indices in the ACGIH annual publication, TLVs® and BEIs®.

Exercise – Using the NIOSH Pocket Guide to Find Occupational Exposure Limits

Utilize the NIOSH Pocket Guide to determine the occupational exposure limits for the chemicals reviewed earlier. (See Exercise Guide)

Exposure Records

Results of any exposure monitoring conducted by your employer are considered part of your medical record and must be available to you upon request.

See the OSHA Standard “Access to Employee Exposure and Medical Records” (29 CFR 1910.1020). Records which workers can request include either environmental information or personal medical records. When requested, the employer must provide access within fifteen working days after the request is made. The employer can comply by either making a copy of the requested record at no cost to the employee, allowing the employee to use the employer copy machine to copy the requested record, or by allowing the employee an opportunity to inspect the record.

Medical Surveillance

Medical surveillance is a program to protect employee health. The contents of the medical exam are not specified in HAZWOPER, but it may include an occupational history, physical examination, and medical laboratory tests. Medical surveillance can be done:

- Prior to a new job assignment
- On a routine basis
- At termination of a job or job assignment
- If an employee exhibits signs or symptoms which may have resulted from exposure to hazardous substances during the course of an emergency incident

Legal Requirements for Medical Surveillance

Under HAZWOPER, certain specific groups of workers exposed to hazardous materials are legally eligible for medical surveillance. Many employers include workers not covered by HAZWOPER in routine medical testing programs.

A licensed physician must perform all medical testing and examinations or supervise those who do. The employer must provide the physician a copy of the HAZWOPER standard and appendices and specific information on the employee's job, exposures and personal protective equipment used. Understanding the worker's job will help the health care provider to be more effective.

Employers are required to pay for mandatory medical surveillance exams. In addition, employees are not to lose pay for the time the exam takes. The exams should be scheduled at a time and place convenient for the employee.

After a medical surveillance examination has been completed, the employer and employee will receive the physician's written opinion relative to the worker's employment. The employee may also receive findings that do not affect employment. The employer must keep the medical report and other exposure records for 30 years after the employee leaves employment.

Things the employee should do:

- Report all work-related injuries or illnesses immediately to the company physician and/or a personal doctor
- Request and keep full copies of medical records
- Examine and keep copies of exposure records
- Actively participate in training on the potential health effect of all chemicals used or stored at work
- Ask questions of health and safety representatives
- See an occupational physician, if a second opinion is wanted

Summary – Toxicology and Health Effects

An acute exposure involves a high concentration (dose) of a toxic chemical for a short period of time

A chronic exposure involves a low concentration of a toxic chemical over a long period of time

Routes of entry for toxic substances are absorption through the skin, inhalation, injection, and ingestion

Exposure-response refers to the relationship between a chemical and toxic response. As the exposure to a toxic chemical increases, uptake into the body (dose) generally increases; as a result, the health hazard to the worker increases.

Local effects of a toxic chemical occur at the point of contact with the body (skin, eyes, and lungs)

Systemic effects occur when a toxic chemical enters the bloodstream and is distributed to all the tissues and organs in the body

The organ of the body is affected by a certain toxic chemical is called the target organ

Occupational exposure limits can be PELs, RELs, IDLHs, TLVs, STELs or Ceiling values for specific chemical exposures. OSHA can enforce compliance with the PELs; groups setting guidelines do not enforcement authority.

- Most PELs, RELs, and TLVs are 8-hour average concentrations
- STELs are set for very few compounds
- IDLH, STELs, and Ceiling limits are for short durations of exposure
- Results of exposure monitoring can be requested by the employee under the OSHA Standard on Access to Employee Exposure and Medical Records (29 CFR 1910.1020)

Medical surveillance is required under HAZWOPER. The employer must pay for the exam and keep a record of this exam and employee exposure records until at least 30 years after the employee last worked.

Material Identification, Physical and Safety Hazards

Recognizing a potential hazard is an important step toward avoiding it. This chapter includes material identification using labels and written documents and physical and safety hazards that may be present at hazardous waste sites.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify information available through the Hazard Communication standard
- Identify hazards using placards and labels
- Identify physical and safety hazards that may be present on a hazardous waste site
- Identify work practices and technologies to control hazards
- Find health and safety hazards and control procedures on a Safety Data Sheet

Hazard Communication

The purpose of the Hazard Communication Standard is to ensure that everyone at a worksite has access to information about the chemicals that are used and has been trained to use them safely.

For workers on a hazardous waste site, chemicals that are inventoried and/or used in remediation or maintenance processes are covered by the Hazard Communication Standard. Hazardous wastes are not covered by this standard. The Hazard Communication Standard (HCS2012) includes major changes in labels for containers and Safety Data Sheets (SDS, no longer MSDS - but the same idea). The updated OSHA standard has the same number (29 CFR 1910.1200).

HCS2012 requires all manufacturers' labels to have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification. HCS2012 covers most chemicals (excluding wastes) in an overall system that looks at physical hazards (such as flammability and corrosivity), health hazards (including both immediate and long-term health effects) and environmental hazards. Employers may continue to use rating systems such as National Fire Protection Association (NFPA) diamonds or HMIS requirements (both discussed later in this chapter) for workplace

labels, as long as they are consistent with the requirements of the Hazard Communication Standard and the employees have immediate access to the specific hazard information for the chemicals (for example, an SDS). An employer using NFPA or HMIS labeling must, through training, ensure that employees are fully aware of the hazards of the chemicals used.

If there is a transfer of a chemical from a labeled container to a portable container that is only intended for immediate use by the employee who performs the transfer, no label is required for the portable container. For more information, see OSHA Brief, Hazard Communication Standard: Labels and Pictograms, http://www.osha.gov/Publications/OSHA3636.pdf.

Exercise – What do these terms mean?

You will use the HCS standard to find definitions of terms. See Exercise Guide.

Pictograms

HCS2012 requires the use of pictograms, graphic symbols to identify hazards. There are eight health and safety pictograms and one (non-mandatory) environmental pictogram. All pictograms are a red diamond, enclosing a black symbol on a white background. The words below each pictogram are all of the Hazard Classes that are covered by the figure.

Exercise – Pictograms

Use an OSHA Quick Card to find information on pictograms. See Exercise Guide.

Labels

Appendix C to HCS2012 describes required elements of container labels. A few key points:

- The label must include the name, address and telephone number of the manufacturer/importer/responsible party. The product identifier on label must match the SDS.
- There is a hierarchy of signal words:
    - Danger or Warning must be used
    - If Danger is used, Warning is not

- There is a hierarchy of pictograms:
    - If the skull and crossbones are used, then the exclamation mark is not used for acute toxicity
    - If a corrosive pictogram is used, the exclamation mark is not used for skin and eye irritation
    - If the health hazard pictogram for respiratory sensitization is used, the exclamation mark is not used for skin sensitization or skin and eye irritation
- Hazard statements can be combined

- There are four types of Precautionary Statements:
    - Prevention
    - Response
    - Storage
    - Disposal
- Each Hazard Class is detailed in Appendix C.4. Shown for each are:
    - Hazard Category
    - Signal Words
    - Hazard Statements
    - Pictograms
    - Precautionary Statements

Look through these pages so you are familiar with them as a resource.

General Industry or Construction Standard

OSHA has different standards for these two types of work sites

Ask your supervisor or the Safety Officer which standards apply.

Consult work plans that reference OSHA, and see what numbers are used for standards. For example for HCS2012:

Do you see 1910.1200? The 1910 indicates General Industry

Do you see 1926.59? The 1926 indicates Construction

Both are Hazard Communication!

Exercise – Labels

In this exercise, you will identify labels that would be acceptable or unacceptable under HCS2012 and find information from labels. See Exercise Guide.

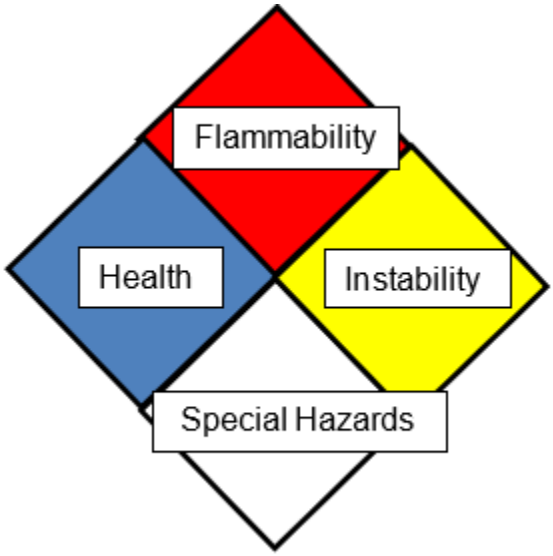
Other systems are described below.

National Fire Protection Association (NFPA) – 704 System

The National Fire Protection Association (NFPA) system may be used on storage vessels and containers at a stationary facility. Some facilities may use this system throughout their departments and put the NFPA label on all hazardous materials. The facility's hazard communication training can inform the worker if this warning system is being used at the work site.

What does the NFPA system look like?

- Diamond-shaped



- Color-coded in four small diamonds:

Color	Hazard
Red	Flammability
Blue	Health
Yellow	Instability
White	Special hazards

- Number-coded in the red, blue, and yellow diamonds–Ranks the potential flammability, health, and instability hazard from 0 (least hazard) to 4 (highest hazard).

- The Special Hazards (white) section of the NFPA-704 label may contain symbols (examples shown below) that give more information about the chemical. The following are symbols and their meanings that might be found in the Special Hazards (white) section of the NFPA-704 label.

NFPA Standard Symbols

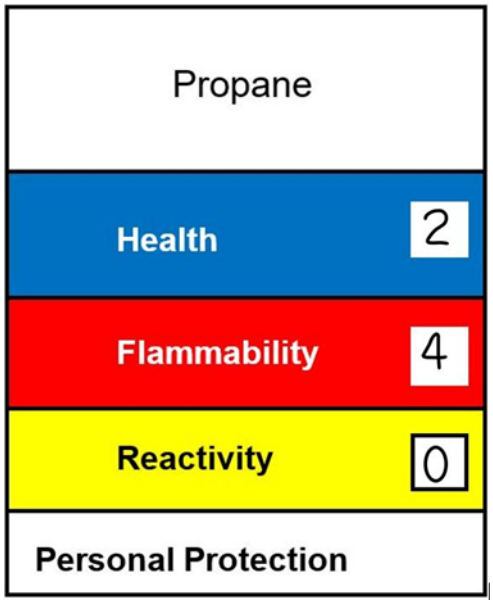
Non-Standard Symbols

- **COR:** Corrosives.
- **ACID** and **ALK** (Alkali) to be more specific.
- **BIO:** Biological Hazard.
- **POI:** Poisonous Material (e.g. strychnine)
- **CYL or CRYO:** Cryogenic Material (e.g. liquid nitrogen)
- **Radioactive trefoil:** Radioactive materials. (e.g. plutonium, uranium)
- The field may also be left blank if no special hazards are present.
- When multiple special hazards exist, add white panels below the placard to list the additional special hazards that apply.

The HMIS (Hazardous Material Information System)

These labels may be used on storage vessels and containers.

What does the HMIS label look like?



- Rectangular
- Color-coded
- Number-Coded
    - Ranks the potential health, flammability, and physical hazard. Ranges from 0 (minimal hazard) to 4 (severe hazard).
- Letter-coded
    - Tells you what personal protective equipment you should use to protect yourself when working with the material. Capital letters range from A (safety glasses) to K (full protective suit with gloves, boots, a hood or mask, and an airline or Self-Contained Breathing Apparatus). If the personal protection is coded X, specialized handling procedures are needed. Lower-case letters n through u, w, y and z are codes for specific protective equipment. For example, q represents boots and u represents an organic vapor respirator. A chart outlining each letter code should be available wherever these labels are used.

The part of the body affected by exposure is also designated: blood, eye, nervous system, kidney, liver, reproductive, skin, or respiratory. Icons are available for each.

Physical hazards include water reactive, organic peroxides, explosives, compressed gasses, pyrophorics, oxidizers and unstable reactives. Each is represented by an icon.

A Hazard Summary Label is available to be used for shipped containers; it has more complete information on health hazards, routes of exposure and physical hazards.

It is important that you report unlabeled or partially labelled containers discovered during remediation activities.

Emergency Response Guidebook–System of Placards and Labels (Enforced by the US Department of Transportation [DOT])

NOTE: The HCS2012 pictograms do not replace the diamond-shaped labels that DOT requires for the transport of chemicals, including chemical drums, chemical totes, tanks or other containers. Those labels must be on the external part of a shipped container and must meet the DOT requirements set forth in 49 CFR 172, Subpart E. If a label has a DOT transport pictogram, HCS pictograms for the same hazard may also appear on the label. While the DOT diamond label is required for all hazardous chemicals on the outside of shipping containers, chemicals in smaller containers inside the larger shipped container do not require the DOT diamond but will require the OSHA pictograms when HCS2012 is implemented.

What does the DOT system look like?

- Diamond-shaped
- Color-coded

Color	**Hazard**
Orange	Explosive
Red	Flammable
Green	Non-flammable
Yellow	Reactive
White	Poisonous
White and red vertical stripes	Flammable solid
White top with black bottom	Corrosive
White top with red bottom	Spontaneously combustible
Yellow top with white bottom	Radioactive

Below is an example of the DOT placard for flammable or combustible (red)

- Word-coded (hazard class name), for example:
  - Explosives
  - Blasting Agents
  - Dangerous (may be used with mixed loads)

Here is an example of the DOT placard for a radioactive hazard

- Symbol-coded:

Symbol	**Hazard**
Bursting ball	Explosive
Flame	Flammable/organic peroxide
W with slash	Dangerous when wet
Skull and crossbones	Poisonous
Circle and flame	Oxidizing material
Cylinder	Non-flammable gas
Propeller/Trefoil	Radioactive
Test tube/hand/metal	Corrosive
Special symbol	Infectious (discussed elsewhere)

Here is a DOT placard with the symbol for a corrosive hazard

- Number-coded

A **four-digit** number in the **center** identifies a specific compound. These numbers are identified in the *Emergency Response Guidebook*. For example, 1223 is kerosene. The DOT placard above has the number 1760, which identifies the contents as one of several corrosive liquids. This number may be in the center of the placard (number placards) or on an orange-colored panel below the placard, along with a "word placard" such as the "Flammable" diamond, as shown below.

Number placards must be displayed on large portable tanks, tank trucks, and rail cars. A word placard means that drums or smaller containers are present.

A **one-digit** number at the **bottom** is the Hazard Identification Code.

#	UN Hazard Class
1	Explosives
2	Gases (compressed, liquefied, or dissolved under pressure)
3	Flammable liquids
4	Flammable solids: spontaneous combustible and Dangerous when wet/ Water Reactive
5	Oxidizing substances and organic peroxide
6	Poisonous, poison inhalation hazard, and infectious substances
7	Radioactive substances
8	Corrosives
9	Miscellaneous hazardous materials

You can find more information on what these numbers and symbols mean in a DOT Chart and the *Emergency Response Guidebook*. The ERG can be downloaded onto your device for free. Here are the websites for each device:

Android phone (at Google store):
https://play.google.com/store/apps/details?id=gov.nih.nlm.erg2012

iPhone or iPad (at iTunes):
https://itunes.apple.com/us/app/erg-2012-for-iphone/id592158838?mt=8&ign-mpt=uo%3D2

Windows: https://www.phmsa.dot.gov/hazmat/erg/erg2020-windows-software

A Spanish-language version can also be selected.

To use the guidebook, you need to know either the chemical name or the identification number.

If you know the **name**, look in the blue pages to find the guide number. Once you have the correct guide number, proceed to the white pages with orange edges, where you will find more detailed information on the chemical.

If you know the **UN number**, look in the yellow pages to fine the guide number. Once you have the correct guide number, proceed to the white pages with orange edges to find more detailed information on the chemical.

Pesticide Labels

A pesticide is generally defined as any chemical or mixture of chemicals used to control or destroy any living organism considered to be a pest, such as some insects (insecticides) or plants (herbicides). Pesticides may be found in containers ranging from paperboard boxes to rail cars.

The Environmental Protection Agency (EPA) is the federal agency charged with regulating the pesticide industry, under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Pesticide labels required by the EPA are different from those on chemicals (covered by HCS2012). The EPA requires the following label elements:

- Name and address of the producer, registrant, or person for whom produced
- Restricted Use Statement (if required)
- Product Name, Brand or Trademark
- Ingredient Statement
- Signal Word, including Skull & Crossbones, if either are required
- First Aid statement, if necessary
- “Keep Out Of Reach Of Children” (KOOROC)
- Precautionary Statements, including Hazards to Humans and Domestic Animals
- EPA Registration Number and EPA Establishment Number
- Mode of Action Numerical Classification Symbol (when used)
- Directions for Use
- Referral Statement to Directions for Use in separate booklet, if any
- Storage and Disposal Statements
- Warranty Statement (voluntary)
- Worker Protection Labeling
- Net weight or measure of contents

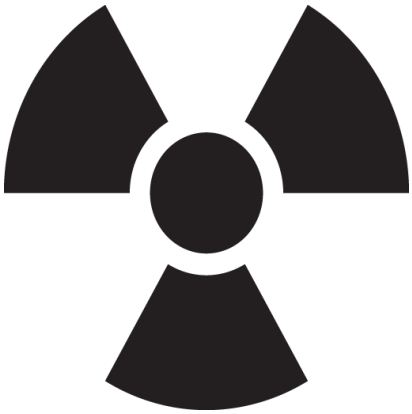
Under FIFRA, the SDS is considered part of the label. Because HCS2012 requires different language in the SDS than that required by EPA on the label, EPA recommends that pesticide manufacturers include in the SDS the hazard information required on FIFRA labeling and a brief explanation for differences between that information and the Safety Data Sheet hazard information.

http://www2.epa.gov/pesticide-registration/labeling-requirements

Infectious Materials

The most common type of packaged biological waste is probably infectious waste from a hospital or other health care facility. This type of waste should be in boxes, plastic containers, or **red** plastic bags marked on all sides with the **fluorescent orange** infectious materials symbol shown here.

Radioactive Materials



Radioactive sources are used in industry and medicine, and radioactive wastes result from energy and weapons production. The best indication that a radiation source is present is the symbol shown on the right. It is usually **magenta** or **purple colored** on a **yellow** background. Workers should keep as far away as possible from any containers with this marking unless they have had specific training and know that they are adequately protected. Where radiation hazards exist, the company must include Standard Operating Guides (SOGs) in the Safety and Health Program.

Radiation Symbol

All forms of radiation should be considered very hazardous.
Treat radioactive materials with respect!

Exercise - Placards and Labels

In this exercise you will compare different types of labels. See Exercise Guide.

Documentation

Written documents are available describing the hazardous chemicals and wastes. Four important sources are shipping papers, manifest forms, waste profile sheets and Safety Data Sheets (SDSs). During site characterization, it is important to know whether these resources were found and the types of information each contains.

Shipping Papers

Each shipment of hazardous materials must have paperwork documenting the specific contents of the shipment and relevant information. When hazardous and non-hazardous materials are listed on the same shipping paper, the hazardous materials must be listed first or emphasized by bold font or contrasting color. This paperwork has different names depending on location, as shown below:

Transportation	Location during transport	Common name(s)
Truck	In the cab	Bill of Lading, Waste Profile Sheet
Train	With the conductor	Waybills, Consists, Wheel Reports, Train List
Barge or Ship	In the wheelhouse or on the barge	Dangerous Cargo Manifests
Airplane	In the cockpit	Shipper's Certification for Restricted Airlines

When a shipment arrives at a plant, a copy of the shipping papers is given to plant personnel. As part of site characterization, shipping papers may be found for materials ultimately transferred to the site.

A copy or electronic copy must be retained and include the date of acceptance by the initial carrier. This is retained by shipper for 2 years and the carrier for 1 year. Hazardous waste manifests must be kept 3 years by both carrier and shipper. These must be accessible at the principal place of business and available upon request.

Shipping papers are required by the Department of Transportation (DOT). The shipper of the material provides this information. One of the most frequent violations of the Hazardous Materials Regulations (HMR), 49 CFR Parts 100-185 is a failure to properly describe hazardous material on the shipping papers.

The proper shipping description of hazardous cargo includes the following 4 categories:

- Basic description
- Additional information, depending on the material and the mode of transport
- The quantity of the hazardous material
- The type of packaging used

The basic description should include:

- Identification number
- Proper shipping name
- Hazard class
- Packing group

The order in which this information must be shown is given in 49 CFR 172, Subpart C.

- The shipper must provide a certification statement, certifying that the shipment complies with the HMR. The shipping papers must also contain an emergency response telephone number, unless exempted. This number must be monitored by a knowledgeable person at all times while the shipment is underway.
- Shipments of hazardous materials must also include emergency response information to assist emergency responders in the event of an incident. The minimum requirements for the contents of the emergency response information are:
- Basic description
- Immediate hazards to health

- Risks of fire or explosion
- Immediate precautions to take in the event of an incident
- Immediate methods for handling fires
- Initial methods for handling spills or leaks
- Preliminary first aid measures.
- For additional information, see http://www.phmsa.dot.gov/

Bill of Lading

The following information must be given in a Bill of Lading:

- Proper shipping name found in the Hazardous Materials Table (HMT) in the HMR
- Hazard class or division number (subsidiary risks)
- Identification number packaging group
- Total quantity being shipped
- Special permits (Examples) DOT-SP, DOT-E
- Emergency Response telephone
- Empty Package
- Transport Modes
- Shipper's Certification
- Packing group
- Marine Pollutants - Vessel mode (non-bulk)
- Poison or toxic inhalation (add info/continuation pages)
- Limited Quantity Hazardous Substance Reportable Quantity (RQ)
- Radioactive

Manifest Form

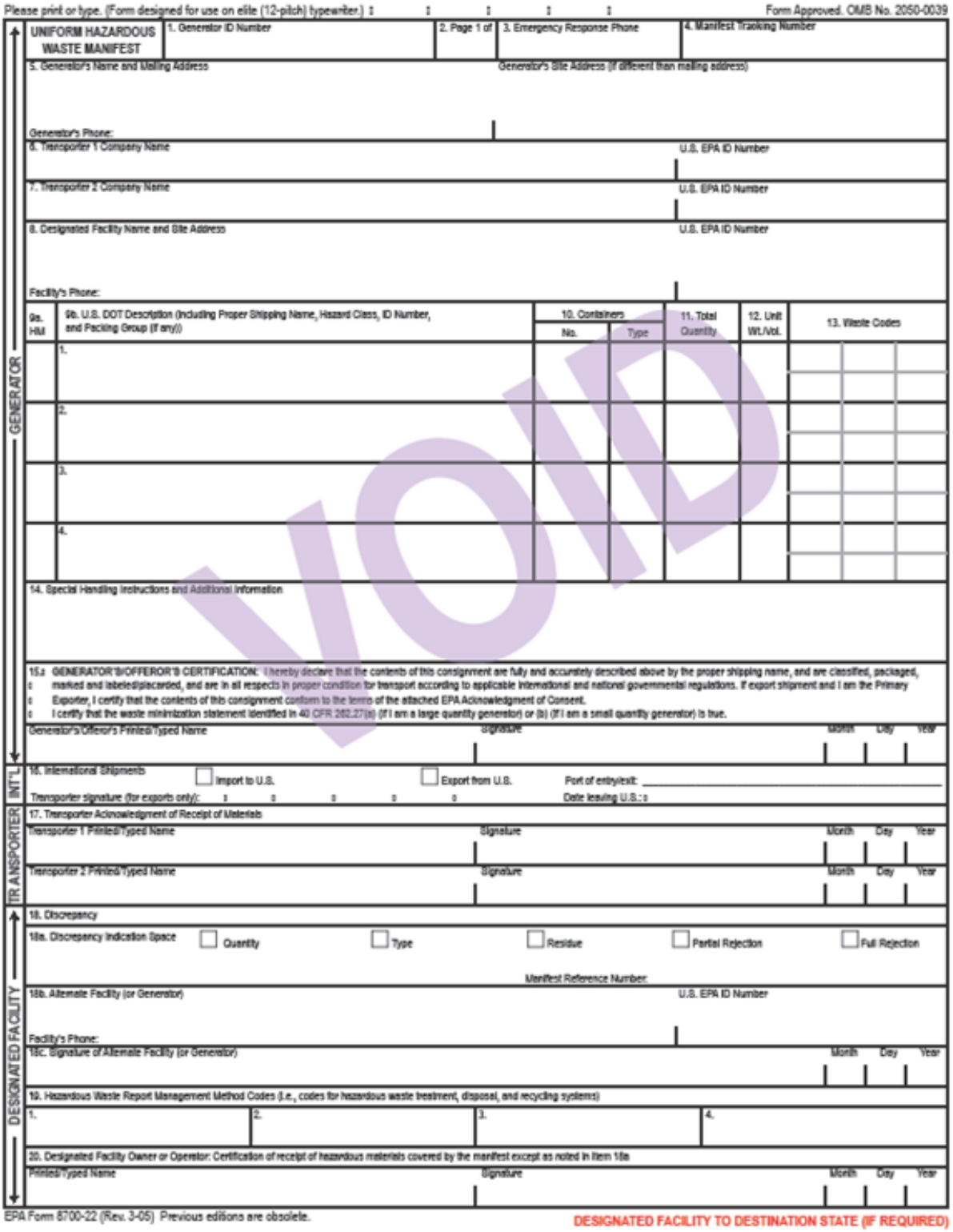
The uniform hazardous waste manifest provides cradle-to-grave tracking of hazardous wastes. As required by the EPA and DOT, all hazardous waste shipments must be accompanied by this form. The manifest consists of a number of copies which are given to the generator, transporter, and site characterization workers. Manifest information may be identified during site characterization. The information on the waste form includes:

- The identification number, name, and address of the generator
- The identification number, name, and address of the permitted work site
- The identification number and name of the hazardous waste hauler
- A description of the contents

For example, a 55-gallon drum of benzene would be labeled U-019 on the manifest form. A hazardous waste stream would have the required EPA identification number on the form (e.g., F002, D001).

An example of a hazardous waste manifest form is presented on the following page.

Uniform Hazardous Waste Manifest Form



Please print or type. (Form designed for use on elite (12-pitch) typewriter.)

Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator ID Number
2. Page 1 of
3. Emergency Response Phone
4. Manifest Tracking Number

5. Generator's Name and Mailing Address — Generator's Site Address (if different than mailing address)

Generator's Phone:

6. Transporter 1 Company Name — U.S. EPA ID Number

7. Transporter 2 Company Name — U.S. EPA ID Number

8. Designated Facility Name and Site Address — U.S. EPA ID Number

Facility's Phone:

9a. HM	9b. U.S. DOT Description (Including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes
	1.					
	2.					
	3.					
	4.					

14. Special Handling Instructions and Additional Information

15. GENERATOR'S/OFFEROR'S CERTIFICATION: I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent. I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name — Signature — Month Day Year

INT'L

16. International Shipments — Import to U.S. — Export from U.S. — Port of entry/exit:

Transporter signature (for exports only): — Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials

Transporter 1 Printed/Typed Name — Signature — Month Day Year

Transporter 2 Printed/Typed Name — Signature — Month Day Year

DESIGNATED FACILITY

18. Discrepancy

18a. Discrepancy Indication Space — Quantity — Type — Residue — Partial Rejection — Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator) — U.S. EPA ID Number

Facility's Phone:

18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1. 2. 3. 4.

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a

Printed/Typed Name — Signature — Month Day Year

EPA Form 8700-22 (Rev. 3-05) Previous editions are obsolete.

DESIGNATED FACILITY TO DESTINATION STATE (IF REQUIRED)

Waste Profile Sheets

The waste profile sheet (pre-acceptance laboratory analysis sheet) is a document provided by the laboratory that conducted the analysis of the hazardous waste. The profile sheet describes the waste sample, including details of the physical and chemical properties such as the concentration, toxicity, and disposal restrictions. Information from any available waste profile sheets is important for site characterization. An example can be found at: https://www.epa.gov/sites/production/files/2015-04/documents/tsdf-wap-guide-final.pdf.

Safety Data Sheets (SDSs)

SDSs are required by the OSHA Hazard Communication Standard (29 CFR 1910.1200). Prior to December 1, 2015, an employer provides the SDSs required by HCS2012, or the older version, Material Safety Data Sheets (MSDSs). After that date, SDSs must be used. Manufacturers and suppliers are responsible for providing the new labels and SDSs.

To make this safety information more useful, the SDS consists of 16 required sections as shown in the OSHA Quick Card: Hazard Communication Safety Data Sheets, on the next page. Regardless of supplier or manufacturer, the order of the information must be as listed.

Workers must be trained in reading SDSs and how to work with materials that are routinely used. The SDSs for products used in remediation must be present on the hazardous waste site and available to employees during all shifts.

Exercise – Contents of the SDS

In this exercise, Appendix D of HCS2012, 29 CFR 1910.1200, will be used to determine the minimum information that must be in each section of the SDS. See Exercise Guide.

Exercise – Using an SDS to Find Safety Information

In this exercise, you will use an SDS to find safety information for a chemical. See Exercise Guide.

OSHA QUICK CARD™

Hazard Communication Safety Data Sheets

The Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, or importers to provide Safety Data Sheets (SDSs) (formerly known as Material Safety Data Sheets or MSDSs) to communicate the hazards of hazardous chemical products. The HCS will requires new SDSs to be in a uniform format, and include the section numbers, the headings, and associated information under the headings below:

Section 1, Identification includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.
Section 2, Hazard(s) identification includes all hazards regarding the chemical; required label elements.
Section 3, Composition/information on ingredients includes information on chemical ingredients; trade secret claims.
Section 4, First-aid measures includes important symptoms/ effects, acute, delayed; required treatment.
Section 5, Fire-fighting measures lists suitable extinguishing techniques, equipment; chemical hazards from fire.
Section 6, Accidental release measures lists emergency procedures; protective equipment; proper methods of containment and cleanup.
Section 7, Handling and storage lists precautions for safe handling and storage, including incompatibilities.
Section 8, Exposure controls/personal protection lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).
Section 9, Physical and chemical properties lists the chemical's characteristics.
Section 10, Stability and reactivity lists chemical stability and possibility of hazardous reactions.
Section 11, Toxicological information includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
Section 12, Ecological information*
Section 13, Disposal considerations*
Section 14, Transport information*
Section 15, Regulatory information*
Section 16, Other information, includes the date of preparation or last revision.
*Note: Since other Agencies regulate this information, OSHA will not be enforcing Sections 12 through 15(29 CFR 1910.1200(g)(2)).

Employers must ensure that SDSs are readily accessible to employees.
See Appendix D of 29 CFR 1910.1200 for a detailed description of SDS contents.
For more information: www.osha.gov

OSHA (800) 321-OSHA (6742) U.S. Department of Labor

Limitations of Documents

Although the SDSs, shipping papers, manifest forms, and waste profile sheets contain important information, they have a number of limitations. Some of these problems are listed below.

- Limited information:
  - Information may be incomplete or inaccurate
  - Space on the form may be inadequate
  - Information may not be relevant for the site or specific use
  - Information may be too general for use
  - SDS may not be current
  - Insufficient time to read and understand the information, particularly in an emergency
  - Insufficient time to call manufacturer/supplier contact, particularly in an emergency
- May not be readily available:
  - Not part of site characterization data
  - SDSs identified during site characterization may be located at a remote location
- Labels on waste containers may be old (not HCS2012) or only partly visible. Alert safety personnel to learn if the contents were identified as part of site characterization.

Physical and Safety Hazards

Physical and safety hazards include a wide range of potential exposures. Hazardous waste sites face many of the same problems as the construction industry, including hazards associated with:

- Ponds and lagoons
- Confined spaces and trenches
- Electricity
- Slips, trips and falls
- Ladder safety
- Struck-by hazards
- Vehicle safety (passenger & heavy equip.)
- Steam
- Ergonomic injuries

- Noise
- Buildings (structural integrity and type of construction)
- Fall from height
- Temperature extremes
- Equipment maintenance

Ponds and Lagoons

Ponds and lagoons found at hazardous waste sites are used to store large volumes of materials. The hazards around ponds and lagoons include:

- Drowning
- Partially solidified surface
- Corrosive or toxic materials
- Gases or vapors

The precautions that should be used around ponds and lagoons include:

- Using protective equipment such as life jackets, safety belts, or lifelines when working close to unrailed areas
- Wearing protective clothing if material could cause injury if contacted or inhaled
- Keeping railings and work surfaces in good repair
- Limiting access
- Training workers

Confined Spaces and Trenches

Confined space work should never be attempted without training in proper procedures. Examples of confined spaces at hazardous waste sites include trenches, leachate collection tanks and cells that receive waste at landfill operations. Confined spaces will be discussed further in the “Work Practices” chapter of this manual. The regulation covering permit-required confined spaces is 29 CFR 1910.146.

OSHA requires a competent person to oversee any excavation. They do not require cave-in prevention in stable soil if the trench is less than 5 feet deep and removed soil is at least 2 feet from the edge of excavation. Unstable soil excavation of any depth requires protection. Excavation workers are generally required to wear head and foot protection to prevent injury. Refer to the OSHA Construction Standard, 29 CFR 1926.651, for additional details.

Other excavation safety considerations include:

- Locating overhead and underground utilities safely. Many communities have numbers to call to have the utility company mark the location of utilities before you dig.
- Removal of soil (spoil) at least 2 feet from the edge of excavation
- Providing access every 25 feet for ingress and egress
- Identifying vibration or moisture sources that may cause the banks to cave in

Electricity

Electrocution may result at hazardous waste sites if there is contact with energized equipment or damaged supply lines. The hazard increases if working in wet areas.

Precautions to prevent electrocution include:

- Lock-out/tag-out. (This will be discussed in more detail in the Work Practices chapter)
- Using double-insulated tools
- Using pneumatic equipment
- Using ground fault circuit interrupters (GFCI) on all circuits on outdoor jobs and other potentially wet areas
- Using cords and equipment in good repair and with ground prong in good condition
- Using the OSHA-required electrical PPE for the voltage rating of the circuit

Electrical repair/maintenance work must be done by qualified personnel only.

Slips, Trips, and Falls

Slips, trips, and falls are common causes of injuries at sites. Prevention is the key to avoiding injuries such as broken bones or injured backs. Avoid wet or oily floors. Don't climb up the fall line on steep slopes. Avoid climbing over equipment. Don't put yourself in situations which could result in injury. Examples of situations causing slips, trips, and falls at sites include:

- Slick surfaces
- Steps
- Ice and snow
- Poor-fitting PPE

Ladder safety

Improper use of ladders is a major cause of falls. To prevent accidents when using ladders, the following practices are suggested:

- Inspect ladders before use
- Extend extension ladders 3 feet above the level to be reached
- Tie off extension ladders to prevent slippage
- Check that the distance from the wall is one-fourth of the used length of the ladder
- Avoid carrying items in your hands when climbing ladders. Use a “tag” line to convey items up and down
- Use cages or fall arrestors when climbing fixed ladders
- Use a step ladder tall enough for the job. Do not stand on the top step.
- Never lean out to the side of a ladder past your navel!

NIOSH has a ladder safety smartphone app available at:
http://www.cdc.gov/niosh/topics/falls/

Struck-By Hazards

In 2017, there were 695 occupational struck-by fatalities (https://www.bls.gov/news.release/pdf/cfoi.pdf). At hazardous waste sites, various types of equipment may be moving in proximity to the workers. To avoid being hit by moving equipment, stay alert to activities around you.

To keep drums from striking other workers, you should observe proper stacking procedures. Inspect pallets prior to use; do not use any that appears damaged or weakened.

Vehicle Safety

Vehicle hazards accounted for 1,299 deaths in 2017. The following procedures for vehicular safety should be noted:

- Do not leave any unattended unit running
- Listen for vehicle back-up alarms/horns
- Transport equipment being loaded or unloaded should have brakes set and wheels chocked

- Heavy-equipment operators must use seat belts for the roll-over protection system to be effective
- Prevent potential carbon monoxide hazards by minimizing exhaust in closed or low areas

Steam

Steam from ruptured lines can cause severe burns. The steam, or the heat from it, may also react with other materials to compound the problem at sites.

It is possible that what appears to be steam may not actually be steam. Some chemicals may give off toxic clouds that appear steam-like. Also, gases escaping from a pressurized container may look like steam.

Always maintain a safe distance.

Ergonomic injuries

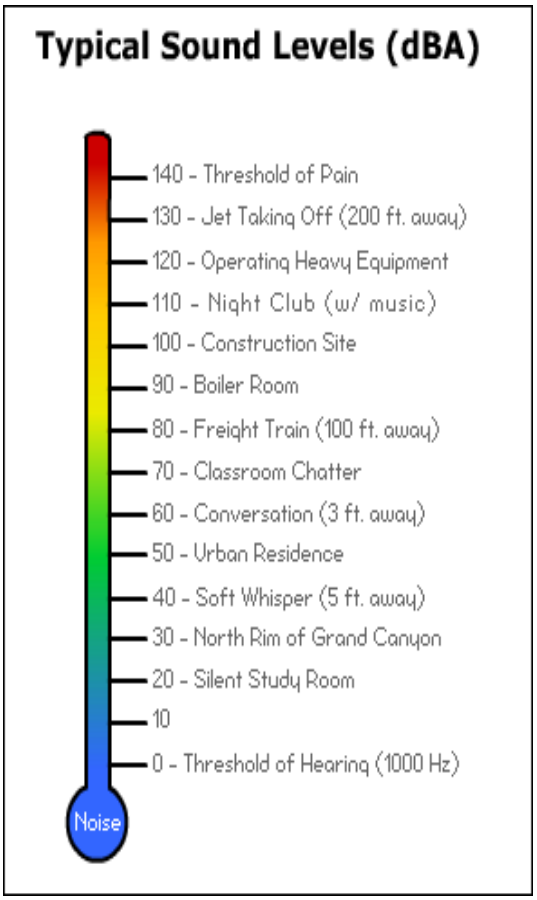
Injuries from overexertion, vibration, awkward posture, repetitive motion or heavy lifting may result from poor design of the job, making it difficult for workers to complete a task without undue stress. These musculoskeletal disorders (MSDs) or injuries affect several parts of the body including muscles, nerves, blood vessels, ligaments and tendons. See the figures in Toxicology and Health Effects.

Noise

At a hazardous waste site, there are many possible sources of noise. Short exposures to high noise levels can cause a temporary change in hearing or the sound of ringing in your ears. Repeated exposures over longer periods of time to noise can lead to permanent effects, including hearing loss. Exposure to high noise levels is also linked to high blood pressure, insomnia, headaches and psychological stress.

Loud noise in the workplace can interfere with communication and concentration resulting in lower productivity, accidents and injuries.

See the exposure levels below for operating heavy equipment and at a construction site.



Notice that the values are shown in dBA, or decibels (dB) measured on the A-weighting scale. This scale mimics the human ear response to sound; it does not measure some of the low frequency sound, as the human ear does not pick up all low frequency sound. Occupational exposure to noise is measured on this scale. dB and dBA cannot be compared easily.

Other useful noise levels are:

Power tools	90-100	dBA
Impact wrench	105	dBA
Air gun	100-120	dBA
Air horn alert system	130	dBA

Over an 8-hour shift, OSHA allows a TWA exposure of 90 dBA. If the sound is louder, less time is allowed; for example, 4 hours is allowed at a TWA of 95 and 2 hours is allowed at a TWA of 100. If the TWA exceeds 85 dBA, a Hearing Conservation Program is required to monitor hearing, provide training and hearing protection. See 29 CFR 1910.95.

NIOSH and ACGIH recommend lower TWA exposures.

NIOSH provides an app for noise measurement. See https://www.cdc.gov/niosh/topics/noise/app.html

Graphic source: https/www.osha.gov/ SLTC/noisehearingconservation/loud.html

Buildings (structural integrity and type of construction)

Often buildings on waste sites have been abandoned for some time. Potential hazards include:

- container and material storage, sometimes shifted from initial placement or with damaged packaging
- process/manufacturing equipment
- rotted structural supports, flooring, stairs
- animals or bird droppings

Enter buildings with caution and maintain communication with emergency personnel unless the integrity of the structure has been documented by engineering.

Falls from heights

Guardrails, safety netting, and/or personal fall arrest systems are used to protect against a fall from a height. If you are working on a construction site, fall protection must be used if you are working 6 feet above the surface or at any height if there are sharp objects (such as ends of rebar or metal debris). If using a scaffold in the construction industry, fall protection is required only at a 10 foot or greater height. However, for activities in general industry, fall protection is required when working four or more feet above the lower level.

Temperature Extremes

Heat

Working in hot environments, especially in protective equipment, puts extra physical stress on the body. Risk increases with increasing temperature.

It is important to know the signs of heat exposure:

- Heat rash
- Heat cramps
- Heat exhaustion
- Heat Stroke

These are described on an OSHA QuickCard that you can keep with you. See https://www.osha.gov/Publications/osha3154.pdf

To monitor the risk of heat-related illness, OSHA has a smartphone app. See https://www.osha.gov/SLTC/heatillness/heat_index/heat_app.html

Cold

Cold stress is less common but does occur during winter months. OSHA provides detailed approaches to minimize cold-related injury.

- Frostbite
- Hypothermia

See https://www.osha.gov/SLTC/emergencypreparedness/guides/cold.html

An additional hazardous situation is getting trapped in a vehicle during extreme weather. If traveling for work or to/from work during winter months ensure that someone knows where you are, have adequate fuel and stow warm clothing in the vehicle for emergency use.

Equipment maintenance

Maintenance activities may involve welding, cutting, brazing, or grinding, known as 'hot work'. Ensure that protective measures are taken prior to starting this work, including a hot-work permit if needed.

Exercise – Hazard Recognition Scenario

In this exercise, you will identify hazards at a mock work site. See Exercise Guide.

Summary – Material Identification, Physical and Safety Hazards

As a worker at a hazardous waste site, you may encounter a variety of hazards that are common to the industry. Being aware of potential hazards and how to prevent them will protect your health and safety.

The purpose of the Hazard Communication Standard is to provide workers with hazard information about chemicals to ensure chemical safety in the workplace.

Labeling is a method used to communicate or identify information about chemicals. Raw materials and chemical products are required by HCS2012 to have hazard labels. Placards are signs on a transportation vehicle which provide information about the material being transported. A Safety Data Sheet (SDS) is a compilation of identification and hazard information required under the OSHA Hazard Communication Standard (29 CFR 1910.1200) and consists of 16 sections in a required order. SDSs must be available on the site for any products used in remediation activities.

A uniform hazardous waste manifest is a one-page form with multiple copies. It accompanies the hazardous waste shipment from its point of origin to its point of disposal.

A waste profile sheet is a source of information about the chemical and physical properties of a hazardous waste.

Ponds and lagoons used for storage and treatment, as well as confined spaces, pose hazards. You should wear the proper protective equipment and have proper training in safe work practices when performing activities in these places.

Excavation sites may pose dangers such as cave-in. Before attempting work in these sites, you need to determine whether shoring is necessary, whether vibration or moisture sources exist, whether protective equipment is available, and where overhead and underground utilities are located.

Electrocution by energized equipment and equipment failure may occur at hazardous waste sites. To prevent electrocution, follow precautions such as using appropriate equipment and not attempting electrical repair/maintenance work unless you are trained and qualified.

Health hazards from heat and cold may be present at the work site. Individuals working under conditions of extreme heat should understand the factors that make heat stress more likely, as well as the symptoms of the condition and necessary actions to take if it develops. Overexposure to extreme cold may produce frostbite or hypothermia, which may require assistance from trained personnel.

Common causes of injury at hazardous waste sites are slips, trips, and falls. When using ladders, check their condition and follow safe, recommended procedures.

Other potential hazards include struck-by hazards from moving equipment or vehicles, steam from ruptured lines that may cause severe burns, ergonomic injuries and noise levels that may impair communication or damage hearing.

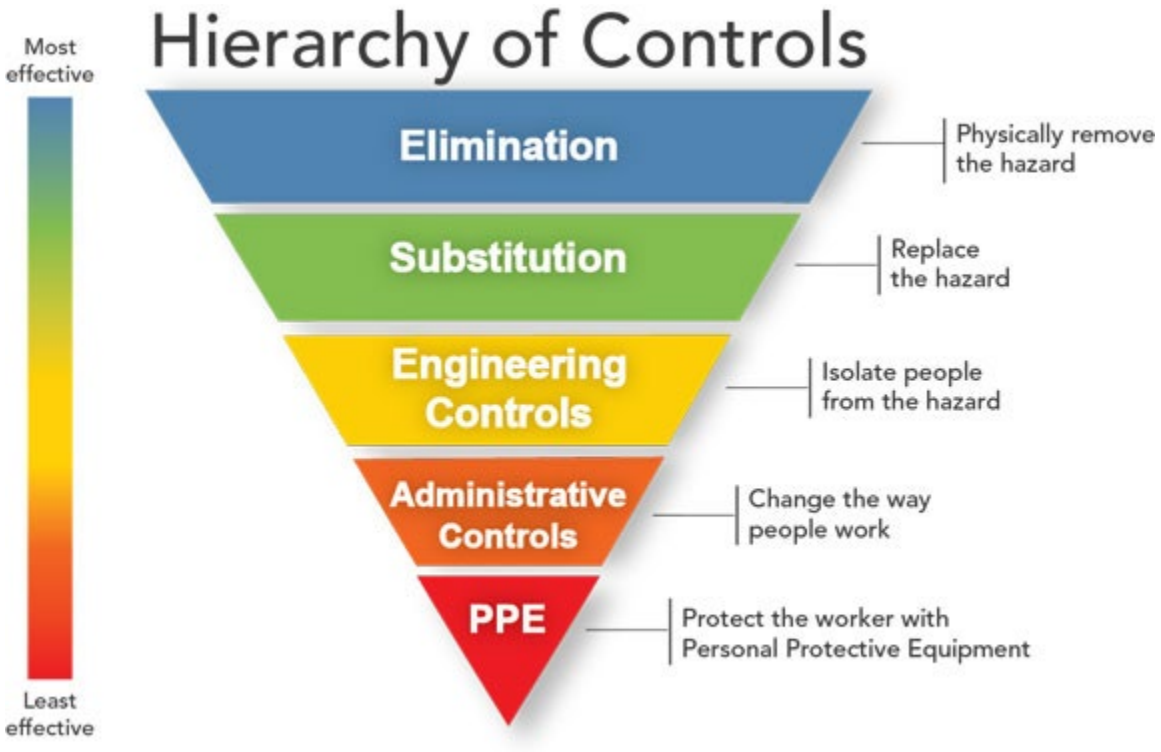
Personal Protective Equipment (PPE) - Introduction

The purpose of PPE is to shield or isolate individuals from the chemical, physical, and biological hazards that may be encountered at a hazardous waste site.

The Occupational Safety and Health Administration (OSHA) requires that employers perform a job hazard analysis and determine if PPE should be used to protect the worker from exposures. Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, ears, face, hands, feet, and head. PPE is required by OSHA and the U.S. Environmental Protection Agency (EPA) for all private contractors working on Superfund sites. OSHA also requires that the selected personal protective equipment must fit the employee who is utilizing it; this can be accomplished by having several sizes. For example, not everyone can wear the same size of gloves; different sizes of coveralls are needed for a man who is 6 feet tall and a woman who is 5 feet tall, even if the waist sizes are the same.

In those cases where it is required, the employer is required to provide and pay for personal protective equipment. The exception is that the employer is not required to pay for PPE that can be used away from the worksite, such as prescription safety glasses and some safety shoes.

Personal protective equipment is the last choice in the Hierarchy of Controls to prevent exposure. The Hierarchy of Controls refers to the preferred methods of hazard control. Traditionally, in order from most-preferred to least-preferred, they are:



source: https://www.cdc.gov/niosh/topics/hierarchy/default.html

This scheme illustrates that the best and surest approaches to control hazards is to eliminate the exposure or substitute a less toxic material or hazardous process.

The prevention strategies rely on modifying the process, contain (build a box), removing through ventilation, a change in work practice that must be done diligently (day after day by everyone) or use of personal protective equipment (may not be 100% effective even when used diligently; requires proper selection, training, cleaning and maintenance).

Work practice controls are often described in written programs (administrative controls called Standard Operating Procedures) that detail how work is to be done or the duration that someone can work in a particular area. For example, an administrative control for noise is to limit the duration of exposure.

See additional examples below.

Elimination – Physically remove the hazard

Example: Disconnecting power at an abandon building (eliminating electrical hazards).

Substitution – Replace the hazard with something less hazardous

Examples: Using a 'green' pesticide made from household chemicals is one example. Using soap and water instead of a solvent-based liquid for hand cleaning is another example of substitution.

Engineering Controls - Modify the conditions using technology

Examples: An air-conditioned cab on a piece of earth-moving equipment can reduce employee heat and noise exposure. A remote drum-puncturing rig and shielding of radiation or explosion exposures can reduce the level of exposure to the worker(s), minimize the release of the contaminant or hazard at the source, and reduce the need for or level of decontamination. Sending a robot to collect soil samples potentially contaminated with radioactive sludge is a modification (compared with sending a person).

Ventilation is a commonly used engineering control. When use of confined-space entry is the only way of accomplishing a task, a ventilation fan is used to provide fresh breathing air inside the confined space, helping to reduce the risk. Removing solvent vapors with *intrinsically safe,* mechanical exhaust at a transfer point of liquids containing a toxic solvent is another example of ventilation.

Administrative Controls – Control hazards utilizing policies and procedures - SOG's & SOP's

Examples: Industrial hygiene monitoring programs, medical surveillance programs, confined-space entry and hot-work permits and policies, and lock-out procedures. Other examples are work plans limiting the duration of exposure (e.g., to noise and radiation), developing a written plan describing the maintenance of protective clothing, and implementing specific work practices which reduce or prevent exposure. Adding a sign-off *and reviewed by competent person* during excavation to assure that trenching has been done according to guidelines is a change in the work practice. When confined-space entry activities are changed to use work practices that do not require personnel to enter the space, the procedure has been modified.

All these controls are examples of a universal Standard Operating Guideline (SOG), the term used for generic procedures. When procedures are plant- or company-specific, the control is referred to as a Standard Operating Procedure (SOP). All potential or

identified hazards at a site and methods to control them **must** be described in writing. These topics are covered in the on-site training and are included in the safety and health program.

Personal Protective Equipment

When the above controls are not possible, personal protective equipment is needed. Example: Level B is required to protect from an individual from solvent-contaminated soil during drum staging. It provides a physically protective barrier, to protect its wearer from physical or chemical hazard.

Personal Protective Equipment Program

A written PPE program is required by OSHA as part of the employer's safety and health program (referred to in many OSHA documents as the Health and Safety Program, HASP). PPE must be selected which will protect employees from known or likely potential hazards.

Remember: PPE must be properly selected and used to be effective

The PPE program must address:

- Selection, based upon a hazard assessment
- Use and limitations
- Work task duration
- Maintenance and storage
- Decontamination and disposal
- Training and proper fitting
- Donning and doffing procedures prior to, during, and after use
- Inspection procedures
- Evaluation of the effectiveness of the PPE program
- Special limitations during temperature extremes, heat stress, and other appropriate medical considerations

- Medical restrictions or physical requirements
- Provision for taking defective or damaged equipment out of service

Procedures provided by a manufacturer should be followed exactly. They may be incorporated into the written programs. If worksite hazards are unknown, OSHA mandates the highest level of protection. These levels are described in Chemical Protective Clothing. Other protective gear is described in the last section of PPE.

PPE - Respiratory Protective Equipment

Respiratory protective equipment (RPE) helps prevent inhalation of toxic dusts, gases and vapors and is required at hazardous work sites where adequate protection cannot be provided through the use of engineering or administrative controls. 29 CFR 1910.134 requires that a written respiratory protection program be developed by the employer where respirators are necessary. This chapter shows different types of RPE, use and care, and limitations. Elements of a respiratory protection program and the required medical exam are listed. You will work with several types of respiratory protection.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Describe the appropriate uses for respiratory protection
- Evaluate scenarios to determine if respiratory protection is required
- Identify the requirements of a respiratory protection program
- Identify the elements of respirator training that should be provided by the employer

Respirator Selection

Different types of hazards require different types of respirators. A number of factors should be considered when selecting a respirator. Respirator types and considerations in respirator selection are presented in the following sections. Selecting the appropriate respirator is the responsibility of designated personnel.

Types of Respirators

Two basic types of respiratory protection are:

- **Air-Purifying Respirator (APR)**, which protects against toxic dusts, gases, and vapors by removing the contaminant from the air before it enters the lungs. APRs include negative pressure and Powered Air Purifying Respirators (PAPR).

- **Atmosphere-Supplying Respirator (ASR)**, which provides breathing air from a source independent of the work environment. ASRs include supplied-air respirators (SAR) and self-contained breathing apparatus (SCBA).

Each is detailed further below.

Air-Purifying Respirators

Air-Purifying Respirators (APRs) are used to protect against specific dusts and toxic chemicals. They work by removing the contaminant by filtering, adsorbing, or reacting with the contaminated air before it is inhaled. If APRs are used:

- all toxic substances must be identified
- the concentration must be known and remain constant, verified by monitoring
- the respirator and cartridge must be selected to protect against those specific chemicals
- the oxygen concentration must be greater than or equal to 19.5%

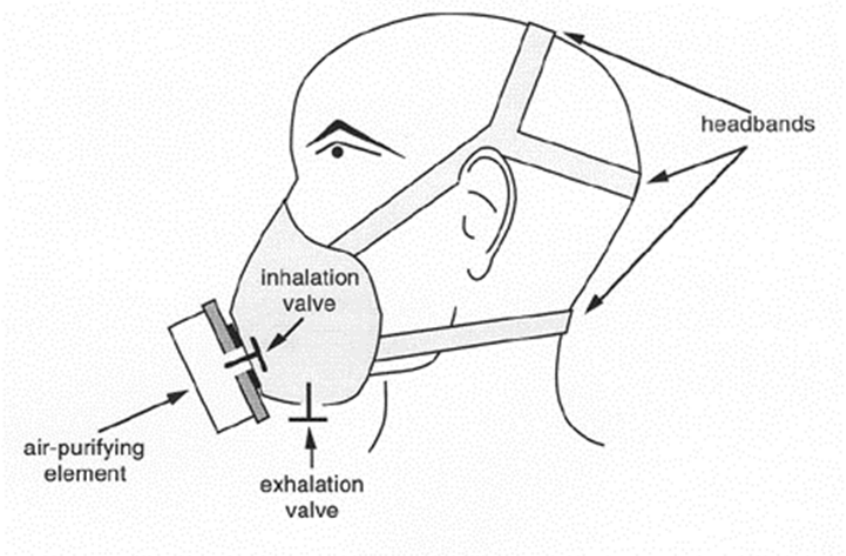
APRs can be reusable or single use. Reusable APRs consist of a facepiece with an exhalation valve and one or two filtering cartridges through which the air enters. The most widely used facepieces are full-face or half-mask. Full-face and half-mask respirators are illustrated below. Single-use types are typically filtering facepiece (FFP) respirators, often referred to as dust masks.

APRs cannot be used in an IDLH atmosphere.

Full-face Air-Purifying Respirator

Half-face Air-Purifying Respirator

Operation of a Reusable Air-Purifying Respirator



Air enters through the cartridges and exits through an exhalation valve. Note the proper placement of the headbands for a half-mask respirator. Reusable half-mask respirators without the head harness (only two single straps) must not be used.

Filters and Cartridges

Two types of air-purifying elements are used with APRs:

- **Particulate cartridge filters** are used to protect against dusts, mists, and fumes
- **Chemical cartridges** are used to protect against certain vapors and gases

Filters and cartridges are selected for specific exposures which are expected. Factors that affect APR selection include the size of the particles, concentration of the substance, and type of filter used. The air-purifying element must be changed when loaded with the dust (particulate) or chemical (cartridge) or if it gets wet. There is no protective cartridge/filter for some exposures; one example is oxygen displacement. NIOSH does not recommend an APR for known or suspected carcinogens.

Cartridge and filter colors designate what type of particulates or chemicals are filtered. OSHA regulation 29 CFR 1910.134 dictates the colors used. The table below lists OSHA-approved color and protection combinations.

Contaminants to Be Protected Against	Color Assigned[1]
Acid gases	White
Hydrocyanic acid gas	White with 1/2-inch green stripe completely around the canister near the bottom
Chlorine gas	White with 1/2-inch yellow stripe completely around the canister near the bottom
Organic vapors	Black
Ammonia gas	Green
Acid gases and ammonia gas	Green with 1/2-inch white stripe completely around the canister near the bottom
Carbon monoxide	Blue
Acid gases and organic vapors	Yellow
Hydrocyanic acid gas and chloropicrin vapor	Yellow with 1/2-inch blue stripe completely around the canister near the bottom
Acid gases, organic vapors, and ammonia gases	Brown
Radioactive materials, except tritium & noble gases	Purple (magenta)
Pesticides	Organic vapor canister & a particulate filter
Multi-Contaminant and CBRN agent	Olive
Any particulates - P100	Purple
Any particulates - P95, P99, R95, R99, R100	Orange
Any particulates free of oil - N95, N99, or N100	Teal

[1]Gray shall not be assigned as the main color for a canister designed to remove acids or vapors.

Note: Orange shall be used as a complete body or stripe color to represent gases not included in this table. The user will need to refer to the canister label to determine the degree of protection the canister will afford.

Chemical Cartridges

How do you tell if the cartridge needs to be changed? The respirator standard, 29 CFR 1910.134(d)(3), requires that respirators used to prevent gas or vapor exposures be equipped with an indicator showing that the cartridge (certified by NIOSH for the contaminant) has expired; this is called an End-of-Service-Life Indicator (ESLI). It is rare to find an ESLI on a cartridge. If no cartridge approved for a specific gas/vapor exposure has an ESLI, then the employer must use objective data to determine a change schedule and describe it in the written respiratory protection program. Should you detect contaminant before the cartridge has “officially expired,” notify the supervisor immediately and change the cartridge. For dust, a wearer may also notice that it is more difficult to breathe as the filter becomes loaded.

The person responsible for establishing a change-out schedule for chemical cartridges shall consider temperature, humidity, contaminate concentration, and work rate. For some chemicals at high concentrations, the change-out schedule may make the use of air purifying respirators impractical.

Particulate Cartridge Filters

There are nine classes of particulate filters which are broken down into three series: N, R, and P. Each series (N, R, and P) is available at three levels, based on their efficiency for filtering out the most difficult size of particulate: 95%, 99%, and 99.97%.

N series	No oil
R series	Oil resistant, one shift only
P series	Oil proof, reusable

Other Reusable APRs

Gas masks are a special type of APR that consists of a full facepiece and a canister containing sorbent material. These masks typically protect against organic vapors, acid gases, ammonia, and certain combinations. Gas masks usually have more purifying elements in the canister than the chemical cartridges described above.

A special type of APR is a **Powered Air-Purifying Respirator** (PAPR); air is pulled through the chemical cartridge or filter and blown into the facepiece, as shown on the right. The type of air purifying element must match the contaminant(s) to which the workers are being exposed. PAPRs consist of a hood or helmet, or tight-fitting facepiece, filter and/or cartridge, and power source.

PAPR selection includes special consideration of the atmosphere where it will be used. As an air-purifying respirator, the oxygen concentration must be at least 19.5%; however, due to the power source, it is necessary to consider whether the atmosphere is combustible or flammable due to oxygen concentration (not greater than 23.5%) or the presence of a flammable chemical. Consult the supplier regarding planned use and guidance on the need for intrinsically safe units.

Limitations for PAPRs are shown in the written respiratory protection program.

PAPRs cannot be used in an IDLH atmosphere.

Single-Use (Disposable) APRs

In a single-use APR (filtering facepiece or dust mask), the respirator is made up of filter material, as shown on the right. It may or may not include an exhalation valve. Filtering facepieces are classified according to the N/R/P and 95/99/99.97 system discussed above. The N95 version is very commonly used. Single-use APRs, just like reusable APRs, must be fit tested; surgical masks are not respirators and do not provide the same protection. Fit testing is discussed in a later section of this chapter.

Atmosphere-Supplying Respirators (ASR)

ASRs may have air supplied from a remote source (supplied air) or from a bottle or tank carried by the user (self-contained) as described below.

Supplied-Air Respirators (SAR)

A supplied-air respirator (SAR) provides a minimum Grade D breathing air to the worker from a stationary tank or other source through an airline that cannot exceed 300 feet in length. When using an SAR, the worker must wear (not carry) an escape bottle containing a minimum of 5 minutes of air. This escape bottle, or egress unit, is required to allow time to escape if the air supply is interrupted.

Escape bottle (image from OSHA.gov)

There are three classifications of supplied air respirators:

- Hose mask with blower (Type A)
- Hose mask without blower (Type B)
- Airline respirators (Type C)

Airline respirator (Type C) (image from DOT.gov)

Airline respirators must operate in either **continuous-flow** or **pressure-demand** mode. In continuous –flow mode, air is always flowing, even when the wearer is not inhaling. In pressure-demand mode, a constant positive pressure is maintained inside the facepiece. Air flows when the positive pressure in the facepiece is reduced as the wearer inhales. A third mode of operation is **demand mode**, in which air only flows when the pressure inside the facepiece becomes negative due to the wearer inhaling. Demand mode provides the least protection, because contaminants can leak into a poorly sealed facepiece when the pressure becomes negative. NOTE: Not allowed in unknown or IDLH conditions.

Compressors used to supply air must meet special requirements. Compressor exhaust and lubricants must not contaminate the air supplied. Compressor air intakes must be located in a contaminant-free area. (29 CFR 1910.134(i).

Self-Contained Breathing Apparatus (SCBA)

A self-contained breathing apparatus is an atmosphere-supplying respirator where the breathing air is designed to be carried by the user. A self-contained breathing apparatus is used when extremely toxic chemicals are present, in an oxygen-deficient atmosphere, or when the contaminant or concentration is not known. SCBAs are also typically used in emergency situations.

SCBAs consist of:

- bottle (tank or cylinder) contains compressed breathing air (2216 psi - 5500 psi)
- harness secures cylinder and connects user to apparatus
- gauge displays current cylinder pressure
- safety/by-pass valve by-passes the regulator in case of malfunction of the regulator; the by-pass valve should be open only when needed
- pressure regulator(s) provide reduced pressure air during inhalation
- full facepiece isolates user’s face from exterior environment

The SCBA is equipped with an alarm to warn the wearer when air in the tank falls below a specified capacity (note that the 2013 edition of NFPA 1981 specifies a 33% capacity alarm; NIOSH specifies 25%). Most SCBAs operate in an open-circuit mode; that is, the exhaled air is vented to the atmosphere and not re-breathed.

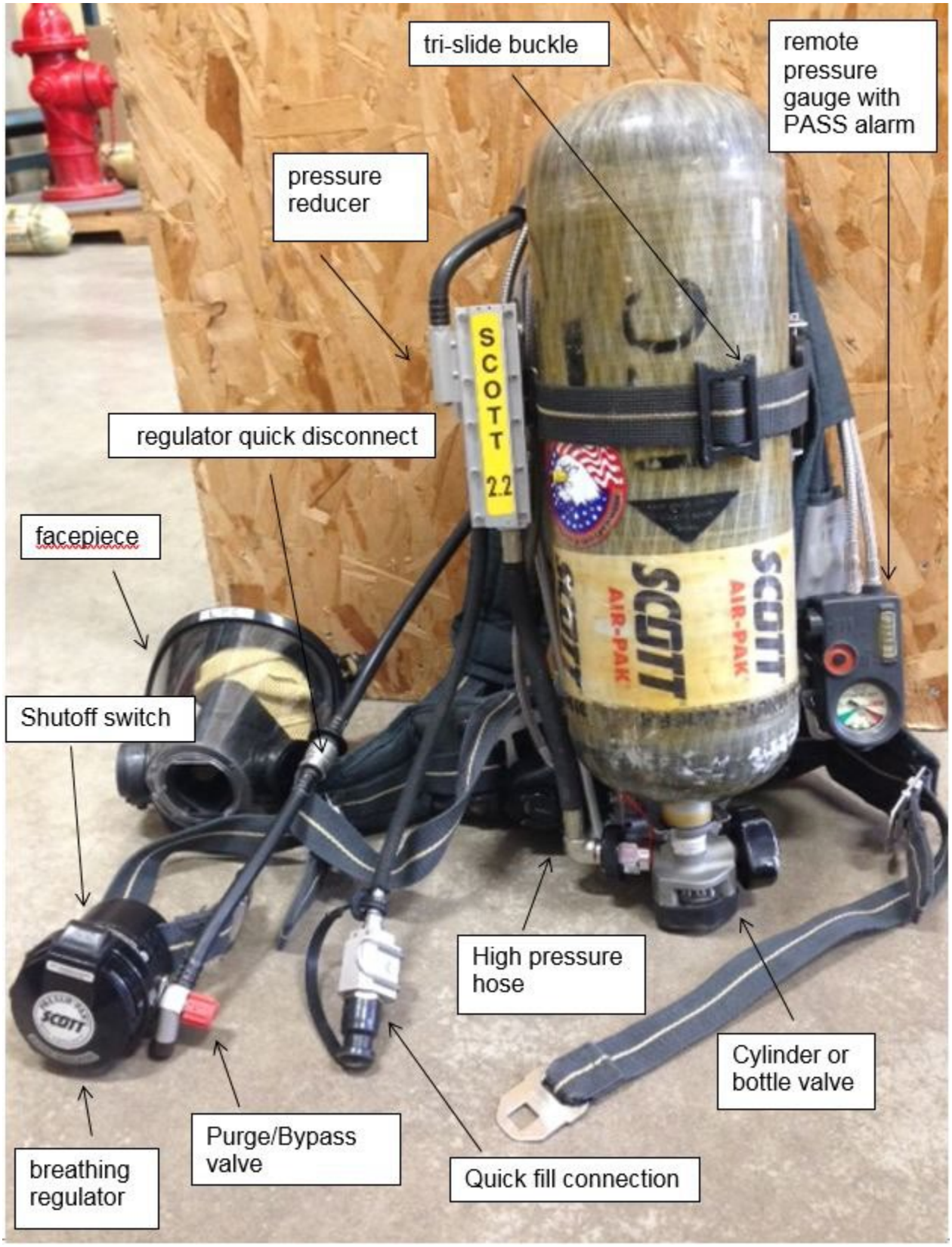
SCBAs and cylinders differ by manufacturer and type. You must be trained in the manufacturer’s instructions and checkout procedures before using any SCBA. These should be NIOSH certified for IDLH, full facepiece and with a minimum duration of 30 minutes or combined with SAR with auxiliary SCBA escape bottle. SCBA can operate in

either demand mode (less protective) or pressure-demand mode. SCBA cylinders may be constructed of steel, aluminum, or composite materials. These have varying service lives and hydrostatic testing requirements. Users should familiarize themselves with their specific cylinders. A positive-pressure SCBA or positive-pressure airline respirator equipped with an escape air supply must be used when exposure levels are likely to present an IDLH situation or impair the ability to escape**.**

The equipment should be donned according to the manufacturer's recommended procedures. Periodic training and practice are especially important for workers who may use this equipment infrequently.

- When the contaminant is unknown, wear a pressure-demand SCBA with a full facepiece, or a pressure-demand SAR with a full facepiece in combination with an auxiliary pressure-demand SCBA.
- Escape or egress units must be of sufficient supply duration to permit escape to safety if the direct air supply is interrupted.

Standards that cover one specific exposure (e.g., asbestos) include requirements for respirator selection and use. A list of requirements for many of these contaminants is found at:
https://www.osha.gov/SLTC/etools/respiratory/advisor_genius_nrdl/substances.html
For any questions on PPE use, the NIOSH Personal Protective Technology Laboratory (NPPTL) may be contacted at 888-654-2294, or emailed at PPEConcerns@cdc.gov.


tri-slide buckle
remote pressure gauge with PASS alarm
pressure reducer
regulator quick disconnect
facepiece
Shutoff switch
High pressure hose
Cylinder or bottle valve
Purge/Bypass valve
breathing regulator
Quick fill connection
SCOTT
2.2
SCOTT
AIR-PAK

Respirator Fit

A respirator is effective only if there is a good seal between the facepiece and the wearer's face. Therefore, all persons wearing respirators must first be fit tested. Fit testing includes qualitative or quantitative testing, as well as routine positive- and negative-pressure fit checks.

Because human faces come in many different shapes and sizes, manufacturers have a number of facepieces to best match an individual. The purpose of fit testing is to find the manufacturer/size combination which offers the best protection. Factors such as weight loss or gain, dentures, dental work, or facial injury can change the shape of the face, thus potentially changing the fit and efficiency of the respirator. If any of these factors exist, retesting is required. There shall be no facial hair in the area of the respirator seal.

A protection factor has been determined in the laboratory for each type of respirator (APR, PAPR, SCBA, etc.) and mask (half- or full-face). Never assume you will get this much protection. That is why fit testing is required.

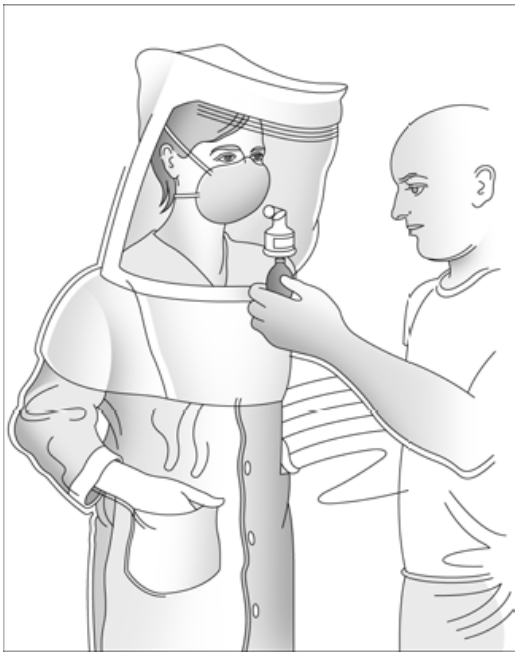
Annual Fit Tests

Two types of fit testing, qualitative and quantitative may be used to determine the size and model of respirator that an individual should wear, as well as how good the face-to-facepiece seal is. These tests should be repeated annually to document respirator effectiveness. Fit tests shall not be performed if facial hair is present in the seal area of the respirator. (OSHA 29 CFR 1910.134)

Qualitative Testing

Purpose: Checks effectiveness of preventing substances from entering the facepiece.

Method: While the individual is wearing a respirator, a test substance is released, as shown on the right. The test substance could be smelly (banana oil), sweet (saccharin), bitter (Bitrex) or an irritant (special smoke tube). The wearer should not be able to detect the substance while performing a series of prescribed tasks.



Requirements: This test or its equivalent is required by OSHA at least once a year.

There are several important cautions to qualitative fit testing:

- Some of the test substances may irritate the eyes or cause coughing
- A sensitivity test is first performed to determine the individual is capable of sensing the test solution
- Fit testing is often done in “ideal” environments. The fit may change after wearing the respirator several hours or during strenuous activity.
- Must be used only for Fit Factor (described later in this chapter) ≤ 100

Note: This method is not appropriate for SCBA facepieces. A quantitative method must be used.

Quantitative (Numerical) Testing

This test provides an objective assessment of the effectiveness of the respirator for the person who will wear it. This test measures the fit factor (FF), which is a comparison of the concentration of the substance outside of the mask to the concentration of the substance inside of the mask. This FF is useful in determining whether the respirator will effectively protect the wearer from specific chemicals. A disadvantage to this test is that special equipment and trained personnel are needed to administer it, although a computer and software can perform the calculations required.

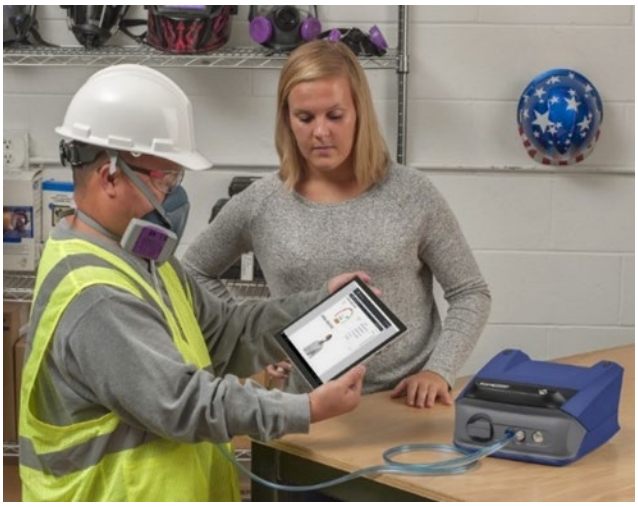


Photo courtesy of TSI Inc. to MWC.

Purpose: Measures effectiveness of the respirator in preventing a substance from entering the facepiece.

Methods: There are two methods for quantitative fit testing based on the fit testing device.

1. While an individual wears a respirator modified with a probe, the concentrations of particulates in the air inside and outside of the respirator are measured, as shown above. The test is repeated while the person performs specific tasks (speaking, running in place, etc.) that may affect fit.

2. While an individual wears a respirator connected to a fit testing device, a vacuum is drawn in the mask to assess seal for leaks. Then the user removes and re-dons the mask and the test is repeated twice.

Requirements: This test is mandated when a minimum fit factor of 50 for a full facepiece is required.

Routine User Checks

Two types of user seal checks, positive- and negative-pressure checks, should be done each time a respirator is donned and before each use in the field to check the seal of the respirator. They do not replace yearly fitting but provide a routine assessment as to whether the fit is still adequate.

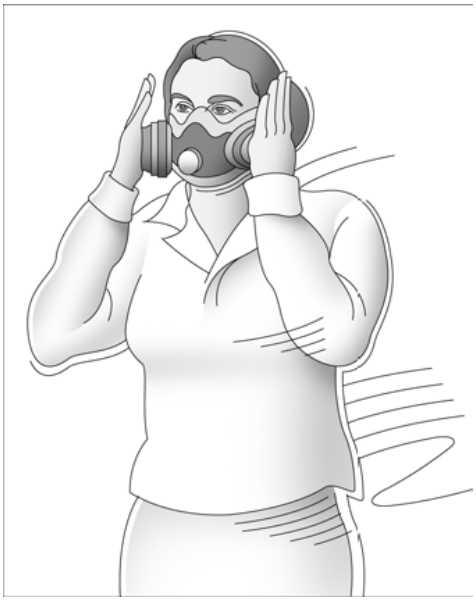
Positive-Pressure User Check

Purpose: Checks the facepiece components for leaks at valves or other points. NOTE: Not all positive-pressure respirators allow easy access to the exhalation valve for this test.

Method: Close off the exhalation valve (if possible) and exhale gently into the facepiece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. For most respirators this method of leak testing requires the wearer to first remove the exhalation valve cover before closing off the exhalation valve and then carefully replacing it after the test. This is only performed if the cover can be manually removed.

Requirements: Shall be done before each use.

Negative-Pressure User Check



Purpose: Checks the facepiece-to-face seal.

Method: SCBA wearer disconnects the regulator and places hands over the hole for the regulator connection and inhales. APR wearer places hands over cartridges and inhales, as shown on the right. No outside air should be felt leaking into the facepiece.

Requirements: Shall be done each time the respirator is donned (first use, break, lunch).

Positive- and negative-pressure checks can be done quickly and easily in the field. If the wearer is unable block the holes or cartridges with their hands, additional measures may need to be performed to accomplish the blocking requirement to detect the leaks.

Assigned Protection Factors

Respirators are selected by using Assigned protection factors (APFs). The higher the APF, the more protective the respirator is. These protection factors are set after testing by NIOSH and are subject to change. Protection factors vary according to the particular respirator type.

Following is a list of APFs:

Type of Respirator	Quarter mask*	Half mask	Full facepiece	Helmet/Hood	Loose-fitting facepiece
1. Air-purifying Respirator	5	10	50	-	-
2. Powered Air-purifying Respirator (PAPR)	-	50	1,000	25/1,000	25
3. Supplied-air Respirator (SAR) or Airline Respirator					
• Demand mode	-	10	50	-	-
• Continuous flow mode	-	50	1,000	25/1,000	25
• Pressure-demand or other positive-pressure mode	-	50	1,000	-	-
4. Self-contained Breathing Apparatus (SCBA)					
• Demand mode	-	10	50	50	-
• Pressure-demand or other positive-pressure mode (e.g., open/closed circuit)	-	-	10,000	10,000	-

*Quarter masks are not widely used in hazardous waste work and are not discussed as part of this course.

Protection factors also exist for combinations of the above respirators. For example, an SAR with a full-face mask and an auxiliary SCBA equals 10,000.

The use of these APFs presumes that the facepiece has been properly selected to provide the best possible fit. These factors do not apply for persons with facial hair as it interferes with the seal of the facepiece. The APFs still apply when choosing a respirator but a person with facial hair that interferes is required to utilize a hood type system and the APF for that is low.

See https://www.osha.gov/Publications/3352-APF-respirators.pdf for additional information about this table.

Never assume you will get this much protection. Quantitative fit testing provides a measure of the maximum protection you can expect. Less protection may occur during work activities.

Fit Factor Calculation

Proper selection of respirators can be accomplished by dividing the known chemical concentration by the APF. The resulting ppm needs to be compared to the occupational exposure guideline used by your employer.

If the calculated ppm is higher than the exposure guideline, then that type of respiratory protection would be inadequate. If the calculated ppm is lower than the exposure guideline, then that type of respiratory protection should be sufficient, provided that the measured concentration will not increase, and provided that the measured chemical concentration is below the IDLH concentration, if using an APR.

Sample Fit Factor Calculation: Cyclohexene may be released from drums. The safety and health officer measured an 8-hour TWA concentration of 400 ppm of cyclohexene, but OSHA PEL is 300 ppm for an 8-hour work shift. Because engineering controls cannot be implemented, respiratory protection must be used. What type of respiratory protection would provide adequate protection against this contaminant?

Formula: $$\frac{measured\ chemical\ concentration\ (ppm)}{APF} = ppm$$

First, use the table of APFs to see if a half-face APR can be used:

$$\frac{400\ ppm}{10} = 40\ ppm$$

The answer is 40 ppm, which means that 40 ppm of cyclohexene could be present inside the facepiece of a properly fitted respirator. A concentration of 40 ppm is less than the OSHA 300 ppm PEL, so this type of respiratory protection would be adequate.

Maximum Use Concentration

If the concentration of the contaminant in the workplace rises to a different level, another calculation of fit factor would need to be done to see if the respirator is still protective at the new concentration. Instead, the Maximum Use Concentration (MUC) is sometimes calculated. To calculate the MUC, multiply the PEL (or other exposure guideline) by the APF:

$$MUC = PEL * APF$$

In the example of cyclohexene above, with a half-face APR, the PEL is 300 ppm and the APF is 10:

$$MUC = 300 * 10 = 3000\ ppm$$

Therefore, the half-face APR could be used up to a cyclohexene concentration of 3000 ppm, as long as that concentration is not above the IDLH. Checking the NIOSH Pocket Guide, the IDLH for cyclohexene is 2000 ppm. An APR cannot be used above the IDLH, so the MUC would only be 2000 ppm. Always check the IDLH when calculating the MUC.

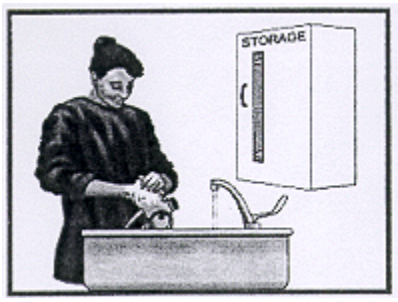
Exercise - Respiratory Protection Factor

In this exercise, you will work in groups to calculate whether a respirator provides protection in a given atmosphere. (See Exercise Guide)

Cleaning, Storage, Inspection and Maintenance of Respirators

Proper inspection, maintenance, and storage are essential to ensure that the respirator is always ready for use. The OSHA respirator standard requires employers to provide for the cleaning and disinfection, storage, inspection and repair of respirators used by employees. Always consult manufacturers' recommendations for use, care and maintenance also.

Cleaning respirators



Appendix B-2 to 29 CFR 1910.134 requires the following respirator cleaning procedures. Manufacturers' recommendations may be used as an alternative, provided that they are at least as effective as those specified here:

A. Remove filters, cartridges, or canisters. Disassemble facepieces by removing speaking diaphragms, demand and pressure- demand valve assemblies, hoses, or any components recommended by the manufacturer. Discard or repair any defective parts.

B. Wash components in warm (43 deg. C [110 deg. F] maximum) water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.

C. Rinse components thoroughly in clean, warm (43 deg. C [110 deg. F] maximum), preferably running water. Drain.

D. When the cleaner used does not contain a disinfecting agent, respirator components should be immersed for two minutes in one of the following:

1. Hypochlorite solution (50 ppm of chlorine) made by adding approximately one milliliter (approximately 20 drops) of laundry bleach to one liter of water (about a 1000:1 dilution) at 43 deg. C (110 deg. F); or,

2. Aqueous solution of iodine (50 ppm iodine) made by adding approximately 0.8 milliliters (about 16 drops) of tincture of iodine (6-8 grams ammonium and/or potassium iodide/100 cc of 45% alcohol) to one liter of water (about a 1250:1 dilution) at 43 deg. C (110 deg. F); or,

3. Other commercially available cleansers of equivalent disinfectant quality when used as directed, if their use is recommended or approved by the respirator manufacturer.

E. Rinse components thoroughly in clean, warm (43 deg. C [110 deg. F] maximum), preferably running water. Drain. The importance of thorough rinsing cannot be overemphasized. Detergents or disinfectants that dry on facepieces may result in dermatitis. In addition, some disinfectants may cause deterioration of rubber or corrosion of metal parts if not completely removed.

F. Components should be hand-dried with a clean lint-free cloth or air-dried.

G. Reassemble facepiece, replacing filters, cartridges, and canisters where necessary.

H. Test the respirator to ensure that all components work properly.

Respirators must be cleaned and disinfected after each use, unless they are being used routinely exclusively by the same employee. In that case, they must be cleaned and disinfected as often as needed to be sanitary.

Respirator Storage

OSHA requires that all respirators be stored to protect them from damage, contamination, dust, sunlight, extreme temperatures, excessive moisture, and damaging chemicals, and that they must be packed or stored to prevent deformation of the facepiece and exhalation valve.

Inspection

Respirators must be inspected before and after each use and checked at least monthly, even if the respirator has not been in use. A company policy may include more frequent inspections. OSHA requires that inspections include:

- A check of respirator function
- Tightness of connections
- The condition of the various parts including, but not limited to, the facepiece, head straps, valves, connecting tube, and cartridges, and canisters or filters
- A check of elastomeric parts for pliability and signs of deterioration
- In addition to the above, SCBA's must be inspected monthly
- Air and oxygen cylinders must be maintained in a fully charged state and be recharged when the pressure falls to 90% of the manufacturer's recommended pressure level. The employer must determine that the regulator and warning devices function properly.

Maintenance

OSHA requires that defective respirators be removed from service immediately and discarded or repaired/adjusted. Repair program guidance follows:

- Repairs or adjustments must be made only by trained persons, using the manufacturer's NIOSH-approved parts
- Repairs must be made according to the manufacturer's recommendations and specifications
- Critical parts including reducing and admission valves, regulators and alarms may only be adjusted or repaired by the manufacturer or a technician trained by the manufacturer

Consult the site-specific respiratory protection program for detailed requirements.

Minimum Requirements for a Respiratory Protection Program

OSHA requires that employers who make respirators available to their employees have a written respiratory protection program with work-specific procedures (29 CFR 1910.134(c). The program must be evaluated and updated as necessary. Programs shall be updated as requirements change and/or modifications occur that reflect changes in the workplace. OSHA requires the use of NIOSH-approved respirators. Approval numbers will be clearly written on all approved equipment, as shown on the next page, or on written materials shipped with the respirator. Respirators manufactured after 2008 are marked with an approval designation known as a "TC" number. [Example: TC #XXX-XXXX].

A respiratory protection program must include the following points:

- Medical evaluations of employees required to use respirators
- Fit testing procedures for tight-fitting respirators
- Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators
- Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators
- Training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations
- Training of employees in the proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance
- Procedures for regularly evaluating the effectiveness of the program

The employer must designate a program administrator who is qualified to oversee the respiratory protection program and conduct the required evaluations of its effectiveness. Respirator training and the required medical evaluations are provided to the employee at no cost. The respiratory protection program also may include:

- Provision for corrective lenses in full facepiece respirators using a spectacle kit that clips into the facepiece or is permanently mounted in the facepiece.
- Restriction of use of contact lenses. (See ANSI Z87.1)
- Communication needs
- Guidelines for use in dangerous atmospheres, including confined spaces
- Guidelines for use in extreme temperatures

The respiratory protection program will include a description of who is responsible for the various aspects of the program including selection, periodic and routine fit testing, inspection, cleaning, repair, and maintenance. Persons using respirators under unusual conditions (e.g., a high concentration of acid vapor) should review special requirements with supervisors or the employee safety and health representatives. For a sample respiratory protection program, see:
https://www.osha.gov/SLTC/etools/respiratory/respirator_basics.html

Medical Fitness to Wear a Respirator

Before an employee receives clearance to wear a respirator, a medical evaluation must be performed by a physician or other licensed health care professional (PLHCP), as described in 29 CFR 1910.134(e). The evaluation helps ensure that the employee is physically capable of working with the added physical stress of a respirator. Any follow-up evaluations and testing will be determined by the PLHCP.

Some medical conditions which may prevent an individual from wearing a respirator include:

- Lung disease
- Claustrophobia
- Severe high blood pressure
- Heart disease

Other conditions that should be considered when wearing a specific type of respirator include:

- Contact lenses
- Eyeglasses
- Moustache
- Perforated tympanic membrane (ruptured eardrum)

Changes in weight or dental work may alter the fit of a respirator and require a new fit test. Special eyeglass kits are available for use with full facepiece respirators.

Exercise – Respiratory Protection Scenarios

Working in groups, evaluate the safety of wearing a respirator in given situations. See Exercise Guide.

On-Site Training – Respiratory Protection

This training course is only part of the training required by the HAZWOPER standard. It is to be followed by one day of on-site training under the direct supervision of a trained, experienced supervisor.

Respiratory protection is a part of on-site training. Based on the training, the employer shall ensure that each employee can demonstrate knowledge of at least the following:

- Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator
- Limitations and capabilities of the respirator
- How to use the respirator effectively in emergency situations, including situations in which the respirator malfunctions
- How to inspect, put on and remove, use, and check the seals of the respirator
- The procedures are for maintenance and storage of the respirator
- How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators
- The general requirements of the respiratory protection standard

Consult your employer for further information. Respiratory protection is one of several topics included in the OSHA resource of 'Program Templates'; see: https://www.osha.gov/complianceassistance/sampleprograms

Summary - Respiratory Protective Equipment (RPE)

Respirators are used to prevent toxic materials from entering the body. The two basic types of respirators are air-purifying respirators (APRs) and atmosphere-supplying respirators (ASRs).

APRs may be reusable or single use. Reusable APRs consist of a facepiece with an exhalation valve and one or two filtering units through which the air enters. Filters may be for dust, vapors, or both. APRs may not be used where the identity of the contaminant is unknown or in an IDLH atmosphere.

ASRs may be supplied-air respirators (SARs) or self-contained breathing apparatus (SCBAs). SCBAs consist of a facepiece, supply of air, gauge, and safety valve. If SARs

are used, an escape unit must also be worn. Routine training and practice are necessary if SCBAs are used.

A respirator is assigned for use after either qualitative or quantitative fit testing. Before each use, the wearer conducts positive- and negative-pressure user checks.

Care of respirators includes diligent cleaning, disinfecting, storing and maintenance. Units should be inspected before and after each use or monthly if not used routinely. Maintenance personnel should be known to users to ensure prompt reporting of defects for repair or replacement.

The employer respiratory protection program is part of the required 3-day onsite training and includes:

- Medical evaluations of employees required to use respirators
- Fit testing procedures for tight-fitting respirators
- Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators
- Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators
- Training of responders in the respiratory hazards to which they are potentially exposed during routine and emergency situations
- Training of responders in the proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance
- Procedures for regularly evaluating the effectiveness of the program

The employer must:

- Designate a program administrator who is qualified to oversee the respiratory protection program and conduct the required evaluations of its effectiveness
- Describe who is responsible for the various aspects of the program including selection, periodic and routine fit testing, inspection, cleaning, repair, and maintenance

At least annually, the employer must provide training in the use of assigned respiratory protection. Content must be understandable by participants and include at a minimum:

- Need for the protection

- How improper fit, use, storage and maintenance can limit protection
- Proper use, inspection, don/doff, user seal checks
- Maintenance and storage procedures
- Medical signs or symptoms that limit use
- General provisions of 29 CFR 1910.134

PPE - Chemical Protective Clothing

This section will focus on several aspects of chemical-protective clothing programs and use, and the levels of PPE ensembles that are designated by OSHA and EPA.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify use of several types of chemical protective suits
- Identify criteria used for selecting CPC
- Identify the different levels of protection
- Identify ways in which the effectiveness of CPC can be reduced
- Identify the advantages and disadvantages of commonly used chemical resistant materials
- Identify precautions to take while wearing PPE
- Describe the reasons to properly inspect, maintain and store PPE

Chemical-Protective Clothing

Chemical-Protective Clothing (CPC) consists of special clothing worn to prevent chemicals from coming into contact with the body. CPC generally includes eye/face protection, aprons, boots, gloves, and suits/coveralls. CPC is used to protect employees from both chemical and physical hazards. The proper use of CPC can prevent or reduce exposure to a hazard. CPC is an important part of a hazardous waste site worker's PPE.

The materials used to construct CPC are chemical-resistant, which means they act as a barrier to keep chemicals from contacting the wearer's skin. Different materials provide protection from different types of chemicals. It is important to select CPC which is designed to protect against the specific chemical or type of chemical that may be encountered during work. Otherwise, you might not be protected, even when you think you are.

Types of Chemical-Protective Suits

Chemical-protective suits are of two general types, totally encapsulating and partially encapsulating.

- **Totally Encapsulating Chemical-Protective Suit (TECP)**: Provides head-to-toe coverage to protect the wearer from chemicals. These suits have special seams and zippers to prevent chemicals from leaking into the suit. These suits have a face shield which is made as part of the hood. They are very bulky to wear, and the wearer can become very hot while working. TECPs are the only vapor-resistant suits. TECP suits protect workers from hazards which are identified during site characterization. TECP suits must pass specific positive-air pressure tests and be capable of preventing inward test gas leakage of more than 0.5%. Specific information about pressure tests can be found in OSHA 29 CFR 1910.120, Appendix A.

- **Partially Encapsulating Chemical-Protective Suit (PECP)**: Provides less protection from chemicals and may or may not have face shields. These suits are used when less skin protection is needed. The hood can either be part of the suit or detached. This type of CPC includes suits which look like totally encapsulating suits but will not pass a pressure test. A large variety of PECP designs are available.

Disposable suits, which provide limited protection from chemicals, can be used in conjunction with these chemical-protective suits. These disposable suits can be worn either on top of other suits to protect them or inside protective suits to protect the wearer from chafing, to limit contamination of personal clothing or to provide added protection during decon.

Selection of CPC and other PPE

Generally, one person or group is responsible for the selection and purchase of protective equipment; however, it is important for everyone to understand the considerations which go into the selection. The selection process should be detailed in the employer's Safety and Health Plan. Questions about PPE selection may be addressed to the person responsible for the selection.

A hazard assessment with a survey of the facility is useful in developing a list of potential hazards. This list can be used in planning for required PPE. Hazards to take into consideration include:

Impact	Penetration/Puncture hazards
Compression (roll-over)	Fire
Heat/cold	Combustible/harmful dust
Light (optical) radiation	Biologic agents
Sources of electricity	Sources of motion or impact
High temperatures	Chemicals

The type of chemical-protective suits selected will depend on the type and nature of potential exposure. For example, totally encapsulating suits may be required for persons over-packing drums, whereas partially encapsulating suits may be required while operating a remote drum handler. Generally, the level of protection provided will be re-evaluated as additional site information is gained.

PPE must be properly selected and used to be effective

Examples of improper selection

- Goggles, when whole body splash is likely
- Gloves known to crack when wetted with ammonia

Examples of improper use

- Respirator 'stored' below the chin
- Continuing to work with a tear in CPC suit

Personal Protective Equipment Program

A written personal protective equipment program is required by OSHA. as part of the employer's Safety and Health Plan. PPE must be selected to protect employees from known or likely potential hazards. The proper selection of PPE is based on many factors, including potential hazards, layout of the scene and surrounding activities.

What examples of improper selection or use have you seen?

The PPE program must address:

- Selection, based upon anticipated hazards (See 29 CFR 1910.132 Appendix B)
- Use and limitations
- Work task duration
- Maintenance and storage
- Decontamination and disposal
- Training and proper fitting
- Donning and doffing procedures prior to, during, and after use
- Inspection procedures
- Evaluation of program effectiveness
- Special limitations during temperature extremes, heat stress, and other appropriate medical considerations

When model procedure descriptions provided by the manufacturer will be followed exactly, they may be incorporated directly into the PPE Program.

Appropriate PPE must be purchased as part of preplanning, and it must be selected and properly used during initial size-up and response activities. The size-up should provide enough information to select PPE to protect personnel from exposures during a response. During size up and other initial actions, responders may need a high level of protection. With the information gathered, including air monitoring, a decreased level of protection may be approved by the person in charge, following the ERP as response activities change. All PPE selected and used must meet OSHA requirements.

CPC Selection Guidelines

Always follow manufacturer's recommendations

Chemical resistance: Different materials are resistant to different chemicals. Management should provide CPC which will provide protection against the chemicals likely to be encountered at the site. This rule is true for whole-body as well as hand and foot protection.

Physical integrity: Construction of the suit is important for the proper functioning of the CPC. Seams and zippers should provide solid barriers to chemicals and should be constructed to provide some flexibility.

Resistance to temperature extremes: Heat and cold can adversely affect CPC. Clothing which will be worn in cold temperatures could crack or become ineffective against chemicals. Likewise, heat may destroy the chemical resistance of clothing or even melt it.

Ability to be cleaned: Clothing must be able to be cleaned and decontaminated after each use. If this is not possible, the clothing must be disposed of after use.

Cost: Initial and ongoing costs of purchasing PPE can be important considerations for management. However, buying less expensive, inferior products which do not adequately protect employees can be more expensive in the long run due to medical costs, lost work time, or, at worst, loss of human life.

Flexibility: Materials need to be flexible enough for the wearer to move and work safely. Overly rigid suits can result in unnecessary accidents from slips, trips, and falls. Gloves which are too rigid may create gripping problems that may lead to other hazards.

Size: CPC should be available in a variety of sizes to accommodate the height and weight of the worker. Suits that are too small will tear easily and provide no protection. Suits that are too large will make walking and/or working difficult. Safety boots that are too big will create both tripping and comfort problems.

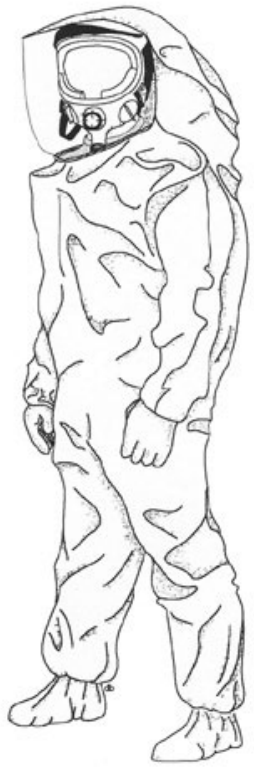
Design: CPC should be designed so that all required respiratory PPE can be used at the same time.

Levels of PPE (see 29 CFR 1910.120, Appendix B)

Level A

Level A is the highest level of protection which can be worn.

What Is Level A Protection?



The following list constitutes Level A equipment; it may be used as appropriate:

- Positive-pressure, pressure-demand, full facepiece SCBA or positive-pressure, supplied-air to full facepiece with escape SCBA (NIOSH-approved)
- Totally encapsulating chemical-protective suit (TECP) (gas tight or vapor tight)
- Inner and outer chemical-resistant gloves
- Disposable protective suit, gloves, and boots (depending on suit construction, may be worn over totally encapsulating suit)
- Coveralls*
- Long underwear*
- Hard hat (under suit)*
- Chemical-resistant boots with steel toe and shank.
- Cooling system (ice vest, water/air circulation)*

*Optional as applicable
Note: Suit must be properly equipped with a pass-through airline connection, referred to as an airline egress if using an SAR.

When Is Level A Protection Needed?

Level A protection is required when:

- The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and respiratory system
- There is potential for splash, immersion, or exposure to vapors, particulates, or gases that are harmful to the skin or may be absorbed through the skin
- Confined space entry may be involved and the need for Level A cannot be ruled out (but explosion hazard has been ruled out)
- The skin absorption hazard may likely result in immediate death or serious illness/injury or impair the ability to escape

Level B

Level B is used when maximum respiratory protection is desired, but the skin/eye hazards do not require Level A.

What Is Level B Protection?

The following constitutes Level B equipment; it may be used as appropriate.

- Positive-pressure, full facepiece SCBA or positive-pressure, pressure-demand, supplied-air to full facepiece with escape SCBA (NIOSH approved)
- Hooded chemical-resistant clothing **OR** total encapsulating chemical suit (not gas tight or vapor tight)
- Inner and outer chemical-resistant gloves
- Outer chemical-resistant boots with steel toe and shank
- Boot covers: outer, chemical-resistant (disposable)*
- Hard hat*
- Face shield*
- Cooling system (ice vest, water/air circulation)*

New Level B chemical-resistant clothing is designed to go over the SCBA. If appropriate for the potential exposures, this CPC should be used to protect the SCBA and prevent its contamination. In this case, the Level B ensemble will resemble a Level A ensemble, but the suit is not vapor-tight.

*Optional as applicable

When Is Level B Protection Needed?

Level B protection is required when:

- The highest level of respiratory protection is needed but a lower level of skin protection is acceptable
- The substances have been identified
- An SCBA is required
- Less skin protection is needed. (Vapor and gases are not believed to be present at high levels harmful to skin or capable of being absorbed through intact skin.)

Level C

Level C provides less skin and respiratory protection than Level A or B.

What Is Level C Protection?

The following list constitutes Level C equipment; it may be used as appropriate.

- A full-face or half-face air-purifying respirator (NIOSH-approved)
- Hooded chemical-resistant clothing
- Inner and outer chemical-resistant gloves
- Coveralls*
- Boots (outer), chemical-resistant steel toe and shank*
- Boot covers: outer, chemical-resistant (disposable)*
- Hard hat*
- Escape mask*
- Face shield*

*Optional as applicable

When Is Level C Protection Needed?

Level C provides protection when:

- The concentration(s) and type(s) of airborne substance(s) are known and the criteria for using an air-purifying respirator are met.
- Direct contact with the hazardous substance will not harm the skin or the substance will not be absorbed through any exposed skin.
- Air contaminants have been identified, concentrations measured, and an air-purifying respirator is available with an acceptable protection factor.
- An adequate level of oxygen (≥ 19.5%) is available and all other criteria for the safe use of air-purifying respirators are met.

Level D

This level offers no respiratory protection and low skin protection.

What Is Level D Protection?

The following list constitutes Level D equipment; it may be used as appropriate.

- Coveralls (work uniform)
- Chemical-resistant boots or shoes with steel toe and shank
- Hard hat*
- Gloves*
- Outer, chemical-resistant boots (disposable)*
- Safety glasses or chemical splash goggles*
- Escape mask*
- Face shield*

*Optional as applicable

When Is Level D Protection Needed?

Level D is required when:

- Minimal protection from chemical exposure is needed. It is worn to prevent nuisance contamination only.
- The atmosphere contains no known hazards.
- Work functions preclude splashes, immersion, or the potential for unexpected inhalation of or contact with hazardous levels of any chemicals.

Typical Uses of Level D Equipment

Level D protection is worn by personnel who may be exposed only to nuisance contamination while working with hazardous materials. Typically, workers involved with support activities such as equipment supply, maintenance, off-site vehicle operation, or supervision/management will wear Level D.

Level D may appear similar to “typical work clothes.” Differences include the chemical-resistant boots with steel shank.

A general rule for which level of protection to use is: **"The less you know, the higher you go."**

Remembering Levels of Protection
A=All Covered, gas/mist tight
B=Breathing Air, splash protection
C=Cartridge Respirator or Air Purifying Respirator
D=Don't Expect Protection, regular work clothes

Characteristics and Properties of CPC

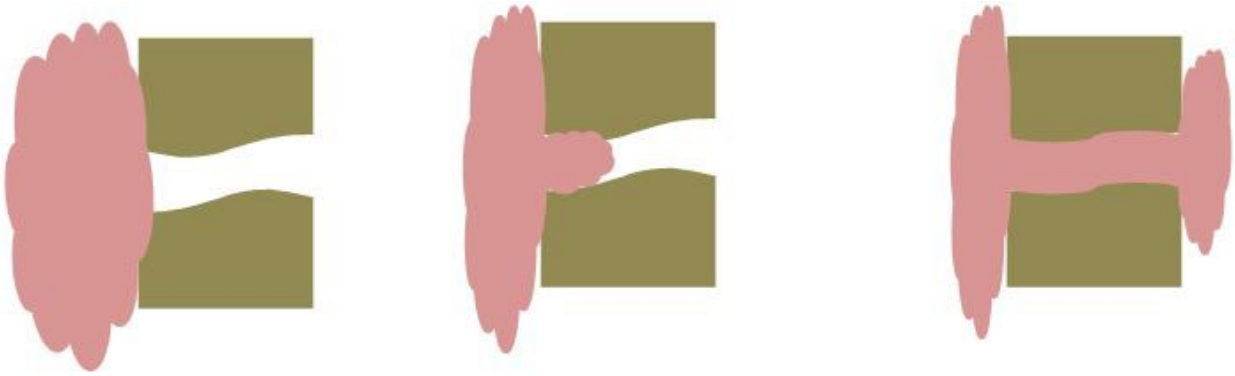
PPE is effective only if it is properly selected, worn, and maintained. Standard Operating Procedures (SOPs) for these types of PPE are included in the Safety and Health Plan. SOPs are company-specific versions of the more general Standard Operating Guides (SOGs) often used in training. SOGs are written instructions for safe work practices and are a form of administrative control.

- Whenever possible, a variety of suit sizes should be on hand to fit the various sizes of personnel.
- The adhesive on tape not approved by the manufacturer may cause degradation of the suit and the warranty may be voided.
- Materials used to make most suits do not "breathe." Rapid heat and moisture build-up will occur in the suit during use.
- All suits have limits as to the temperature at which they can be worn without damage. This information may be particularly important for emergency response or hot-work activities. Check the manufacturer's data.
- Most suits offer no fire protection and in some cases increase the possibility of injury because they will melt and may burn.

Penetration, Degradation, and Permeation

Chemicals can reduce the effectiveness of CPC garments through penetration, degradation, or permeation.

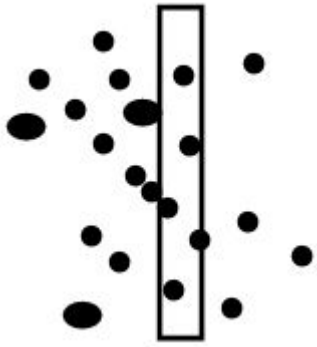
Penetration The flow of a chemical through zippers, stitched seams, or imperfections in the material.



Degradation A reduction in one or more physical properties of a protective material due to contact with a chemical.

Permeation The process by which a chemical moves through a protective material on a molecular level. The rate of permeation is dependent on six major factors:

- Contact time
- Material thickness
- Concentration
- Temperature
- Physical state of chemicals



- Size of the contaminant molecules and pore space

The following pages show some chemical-resistant materials used in CPC and their advantages and disadvantages.

Chemical-Resistant Materials

The following list describes some commonly used chemical-resistant materials and their advantages and disadvantages. Materials for chemical protection may be blended or laminated and require manufacture's data when determining proper selection(s). This list should not be used to select materials; manufacturer's guidelines and other references should be consulted.

Butyl Rubber

Use Mainly in encapsulating suit, but some gloves, boots, and splash gear.

Advantages Good for bases and many organics. Very resistant to gas/vapor permeation. Readily releases contamination. Good heat and ozone resistance.

Disadvantages Poor for aliphatic and aromatic hydrocarbons, gasoline, halogenated hydrocarbons, and abrasion resistance. More expensive than PVC or neoprene.

Chlorinated Polyethylene (CPE)

Use Only in fully encapsulating suits

Advantages Good for aliphatic hydrocarbons, acids and bases, alcohols, and phenols. Resists abrasion and ozone.

Disadvantages Poor for amine, esters, ketones, and halogenated hydrocarbons. Becomes very rigid when cold.

Natural Rubber

Use For boot covers because of durability and for disposable inner and outer gloves.

Advantages Good for bases, alcohols, and dilute acids. Inexpensive. Flexible.

Disadvantages Poor for organic chemicals. Ages (affected by ozone).

Neoprene

Use In all types of protective clothing.

Advantages Better than polyvinyl chloride (PVC) for organics. Durable. Abrasion- and cut-resistant.

Disadvantages Not as good as PVC for acids and bases. Poor for chlorinated aromatic solvents, phenols, and ketones. More expensive than PVC.

Nitrile Rubber

Use In gloves and boots and one encapsulating suit.

Advantage Made specifically for petroleum products. Abrasion- and cut-resistant. Flexible. Good for bases, peroxides, PCBs, phenols, and alcohol.

Disadvantage Poor for aromatic and halogenated hydrocarbons, amines, ketones, and esters. Loses flexibility in cold weather.

Polyurethane

Use In boots and splash gear.

Advantage Good for bases and organic acids, oils, and alcohols. Abrasion-resistant. Flexible (especially in cold weather).

Disadvantage Poor for inorganic acids and other organic solvents.

Polyvinyl Alcohol (PVA)

Use For gloves only.

Advantage Excellent (the best) for oils, aromatic solvents, and chlorinated hydrocarbons. Ozone-resistant.

Disadvantage Degraded by water. Not flexible. Expensive.

Polyvinyl Chloride (PVC)

Use All types of protective clothing.

Advantage Excellent for acids and bases. Very durable. Relatively inexpensive.

Disadvantage Poor for chlorinated and aromatic solvents. Difficult to decontaminate.

Viton

Use In fully encapsulating suits and gloves.

Advantage Good for most organics including chlorinated hydrocarbons. Fair durability. Good for acids. Good for decontamination. Good for physical properties.

Disadvantage Poor for oxygenated solvents—aldehydes, ketones, esters, and ethers. Expensive.

Teflon

Use In fully encapsulating suits.

Advantage Excellent chemical resistance against most chemicals.

Disadvantage Limited permeation test data. Expensive.

Nomex

Use For flame PPE and a base fabric for some suits.

Advantage Acid- and fire-resistant. Durable.

Disadvantage Readily penetrated.

Tyvek®

Use Predominantly for coveralls.

Advantage Dry particulate and dust protection. Disposable, lightweight, and inexpensive.

Disadvantage Penetrable if not chemically treated. Poor durability.

Polyethylene (coated Tyvek®)

Use Predominantly for coveralls, but also gloves and booties. It can be worn over CPC to prevent gross contamination of non-disposables.

Advantage Good for acids and bases, alcohols, phenols, and aldehydes. Good for decontamination (disposable) and lightweight.

Disadvantage Poor for halogenated hydrocarbons, aliphatic and aromatic hydrocarbons. Not very durable. Easily penetrated (stitched seams).

Polyethylene/Ethylene vinyl alcohol (PE/EVAL) – 4H® or Silvershield®

Use Gloves, aprons, sleeves and booties

Advantage Good for alcohols, aliphatics, aromatics, chlorines, ketones and esters, economical

Disadvantage Poor fit of gloves impacts dexterity, easily punctured.

Trellchem®

Use Fully encapsulating and partially encapsulating suits

Advantage Resistant to a wide range of chemicals, some models also including chemical warfare agents, abrasion resistance and flame resistance.

Disadvantage Stiff and bulky, expensive

Tychem®

Use Fully encapsulating and partially encapsulating suits, coveralls and hoods

Advantage Resistant to a wide range of chemicals, some models also including chemical warfare agents, puncture and abrasion resistance; heat, arc flash and flame resistance.

Disadvantage Expensive, stiff and bulky

See resources from manufacturers when selecting CPC. The rating for a material does not necessarily predict performance of a garment; thickness, formulation, substrate and manufacturing process can all affect the product performance.

A general rule of thumb is that the permeation rate is inversely proportional to the thickness (2 x thickness = 1/2 x permeation rate). Other important factors are chemical concentration, contact time, temperature, material grade, humidity, and solubility of the material in the chemical. Consult the manufacturer for more information.

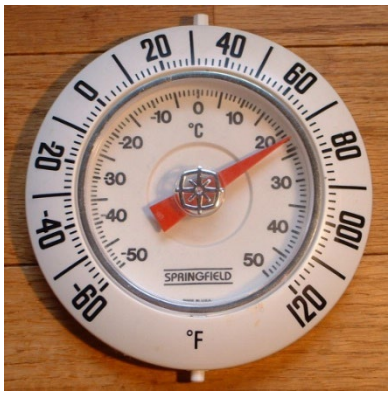
Precautions When Wearing CPC

Every level of chemical-protective clothing has limitations. The following precautions should be considered.

- Hearing and speaking are difficult in CPC with respiratory protection. It is important to establish other ways to communicate with each other. Hand signals or audio signals such as horns, sirens, and whistles can be used to communicate. Communication can also be improved by using two-way radios, such as a portable radio with microphone or radio with a microphone and speaker combination attached to the full-face respirator. Remember, any radio must be intrinsically safe to prevent an ignition hazard. Be aware of potential traffic areas.

- Due to the size and weight of some suits, motion is restricted, especially when climbing, working in tight areas, or using hand tools.

- Look for signs of heat stress (dizziness, headache, nausea, perspiration ceases), especially at temperatures over 70ºF.



- Always wear the correct size of footwear in order to prevent accidents. You should also make certain that the soles provide a proper grip for the surfaces that you will be encountering. Steel shanks, toes, and shin guards help to prevent puncture wounds and/or crushing injuries.

- Disposable booties may be slippery. Use caution when walking to prevent slips and falls.

- Care should be taken when donning and doffing inner and outer gloves. When donning gloves, make sure that no cracks or tears are present. When doffing gloves, take care not to spread contamination.

- All joints such as suit-to-boots and suit-to-gloves in Levels B and C protection should be secured with tape. Fold the end of the tape back under to make a tab for easy removal. Use special care when removing tape.

- Goggles and eye/face protection may become clouded due to moisture condensation during use. Follow manufacturer recommendation regarding use of products such as anti-fog film or spray on protective eye/face gear. Similarly, follow manufacturer instructions regarding clearing away any fog that may form on the inside of the face shield of a fully encapsulating suit.

- Be sure you are adequately hydrated prior to and after use of CPC.

- Avoid placing your hands or knees on the ground when in the Hot Zone to prevent contamination by chemicals and abrasion to the suit material. Avoid sitting on anything sharp in suits.

- When removing a suit, open and fold into itself as it is removed to prevent contamination of internal clothing.

- Suits have weak seams, especially if they are disposable. Be careful not to strain and split them. If splitting occurs, report it and follow the appropriate SOP (standard operating procedure).

- Use caution when suits are used in potential fire areas. If fire occurs, get out of the area.

- When dressing out with a team be careful to coordinate your dressout at the same speed and level as your team/buddy. The longer you are dressed out, the more stress is being put on your body.

- Completion of dressout should be delayed until ready to enter the work zone.

- Medical clearance is required for use of respirators.

Inspection, Maintenance and Storage of CPC

It is important to inspect CPC, for evidence of chemical damage. CPC that is torn, degraded, or otherwise non-functional will not offer adequate protection to the wearer. The site Safety and Health Plan should describe or reference SOPs for CPC inspection, maintenance and storage. The inspection SOP generally includes when:

- Received from the distributor
- Issued to workers
- Put into storage
- Taken out of storage
- Used for training
- Used for work or an emergency response
- Sent for maintenance

An inspection checklist should be developed for each item. Factors to consider are:

- Cuts, holes, tears, swelling, and abrasions
- Weakness in zipper or valve seals
- Signs of contamination such as discolorations or visible chemical residues
- Signs of malfunctioning exhaust valves

Note: CPC may be contaminated even though it doesn't appear discolored.

Proper maintenance can prevent CPC deficiencies and prolong its life. A detailed SOP must be developed by the employer and followed rigorously.

Proper storage is important in order to prevent failures. The written SOP should describe storage before the CPC is issued to the wearer (in a warehouse, on-site, etc.), as well as storage after use. Check manufacturer data, as most CPC used now has specific temperature and humidity storage requirements, a shelf life and an expiration date.

Exposure-Specific Protective Clothing

There are specific types of protective clothing that are developed for specific exposures. Those exposures might include high temperature, low temperature, arc flash, welding, diving, flash fire, hazardous equipment, hazardous animals. Equipment designed for a specific exposure may not protect against other types of exposures, such as a chemical exposure. Some of this clothing can be made by the manufacturer to protect against some hazardous materials. Never assume protective clothing will protect for anything it does not specifically state it will protect you for on the manufacturer's information or label.

High-Temperature Clothing: High-temperature clothing may be referred to as flash-over protective. Many Level A suits also offer flash fire protection; refer to manufacturer information, as needed.

Although high-temperature clothing protects against brief exposure to heat, it is not intended for long-term exposure to fire.

Arc Flash Protection: The recent increased awareness of the dangers of arc flash has resulted in an increase in arc flash personal protective equipment (PPE). The materials are tested for their arc rating. The arc rating is the maximum incident energy resistance demonstrated by a material prior to break open (a hole in the material) or necessary to pass through and cause with 50% probability a second- or third-degree burn. Arc rating is normally expressed in Cal/cm² (or small calories of heat energy per square centimeter). The tests for determining arc rating are defined in ASTM F1506 Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards. Among the best fabrics for protection against electric arc flash are the Modacrylic-cotton blends.

Selection of appropriate PPE, given a certain task to be performed, is normally handled in one of two possible ways. The first method is to consult a hazard category classification table, like that found in NFPA 70E. Table 130.7(C)(9)(a) lists a number of typical electrical tasks by various voltage levels and recommends the category of PPE that should be worn. The second method of selecting PPE is to perform an arc flash hazard calculation to determine the available incident arc energy. IEEE 1584 provides a guide to perform these calculations given that the maximum fault current, duration of faults, and other general equipment information is known. Once the incident energy is calculated, the appropriate ensemble of PPE that offers protection greater than the energy available can be selected.

PPE provides protection after an arc flash incident has occurred and should be viewed as the last line of protection. Reducing the frequency and severity of incidents should be the first option and this can be achieved through a complete arc flash hazard assessment and through the application of technology such as high-resistance grounding which has been proven to reduce the frequency and severity of incidents.

Other Protective Clothing and Equipment

Some situations may require other forms of protection. For example, chemical-resistant gloves, face shield/goggles, and apron might be added to Level D when no respiratory hazard is present, but some risk of skin contact exists.

Exercise - Levels of PPE

This exercise will allow you to apply knowledge gained from this section to a “real-life” situation. See Exercise Guide.

Donning and Doffing PPE

Proper donning and doffing of PPE will preserve the integrity of the PPE and protect the wearer from chemical exposure. An example of an SOG for donning Level B PPE is given below.

Level B Dress Out (Entrant/Decon) SOG

- Receive medical check (Optional)
- Verify that all PPE is ready and in the dress out area
- Perform an operational check of the SCBA
- Remove watches, jewelry, leather shoes and other personal items
- Don inner suit (Optional)
- Inspect suit
- Don Level B suit to waist
- Don chemical resistant boots with boot covers
- Conduct entry briefing
    - Describe Incident
    - Identify Hazards
    - Assign Duties/Jobs
    - Confirm Equipment and Decon Readiness

  - Confirm Primary, Secondary and Emergency Communications
  - Identify Emergency Showers/Decon
- Don inner glove
- Don middle glove
- Insert arms into the sleeves of the suit and pulling it over shoulders
- Gloves will be turned inside out over the thumb and palm of hand, then carefully taped making sure to stretch the elastic as far as possible and folded back over suit.
- Don chemical resistant outer gloves, and tape seam between glove and suit leaving a tab
- Don facepiece
- Don attached hood of suit, zip up front zipper, attach zipper flap and tape flap leaving a tab
- Don SCBA
- Conduct a positive and negative pressure check of respirator facepiece
- Don hardhat, if required (tape if needed)
- Assign suit number
- Rapid Intervention Team/Decon people to decon line
- Entrant connects regulator to facepiece and enters Hot Zone after Decon line is ready and IC approves
- Ensure wearer is breathing air and indicates readiness with a thumbs-up sign

The company-specific Standard Operating Procedure will specify the exact units and supplies to be used at the facility.

Summary - Chemical-Protective Clothing

PPE includes respirators, chemical-resistant suits, boots, gloves, chemical goggles, and face shields. PPE is required by OSHA regulations and protects workers from chemical contact with skin and eyes.

PPE is selected based on anticipated hazards during work activities; a written program must be available to guide selection, inspection, cleaning, storage and maintenance. Workers must be trained in the use and limitations of assigned PPE. You must inspect PPE and report possible deficiencies and properly comply with cleaning, storage and maintenance protocols included in the written PPE Program.

The four levels of protection combine RPE, CPC and foot protection as summarized below:

Level A provides the most protection and includes:

- A positive-pressure, full facepiece SCBA or supplied-air respirator with escape unit
- A totally encapsulating chemical-protective suit. Inner and outer chemical-resistant gloves
- Chemical-resistant boots with steel toe and shank

Level A protection is required when:

- The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and respiratory system
- There is potential for splash, immersion, or exposure to vapors, particulates, or gases that are harmful to the skin or may be absorbed through the skin
- Confined space entry may be involved and the need for Level A cannot be ruled out (but explosion hazard has been ruled out)
- The skin absorption hazard may likely result in immediate death or serious illness/injury or impair the ability to escape

Level B includes:

- A positive-pressure, full facepiece SCBA or supplied-air respirator with escape unit

- Hooded, chemical-resistant clothing
- Inner and outer chemical-resistant gloves
- Chemical-resistant boots with steel toe and shank

Level B protection is required when:

- The highest level of respiratory protection is needed but a lower level of skin protection (than Level A) is acceptable
- The substances have been identified
- An SCBA is required
- Less skin protection is needed. (Vapor and gases are not believed to be present at high levels harmful to skin or capable of being absorbed through intact skin)

Level C includes:

- Full-face air-purifying respirator (APR)
- Hooded, chemical-resistant clothing
- Inner and outer chemical-resistant gloves
- Chemical-protective boots with steel toe and shank

Level C provides protection when:

- The concentration(s) and type(s) of airborne substance(s) are known and the criteria for using an air-purifying respirator are met
- Direct contact with the hazardous substance will not harm the skin or the substance will not be absorbed through any exposed skin
- Air contaminants have been identified, concentrations measured, and an air-purifying respirator is available with an acceptable protection factor
- An adequate level of oxygen (≥ 19.5%) is available and all other criteria for the safe use of air-purifying respirators are met

Level D includes:

- Coveralls
- Chemical-resistant boots with steel toe and shank

Level D is required when:

- Minimal protection from chemical exposure is needed. It is worn to prevent nuisance contamination only
- The atmosphere contains no known hazards that require skin or respiratory protection

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

Levels A, B or C may be used depending on the work to be accomplished. The selection will be determined by the person in charge, according to the Safety and Health Program.

The effectiveness of protection is reduced by many factors, including:

- Inadequate inspection, storage, cleaning, maintenance
- Penetration, permeation, degradation
- Temperature extremes
- Improper fit
- Use of tape not approved by the manufacturer

The advantages and disadvantages when using various chemical-resistant materials can be found in charts and learned from manufacturers.

Motion may be restricted when wearing PPE. Slips and falls could result. Heat buildup in suits can pose a risk of heat stress. Communication is essential to ensure that any health or safety concern can be remediated.

Routine practice donning and doffing protective gear will contribute to safe work practices

PPE - Other Protective Gear

PPE for site workers includes respirators, chemical-resistant suits, boots, gloves, eye protection and hand protection.
PPE is required by OSHA regulations for protection from:

- Chemical contact with skin and eyes. (suits, aprons, gloves, goggles, face shield)
- Respiratory hazards (respirator)
- Physical hazards. (boots, hard hat, gloves, sleeves, thermal protection, hearing protection)

Objective

When you have completed this section, you will be better able to:

- Recognize OSHA standards and guidelines from other organizations for hearing, eye/face, hand, head and foot protection

In addition to RPE and CPC, other types of PPE may be required at the site. OSHA standards for additional PPE include:

- 1910.95 Hearing Protection
- 1910.133 Eye and Face Protection
- 1910.135 Head Protection
- 1910.136 Foot Protection
- 1910.137 Electrical Protective (gloves and sleeves)
- 1910.138 Hand Protection

With the exceptions of hearing protection and electrical protection, these protective devices are required in one or more of the Levels of Protection (A, B, C, D). General overall guidance for PPE is shown in 29 CFR 1910.132, General Requirements: Personal Protective Equipment.

Guidelines for head, shoe and eye/face protection testing and use are shown below:

Protective Equipment	Use/Testing Guideline
Hard Hats	ANSI Z89.1-2009 Industrial Head Protection ANSI Z89.1-2003 Industrial Head Protection ANSI Z89.1-1997, Protective Headwear for Industrial Workers
Shoes	ASTM F-2413-2018, Standard Specification for Performance Requirements for Protective (Safety) Toe Cap Footwear ASTM F-241218a--2018, Test Methods for Foot Protection ANSI Z41-1999, Personal Protection --Footwear Note: ASTM F-2413 current version -18 has not been adopted by OSHA
Eye/Face	ANSI Z87.1-2010, Occupational and Educational Eye and Face Protection Devices ANSI Z87.1-2003, Occupational and Educational Eye and Face Protection Devices ANSI Z87.1-1989, Occupational and Educational Eye and Face Protection

The use of hearing protection includes proper selection and training in order to help ensure that the risk of noise-induced hearing loss is reduced. Specific noise levels are shown in the physical hazards section of this manual.

Summary – Other Protective Gear

OSHA standards cover

- Hearing Protection
- Eye and Face Protection
- Head Protection
- Foot Protection
- Electrical Protective (gloves and sleeves)
- Hand Protection

ANSI publishes guidance on the testing of hard hats, safety shoes and eye/face protection.

Monitoring

Detecting and measuring hazardous substances at a work site is very important for the safety and health of workers. Potentially toxic compounds can be detected and measured using a variety of different monitoring instruments.

Exposure levels and explosive limits have been determined by government agencies as well as non-governmental organizations. These levels and limits are used to determine proper protective equipment and ensure a safer work environment.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify hazards that can be detected or measured
- Identify equipment used to monitor air, water, soil and surfaces
- Identify the procedures required when conducting monitoring
- Demonstrate the use of one or more monitoring devices

Monitoring for Workplace Hazards

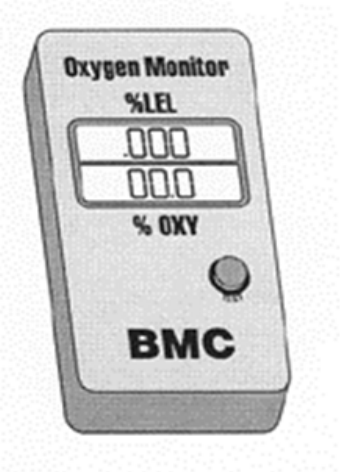
Monitoring provides important information about the presence of hazardous substances at a work site. Proper use of air-sampling equipment can provide information needed to protect life and property.

29 CFR 1910.120 (c) and (h) requires air monitoring:

a) Upon initial site entry
b) When work begins on a different part of the site
c) When you start handling chemicals that weren't found before
d) At the start of a different operation, such as opening drums instead of well drilling
e) When you are handling leaking drums or working with liquid contamination, such as a spill or a lagoon

Monitoring is performed when there is a question as to whether employees may be exposed to hazardous substances; the results are used as one factor in selecting PPE. The reasons for monitoring are:

- To detect whether potentially hazardous condition(s) exist, or a hazardous substance is present.
- To measure the concentration of hazardous substances.



LEL meter – used to DETECT

Solid sorbent tube, personal pump, lab analysis (MEASURE concentration)

Monitoring is also done in order to:

- Determine the effectiveness of hazard controls, such as ventilation
- Determine whether hazardous materials are present during normal operations
- Determine possible immediate effects of hazards, especially conditions which are immediately dangerous to life and health (IDLH)
- Determine when sudden releases of toxic materials occur that would require a change in work practice or donning of a specific type of protective equipment
- Determine the levels of hazardous substance(s) remaining after a sudden release

Whenever a contaminant is detected, it is desirable to measure the concentration if possible and the result can be compared to occupational exposure limits.

Measurement of concentrations is necessary in order to:

- Determine worker exposure level
- Determine the extent of hazardous conditions
- Determine community exposure
- Assist in planning work activity, including PPE needed
- Provide records of exposure
- Provide a historical record to submit to regulatory agencies
- Determine whether there is a need for medical monitoring

Initial entry monitoring is designed to detect IDLH situations at representative areas of the site. Other situations to be identified as part of initial entry monitoring include possible overexposure to chemicals, dusts or radioactive materials, or other dangerous situations such as the presence of flammable or oxygen-deficient atmospheres.

Real-time monitoring will alert workers to hazardous conditions and should be conducted when an IDLH condition is suspected, flammable atmospheres, or indications that exposures may have increased above permissible or published exposure limits since the last monitoring. It is possible that exposures may have changed when:

- Work begins in a different area of the site or tasks change
- Contaminants other than those previously identified are being handled
- Chemical contamination is identified in the work area

The results of monitoring of employees with high exposures will be used to determine future sample collection and:

- If some workers exceed exposure limits, then the program is expanded to identify all overexposed workers
- The monitoring must be repeated if work activities or types of materials handled change

Basic principles for using monitoring equipment:

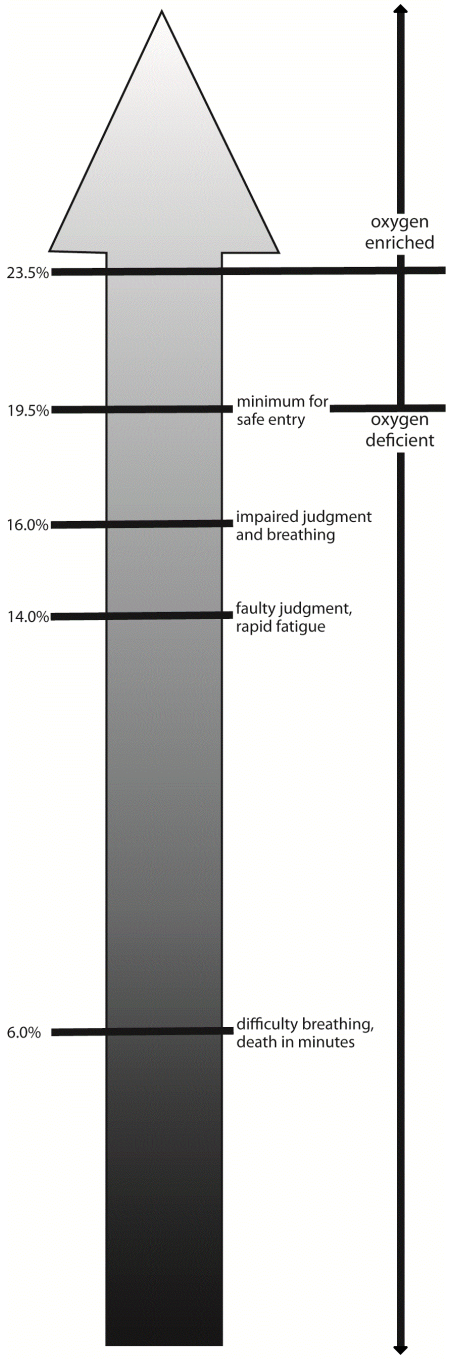
- No one monitor can detect all hazardous situations. Select the monitor with the correct sensors for the work area you are entering.
- Know how they work and how to use them
- Know the limitations (consult manufacturer data) of the monitor to be used
- Try to use more than one type of monitor to verify identification

What Can Be Monitored in the Air?

Air monitoring can be used to detect and measure many hazards, including:

- Oxygen Deficiency/Enrichment
- Fire and Explosion Hazards
- Toxic Chemicals
- Corrosivity
- Radioactivity
- Biological Hazards

Oxygen-Deficiency/Enrichment



Oxygen Deficiency

Without an adequate concentration of oxygen in the air, the worker is in an immediately dangerous to life and health (IDLH) atmosphere. Normal breathing air contains 20.9% oxygen. OSHA requires a minimum of 19.5% oxygen to be present at the site; otherwise the atmosphere is considered **oxygen deficient**. Confined spaces such as tanks, pits, silos, pipelines, boilers, vaults, and sewers are examples of possible oxygen-deficient work areas. Oxygen levels can be reduced during certain chemical reactions, rusting, or some bacterial action (fermentation). Oxygen-deficient atmospheres may cause a person to feel lethargic and potentially lose consciousness. OSHA requires supplied-air respiratory protection or SCBA in atmospheres below 19.5% oxygen.

Oxygen Enrichment

The atmosphere is defined as **oxygen-enriched** if it contains more than 23.5% oxygen. This situation poses a threat of explosion, especially if flammable materials are present. As a result, special procedures are necessary in the area.

Note: 1% concentration equals 10,000 parts per million (ppm). Oxygen (atmosphere) averages 20.9% or 209,000 ppm. Therefore, toxic concentrations of gases or vapors will not result in a change in oxygen concentration.

Note: At 19.5% most people should be able to make good decisions and safely escape the environment.

Discussion Question: O_2 levels were measured prior to entry into a trench. Please review the measurements reported and comment on whether entry is permitted and any notes or considerations that you might have regarding each reading.

0_2 = 19.5%
0_2 = 20.5%
0_2 = 23.5%

Fire and Explosion Hazards

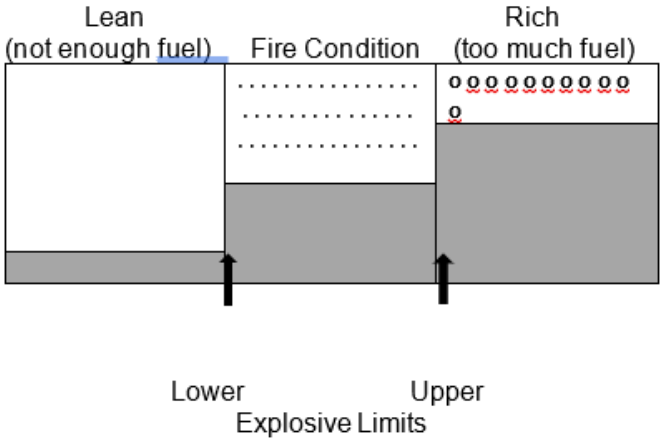
Determining whether there is a possibility of fire or explosion is critical. Flammable and explosive atmospheres develop when reactions occur with oxygen in the air, evaporation of flammables, gas leaks, and dust accumulation. Potentially flammable atmospheres must be monitored frequently in accordance with the Emergency Response Plan (ERP). Protective clothing and respirators which protect the worker from toxic hazards provide little, if any, protection against fire or explosions.

Explosive Limits

Monitoring results reported as percent can provide information about substances in the air which may potentially cause an explosion. For flammable vapors and dusts, explosive limits have been determined. Two determined limits are listed below:

Lower Explosive Limit (LEL) is the minimum concentration of a flammable gas in the air which can result in ignition. Concentrations below the LEL will not ignite. Below the LEL, the mixture is called “lean.”

Upper Explosive Limit (UEL) is the maximum concentration of a flammable gas in the air which can result in ignition. Concentrations above the UEL will not ignite. Above the UEL, the mixture is called “rich.”



Explosive Range is the concentration of a flammable gas in the air between the LEL and UEL. In this range, the substance will readily ignite.

Toxic Chemicals

The ability to determine the specific hazard by monitoring the air, soil, water, or surfaces will be limited to the capabilities of the monitoring instrument used.

For immediate results direct reading instruments are used; these provide information about the presence (detect) and sometimes the concentration (measure) of the gas, vapor or dust hazard. These are generally used near active work or the breathing zone workers; this is referred to as area monitoring. Conducting personal monitoring of gas, vapor, or dust exposure requires a worker to wear a sampling device; generally the

sample is sent to a laboratory to as a measure of the concentration of specific materials in the air.

Soil, water and surface contamination samples generally are analyzed in a laboratory.

Corrosivity

Corrosives (acids or bases, having significantly low or high pH) can have adverse health effects, including damage to skin, eyes and the respiratory system. In addition, they can damage monitoring equipment and PPE. Corrosive compounds in the air can be detected using pH paper. If strong acids or bases are present, the pH paper will change color.

Compatibility Testing

Tests performed in a laboratory are used to determine whether the hazardous materials can be mixed (compatible or incompatible) or packed together for processing (lab packs).

Compatibility software programs have been developed by the U.S. EPA, Army Corp of Engineers, and other groups. These approaches to compatibility assessment are qualitative. Compatibility testing is essential to avoid emergency situations from mixing two incompatible materials.

Radiation from Radioactive Substances

If the presence of radioactive waste is detected, adequate precautions can be implemented to prevent exposure. The presence of radiation usually requires special technicians (Radiation Safety Officers) to conduct monitoring. No single instrument can measure all forms of radiation accurately.

Biological Hazards

Workers may also be exposed to biological hazards such as bacteria, viruses, certain parasites, mold, and animal droppings. Specialized training and equipment are needed to detect and measure biological hazards. The presence of these agents will help determine the selection of PPE, as well as decontamination and disposal procedures. When it is suspected that biological hazards are present, specialists must be brought in to investigate.

What Can Be Monitored in Soil, Water or on Surfaces?

Evaluation of contaminants in media other than air may be performed. Assessment of water, soil, and surface contamination may be conducted. In addition, corrosivity and compatibility tests may be conducted.

See manufacturer literature for the range environmental monitoring equipment. For specific protocols, search the EPA website.

Soil Sampling

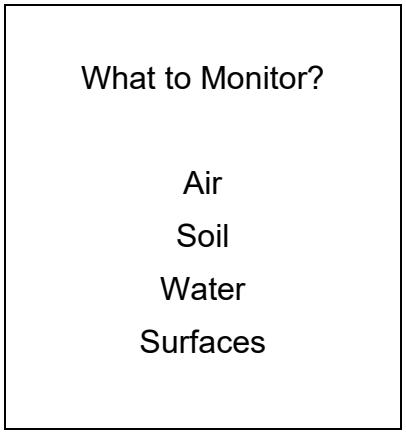
Soil samples may be collected at a site, or on neighboring property to determine if waste has migrated and been released to the soil. Laboratory analysis of soil samples will indicate if there is contamination and the depth and area of the contamination. Contamination by solids, liquids and vapor may be evaluated.

Water Sampling

Sampling and laboratory analysis of effluent groundwater and water from wells, ponds, and streams may be performed at a site to determine whether wastes (examples: metals, biologic, organic compounds) are present or have migrated off-site.

Wipe (Swipe) Testing for Surface Contamination

Surface contamination is evaluated by collecting a sample by passing a filter or wipe across a surface according to a specified procedure and then submitting the sample to a laboratory for analysis. Swipes are often used to evaluate metals and radiation hazards. Contamination of PPE or human skin can also be evaluated by wipe testing.



Overall Guidance

Site management is responsible for selecting equipment appropriate for routine sampling and anticipated emergencies. Manufacturers provide information about equipment used and its limitations. NIOSH (National Institute of Occupational Safety and Health) and the EPA (Environmental Protection Agency) also provide information about equipment.

Real-time monitoring with direct-reading instruments provides an immediate result and can be done with a range of devices depending on the information required. If the exposure of a worker is to be evaluated, personal monitoring is conducted; the sample may be sent to a laboratory and therefore may not be available immediately.

Some general considerations when selecting/using monitoring equipment follow:

- The unit should be intrinsically safe. (It will not produce sparks that could trigger an explosion.) Check the label and the manufacturer guide.
- Most direct-reading instruments are designed to detect or measure only one contaminant or group of contaminants.
- There are no instruments which can sample all toxic substances.
- Equipment should be easy to transport and operate in the field under changing conditions and be decontaminated after use as needed.
- Instruments should operate properly at temperatures which are anticipated during site activities.
- Instrument should be easy to observe/operate while wearing PPE
- Instrument training should be provided through routine “hands-on” practice.
- Many sampling instruments have rechargeable batteries that typically last longer than 8 hours when new and fully charged. Operation may reduce the battery life. Cold temperatures also reduce battery duration of use; never store fully charged equipment in a cold location prior to use.
- Some equipment can be operated with non-rechargeable batteries that can be an option when working in the field.
- For rechargeable batteries, periodically discharge the battery fully and recharge to prevent ‘battery memory’.
- Many instruments do not reach the highest readout instantaneously. For chemical sensors, the time to reach 90% of the actual concentration is referred to as T90 and is typically in the range of 15 seconds to 2 minutes.

Sampling Plan or Protocol

A sampling plan is designed to provide representative and accurate information on exposure.

A sampling plan includes:

- Areas where sampling is required
  - By regulation
  - By Site Safety and Health Plan
- Equipment needed
- Frequency, duration and procedures
- Sampling methods
- Analytical method (if needed)
- Benchmarks for comparison of result with accepted values
- Name (and signature)/date of plan developer and any amendments

Documentation for sampling generally includes:

- Pre- and post-calibration (if specified in protocol; initials of person doing it)
- Name/number of sampling/analytical method (if used)
- Person conducting the monitoring
- Person monitored (if personal monitoring)
- Equipment ID number
- Drawings showing location of sample collection
- Notes regarding activities conducted during sampling
- Notes regarding work practices and other exposure controls
- Use of any PPE
- Any observed problems with the equipment
- Any deviation from the sampling protocol
- Chain of Custody, as appropriate
- Result (recorded by sampling personnel or laboratory report)
- Record of transmitting result to person sampled (if personal monitoring)

A Calibration and Maintenance Logbook will include the following for each device:

- Description of required calibration and maintenance
- Date of each calibration/maintenance
- Results (often as a letter from an external source)
- Location of Manufacturer Literature for review, as needed

Note: electronic calibrators must be calibrated according to manufacturer's recommendations

Sampling personnel must be trained in the collection method(s) and use of all needed equipment and how to recognize problems during sample collection.

Before you sample…

For any sample collection, first make sure you have been trained in the methods and the use of the equipment. It is also important to be trained to recognize problems during sample collection and who to alert if you need assistance.

Below are several considerations for use of instruments during exposure monitoring:

Direct-reading instruments

1. Calibrate

Check with the safety officer to be sure that it has been properly calibrated. Calibration involves exposing the instrument to a known concentration of a compound and testing for the proper response. It is important that all instruments be calibrated on a regular basis. Some direct-reading instruments are compatible with a docking station interface (consult manufacturer's data for more information).

2. Be conservative

If the instrument gives an unexpectedly high response, assume that it is correct. If the reading is suspiciously low, assume that there may be an instrument problem.

3. A zero reading does not mean clean air

Always remember that a reading of zero does not mean that the air is clean. Some highly toxic materials are not detected by common direct-reading instruments. A reading of "zero" may mean contaminants are present but at levels below the detection capability of the instrument.

4. Read even a small response as positive

Any response, even a small one, on a direct-reading instrument should be interpreted as indicating a potentially dangerous situation. It is far safer to assume that if the

instrument can detect a chemical, the concentration may be high enough to pose a health threat.

5. Use multiple instrument types

Whenever possible, use more than one type of direct-reading instrument. Remember that each type of instrument has different capabilities, so a reading of zero on one instrument could turn out to be a high reading on another instrument.

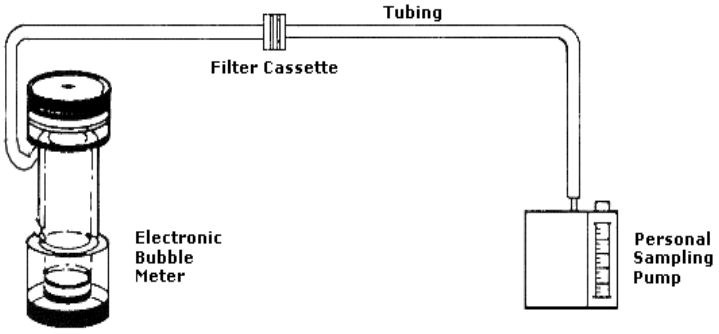
6. Have maintenance guidelines been followed?

All equipment is supplied with a recommended maintenance schedule. Follow it. Should any indication of malfunction be noted during routine checks or usage, report it to the safety officer or other designated person.

Personal Monitoring

1. Calibrate (pumps and alarms)

Check with the safety officer to be sure that it has been properly calibrated. If a personal pump is to be used, this will ensure that the amount of air flow through the sampling media matches the method being used. Calibration will also be conducted after sample collection to determine the total volume (duration x flow rate). If the flow rate has changed by more than 5%, resampling may be required. Consult the method cited in the sampling plan. If a personal alarm is to be used, this will ensure that the monitor responds according to manufacturer specifications.



Calibration set up for personal sampling pump, with filter cassette in-line.

2. Sampling lines

If you will use tubing to connect a pump and a collection filter/tube, ensure that you have different lengths of tubing (for different heights of workers) and methods to keep the tubing close to the wearer's clothing (tape or pins). Sampling lines can separate from the pump and may result in loss of a sample. Loose or floppy tubing can be a safety hazard to the wearer.

3. Know the demands of work, and the schedule

Wearing a sampling device is an imposition. If you know the work demands, you can better ensure that it will not interfere with usual activities. For example, forklift operators will not want a pump positioned in the small of the back. Women often need a belt to hold a pump—so be ready to provide a belt, as needed. Folks who want to leave the workplace at lunch will not wait for you to come when it is time to leave. You may jeopardize sample collection if it is removed and placed on a contaminated work surface.

4. Tell each person what to expect

Go over the reason for sampling, how the equipment works and what will happen after the collection. Ask if the equipment is comfortable (or as much as possible) and if there are any other questions.

5. Let workers know where you will be

Let each person know how to reach you during the shift if there is a question or a problem. Most pump protocols require at least hourly observation, so you will be on site for the entire shift.

6. Have maintenance guidelines been followed?

All equipment is supplied with a recommended maintenance schedule. Follow it. Should any indication of malfunction be noted during routine checks or usage report it to the safety officer or other designated personnel.

7. Assemble supplies for Chain of Custody for any sample to be shipped to detect any tampering when outside your control. Wrap seals around entry/exit plugs or caps.

Air sampling cassette for particles ready for shipment

After you sample…

After-sampling actions are also part of the plan.

These activities are specific to the type of sampling conducted and may include:

1. Is there reason to decontaminate the equipment before leaving the field?
   Follow protocol, as appropriate.
   Dispose of contaminated materials appropriately.
2. Post calibrate, if included in the protocol.
   Record results and determine if the sample is valid as described in the protocol.
3. Complete paperwork.
   Record results, chain of custody etc.
   Log any problems with the instrument and notify appropriate personnel
   Report results as required
4. Prepare samples for shipment, as needed.
   Follow instructions from the receiving laboratory.
5. Ensure proper disposal of waste.
   For example, the glass shards from colorimetric tubes and the tubes must be disposed of in a manner to ensure no one is cut when handling waste.
6. Follow post-use, back-to-service protocol.
   Store equipment, recharge, restock depleted supplies, etc.

Sampling Instruments and Tools

Uses of some types of instruments and tools for taking samples of air, soil, water and surface contamination are described in this section, specifically:

pH paper

Oxygen/Combustible Gas/Combination Instruments

Colorimetric tubes

Personal Alarms

Hydrocarbon Detectors

Flame Ionization Detectors

More specialized Instruments:

- Infrared Spectroscopy
- Ion Mobility Spectrometry
- Surface Acoustic Wave
- Raman Spectroscopy
- Gas Chromatography
- Metal Oxide Sensors

Radiation Exposure Monitoring

Noise Monitoring

Personal Monitoring for Organic Vapors and Particles

Area Monitoring for Particles/Fibers/Dust

Water Sampling

Soil Sampling

Surface Contamination Sampling

Use, readout and notes are shown. These overviews do not replace manufacturer instructions.

ALWAYS: read and follow the manufacturer instructions carefully

pH paper

When exposed to a chemical, pH paper changes color.

Use:

- Measure presence of corrosive substance

Read-out:

- Observed color matched to chart

Notes:

- When pH paper changes color in the presence of corrosive vapors, the color change is easy to interpret. The color change may be harder to interpret when testing liquids.
- Hydrocarbons, which are neutral, may appear to change the color of the paper. In this case, the border between the wet and dry sides of the paper will be straight. If the border is jagged, multicolored, and the liquid seems to be wicking through the pH paper, the liquid is actually corrosive.
- Readings can sometimes not give a clear understanding of chemicals present. In the presence of hydrocarbons, the pH paper may give a misleading reading.
- When using the wetted pH paper for corrosive vapor detection, a neutral reading should not give you a sense of security. Other hazards may be present.
- pH paper can be attached to a stick or an extension tool when entering an unknown situation, such as during site characterization.
- Utilize two pieces of pH paper (one wetted and one dry). The wetted paper reacts more quickly than the dry paper especially for low levels of a chemical in the air. The wetted pH paper is used for detecting corrosive vapor and dry is used to dip into liquids.

Tip: pH meters are subject to interferences, so pH paper is preferred.

Oxygen and Combustible Gas Meters, and Combination Meters

Oxygen Meter

Use:

- To sample oxygen concentration, particularly near and in confined spaces

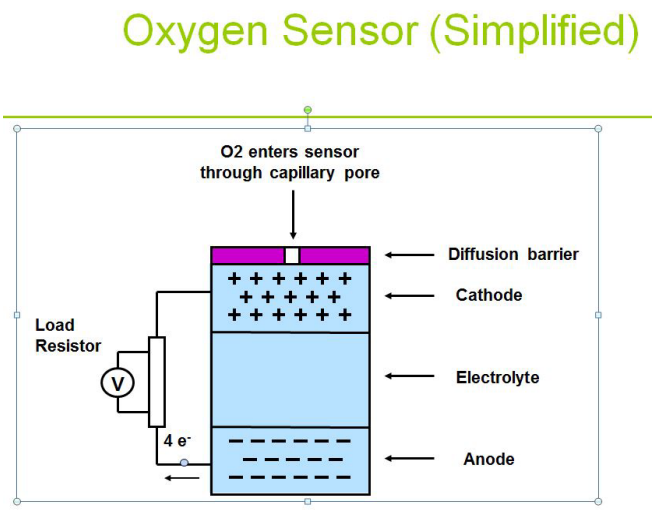
Read-out:

- Usually 0%–25% oxygen concentration.
- At greater than 23.5% oxygen, the explosion hazard increases.
- The normal oxygen concentration is 20.9% - any deviation from this is abnormal and should be investigated as to why there is a change. (Theoretically, a 0.1% decrease in oxygen due to displacement of the air by another chemical is indicative of a concentration of approximately 5,000 ppm of other chemicals –replacing 1/5 of O_2 and 4/5 of N_2).
- At less than 19.5% oxygen, do not enter without an SCBA or SAR.

Notes:

O2 sensors

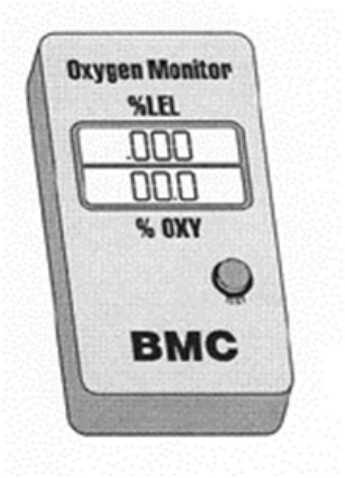
- Need about 2-3 minutes to warm up
- Continuously react with the air
- Contain electrolyte solution
- Operating range: -5° to 120°F
- Affected by temperature and pressure
- High carbon dioxide levels may affect reading
- Typically the meter calibrates for oxygen during each startup
- Requires maintenance (Life of sensor is approximately 2 years under normal use)



- Acid vapors shorten the life of the electrochemical sensor
- Condensation and/or absorption may occur in long probes
- User must be trained

Tip: At -5°F to 32°F sensor reaction time slows and eventually will freeze at extreme temperatures

Combustible-Gas Indicator (CGI)/ LEL Meter/Explosion Meter



Use:

- To measure flammable vapor concentration in percent, particularly near and in confined spaces
- General purpose for most combustible hydrocarbons
- Responds to all combustibles present

Read-out:

- % LEL (sometimes referred to as Lower Flammability Limit, or LFL).
- A reading above 10% should be considered a potentially explosive atmosphere. (Know what to do when a potentially dangerous reading is noted—for example: leave the area, notify supervisor). For added safety, many companies use lower values such as any positive reading, or 5%. The primary reason for this is for a flammable chemical that is also toxic. A low meter reading, or no reading at all, could still be a dangerous environment.
- Accurate over most of its range

Notes:

- Requires periodic calibrations. Normal practice is at least every 30 days.
- Relatively unaffected by temperature and humidity
- Does not respond the same to all vapors
- Oxygen must be measured first. Many combustible-gas instruments require sufficient oxygen (consult manufacturer's manual) in order to determine LEL.
- User must be trained.
- Calibration should be checked or done before each use, as per the manufacturer's requirements. Recommendations vary by manufacturer, but before each use is best practice. It is a good idea to check calibration after using an instrument to verify good data and confirm the sensor was not compromised or injured.
- Should be bump tested to ensure that all sensors are operating before each use
- Nonspecific. Reflects total combustibles present. The specific flammable(s) is not identified. The %LEL is read as if the flammables were the calibration

gas. (If a single flammable is present, the manufacturer may provide correction factors.)

- Not recommended for chlorinated hydrocarbons or tetraethyl lead-containing compounds
- Avoid exposing sensors to these poisons (lead compounds, compounds with sulfur, silicones, phosphates and phosphorous) and inhibitors (hydrogen sulfide, halogenated hydrocarbons).

Example:

LEL of methane is 5% by volume
100% LEL = 5% VOL = 50,000 PPM (ignite)
10% LEL = 5,000 PPM Alarm
1% LEL = 500 ppm (LEL 1)
449 PPM $\Rightarrow$ meter displays 0

Example:

calibrated with methane, used in an atmosphere known to only contain pentane

reading of 5%

pentane correction factor is 2.0

$\rightarrow$actual value is 10% of the pentane LEL

Tip: The common LEL meter is calibrated to read 100% at the LEL of the calibration gas. A small % reading on the meter, while indicating a low risk of fire/explosion at the meter may indicate a potentially toxic concentration. For methane a reading of 5% on the meter indicates a methane concentration of 0.25% or 2,500 ppm.

Important background: LEL sensor technology is typically either catalytic bead on a wire or infrared (IR). The flammable is burned at the bead, increasing the resistance in the wire; the resistance is adjusted for air temperature using a Wheatstone bridge and converted to a reading of LEL. Therefore, oxygen is needed for the meter to function; typically 14% is the minimum required (see manufacturer specs). The IR sensor does not require oxygen for operation.

Problem:
At an abandoned paint factory that is now a waste site, monitoring of a leaking drum of toluene results in an LEL reading of 8% 30 feet from the drum. The calibration gas was methane. Using the toluene correction factor of 1.3, answer the following:

What is the LEL % for toluene?
What is the ppm?
What type of respiratory protection should be used?

Combination Instruments

The meter shown above for combustible gases is also used to measure oxygen. This is a common combination. Combination real-time monitors for oxygen and flammability (LEL, explosivity, combustibility) are approved for use in flammable environments where the oxygen does not exceed 20.9%, unless tested and approved for use in high-oxygen environments. An alternative is to have sample tubing (probe) to draw the air into the meter that is positioned at a location with acceptable oxygen concentration. The length of the sample tubing will vary for each meter, but typically ranges from 30 to 100 feet. Common problems with drawing samples through tubing include condensation of vapors, and absorption onto the tubing.

Three or more hazards can be measured with other combination meters. These multi-gas instruments, which may be called 3-gas or 4-gas meters or something similar, are used to measure oxygen and combustibles and other gases such as carbon monoxide and/or hydrogen sulfide. They are often used to test the atmosphere before entry into a confined space.

Notes:

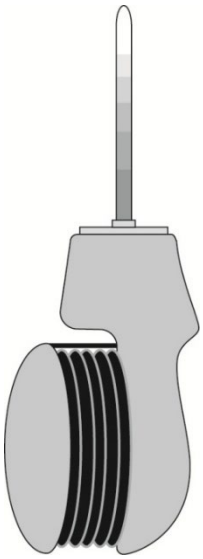
- The chemical sensors respond to a specific chemical or class of chemicals. Interferences are usually limited (refer to manufacturer literature).

- In addition to temperature, a limitation of these electrochemical sensors is that use in high concentration atmospheres may us up all the reactivity of a cell in a single measurement, rendering the sell useless until there has been time (hours) for the cell to re-stabilize.

  Example:

  While investigating the source of CO in a warehouse demolition, putting the CO monitor near the exhaust of the pay loader may ‘blow it away’ and require replacement or recalibration of the sensor.

Colorimetric Detector Tubes (Dräger, MSA, Sensidyne, RAE)



A colorimetric detector tube is a glass tube containing chemically treated granules that change color when air contaminated with a specific gas or vapor passes through the tube. A tube is selected for the specific contaminant of interest. When the detector tube is used, the ends are broken off and the tube is inserted into a bellows or piston pump. An arrow on the tube indicates which end of the tube to insert into the pump orifice. A predetermined volume of air is pulled through the pump. The contaminant of interest reacts with the chemical in the tube. This reaction produces a stain in the tube with a length proportional to the concentration of the contaminant. Reagent changes include color intensity, length of change and change of color. Compare color to unused tube as changes can be very subtle.

Use:

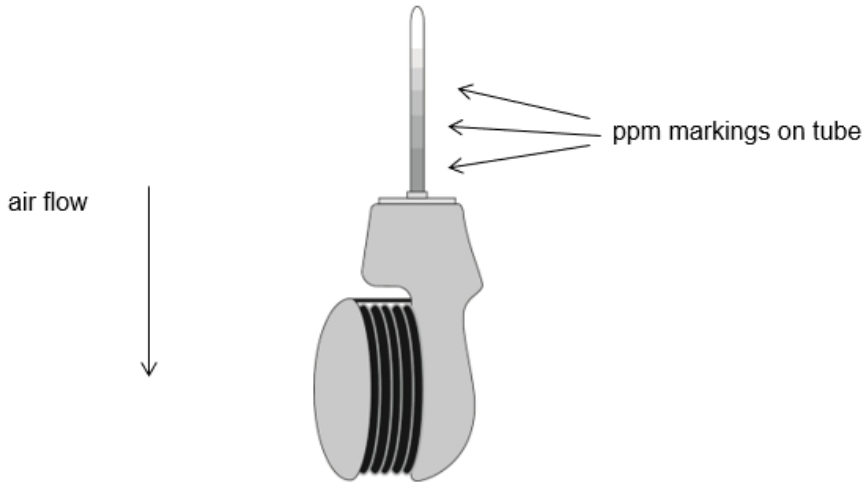
- Measure gas or vapor concentration
- Identify chemical family of contaminant using manufacturer decision charts and tables.

Read-out:

- Concentration in ppm, mg/m3 or percent is indicated by color change or length of color stain.

Notes:

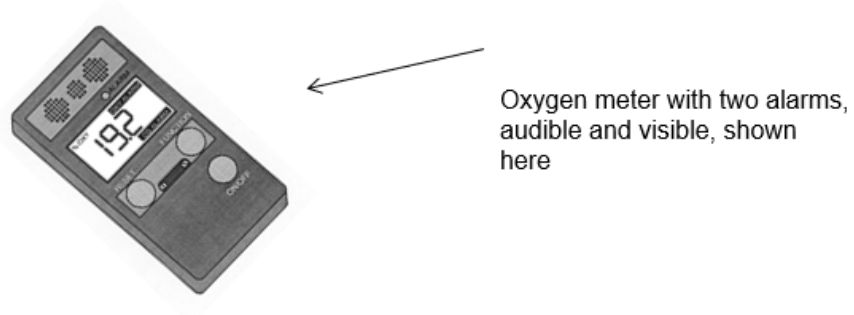
- Not very accurate—within 25% of the real value at best
- Pump must be checked for leaks and calibrated
- Tubes have a limited lifetime so the expiration date on the container should be checked before use
- User must be trained in reading the scales on the tubes used
- User must follow specific pump-stroke requirements and all other directions
- Interferences are possible; not very specific
- May be misread if the sample-taker is color blind
- Specific temperature and humidity ranges shown in directions
- Tube heaters are available from some manufacturers
- Tubes may be marked with number of required pump strokes



Tip: The Dräger Chip Measurement System (CMS)® includes a chip for the chemical of interest. The measurement is complete and digital result read on the screen in 30 seconds to 5 minutes, depending on concentration and chip type. Note that there are not as many chemicals available in the CMS as there are when using single colorimetric tubes.

Personal Alarms

Monitors worn on the belt or in a pocket are used to detect a specific level of a contaminant and sound an alarm to exit the area. Worker in areas where there may be an oxygen deficiency or exposure to carbon monoxide or hydrogen sulfide are among those who may use personal alarms.



Use:

- To detect gas or vapor compared with a pre-set concentration in any workspace
- Alert workers to levels of contaminants to which they should not be exposed

Read-out:

- Audible alarm and sometimes visible alarm and/or display of concentration (examples: ppm or %)

Notes:

- Inaccurate readings may be given if there are interferences
- Battery-operated
- Wearers must be trained in actions to take if the alarm sounds

Hydrocarbon Detectors

The total amount of all detectable flammable organic compounds can be measured using a device with either a Flame Ionization Detector (FID) or a Photoionization Detector (PID). These devices are used to measure exposure to solvents, fuels and volatile organic compounds (VOCs) in the work area; results are compared with exposure guidelines.

Photoionization Detectors (PID)

In PID instruments, ultraviolet radiation is used to ionize (break apart the molecules) gases and vapors. The current produced is proportional to the number of ions and is a measure of concentration.

The energy needed to ionize a compound is its characteristic "ionization potential" (IP), expressed in electron volts (eV). Ionization potentials for selected materials are shown below.

Chemical	IP (eV)	Chemical	IP (eV)
Hydrogen cyanide	13.9	Hydrogen sulfide	10.5
Methane	13.0	Hexane	10.2
Chlorine	11.5	Acetone	9.7
Benzene	9.2	Phenol	8.5

Use:

- To sample toxic and some flammable vapor concentration, particularly near and in confined spaces

- Detects organic and some inorganic gases such as Ammonia, Arsine, Phosphine, Hydrogen Sulfide, Bromine, and Iodine (0.1 – 10,000ppm) (most 1-2000 ppm.)
- Can alert to areas of concern or contamination and be used to find leaks.

Readout:

- Concentration in ppm

Notes:

- Ability to detect wide variety of chemicals in small amounts
- Does not destroy sample
- Quick response
- Can operate in low-oxygen environment
- Detects only those compounds with ionization potentials less than the energy of the lamp
- Response affected by composition of mixed gases
- Only quantifiable if measuring a known substance
- Lamps affected by high humidity, high levels of methane and dust
- Does not detect methane, CO, CO_2, or SO_2
- Cannot separate mixtures
- Other voltage sources may interfere
- Requires calibration (usually with isobutylene)
- User must be trained
- Must know lamp voltage and correction factor (CF)
- Requires regular maintenance

Correction Factors (10.6 eV Lamp)

	RAE	BW	Ion		IP (eV)
Acetaldehyde	5.5	4.6	4.9		10.21
Acetone	1.1	0.9	0.7		9.69
Ammonia	9.7	10.6	8.5		10.2
Benzene	0.5	0.55	0.5		9.25
Butadiene	1	0.9	0.85		9.07
Diesel fuel	0.8	0.93	0.75		n/a
Ethanol	12	13.2	8.7		10.48
Ethylene	10	11	8		10.52
Gasoline	0.9	0.73	1.1		n/a
n-Hexane	4.3	4	3.3		10.18
Jet fuel (J.P.8)	0.6	0.51	0.7		n/a
Kerosine	n/a	1.11	0.8		n/a
Methylethylketone	0.9	0.78	0.77		9.53
Naptha (iso-octane)	1.2	1.2	1.1		9.82
Styrene	0.4	0.45	0.45		8.47
Toluene	0.5	0.53	0.51		8.82
Turpentine	0.4	0.45	0.45		n/a
Vinyl chloride	2	2.19	2.2		10.0
Xylene	0.4	0.5	0.43		8.5

PIDs are often calibrated with isobutylene, which has a correction factor of 1.0. If you know that a single gas is present in the atmosphere, you multiply the correction factor for that gas by the instrument reading to obtain the true concentration of the chemical.

Example:

A RAE instrument is being used to measure toluene, with a CF of 0.5.

The instrument calibrated with isobutylene reads 100 ppm.

The actual concentration is:

$$C = 0.5_{CF} \times 100\ ppm_{iso} = 50\ ppm\ of\ toluene$$

Flame Ionization Detectors (FID)

In FID instruments, the gases and vapors are ionized (molecules broken apart) in a flame. A current is produced which is proportional to the number of carbon atoms. The current is converted to a measure of concentration.

Use:

- To detect many organic gases and vapors
- Can see chemicals with higher IP than PID (more accurate) (1.0-100,000ppm)
- Only organics

Readout:

- ppm

Notes:

- Requires gas chromatography option to identify and measure specific compounds
- Does not detect inorganics
- Affected by low temperatures, high contaminant concentrations, and oxygen-deficient atmospheres
- Must be calibrated
- User must be trained
- Requires maintenance and leak checks
- Must be intrinsically safe if used where explosive atmospheres may exist; some models are not intrinsically safe
- Flame out in high wind
- Only carries limited amount of hydrogen
- Destroys sample
- Needs O_2 to operate

More specialized monitoring instruments

In addition to the widely used instruments listed previously, newer types of instruments are increasingly being employed in hazardous waste site work. The following

instruments may have specialized capabilities or lower measurement ranges than the instruments described before. In many cases, they are more expensive.

Infrared Spectroscopy

Infrared (IR) Spectroscopy may be used to detect and measure chemicals in air, liquids and solids. It functions by comparing the infrared absorption spectra of contaminants to the known spectra of pure chemicals. It can be used for contaminants such as volatile and semi-volatile organics, ammonia, carbon disulfide, carbon monoxide, hydrogen sulfide, acids, nitrogen oxides, and many others. It does not respond to noble gases, vapor-phase metals, and chemicals that are made up of two atoms of the same element, such as oxygen (O_2), nitrogen (N_2) and chlorine (Cl_2). Water vapor and carbon dioxide are frequent interferences. On a hazardous waste site, IR spectroscopy may be deployed in several different configurations.

Active Open-path Fourier transform IR

Active open-path Fourier transform IR (Active open-path FTIR or active OP-FTIR) may be deployed for fence line or perimeter monitoring or worker exposure monitoring. The technique relies on instruments placed in two different fixed locations in sight of one another. In this configuration, it can measure an average concentration of contaminants across the straight-line path between the two instruments. Measurements down to the low parts-per-billion can be achieved.

Passive Open-path Fourier transform IR

Passive open-path Fourier transform IR (Passive open-path FTIR or passive OP-FTIR) is operated as a portable “point and shoot” instrument that can be used to detect, but not measure, chemical releases. It also cannot tell the difference between different chemicals. The technique relies on an infrared source in the environment, such as the sun, instead of generating its own infrared source, as active OP-FTIR instruments do. Its detection limits are higher than for active OP-FTIR, in the range of hundreds of ppm, but its range is longer, up to a mile or more.

Handheld Fourier transform IR for solid and liquid identification

Handheld Fourier transform IR (FTIR) units are available for identification of unknown solids and liquids. They can work from a library of over 10,000 chemicals to identify substances including chemical warfare agents, explosives, toxic industrial chemicals, narcotics, suspicious powders and other dangerous chemicals. Analysis is performed by placing a small amount of unknown substance onto the interface.

Ion Mobility Spectrometry Instruments

Portable ion mobility spectrometry (IMS) instruments can be used to identify airborne chemicals. The instruments utilize built-in pumps to draw air through the instrument. Substances that can be identified include chemical warfare agents, toxic industrial chemicals, narcotics and explosives. These instruments utilize an ionization source, which may or may not be radioactive, to put a positive or negative charge on a chemical. The ion mobility spectrum of the chemical is compared to the spectra of known chemicals to identify the unknown. Substances that will interfere with the reading include menthol, oil of wintergreen, perfumes, food flavorings and engine exhaust. It is sensitive down to parts per billion of a chemical but may not detect at levels below the IDLH for chemical warfare agents.

Surface Acoustic Wave

The NRL SAW sensor.

Surface acoustic wave (SAW) instruments utilize vibrating piezoelectric crystals to detect and identify airborne chemicals. Chemicals adsorbed onto the crystal surface change the frequency of the vibration. The change is compared to the change for known substances to identify the unknown chemical. These instruments may be calibrated to detect chemical warfare agents. Like IMS instruments, SAW instruments cannot usually detect chemical warfare agents below IDLH levels, but they are less susceptible to interference from other chemicals.

Raman Spectroscopy

Raman spectroscopy utilizes laser light scattering to detect and measure chemicals. It can be used in an open-path mode, similar to open-path FTIR, but unlike IR methods, water and carbon dioxide do not interfere with the readings. Portable systems generally have a range of less than 50 yards, but large, fixed systems can cover up to 6 miles at night. A wide range of airborne, solid, or liquid chemicals can be measured, with detection limits from the low ppm to percent levels, although better detection limits can be achieved.

Gas Chromatography

Gas chromatography (GC) uses a stationary phase and a mobile phase to separate contaminants based on how strongly they are attracted to the stationary phase. It can be employed for site characterization, source testing and monitoring, employee exposure monitoring, fence line or perimeter monitoring and emergency response. A large number of different detectors can be used with this technique. Depending on the detector, different volatile and semi-volatile organic chemicals can be detected and measured, sometimes at levels as low as parts per billion. When a mass spectrometer is used as the detector, the technique is called GC-mass spec, or GC-MS.

Metal Oxide Sensors

While not new, these semiconductor sensors are used in special applications (generally when the contaminant is known). The sensor will react to a variety of chemicals and is therefore non-specific. Calibration is done for a specific chemical, but it will detect other contaminants if present.

Radiation Exposure Monitoring

No single instrument can measure all forms of radiation. Where radiation sources are present, a specific monitoring program will be included in the Site Safety and Health Plan detailing the type of hazard, how monitoring devices were selected, and exposure control methods.

Area monitors (for example, the Geiger counter and the Cutie Pie survey meter) are available. Personal monitors include the film badge and thermoluminescence detectors.

Pancake monitors such as Geiger counters which use a thin-window pancake-shaped detector are best for monitoring particle emissions.

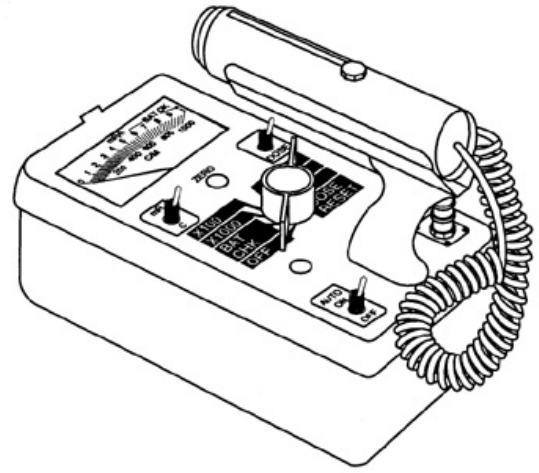
- used for measuring alpha and beta
- sensitive for gamma rays, but not generally preferred for determining exposure rates because of the irregularity of the thickness and density of the walls and the energy response curve

The Geiger-Mueller is sometimes equipped with the external probe for alpha and beta radiation and an internal probe for gamma radiation.

- When the amount of radiation is higher, the surveyor switches to the internal probe that will pick up background radiation which should be minimal

Pancake detectors are used when surveying for contamination. The detector is housed in an aluminum casing; the thin mica window of the detector is protected by a stainless-steel screen.

Another type of instrument often referred to as a “hot dog” detector is useful for measuring background levels of gamma radiation. The detector is used for surveying direct radiation. The detector has a rotary shield which is used to differentiate between beta and gamma radiation. When the shield is closed, only gamma can be detected. A description and illustration of a Geiger-Mueller detector follows.



Victoreen CD V-700 overview

Geiger-Mueller Tube

Use:

- The tube is filled with gas. When radiation enters the tube, it reacts with the gas, causing the release of energy.
- Used to scan surfaces rapidly.
- Detects beta, gamma, and X-rays; can detect alpha only with the cap removed.

Readout:

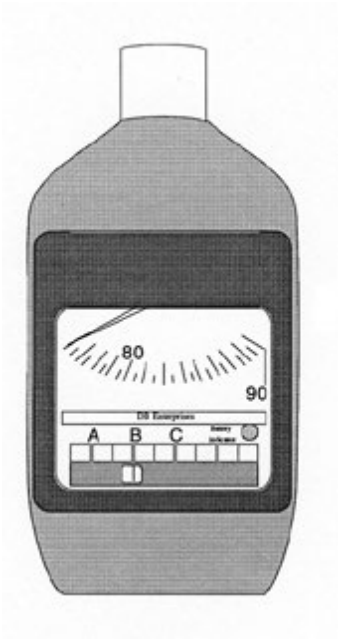
- Clicks per minute. The amount of energy released is related to the number of counts per minute.

Notes:

- Audible “clicks” alert user to changes in amount of radiation detected
- Wide range and sensitive
- Area monitor only
- Not a measure of dose
- Not accurate at high exposure rates
- Rugged instrument

Noise Monitoring

A Sound Level Meter (SLM) is a direct-reading instrument. Some models have additional features such as



- measure sound in small bands across the entire spectrum of sound, called octave bands
- data-logging for future analysis

Use:

- To monitor noise exposure in the area

Read-out:

- Decibels (dB) usually on the A scale

Notes:

- A-Scale used for occupational exposure
- A-Scale developed to mimic the way the human ear responds to noise
- Requires calibration before and after each use
- Some instruments require manually changing the range of noise that can be measured
- Battery must be checked before use
- General-purpose meters are designed to measure continuous noise only (sounds which last at least 1 second)
- Personnel must be trained to use the instrument

Tip:	Personal noise dosimeters are also available for routine operations. These instruments are worn by the employee during the entire shift and give a time-weighted average exposure.
Tip:	iPhone and Android apps are available for noise monitoring with your phone.

Personal Monitoring for Organic Vapors and Particles

Individual worker exposure is generally measured during routine or scheduled operations because the equipment is specific to the exposure. Provides the most accurate measurement of a worker's actual exposure, because it goes where the worker goes and can be placed in the breathing zone (near the nose).

- Results can be compared with a TWA or STEL set by OSHA, ACGIH, NIOSH or the company
- Documents an individual's exposure without regard to protective equipment

In some instances, personal monitoring may be done during an emergency.

In planning to conduct personal air monitoring for exposure assessment, identify a published method and laboratory that is experienced in the analytical procedure you want used. Methods are shown at NIOSH and OSHA websites.

Specific storage requirements may be needed for some samples. Whenever collecting a sample to characterize exposure to a contaminant for the first time, always discuss the method you will use with the laboratory in advance. The laboratory personnel will alert you to the number of blanks required and discuss other issues such as the collection media and turn-around time. When the media is rarely used, it may be obtained from the laboratory, rather than purchasing a larger quantity from a vendor.

<u>Gas and vapor sampling</u>

Use: Measure gas or vapor exposure

Readout:

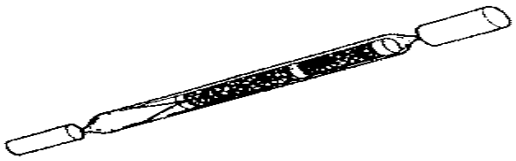
- None immediately
- Laboratory reports result

Notes:

Sampling media selected for specific hazard. Generally a solid sorbent in a glass tube is used. An example use of several types are:

- Coconut shell charcoal – acetone
- Silica gel - sulfuric acid
- XAD-2 (2-hydroxymethyl piperidine) - acetaldehyde
- Soda lime - hydrogen sulfide

Each glass tube has two sections of solid sorbent. The larger part is generally twice the volume of the smaller (back up) section. The ends of the tube are broken off, the tube is placed in a 'tube holder' and connected to the pump, with the air flowing in the direction shown on the tube. Caps are supplied to cover the ends of the tube when sampling is complete.



See examples with the sampling train (pump, tubing, and holder) pictured below.

- Battery operated pump must be calibrated before and after use
- One or more tubes is taken into the field, opened and capped and submitted to the lab as a field blank
- Sampling personnel must be trained
- Use care in breaking the glass tubes (use a tube cutter and wear safety glasses)
- Dispose of any glass ends or broken tubes to minimize cuts to personnel handling trash
- Position the sample holder near the breathing zone; ensure pump does not hinder work
- Monitor pump operation during use to prevent loss of sample due to malfunction
- Have back up pumps and media
- Match media to the contaminant by following an available air sampling/analysis method
- Match duration of sampling to exposure guideline (TWA, STEL, C)
    - Use multiple tubes for TWA, as needed
    - If collected over several hours, result cannot be compared with STEL or C
- Media are dated for service life; some are temperature-sensitive
- Calculate sample volume/flow rate based on expected concentration
- Resample if needed due to questionable/invalid result

Tip: Personal air samples for some contaminants can be collected by using a passive monitor. This device is a badge clipped to the worker's collar which collects one or more contaminant in the air without using a pump. The monitor is sent to a laboratory for analysis.

VOCs and mercury are often measured with a passive badge.

Holder with media to collect contaminant from the air

Tubing must be secured to shirt with clips

Tubes containing media; ends are broken for sample collection then sealed with the red caps before shipping to a laboratory.

Personal monitoring sampling train for gas or vapor

Particle/Particulate/Fiber/Dust Sampling

Dust, fibers, flakes and mists are particles or particulates; the shapes are not all the same, and mists are liquids, not solids. For air sampling, they can be grouped, as the collection method is generally a filter.

Use:

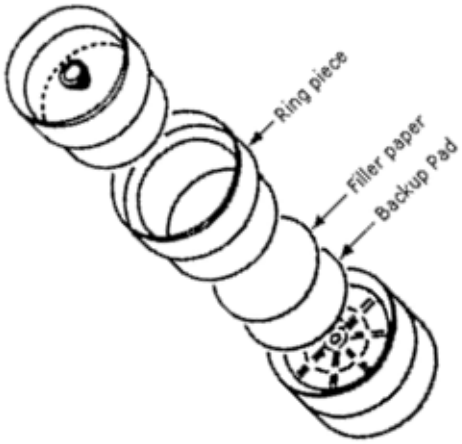
- Measure exposure to solids in the air

Readout:

- None immediately
- Laboratory reports result

Notes:

- The filter is selected for the contaminant and the analysis method. Several examples of filters and use are:
    - MCE (mixed cellulose ester) - Lead, Asbestos (analysis by polarized light microscopy)
    - PVC (poly vinyl chloride) - Lead Chromate
    - Quartz filter - diesel particulate
    - Polycarbonate - Asbestos (analysis by transmission electron microscopy)
- The filter is held in a two- or three-piece cassette and supported by a back-up pad that rests on the part of the cassette that has ridges; air flows across the filter, through the back up pad and to the pump. Plugs removed just prior to sampling are replaced when sampling is complete.



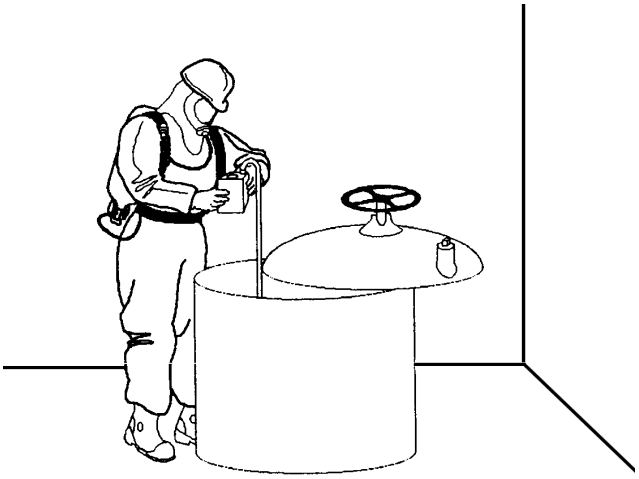
Expanded view of three-piece cassette for sampling particles in the air.

- One or more cassettes are taken into the field, plugs removed and immediately reinserted and submitted to the lab as a field blank
- Sampling personnel must be trained
- Battery operated pump must be calibrated before and after use
- Monitor pump operation during use to prevent loss of sample due to malfunction
- Have back up pumps and media
- Match media to the contaminant by following an available air sampling/analysis method
- Match duration of sampling to exposure guideline
- Use multiple cassettes if overloading is possible
- Media are dated for service life
- Calculate sample volume/flow rate based on expected concentration
- Resample if needed due to questionable/invalid result

Tip: There are exceptions to filters being used to sample solids.
Example: ozone is captured on two nitrite-impregnated glass filters.

Area Air Monitoring

Many of the direct reading instruments described in detail in this manual are used for area air monitoring. For example, testing of a confined space is illustrated below:



Real-Time Area Monitoring

Considerations for the sampling protocol for use of each of these direct-reading instruments are covered above.

Area Monitoring for Particles/Fibers/Dust

Potential movement of particulate contaminants from the work site to the perimeter boundry or beyond may require sampling. To do this a pump with large capacity is needed.

Use:

- Measure exposure to solids in the air at the perimeter fence

Readout:

- None immediately
- Laboratory reports result

Notes:

- Requires electric power source
- Noisy, may have to be housed in noise-absorbing box if residents nearby

- Flow rates of 1 cfm or more
- Sampling personnel must be trained

High volume area sampling pump

- Requires calibration or use of a flow regulator that is calibrated
- Monitor pump periodically for proper function
- Match filter media to contaminant by following available air sampling/analysis methods

Water Sampling

Contaminants may be in surface water, run off from production process or in wells. An overview of equipment for water sampling is provided. There a several types of water samples, as described below.

Readout:

- None immediately
- Laboratory reports result

Type 1: Grab sample from the surface

Use:

- Collect water samples at or just below the surface to test for contaminants or environmental parameters (such as pH, conductivity, oxygen)

Notes (Grab sample from the surface)

- On-site or laboratory testing
- Ensure that sample container is correct for contaminant/test

  (stainless steel, glass, plastic)

- Do not contaminate sample with your hand—wash before collecting, wear gloves
- Follow requirements for sample preservations (chemical, temperature)
- Decontaminate between samples

Type 2: Below the surface using Bomb Discrete Sampler, Van Dorn-style Bottle, Kemmerer-style, Peristaltic and Vacuum pumps

Uses:

- Evaluate for specific contaminant(s)

Notes:

- On-site or laboratory testing
- Ensure that sample container is correct for contaminant/test

(stainless steel, glass, plastic)

- Do not contaminate sample with your hand—wash before collecting, wear gloves
- Follow requirements for sample preservations (chemical, temperature)
- Decontaminate between samples
- Follow site specific water safety SOP as necessary

Type 3: monitoring well sampling using

- Bailers (hand or pump)
- Samplers (hand, vacuum, pneumatic, peristaltic, battery or 120V electric powered, submersible)
- Liquid level indicators (meters available to indicate the level of an organic such as gasoline floating on the water and the level of the organic/water interface

Uses:

- Monitor water levels in wells and collect samples for analysis

Submersible Pump - can be operated by battery or electricity source

Sampling apparatus:

Bury to sample through tubing, as needed

Notes:

- On-site or laboratory testing
- Well depth and size may dictate/limit types of equipment to be used
- Ensure that sample container is correct for contaminant/test (stainless steel, glass, plastic)
- Do not contaminate sample with your hand—wash before collecting, wear gloves
- Follow requirements for sample preservations (chemical, temperature)
- Decontaminate between samples or use dedicated equipment to prevent cross contamination.
- Follow site specific water and electrical safety SOP(s) as necessary

An interface meter: Used to determine the light (floating on water) phase <u>and</u> the dense (sinking) phase

Tip:	Permanent soil water samplers may be installed in the vadose zone (above the water table). Two tubes from the buried sampler allow water samples to be taken with pressure/vacuum.
Tip:	Initial soil water investigations may be done with a piezometer, a device driven directly into the ground or down a small bore hole; a ground water sample is retrieved through tubing.

Soil Sampling

Contaminants in soil at the surface or below the surface may be evaluated. Sampling at each location is described here.

Readout:

- None immediately
- Laboratory reports result

Type:

- Surface sampling using trowel, spoon, spade

Use:

- collect soil from the surface for testing in the lab

Notes:

- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis

Below the surface—manual collection

Readout:

- None immediately
- Laboratory reports result

Type:

- Below surface sampling - handheld, manual collection using oil Recovery Probe, Auger or push type

Use:

- Collect Grab or Undisturbed soil sample below the surface, typically up to 24 inches

Notes:

- Select auger head for soil type
- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis
- Soil type may dictate/limit sampler type
- Must use plastic liner to take an undisturbed soil sample/profile; may not be compatible with some organic chemicals

Below surface Sampling—mechanized

Readout (Types A and B):

- None immediately
- Laboratory reports result

Type A:

- Below surface sampling, mechanized using Augers--electric powered, gas powered hand-held and mechanized

Use:

- Collect at greater depths than manual tools allow

Notes:

- Auger may be used to access the sample depth, then a different soil sampler is used to collect the sample
- Soil type and depth guide decision on sampler used
- Soil type and condition may increase possibility of contamination with soils closer to the surface. Training is required to recognize and prevent/reduce this contamination and may require consideration in selecting the collection tools.
- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis
- Must use plastic liner to take an undisturbed soil sample/profile; may not be compatible with some organic chemicals
- Mechanized equipment hazards

Type B:

- Below surface sampling using

  Split Spoon

Use:

- Collect soil sample cores at extended depths or in ‘hard, compacted’ ground.
  - A hole is augered with a mechanical device
  - The spoon is attached to replace the auger and driven into the soil to collect a profiled soil sample
  - (Alternatively, drive the spoon down without augering, collecting samples in series)
  - The spoon is extricated and split open to remove the core, typically 12-24 inches

Notes:

- Soil type and depth guide decision on sampler used
- Soil type and condition may increase possibility of contamination with soils closer to the surface. Training is required to recognize and prevent/reduce this contamination and may require consideration in selecting the collection tools.
- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis
- Must use plastic liner to take an undisturbed soil sample/profile; may not be compatible with some organic chemicals
- Mechanized equipment hazards including drilling and impacting to obtain the split spoon sample. Site-specific on-the-job training may be required.

Soil sampling tools (from the top):

Metal sampling tool, for collecting in shallow areas, up to two feet

Plastic attachments (liner) to contain sample; metal extender

Split spoon sampler

Plastic liner sample container and metal probe that fits over liner

Surface Contamination Sampling

Possible contamination of surfaces is of interest for several reasons, including:

- Evaluating decontamination of PPE and tools
- Identification of possible spread of contaminants
- Document possible need for cleanup or additional cleanup

There are some published guidelines regarding allowable contamination (e.g., lead, radiation), but many determinations are made on present (above the limit of detection) and not present (below the limit of detection). Commercial kits are available for some contaminants of interest.

Use:

- Determine surface contamination

Readout:

- None for chemicals; laboratory report needed
- Radiation evaluated with direct-reading instrument

Notes:

- Consult with laboratory personnel
  - Collection media (filter, swipe)
  - Need for bulk material
  - Packing and shipping requirements
- Consult with laboratory personnel if bulk material is required for analysis

  Packing and shipping requirements

- Follow a protocol carefully
  - Collection media
  - Area swiped
  - Direction and pressure of swiping

- Document location
  - Written notes
  - Photos, if possible

Monitoring at an Emergency

It is important to carefully monitor the atmosphere during response to an unexpected release. Failure to recognize toxic, explosive, or oxygen-deficient atmospheres could result in serious damage to life and property. The ERP provides a plan for monitoring as part of the emergency response.

Some general considerations follow:

Preplanning

- Monitoring equipment appropriate for anticipated hazards should be selected by site or plant management
- Members of the emergency response team who are expected to use the equipment must be trained in its use
- Emergency response team members should practice using the equipment during emergency response drills
- Equipment must be properly maintained and stored so it is ready for use during an emergency
- Spare parts should be available to repair the equipment in case it is damaged during response activities
- Someone on each shift should be trained to make emergency repairs

During an Emergency Response

Before use:

- Allow adequate warm-up time as appropriate
- Calibrate equipment as appropriate
- Cover with plastic to prevent contamination as appropriate

During size-up (risk assessment)

- Enter upwind from the spill or release
- Begin monitoring at a distance where no contamination is expected
- Monitor for oxygen first, then flammable/explosive limits and toxic substances
- Continue to take readings as the spill or release is approached
- Take readings at ground level, a few feet from the ground, and higher in the air

- Take readings at the entry and throughout a confined space; do not enter if there is inadequate oxygen or an explosive or toxic atmosphere.
- Leave the area immediately if readings indicate that PPE is inadequate

During response actions

- Continuously monitor all areas near the source of the spill where response activities are occurring; conditions can change rapidly
- Retreat immediately if readings indicate that PPE is inadequate
- Decontaminate the equipment properly

After response

- Recharge power sources and replace any damaged or expended parts
- Store monitors properly to be ready for any future use
- Reorder any needed disposable supplies or damaged parts

Note: Detailed information on air monitoring must be included in each company's ERP to ensure adequate training, appropriate use, and proper storage and maintenance of equipment.

Exercise - Monitoring

During this exercise, you will have the opportunity to use a combustible-gas indicator, indicator tubes, and an oxygen meter. See Exercise Guide.

Summary - Monitoring

When there are questions of employee or off-site resident exposure to substances, monitoring is done to evaluate the level of exposure and provide input to control plans.

Toxic chemicals, fire and explosion hazards, oxygen-enriched and oxygen-deficient atmospheres, corrosivity, radioactivity, and biological hazards can be monitored at the site. Sampling water, soil and surfaces provides additional information regarding the extent of contamination and groups that may be at risk of exposure.

There are several ways to describe evaluation of exposures using a variety of sampling instruments and tools:

Where performed

Personal sampling is used to measure the amount of a toxic chemical in the air to which a worker is exposed, and it requires laboratory support. Personal sampling (when the worker wears a small pump all day and the sample is taken in the breathing zone) gives the best information on a worker's exposure.

Area monitoring gives you a measurement of the air concentration of a substance at a particular place**.**

What can be sampled

Air

Water

Soil

Surfaces

Information obtained

Detect a hazard means that it is present; detect a hazardous substance means that it is present in an amount greater than the limit of detection.

Measure a substance means that a concentration is determined.

When is result obtained

Direct-reading or **real-time instruments** provide a reading of air contamination when the monitoring is conducted. Direct-reading instruments may be used to detect IDLH conditions, flammable vapors, oxygen, and toxic materials.

Laboratory Analysis. If laboratory analysis is needed, the results will not be available for some time. Consult with the lab regarding time needed for analysis.

Personnel taking samples for exposure assessment must be trained and use calibrated and maintained equipment. A written sampling plan is used for routine operations and planning for emergencies must include procedures to ensure that any equipment that would be needed in an unexpected situation is always ready for use.

Decontamination

The decontamination process is designed to protect site workers, residents, and the environment from exposures to contaminants from the site. This section covers the principles of decontamination and the establishment of work zones to prevent the spread of hazardous materials from one location to another.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify steps in pre-planning decontamination
- Identify methods to prevent contamination of personnel, PPE and equipment
- Identify the purpose of each work zone put in place for decontamination.
- Identify basic decontamination methods
- Identify safe procedures for decontamination line operators

Introduction

Decontamination (decon) is the process of removing and/or neutralizing contaminants from PPE, personnel and equipment to prevent exposure to the worker or others or the spread of contamination. Proper decontamination or replacement of protective clothing or equipment is critical in controlling hazards and ensuring the health and safety of workers. The need for decontamination is required to be documented in the employer's Safety and Health Plan. Decontamination procedures are detailed in the Plan.

Adequate decon may be as simple as thorough hand washing or it may require scrubbing of PPE prior to removal and a shower. For most chemicals, soap and water washing is sufficient to decontaminate someone once their clothing is removed. Clothing can account for up to 90% of the contamination.

Pre-Planning for Decontamination

Each waste site has different risks of contamination. According to the HAZWOPER standard 20 CFR 1910.120(k), procedures for all phases of decontamination must be developed and implemented as follows:

- Procedures must:
    - Be developed, communicated to employees and implemented before employees or equipment enter contaminated area
    - Minimize employee contact with hazardous substances or contaminated equipment
    - Ensure that employees leaving a contaminated area are appropriately decontaminated, and that all contaminated clothing and equipment is appropriately decontaminated or disposed of
    - Be developed to ensure, where appropriate, manufacturers' recommendations for decontaminating equipment are followed
    - Be monitored by the site safety and health supervisor for effectiveness and improved if found to be ineffective

- The location of decontamination actions must minimize exposure of uncontaminated employees and equipment to contaminated employees and equipment

- Personal protective clothing and equipment:
    - Must be decontaminated, cleaned, laundered, maintained or replaced as needed to maintain effectiveness
    - If it becomes contaminated it shall be immediately removed and the employee shall be decontaminated according to the site-specific decontamination plan. The clothing must be disposed of or decontaminated before it leaves the work zone.

- Equipment and solvents used for decontamination must be decontaminated or disposed of properly

- Unauthorized employees are not to remove protective clothing or equipment from change rooms

- If commercial laundries or cleaning establishments decontaminate protective clothing or equipment, they must be informed of potential harmful effects of exposure to the contaminant(s)

- Where the decontamination procedure specifies regular showers and change rooms outside of a contaminated area, they shall be provided according to the requirements of 29 CFR 1910.141. If water cannot be used due to temperature conditions, then other effective cleansing means shall be provided and used.

The following examples illustrate situations when decontamination should be utilized:

- When PPE or clothing becomes contaminated
- Before personnel go from a “dirty” to “clean” work area
- Before workers eat, drink, smoke, or use restroom facilities
- Before transport trucks leave the site
- Before any equipment is taken off the site

Preventing Contamination

The primary goal should be to avoid employee contamination or minimize contact with hazardous materials.

Site-specific procedures are used to prevent personal contamination. For example, procedures for donning PPE will minimize the potential for contact with a hazardous material, such as:

- Inspecting PPE before each use to ensure it is in proper condition
- Closing zippers, buttons, and snaps fully
- Proper layering of gloves and sleeves will be specified in the SOP to prevent contaminants entering between the two
- Wearing a third pair of tough outer gloves over the sleeves
- Putting legs of outer clothing over boot tops
- Place any head covering that is not attached to a suit, outside the collar
- Taping all junctures (with tape adhesive that is compatible with suit materials) to help prevent contaminants from running inside gloves, boots, and jackets

Other precautionary measures can help reduce the amount of contamination during routine work activities, such as:

- Using work practices that minimize contact with hazardous substances
- Avoiding puddles, plumes, or areas of obvious contamination
- Properly disposing of equipment and solvents used for decontamination
- Not touching surfaces potentially contaminated with hazardous substances
- Using remote sampling, handling, and container-opening techniques and devices such as drum grapplers, robots and impact wrenches
- Covering monitoring and sampling instruments (plastic bags with openings for sensors or intake ports), following manufacturer recommendations for preventing contamination to instruments and decontaminating those instruments after use
- Wearing disposable outer garments

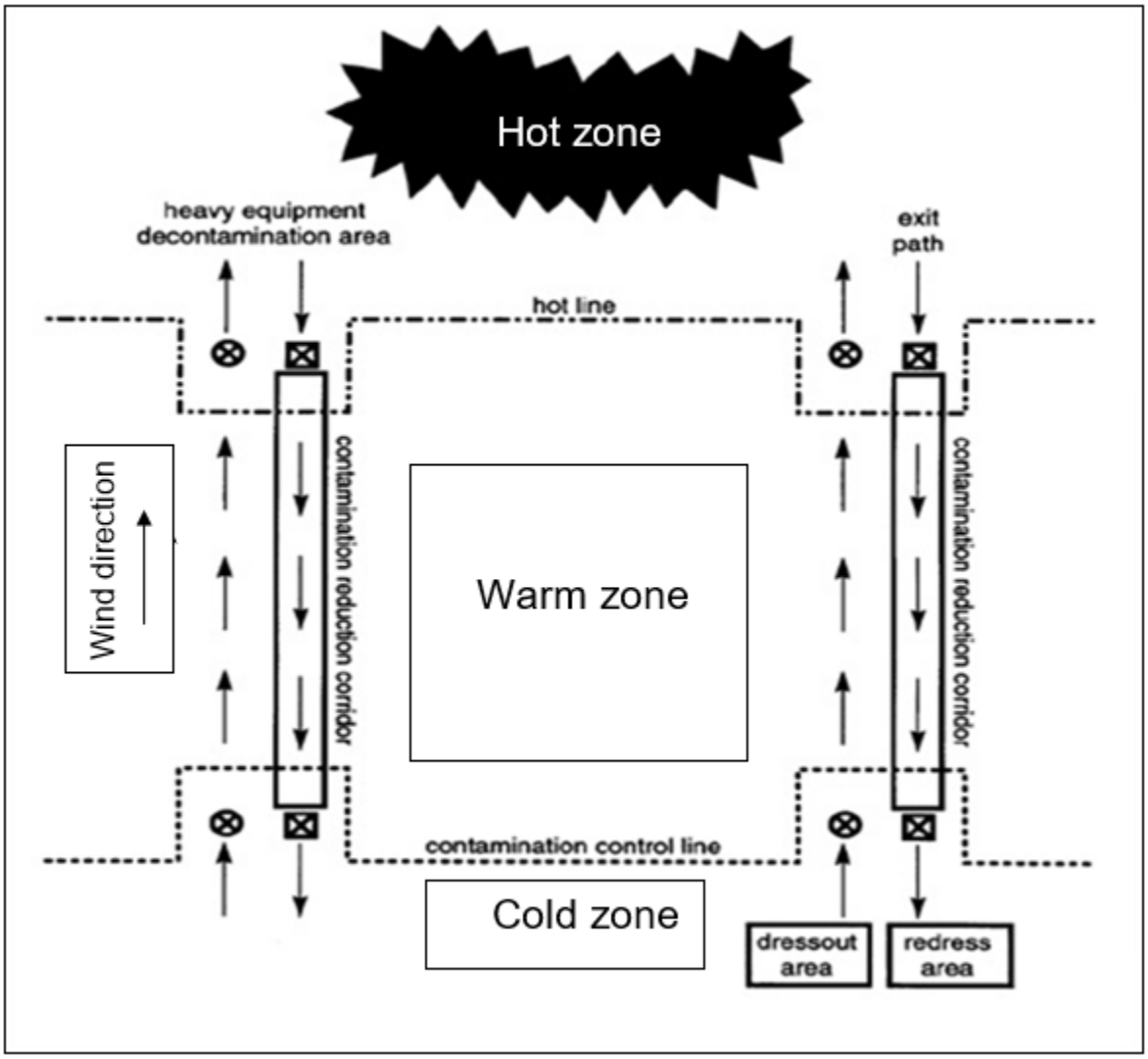
- Using disposable equipment where appropriate
- Containing the source of the hazardous substance
- Covering equipment and tools with a coating which can be stripped away during decontamination

Work Zones

Zones are established to limit movement of contaminated materials and contaminants at a site. Three work zones are used:

- The **Hot Zone**, or **Exclusion Zone**, which is the area of highest contamination.
- The **Warm Zone, or Contamination Reduction Zone (CRZ)**, which is the area surrounding the hot zone, where decontamination occurs.
- The **Cold Zone, or Support Zone**, which is the area free of contamination, where support activities occur.

These zones are shown in the figure below:


Hot zone
heavy equipment decontamination area
exit path
hot line
Wind direction
contamination reduction corridor
Warm zone
contamination reduction corridor
contamination control line
Cold zone
dressout area
redress area

Primary Activities in Each Work Zone

Different activities are performed by authorized employees in each zone. These activities and the personnel required to conduct them should be restricted to the appropriate zones. Movement of personnel and equipment between zones occurs at specific access control points. Other considerations include wind direction and site activities.

Decontamination takes place in a designated area called the Contamination Reduction Corridor (CRC). Decontamination begins as the worker exits the Hot Zone into the CRC and is complete at the exit of the CRC into the Cold Zone. The degree of contamination decreases as the worker moves along the CRC toward the Cold Zone.

Hot Zone/Exclusion Zone/Danger Zone: This zone refers to the area where the hazard is being assessed or is known to be present. Primary activities in this zone include site characterization (mapping, photographing and sampling); installation of wells for monitoring of groundwater; and cleanup work.

The size of the zone is determined by the characteristics of the site and access points. The “Hot line” is the outer boundary and should be clearly marked with hazard tape, lines, signs, or ropes. Further subdivision of the area may be necessary depending on the hazard and activities being conducted. The level of PPE necessary will be determined by the type of substance, monitoring results, and the HASP. It will usually be Level A or Level B; Level C may be used when the hazard is identified, and the toxicity known. The Health and Safety Officer will make the decision about PPE, according to the SOP.

Warm Zone/Contamination Reduction Zone/Decontamination Zone:
Decontamination takes place in a designated area called the Contamination Reduction Zone (CRZ) in a series of steps and is the primary activity in the Warm Zone. This is also referred to as the Contamination Reduction Corridor. The boundary of this zone is called the Contamination Control Line.

The degree of contamination decreases along the CRZ, from the Hot Zone to the Cold Zone. Tools are dropped and clothing and protective gear are removed step by step to prevent the transfer of hazardous substances to cleaner areas. PPE for workers in this zone is usually one level lower than that used in the Hot Zone. Depending on the substance, the same level of PPE may be required.

Cold Zone/Support Zone/Clean Zone: The Cold Zone is free of known contamination. Here, workers exiting the Hot Zone have removed all PPE. Final determinations should

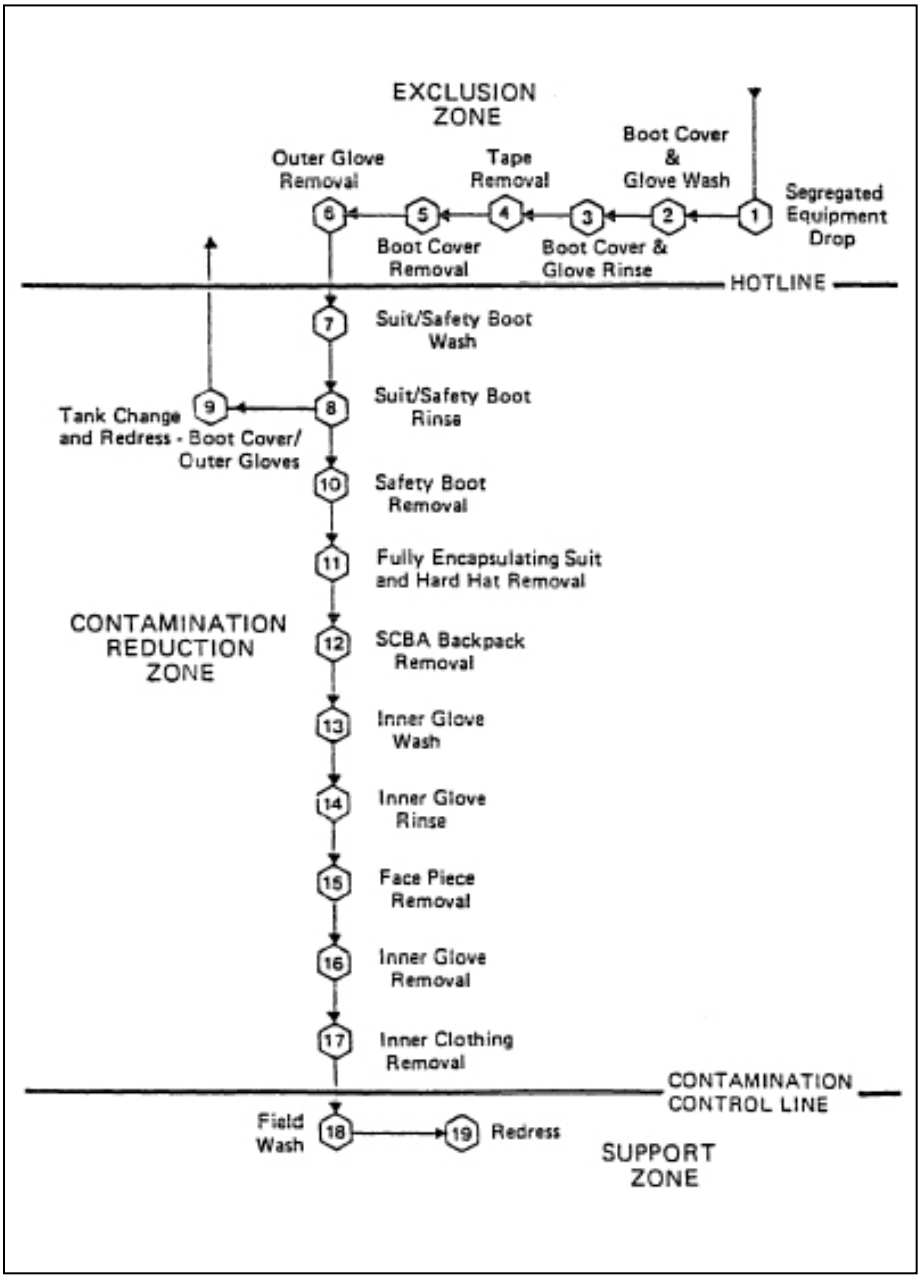
be made here about the effectiveness of the decontamination line by visual examination and use of monitoring equipment, as shown in the site-specific SOP.

This zone also contains the administrative and other support functions that keep the project work running smoothly.

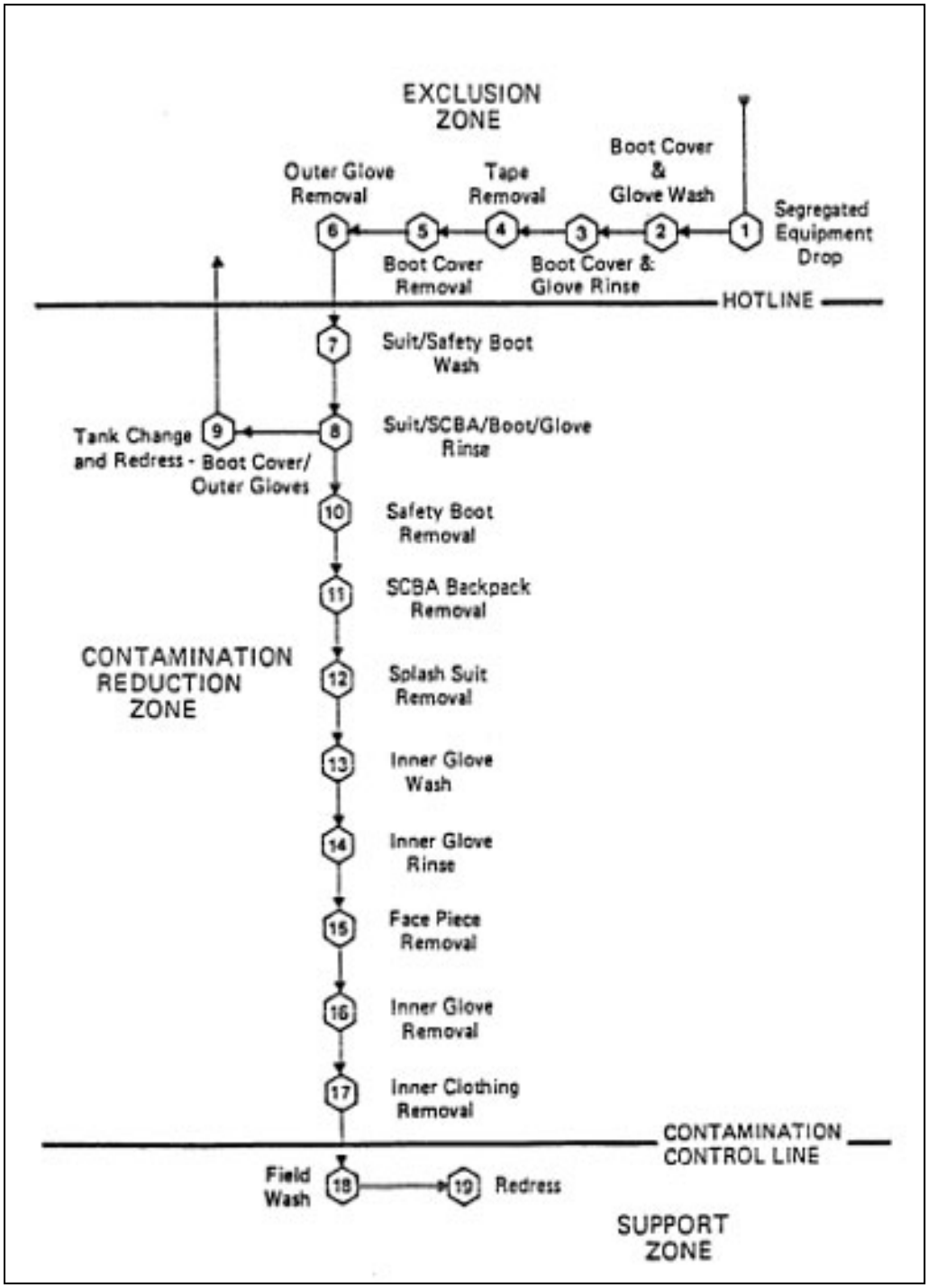
Decon Lines

The following graphics show generic decontamination layouts, as labeled:

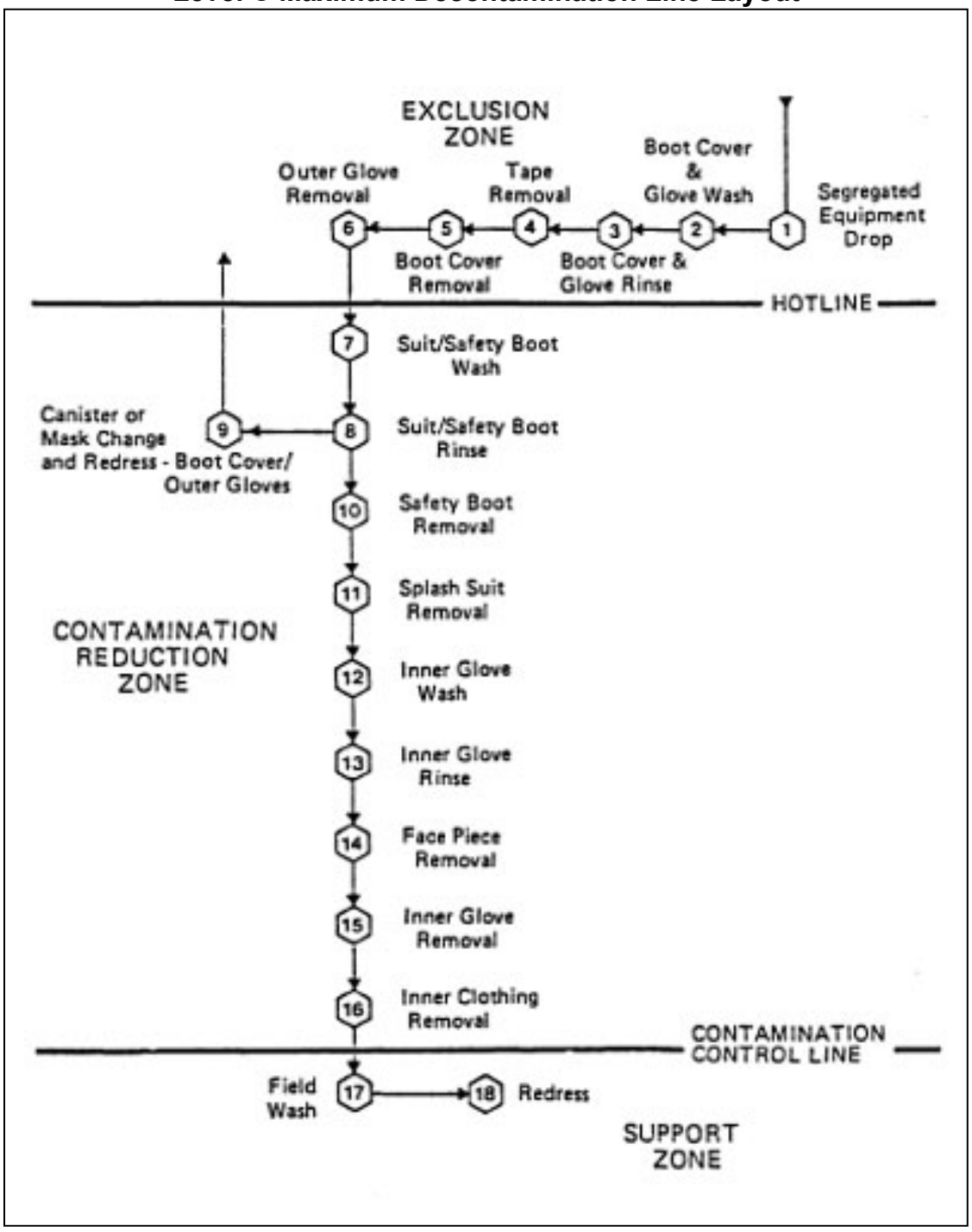
Level A Maximum Decontamination Line Layout

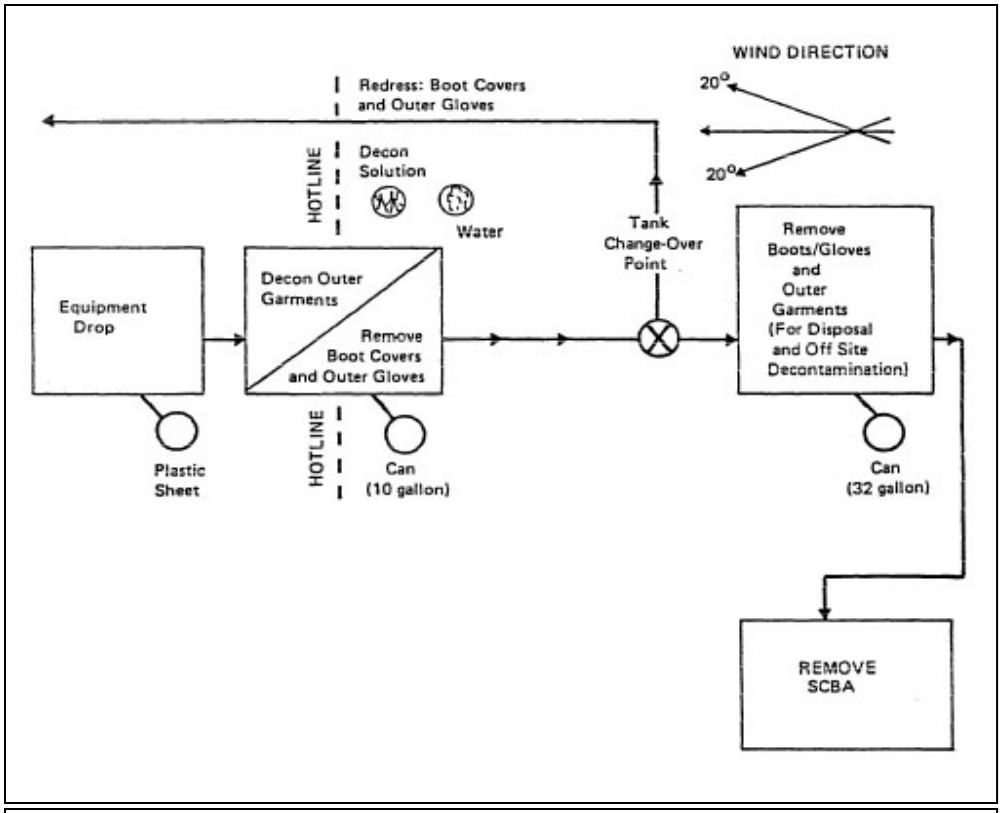


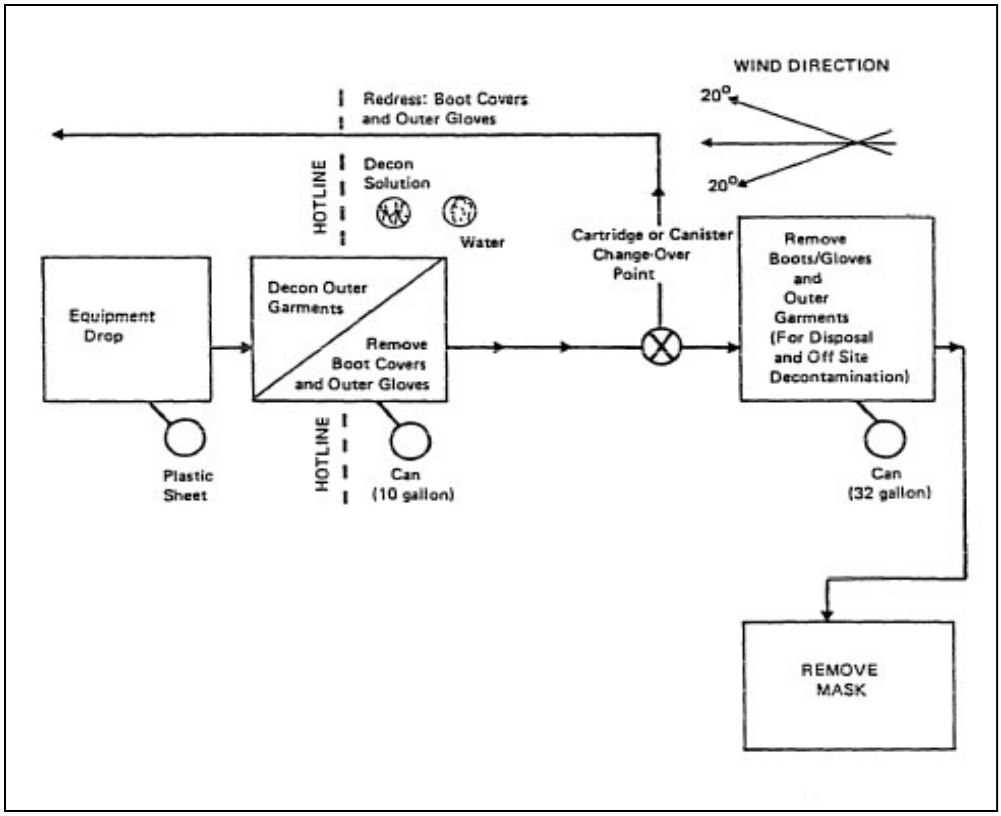
Level B Maximum Decontamination Line Layout



Level C Maximum Decontamination Line Layout







Source: https://www.osha.gov/SLTC/hazardouswaste/training/decon.html

As shown above, the decontamination line (CRZ) is an organized series of procedures performed in a specific sequence to reduce levels of contamination on personnel, PPE, and equipment. Each procedure is performed at a separate station. The stations are arranged in order of decreasing contamination, preferably in a straight line. The layout of the line is determined by the level of PPE and pre-planned guidance shown in the decon SOP for the activity and contaminant(s) involved, weather, wind direction and other considerations.

Some important observations:

- First, outer more heavily contaminated items such as boots, gloves, and suits are decontaminated and then removed
- Next, inner, less-contaminated clothing (inner boots and gloves) is decontamination and removed
- Facepieces are removed near the end of the line
- Note: Complete decontamination of protective clothing may not be possible if the contaminant has permeated into the CPC. If permeation has occurred, the CPC should be discarded.
- Tools and equipment are dropped at specified locations
- Materials that cannot be decontaminated are discarded
- Each procedure is performed at a separate station. The stations are arranged in order of decreasing contamination, preferably in a straight line.

As a general guideline, if a team of workers comes to the decontamination area at the same time, the least contaminated individuals should be decontaminated first. Exceptions to this guideline are medical emergencies and workers who are low on air or who have damage to PPE that might be causing direct contamination to the worker.

Decontamination Procedures

All personnel, clothing, equipment, and sample containers leaving contaminated areas must be decontaminated to remove any hazardous materials that may have adhered to them.

Decontamination can be accomplished by:

- Physically removing contaminants
- Chemically removing contaminants
- Rinsing off contaminants
- Disinfecting and sterilizing (infectious materials)
- A combination the above methods

Physical Removal

Some contaminants stick to the surface of PPE and equipment and can be removed by scraping, brushing, washing, vacuuming, pressurized air jets, and wiping.

Dust and vapors that cling to PPE and equipment may become trapped in small openings, such as the weave of the fabric, and can be removed with water or a liquid rinse.

Volatile liquid contaminants can be removed from protective clothing or equipment by evaporation followed by a water rinse. Care must be taken to prevent inhalation of the evaporated chemicals.

Removal of tightly adhering contaminants such as glues, cements or resins may be improved by solidifying, adsorption or absorption (powdered lime, kitty litter, clay, charcoal, poly fibers, or other materials); melting or freezing (dry ice or ice) may be used on PPE after removal, if compatible with the manufacturer instructions.

Chemical Removal

Removing contaminants with a chemical requires special planning and training. The solution must be chemically compatible with the clothing and equipment being cleaned. Some specific methods of chemically removing contaminants include halogen stripping, neutralization, oxidation/reduction, and thermal degradation.

Rinsing off Contaminants

A soap and water solution is most frequently used to help remove contaminants. Such solutions are called surfactants. Rinsing is an important method. Multiple rinses with clean solutions will remove more contaminants than a single rinse with the same volume of solution. Examples of this type of removal are water rinse with or without soap, either pressurized or by gravity flow; chemical leaching; extraction; evaporation; vaporization; and steam jets.

(photo from tools.niehs.nih.gov)

Disinfecting and Sterilizing

Chemical disinfectants provide a means of deactivating infectious agents. Examples of methods are dry heat, gas/vapor, irradiation and steam sterilization. Disposable PPE is recommended for use with infectious agents.

All equipment and solvents used for decontamination must be decontaminated and /or disposed of properly.

Testing for the Effectiveness of Decontamination

Decontamination methods vary in their effectiveness for removing different substances. The effectiveness of any decontamination method should be assessed at the beginning of remediation and periodically throughout the project. If contaminated materials are not being removed or are penetrating protective clothing, the decontamination program must be revised. The following methods may be useful in assessing the effectiveness of decontamination.

Visual Observation

There is no reliable test to immediately determine how effective decontamination is. In some cases, effectiveness can be estimated by visual observation.

In natural light, discolorations, stains, corrosive effects, visible dirt, or alterations in clothing fabric may indicate that contaminants have not been removed. However, not all contaminants leave visible traces; many contaminants can permeate clothing and are not easily observed.

Ultraviolet Light

Certain contaminants, such as polycyclic aromatic hydrocarbons, which are common in many refined oils and solvent wastes, fluoresce and can be visually detected when exposed to ultraviolet light. Ultraviolet light can be used to observe contamination of skin, clothing, and equipment; however, certain areas of the skin may fluoresce naturally, thereby introducing uncertainty into the test. In addition, use of ultraviolet light can increase the risk of skin cancer and eye damage; therefore, a qualified health professional should assess the benefits and risks associated with ultraviolet light prior to its use at a waste site.

Wipe Sampling

Wipe testing provides after-the-fact information on the effectiveness of decontamination. In this procedure, a dry or wet cloth, glass fiber filter paper, or swab is wiped over the surface of the potentially contaminated object and then analyzed in a laboratory. Both the inner and outer surfaces of protective clothing should be tested. Skin may also be tested using wipe samples.

Cleaning Solution Analysis

Another way to test the effectiveness of decontamination procedures is to analyze for contaminants left in the cleaning solutions. Elevated levels of contaminants in the final rinse solution may suggest that additional cleaning and rinsing are needed.

Testing for Permeation

Testing for the presence of permeated chemical contaminants requires that pieces of the protective garments be sent to a laboratory for analysis.

Decontamination of Equipment and Breathing Apparatus

Decontamination of equipment is an important method of controlling the spread of hazardous substances and preventing deterioration of the equipment.

- **Monitors -** If monitoring equipment becomes contaminated, it will require special cleaning. The manufacturer or local/regional government agencies can provide information on proper decontamination methods.
- **Tools -** Metal tools should be cleaned, as appropriate, by chemical or physical means. EPA regional laboratories may be consulted for specific methods to decontaminate tools. Wooden tools and tools with wooden handles are difficult to decontaminate because they absorb chemicals. Wooden tools should be discarded if contamination is suspected.
- **Respirators and SCBAs -** Certain parts of contaminated respirators and SCBAs, such as the harness assembly and leather or cloth components, are difficult to decontaminate. If grossly contaminated, they may need to be discarded. Rubber components can be soaked in soap and water and scrubbed with a brush depending on the contaminant. All parts of the respirator should be decontaminated and maintained according to the manufacturer's recommendations. Persons responsible for decontaminating respirators should be thoroughly trained in respirator maintenance. The SOP must detail the methods to be used to decontaminate respirators and SCBAs.

Preventing Spread of Contamination

Contaminated wash and rinse solutions must be contained by using step-in containers to hold spent solutions, or other methods of containment. Tools that were used in the hot zone must not be removed without proper decontamination.

Disposal of Contaminated Materials

All contaminated material and equipment used for decontamination must be disposed properly. Clothing, tools, buckets, brushes, and any other contaminated equipment must be secured in drums or other containers and properly labeled. The spent solutions must be transferred to drums which are appropriately labeled, and disposed of according to local, state, and federal regulations.

Other Considerations

Protecting Decontamination Line Workers

Workers may be stationed in the warm zone to assist in decontaminating those who have performed duties in the hot zone. Decontamination workers at the beginning of the line (closest to the Hot Zone) will require more protection from contaminants than decontamination workers who are assigned to the last station in the decontamination line. The workers on the decontamination line generally wear protection one level below that of personnel in the Hot Zone. For example, if Level B is worn in the Hot Zone, Level C may be appropriate for decontamination workers. In some cases, decontamination personnel should wear the same levels of PPE as workers in the Hot Zone. All decontamination personnel must be decontaminated before re-entering the Cold Zone. The Safety and Health Plan should specify the level of PPE to be worn at all positions by decon line workers.

Decon line workers go through the appropriate decon following exit of the hot zone workers.

Safety Precautions for Decontamination

- Decontamination solutions must be compatible with the hazardous substances being removed to prevent a reaction which could produce an explosion, heat, or toxic products
- Include adequate personnel to help each person through the line
- If plastic sheeting is used or other slippery surfaces may be encountered, “gripper” decals or other material should be used to reduce the likelihood of slips

- Provide stools (not wooden unless they will be disposed of after the job) for personnel to sit on at stations where boots or suits are removed
- Shower and change rooms provided outside of a contaminated area must meet the requirements of OSHA 29 CFR 1910.141
- Unauthorized employees must not remove protective clothing or equipment from change rooms to avoid the spread of contamination
- Provide handholds for use at decon stations

Walker provided as hand-hold device if needed during physical removal
(photo from tools.niehs.nih.gov)

Emergency Decontamination Line

Emergency decontamination procedures must be established. In an emergency, the primary concern is to prevent the loss of life or severe injury to site personnel. If immediate medical treatment is required to save a life, decontamination should be delayed until the victim is stabilized. If decontamination can be performed without interfering with essential life-saving techniques or first aid, or if a worker has been contaminated with an extremely toxic or corrosive material that could cause severe injury or loss of life, decontamination must be performed immediately. If an emergency due to a heat-related illness develops, protective clothing should be removed from the victim as soon as possible to reduce the heat stress. During an emergency, provisions must also be made for protecting medical personnel and disposing of contaminated clothing and equipment. The affected individuals may be unconscious and may need the use of a backboard or Stokes basket to move the individual. Many hospitals and emergency response groups may not assist with a patient until the decontamination process is completed due to need to maintain the integrity of the facility.

Summary – Decontamination

Decontamination is important for preventing the spread of hazardous materials beyond the scene of the incident. The HAZWOPER standard requires proper procedures to be developed before employees or equipment enter a contaminated area. Precautions should be taken to prevent contamination of personnel and expensive equipment, such as monitors. During the development of the work plan, work zones should be established to control the spread of contaminants.

There are three zones:

- The **Hot Zone or Exclusion Zone** is the area immediately contaminated by the spill or release. Only personnel in adequate PPE should be in this zone.
- The **Warm Zone or Contamination Reduction Zone (CRZ)** is the area surrounding the hot zone where decontamination occurs.
- The **Cold Zone or Support Zone** is the area where there is no contamination and support activities occur.

Methods to decontaminate personnel, PPE, and other equipment will vary depending on the substances at the site. Basic methods include:

- Rinsing or dissolving
- Scraping, brushing, and wiping
- Evaporation then rinsing
- Using surfactants, such as soap
- Chemical disinfection
- Combinations of the above methods

The decontamination line or corridor is:

- An organized series of procedures performed in a specific sequence.
- Used to reduce levels of contamination on personnel, PPE, and equipment.
- In operation until no contaminant is present

Each procedure is performed at a separate station. Stations are arranged in order of decreasing contamination, preferably in a straight line. Decontamination activities are located in the Contamination Reduction Zone (CRZ).

All personnel working the decon line must be decontaminated before leaving the CRZ. All decon equipment must be properly decontaminated or disposed of properly.

When decontamination of materials is incomplete or not possible, the materials must be disposed of appropriately.

Work Practices

Every hazardous waste site is unique:

What chemical hazards are being remediated?
What are the physical characteristics of the site?
What processes are used for remediation?

Written work practices are prepared for activities at each site. Some of these activities are very specialized (for example, use of robots in surveillance); other operations are used at many sites. Development and use of safe work practices will minimize exposure to workers, the environment, and nearby community residents.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify general work practices for some waste site activities
- Identify essential elements of a model work practice
- Develop written work practice guidance for a waste site activity
- Identify the need for adequate illumination and site sanitation

Site Activities

The Safety and Health Program includes detailed descriptions of activities to be conducted at the site and procedures to follow during specific conditions. These may include some of the following:

- Site security
- Soil excavation and trenching
- Communication
- Loading and unloading procedures
- Heavy equipment operation
- Spill control
- Ladder and scaffolding use
- Decontamination
- Extreme weather work
- Power tool use
- Lock out
- First Aid
- Evacuation plan
- Maintenance activity/hot-work permit
- Chemical Protective Clothing
- Motor vehicle safety
- Respirator use and maintenance
- Equipment and vehicle operation
- Exposure monitoring
- Working at heights

- Machine guarding
- Arc Flash
- Emergency Response and Termination
- Confined Space Permitting
- Working on water
- Extreme weather
- Equipment start-up and shut down
- Water safety
- Bonding and ground (drums, equip.)
- Safe lifting
- Walking/working surfaces
- Emergency alerting signals
-

Details considered in work practices for several of these activities are provided in this section. Training in work practices that you will be conducting on a site is included in the site-specific training or as needed when activities change.

A very important work practice for hazardous waste site workers is the Buddy System. Workers are organized into teams and assigned to observe at least one person in the group. The "buddy" provides the partner with assistance; observes for signs of distress, heat exposure, and fatigue; and alerts others if emergency help is needed (See Hazard Control Section). In the Safety and Health Program for the site, each of the written descriptions of the operation and safe work practices is referred to as a Standard Operating Procedure (SOP). The SOPs are site-specific and will be part of your three-day, on-site training. SOPs are written by someone familiar with the activity and the employer's policies and should include enough detail that someone with limited experience in performing the work can successfully conduct the activity; contributions from a team of developers that include users will be useful. An SOP includes required training that must be completed prior to conducting the activity.

In this program, we use the term Standard Operating Guide (SOG) as a generic term to describe elements of the safe work practice that will be tailored to the site – the site-specific procedure is an SOP.

Elements of an SOP

A standard format for safe work practices helps everyone find needed information. An example format for an SOP is shown here.

SOP Sections

- Title Page or Title Block – identification of the activity, date and approvals
- Table of Contents (for a long SOP)
- Definitions of any specialized or unfamiliar terms

- Purpose, including any applicable standards or regulations
- Scope – what is covered by the SOP, and, if necessary, what is not covered
- Personnel – required training for workers who will complete the work and who else must approve or take part in the activity
- Equipment and/or materials needed
- Procedure or steps

Examples of Essential Information

The written Work Practice should include any information essential to the safe and efficient completion of the activity. Some examples of such information follow.

Required PPE:

All PPE required for the task should be listed in Equipment.

Limits and Emergency Procedures are shown for each step:

Include any limits for operating parameters, such as temperature, pressure, relative humidity, or chemical concentrations. For example, for use of an air-purifying respirator, an SOP might specify that the percent oxygen in the atmosphere must be 19.5% or greater and not more than 23.5%.

If known, the description should contain information on conditions that may interfere with the work or cause a potential safety hazard. For instance, for calibration of an instrument in an enclosure in a remote area of a site, a warning may be appropriate if snakes or poisonous spiders are sometimes found inside the enclosure.

Anticipated reasons to terminate the work due to safety considerations should be described; for example, if chemical concentrations in the air exceed a given level. It may be desirable to specify conditions under which emergency responders or government agencies must be notified or medical help must be summoned.

Forms and/or Checklists are provided to document steps in the work:

Forms and checklists can be very useful in helping to ensure that all steps are completed, and approvals obtained during an activity.

Qualifications are shown for personnel:

Any required specialized training or education is necessary to perform the activity should be specified. An example might be HAZWOPER 40-hour site worker training, or training in care and maintenance of SCBA air bottles.

References are appended or included in each section, as appropriate:

References to other sources of information may be helpful. These may be reference books, SDSs or other written work practices.

It is acceptable to reference an SOP from one section of the Safety and Health Program in another section to reduce duplication. For example, in 29 CFR 1910.120, medical surveillance is to be included in the Safety and Health Program, the Comprehensive Work Plan and the Safety and Health Plan. As appropriate, medical surveillance may be described once and referenced in the other sections.
In this program, we use the term SOG (Standard Operating Guideline) for a generic work practice description. These are useful for training but are not specific for the work at any remediation site. SOPs will be covered in your three-day site-specific training and throughout the site work as activities progress (and change).

SOP - Site-specific - Covered in site-specific training
SOG – Generic - Guidance for SOP content

Confined Space Entry

A **confined space** generally has three distinct properties which set it apart from other areas and dramatically increase the risk of injury or illness.

Properties of confined spaces:

- Limited ways to get in and out of the space
- Not intended for continuous human occupancy
- Bodily entry is possible, and work can be performed

Some common confined spaces that are found at hazardous waste sites include, but are not limited to:

- Ditches, culverts, and ravines
- Excavations and trenches

- Tank cars
- Vaults
- Sewer system with manhole entrance
- Vats
- Tanks

Lack of natural ventilation makes it easier for toxic or flammable materials to accumulate. Something as simple as rusting metal or the operation of fuel-powered engines can deplete the existing oxygen supply. Decaying organic materials such as plants or animals can create hydrogen sulfide gas.

Many toxic gases don't have any warning properties, so workers about to enter the confined space have no way of knowing what hazards they might face without first testing the air. The most common confined space injuries are asphyxiation from lack of oxygen, being overcome by very high concentrations of toxic vapors, or rapid skin absorption of organic solvents. Other common confined space hazards involve explosions or fires. Getting in and out of a confined space can cause injuries and hinder rescue efforts in emergencies. Entry into confined spaces may block your view of what else is happening around you.

Each confined space must be evaluated to determine if a permit is required for entry; see OSHA standard on Permit-Required Confined Spaces (29 CFR 1910.146).

A permit-required confined space (permitted space) has one or more of the following characteristics:

- Contains (or has a potential to contain) a hazardous atmosphere
- Contains a material that has the potential for engulfing an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section
- Contains any other recognized serious safety or health hazard

Several steps make work safer in confined spaces. Careful advance planning for confined space entry can help minimize the risk of injury. This advance planning must include the following points:

- Identifying confined spaces (Determine which require a permit to enter)
- Developing written procedures

- Arranging for and strategically locating adequate supplies of air-supplying respirators and protective and life-saving equipment
- Training personnel who must enter permit-required confined spaces to deal with emergency events
- Training personnel how to monitor and properly safeguard the space before and during entry
- Posting a qualified and trained safety attendant outside the confined space entrance at all times
- Training personnel to recognize when the hazards of a confined space may have changed

The hazards of confined space entry are further reduced by:

- Monitoring confined spaces before entry and during work for oxygen deficiency and flammable or toxic atmospheres. Monitoring must be conducted throughout the space, not just at the entry point. The maximum %LEL for confined space entry may differ from one facility to another.
- Providing appropriate ventilation before and during the work.
- Complying with the permit and logging system. Under this system, confined space entry is permitted only after information about oxygen and toxic and flammable vapor levels has been collected. The permit must be signed by a responsible manager. No personnel can enter the confined space without a signed entry permit. Permits are valid only for a specific date, time, and place.

Through careful monitoring, training and planning, the written confined space entry procedures minimize danger by controlling factors that may cause or contribute to accidents or emergencies. These required standard procedures are an administrative control. An example of a confined space entry permit is illustrated on the next two pages. Other samples can be found in 29 CFR 1910.146, Appendix D.

The confined space entry program must be in writing. The initial training of attendant, entrant, supervisor, and rescue workers is detailed in 29 CFR 1910.146, as is the documentation of annual retraining. All procedures to be used during activities related to the entry are included. The program must include a description of procedures to:

- Prevent unauthorized entry
- Identify/evaluate hazards prior to entry
- Provide means/practices for safe entry
- Provide equipment for testing, monitoring, ventilating, communication, PPE, lighting, barring and shielding, safe access/egress, and rescue and emergency

- Evaluate conditions during operations
- Provide at least one attendant
- Provide adequate response capability
- Designate roles and responsibilities
- Summon rescue/emergency personnel
- Carry out the permit system
- Coordinate operations if multiple employers are represented
- Provide for conclusion of entry
- Review operation
- Review program
- Provide training

Confined Space Entry Permit

Date and time issued: _____Date and time expires: _____

Job site/space ID: _____Job supervisor: _____

Equipment to be worked on: _____ Work to be performed: _____

Stand-by personnel: _____

1. Atmospheric checks:

   Time _____

   Oxygen _____%

   Explosive _____% LFL

   Toxic _____PPM

2. Tester's signature: _____

3. Source isolation (no entry):

   Pumps or lines blinded, disconnected, or blocked ……..☐ N/A ☐ Yes ☐ No

4. Ventilation modification:

   Mechanical……. ☐ N/A ☐ Yes ☐ No

   Natural ventilation only…….. ☐ N/A ☐ Yes ☐ No

5. Atmospheric check after isolation and ventilation:

   Oxygen _____% ≥ 19.5 %

   Explosive _____% LFL < 10 %

   Toxic _____PPM < 10 PPM H_2S

   Time _____

Tester's signature: _____

6. Communication procedures: _____

7. Rescue procedures: _____

Confined Space Entry Permit, cont.

8. Entry, standby, and back up persons:

Successfully completed required training?..... ☐ Yes ☐ No

Is it current?..... ☐ Yes ☐ No

9. Equipment:

Direct reading gas monitor tested……. ☐ N/A ☐ Yes ☐ No
Safety harnesses and lifelines for entry and standby persons…… ☐ N/A ☐ Yes ☐ No
Hoisting equipment ……..☐ N/A ☐ Yes ☐ No
Powered communications…….. ☐ N/A ☐ Yes ☐ No
SCBAs for entry and standby persons……... ☐ N/A ☐ Yes ☐ No
Protective clothing…….. ☐ N/A ☐ Yes ☐ No
All electric equipment listed Class I, Division I,
Group D, and non-sparking tools……. ☐ N/A ☐ Yes ☐ No

10. Periodic atmospheric tests:

Oxygen _____%	Time _____	Oxygen _____%	Time _____
Oxygen _____%	Time _____	Oxygen _____%	Time _____
Explosive _____%	Time _____	Explosive _____%	Time _____
Explosive _____%	Time _____	Explosive _____%	Time _____
Toxic _____%	Time _____	Toxic _____%	Time _____
Toxic _____%	Time _____	Toxic _____%	Time _____

We have reviewed the work authorized by this permit and the information contained herein. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any squares are marked in the “No” column. This permit is not valid unless all appropriate items are completed.

Permit prepared by: (Supervisor)_____

Approved by: (Unit Supervisor) _____

Reviewed by: (CS Operations Personnel) _____

This permit to be kept at job site. Return job site copy to Safety Officer following job completion.
Copies: White Original (Safety Office), Yellow (Unit Supervisor), Hard (Job site)

Important considerations of any pre-entry, entry, and post entry into a confined space include the following:

Pre-Entry Procedures

- Install signs and barricades, and secure the perimeter
- Isolate space from unauthorized personnel
- Obtain and fill out a confined space permit
- Test and continually monitor the atmosphere
- Ventilate and reset space
- Mandatory use of retrieval lines with harness

Entry Procedures

- An entry worker makes initial atmospheric tests within space
- Attendant remains outside at all times and records atmospheric readings on the confined space permit
- Attendant maintains continuous communication (visual or radio) with entry workers
- Retrieval lines are manned outside by rescue personnel
- Under no circumstance shall workers enter an IDLH environment unless wearing a harness and retrieval line
- If retrieval line may cause a tripping or entanglement hazard, another suitable rescue mechanism must be used
- An entry worker attendant or supervisor must have authority to evacuate the space
- All housekeeping duties must be performed during or after completion of the work

Post-Entry Procedures

- If any problems were encountered, have follow-up critique to resolve
- Check all equipment, repair as necessary and store
- Complete report

Annually the entire program should be reviewed and updated. If you are involved in confined space work, additional training is required as detailed in the SOP included in site-specific Safety and Health Plan.

Lock-out Procedures

Lock-out procedures are used to prevent injury during repair of mechanical equipment. The equipment is locked out of operation so that it will not be turned on by someone who is unaware of the activity of another worker.

> Know the site lock-out procedure before any operation is attempted.
>
> Never assume a machine, circuit, or pipe is locked out just because it should be.
>
> **When in doubt, lock it out!**

The following are common examples of equipment requiring lock-out:

- Electrical junction boxes
- Pipes with liquid, steam, etc.
- Mechanical equipment with moving parts (grinders, crushers, pulverizers, hydraulics)

The risk of ignition of flammable materials and the risk of electrocution are lessened by locking out an electrical circuit. Locking out a steam or hot water pipe may cut off a transmission path for vapors and prevent burns or accidental contact with the contents of the piping system.

Lock-out requirements are described in 29 CFR 1910.147, The Control of Hazardous Energy (Lock-Out/Tag-Out).

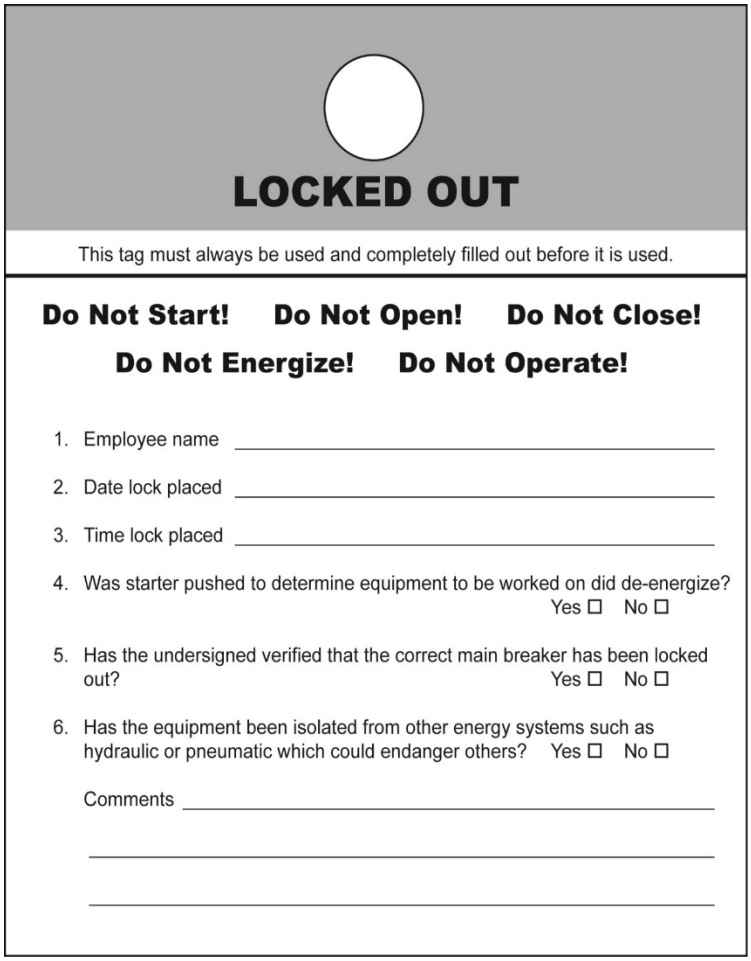
The minimum recommended elements of a lock-out procedure are listed below:

- Get lock-out approval/permit (lock-out tag).
- The first person to work on a piece of equipment should be sure the primary energy source is turned off and install a personal lock with a lock-out clamp. This clamp must be installed so that the energy source cannot be turned on with the clamp and lock in place. The switch is then activated to see if the circuit is truly de-energized.
- Each person who works on the equipment must go through the standard process described above.
- Each person must remove any lock they attached after completing the job and all personnel are out of the danger area. After the last lock and clamp

are removed, the warning tag can be removed, and the equipment re-energized.

- A lock must be removed only by the person who installed it. Any exceptions are detailed in the written procedures and must be included in the site-specific training.
- Critique any problems and revise the written procedures.
- Annually, review and update written procedures if needed.

Example of a Lock-Out Tag



LOCKED OUT

This tag must always be used and completely filled out before it is used.

Do Not Start! Do Not Open! Do Not Close!

Do Not Energize! Do Not Operate!

1. Employee name _____
2. Date lock placed _____
3. Time lock placed _____
4. Was starter pushed to determine equipment to be worked on did de-energize? Yes ☐ No ☐
5. Has the undersigned verified that the correct main breaker has been locked out? Yes ☐ No ☐
6. Has the equipment been isolated from other energy systems such as hydraulic or pneumatic which could endanger others? Yes ☐ No ☐

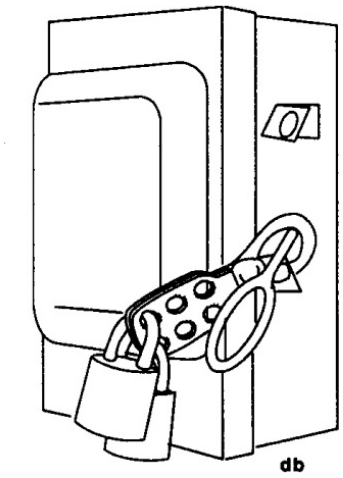
Comments _____

_____

_____

Failure to follow lock-out procedures may result in immediate hazards to life and property. Hazards to worker safety and health include amputation; electrocution; chemical or other burns; or being caught in or crushed by mechanical, pneumatic, or other moving parts.

Typical Lock-Out Device with Spaces for Multiple Locks



One lock per person for safety

Drums and Drum Handling Procedures

Safe work practices for handling drums must be included as a written procedure in the company's Safety and Health Program. All site activities must be organized so that drum or container moving is kept to a minimum.

Especially dangerous wastes may require specific procedures and PPE to handle, even in drums. In some instances, special PPE may be required such as bomb suits for those operating the equipment for the remote handling of reactive waste. Especially dangerous wastes should always be handled with extreme care and with strict adherence to the specific written procedures.

If plans for treatment of the waste include bulking or mixing of drummed waste, all material should be tested for compatibility before mixing. Incompatibility may cause violent reactions, including fire and explosion and the release of deadly fumes and gases. Additionally, incompatibility may cause damage to processing equipment through the possible solidification of the material.

Tanks, vaults, and other containers must be handled in the manner described here for the "generic" hazardous waste drum.

Shipment of Drums

Some characterized waste is not bulked but leaves the site in drums and overpacks.

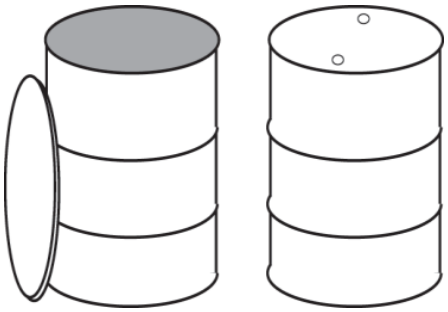
The procedure involves:

- Shipping drums from the site in properly sealed and labeled drums and overpack drums
- Using drum grappler or similar equipment to lift drum to the bed of the truck and position it
- Moving drums if necessary

Types of Drums

Closed-top drums are sealed and have small openings called bungs in the top through which liquids can be poured. Open-top drums have removable lids, and some do not have the small openings characteristic of the closed-top drum. Some types of drums and what they contain are listed below:

- Closed-top metal drums normally contain noncorrosive products in liquid form (DOT specification 17E, liquid waste).
- Closed-top plastic or composite (plastic inside metal or cardboard) drums usually contain corrosive liquids (DOT specification 37M, 6D, or E8585).
- Open-top metal drums usually contain noncorrosive solids or sludges (17C -PCBs, 17H-HAZ, and solid waste).
- Open-top plastic drums usually contain corrosive solids or sludges (DOT specification 21C or E711 most common).
- Other types of drums such as stainless steel, nickel, and Monel® are used for chemicals that require special containers for safe containment. These containers usually can be recognized because they are unpainted.
- Overpack drums (DOT specification E9618 most common) made of metal or plastic may contain any of the above drums.



Open Top **Closed Top**

Assume all drums contain hazardous materials

The type of drum may provide information on the contents and specific hazards. For example:

- Drums lined with polyethylene or PVC (polyvinyl chloride) may contain strong acids or bases
  - If the lining is damaged, steel drums may corrode
- Drums made of special metals (Monel®, nickel, stainless steel) are more expensive and usually contain Extremely Hazardous Substances (EHS) or food-grade material(s)
- Drums with fittings for pressurizing with inert gas will contain harmful chemicals.
  - Reactives
  - Flammables, explosives
- Drums which are lab packs sometimes contain a variety of expired chemicals and process samples and may contain dangerous and incompatible materials.

Drum Inspections

Careful inspection of drums is an important activity at sites where drums have been stored. Inspection is done whenever a drum is “discovered;” this initial inspection will provide information on hazards such as:

- Drums labeled as radioactive
- Drums labeled as or suspected of being explosive or shock-sensitive
- Glass bottles or small metal containers with formed crystals around the cap, because contents may be explosive or shock-sensitive

- Bulging or swelling drums: Use remote-puncturing or bung-removal equipment
- Lab-pack drums

Each of these conditions should be reported to the supervisor. Unlabeled drums and containers must be considered to contain hazardous materials and handled accordingly until the contents are positively identified and the container labeled.

Monitoring for gamma radiation, organic vapor, and combustible gas needs to be performed in the area where the drums are identified to provide information about contents and detect conditions hazardous to workers like holes, leaks, etc. Ground-penetrating instruments need to be used to detect buried drums and estimate their location and depth. Drums or containers known or suspected to contain radioactive wastes must not be handled until the hazards to employees are properly assessed by specially trained personnel. Drums may be unlabeled or improperly labeled. Do not rely on drum markings alone to identify hazards.

Routine inspections are conducted where drums or containers are present. Inspect all drums daily or per site procedure and report these or other conditions to the supervisor.

- Leaking
- Swelling or bulging
- Rust or other evidence of deterioration
- Other changes such as exterior corrosion or crystallization

Moving Drums

Before any drums are moved, all employees engaged in the transfer operations must be warned of the potential hazards associated with the contents of the containers. Fire-extinguishing equipment must be on-hand and ready to use during the activity.

Minimize the number of workers in the area. Approach all drum areas with caution, as the ground may be contaminated or unstable due to buried drums. If practical, drums and containers should be inspected, and their integrity verified before any attempt is made to move them. It may be impossible to inspect drums if they are buried under the ground, stacked behind other containers, or stacked too high in a pile. In these or other situations where inspection must be delayed, the drum is moved to an accessible location and inspected before any further handling. Soil over buried drums must be removed with extreme caution to prevent rupture. Drums near or in a pond or lagoon may pose a hazard to

personnel suited in heavy protective equipment. Solid wastes may float on the surface, giving the appearance of solid, cracked mud; and weight from equipment or people may cause collapse. If it is essential to go over the surface, include water safety gear such as lifeboats, life jackets or preservers, tag lines, safety harness, safety nets, and railings.

The risk of injury as well as other safety hazards can be minimized when proper drum moving procedures are employed. The drum handling plan will describe which personnel should be used and what procedures should be followed.

When manually moving drums, you should use the following procedures:

- Tip slowly and watch bungs or lid seal for leakage
- Tip to edge slowly and steadily when moving by hand. DO NOT JERK, as back injury may result
- Be aware of lid ring bolt so it does not catch hand when rolling open-top drums
- Be sure the mechanical device is firmly attached before attempting to tip or move drum
- Use necessary PPE to prevent skin contact
- Use proper respirators if there is danger of airborne contaminants

If mechanical equipment is used to move drums, it must be selected, positioned, and operated in a manner which will minimize sources of ignition. Sparks or heat from mechanical equipment could ignite vapors released from contaminated soil or ruptured containers.

The contents of deteriorated drums should be transferred to clean drums when the deteriorated drums cannot be moved without rupture. The clean container must be appropriate for the contents and meet DOT, OSHA, and EPA requirements.

Spills may occur during a transfer operation. U.S. DOT-specified salvage drums or containers and proper absorbent supplies must be kept readily available and used if a spill, leak, or rupture occurs. If a major spill could occur, the employer must have a written spill containment program as part of the Safety and Health Plan. Equipment, supplies, and trained personnel must be available to contain and isolate the entire volume being transferred.

Know in advance what to do if a major spill occurs.

Explosives or Shock-Sensitive Wastes

OSHA lists minimum special handling precautions which must be taken if a container is known or suspected of holding shock-sensitive wastes (29 CFR 1910.120[h][5]). These precautions are listed below:

- Evacuate all non-essential employees from the transfer area
- Provide all material handling equipment with explosion containment devices or protective shields to prevent injury to operator or damage to equipment if an explosion occurs
- Maintain continuous communication between the employee in charge of the handling area, the site safety and health supervisor, and the command post until the operation is complete; communication methods shall not increase the hazard of an explosion.
- Determine cause of any evidence of pressure build-up (bulging or swelling), and implement appropriate containment procedures to protect employees BEFORE drum or container is moved
- Assume a drum or container of packaged laboratory wastes contains shock-sensitive or explosive material until all contents have been thoroughly characterized

Lab Packs

Special requirements for handling lab packs are also detailed by OSHA 29 CFR 1910.120(j)(6). These minimum requirements include the following:

- Open the lab pack only when necessary
- Only persons knowledgeable in inspection, classification, and segregation of wastes according to hazard groups can open a lab pack
- Handle as a shock-sensitive waste if crystalline material is seen on any container until the contents are identified

Drum Staging

Staging means to set drums with similar classifications (markings, contents) together. Staging will assist with characterization and remedial action as well as protect drums from other site hazards such as damage from equipment which could cause leaks or mixing with incompatibles.

After the contents are identified, drums and containers may be packaged in the staging area for shipment.

Staging area functions may include:

- Initial staging
- Drum opening
- Sampling
- Holding
- Bulking
- Loading and shipping

The number of staging areas must be kept to a minimum. Adequate access and exit routes must be maintained at all times.

Drum Storage

Drums should be stored by compatible chemical groups to prevent:

- A reaction if a drum leaks and causes a second drum to release product
- A reaction in case of fire or other upset
- The feeding of wrong materials to the treatment process

If drums are stored on pallets, the following procedures should be followed:

- Store only compatible substances on the same or adjacent pallets
- Drums must sit squarely on pallets and not hang off edges
- Use only intact pallets without broken or damaged boards
- Band drums together if possible
- Place drums with labels and R numbers facing outward, readily visible

The contents of drums must be characterized. These activities may involve visual observation of the storage vessel and/or analysis of the contents. Drum opening and sampling procedures follow.

Certain drumheads are associated with specific materials.

Drum Opening Procedures

Specific procedures are required in areas where drums or containers are being opened. The HAZWOPER standard, section (j)(2), requires the following:

- Protect the source of air to a supplied-air respirator (SAR) from contamination
- Protect the entire SAR system from physical damage such as cutting off the airline or damage to the air compressor
- Keep employees not involved in the opening operation at a safe distance
- To protect against accidental explosion, erect a suitable shield to protect workers who must work near the drums that are being opened; the shield should not interfere with the work being done.
- Locate controls for opening equipment, monitoring equipment, and fire-suppression equipment behind the explosion-resistant barrier
- Use material handling equipment and hand tools which minimize sources of ignition when there is a reasonable probability of flammable atmosphere
- Use methods which relieve excess pressure in the container. If the pressure cannot be relieved from a remote location, place an appropriate shield between the container and worker.
- Never stand on drums or containers

The following procedures and precautions are recommended practice:

- Ensure proper bonding and grounding procedures have been performed.
- Wear appropriate respiratory protection and chemical-protective clothing (CPC) for the chemicals or wastes that are contained in the drums.
- Use remote-control devices if possible. Use pneumatically operated impact wrench or non-sparking bung wrench to remove lid bolts and rings and drum bungs. Use hydraulic or pneumatic drum piercers for puncturing drums. Use hydraulic, pneumatic, or electric cutters to cut out tops.
- Do not use chisels, picks, or other hand-held tools to puncture drums. Hydraulic or pneumatic drum piercers are available for puncturing drums. Backhoes also can be equipped with a puncture device.
- Open exotic metal and PVC-lined drums through the bung by removal or drilling. Use extreme caution when handling these containers.
- Re-seal open bungs and lids after emptying to avoid vapor generation and prevent leakage of residue.
- Check overpacks frequently for leaks, especially if corrosives are overpacked in steel. Use caution when handling overpacks, as the drum shifting inside makes the overpack hard to handle. Standard drum handling equipment may not fit overpacks, which could create handling problems.

Drum Sampling Procedures

Collection of a sample from a drum is necessary to more fully characterize unknown contents. Sample collection and subsequent handling must be included in the Safety and Health Plan.

Before sampling a drum, inspect the area and the drum for the presence of hazardous conditions. If any of the following conditions are present, do not attempt to sample the drum; immediately report the condition to your supervisor:

- The drum has a bulging top. This condition warns of an excessive build-up of pressure within the drum.
- The drum appears damaged in some way, such as a large dent. This condition could also cause a build-up of pressure.
- There is an appearance of vapor or mist coming from the top of the drum, usually near the bung hole.
- There is an obvious leak.

Some general procedures which may be included in procedures for manual sampling are listed below:

- Review appropriate documents (Waste Profile Sheet, Profile Record), if available
- Prepare sampling equipment
- Wear appropriate PPE
- Establish a sampling plan that indicates how to mark drums
- Mark the drums and sample bottles so that they can be related
- Determine the number, volume, and locations of samples
- Follow recommended procedures when opening a drum
- Conduct sampling operations only after the opening operations at the drum have been fully completed
- Cover drum tops with plastic sheeting to avoid worker contact when sampling
- Use ladders or platforms to reach stacked or palletized drums; do not stand on other drums
- Do not lean over the drums to reach the one being sampled
- Use appropriate sampling device for material (Coliwasa, thief, auger, shovel, dipper, etc.)
- Close drum
- Dispose of or decontaminate sampling equipment according to the sampling plan

There are situations where manual sampling may not be done due to hazardous drum conditions; therefore, remote puncturing of the drum will be required. Specialized procedures will be detailed in the Safety and Health Plan for sample collection and handling.

Spill Control

A spill containment plan is required whenever drum or container rupture may result in a major spill. (OSHA does not define 'major'). This program may be part of an overall spill control plan that describes actions to be taken if either a minor or major spill occurs.

Spill control activities are often categorized as:

Basic – prevents further release (shut off a valve, position drum with hole at top)

Confinement - working away from the spill, keep material from spreading by:

Diking - dikes may be built around the perimeter of the leak with sand, earth, straw, sorbent or similar materials. The diking material must be compatible with the spill material(s). Plastic sheeting can be used as an additional barrier to slow the leakage, if appropriate.

Blocking - Drains, ditches or storm sewers should be covered and blocked to prevent run-off of spill materials. This blocking can be done with a sorbent pad, piece of plastic or a rubber pad. If flammable or toxic materials enter these systems the potential for damage to property or people is increased. The blocking material must be compatible with the spill material(s).

Absorption - Run-off can sometimes be absorbed with dirt, sand, soda ash, sawdust, wood chips, peat moss, vermiculite or other compatible material. The sorbent material should be position so that the spill material runs into it.

Collection - Collect run-off in containers such as drums or buckets.

Containment - approach the source to keep the material in the container by:

Plugging - a plug is placed in the leaking drum to prevent or limit further release. Common plugging materials include wood, soap and rags. All plug materials must be compatible with the chemical(s) that are leaking.

Patching - a patch is applied over the area of the leak. Patching materials include rubber, patching mud and tape. All patching materials must be compatible with the chemical(s) that are leaking.

Overpacking - place the leaking drum into a larger drum to contain the spread of the contents.

Fire Prevention

Fires or explosions may occur at a waste site due to operation of heavy equipment near flammable materials, as a result of mixing incompatible chemicals, or during hot-work activities such as using a cutting torch.

Although it is necessary to monitor for the presence of flammable vapors, constant attention must also be given to preventing fires and explosions. Prevention is the responsibility of both the employer and the employee. Standard operating procedures for fire prevention usually include safety rules, equipment maintenance/testing, training, and warning signs.

Employer Responsibilities for Fire Prevention:

- Maintaining adequate supplies of fire-extinguishing media appropriate for the hazards
- Making certain that fire-extinguishing equipment and supplies are properly positioned
- Ensuring that responsible fire brigade crews are adequately trained to use the specific firefighting equipment and supplies for the hazards which may be present
- Conducting routine evacuation and fire-response drills
- Conducting frequent walk-through inspections for fire safety purposes
- Inspecting fire-suppression equipment routinely
- Posting evacuation routes
- Training employees in hazard recognition
- Proper handling and storing of compressed gases

Worker Responsibilities for Fire Prevention:

- Using non-sparking tools
- Observing no-smoking rules
- Using only non-sparking (i.e., “intrinsically safe”) radios and other electrical equipment
- Following other reasonable rules to reduce the possibility of fire

To be effective, fire prevention SOPs require ongoing worker training and follow-up reminders, as well as inspections, warning signs, and monitoring at the site.

Equipment Maintenance

Equipment maintenance will be an ongoing process at any hazardous waste site. Before equipment receives maintenance or service, it should be removed from the Hot Zone through the decontamination process and taken to the support area for repairs, unless:

- Repairs are minor
- Equipment cannot be moved by any method or without causing additional damage

If the above criteria are not met, mechanics qualified for entry, wearing PPE as required, will have to make repairs in the Hot Zone. Special training may be required to ensure that the repair work can be completed in the PPE.

Equipment to be repaired in the support area should be positioned away from site activity, traffic, and flammable and combustible materials, especially if welding, cutting, or heating will be required. Equipment, blades, end-loader buckets, dump bodies, and similar equipment shall be either fully lowered or blocked when being repaired, as described in OSHA 29 CFR 1926.600 (a)(3)(i), Equipment. All controls shall be in a neutral position, with the motor stopped and brakes set, unless the work being performed requires otherwise.

Hot work

Cutting, welding, or grinding activities may be conducted at a hazardous waste site in order to open vessels or reduce the size of storage vessels for further decontamination or storage. Because these heat-generating activities can create an emergency situation if done without adequate safeguards, hot-work SOPs

include a permit system. Following the SOP will help prevent injury due to chemical exposure, fire, or explosion.

An example of a hot-work permit is shown on the next page. Before welding repairs are begun, breathing air and other storage cylinders should be removed from the area. Welding on equipment or vessels that may contain traces of heavy metals or chlorinated solvents must be done with adequate ventilation and personal protective equipment. OSHA 29 CFR, 1926.353 (c) must be complied with on construction sites.

Hot-Work Permit

Check one:	Valid on this day, up to day shift of the following day	Permit is void as follows:
☐ Hot Work	Date _____	1. When conditions change, making continuation hazardous.
☐ Vessel Entry	Work to begin at _____ AM/PM	2. When starting work delayed or stopped for ___ hr(s).
		3. Permit expires at _____ AM/PM.

Section 1

Permission is granted to _____ to use _____ to enter _____ hot work only.

Description of work planned and specific location _____ *unit or area*

Section 2

A. Proposed work has been checked with supervisor and/or operator in charge	☐ Yes	☐ N/A
B. Pressure in equipment and pipeline	☐ Yes	☐ N/A
C. Equipment has been properly drained and purged or cleaned	☐ Yes	☐ N/A
D. Equipment has been properly blinded or blanked	☐ Yes	☐ N/A
E. Equipment has been properly tagged and/or locked out	☐ Yes	☐ N/A
F. Precautions taken against release of gas or oil in area	☐ Yes	☐ N/A
G. All combustible or flammable liquids have been removed or protected	☐ Yes	☐ N/A
H. Underground drawings checked before excavation	☐ Yes	☐ N/A
I. Sewer openings have been covered	☐ Yes	☐ N/A
J. Facilities available for control and disposal of hazardous material	☐ Yes	☐ N/A
K. Special warning/caution signs posted	☐ Yes	☐ N/A
L. Overhead work has been barricaded	☐ Yes	☐ N/A
M. Gauge glass columns have been drained and closed or protected	☐ Yes	☐ N/A
N. Welding machine is safely located, safely grounded, and sparks controlled	☐ Yes	☐ N/A
O. Stand-by fire equipment needed (list): _____	☐ Yes	☐ N/A
P. Ventilation equipment has been installed	☐ Yes	☐ N/A
Q. Proper means of access or egress is available	☐ Yes	☐ N/A
R. Personal protective equipment is needed and will be worn (check boxes)	☐ Yes	☐ N/A

Eyes: ☐ Safety Glasses ☐ Face Shield ☐ Safety Goggles

Extremities: ☐ Boots ☐ Helmet ☐ Gloves

Lungs: ☐ Dust Respirator ☐ Cartridge Respirator ☐ Compressed Air Supply Respirator ☐ Fresh Air Supply Respirator

S. Protective suit	☐ Yes	☐ N/A
T. Safety harness/lifelines	☐ Yes	☐ N/A
U. Other personal protective equipment (list): _____	☐ Yes	☐ N/A
V. Rescue personnel designated (list): _____	☐ Yes	☐ N/A
W. Craftsmen are trained for hazard they may encounter	☐ Yes	☐ N/A
X. Additional precautions listed in Section 3 will be followed	☐ Yes	☐ N/A

Signature

Section 3—Vapor Tests and Safety Report

☐ Hydrocarbons ☐ Carbon monoxide ☐ Oxygen ☐ Other (list): _____

Type:	**Flammable Vapor**								
Time									
% or PPM									
Initials of Tester									

Vapor test to be repeated every _____ hr(s). Re-inspection every _____ hr(s). Additional precautions required _____

Section 4—Approval Signatures

Safety Checked	Work Authorized

Section 5—Re-Inspection

Initial in columns below if original conditions prevail.

Time of reinspection			
Authorized person, Section 2			
Safety checked			
Work Authorized			

Power Tool Use

The use of power tools may pose safety and health hazards such as:

- Cuts and puncture wounds
- Electrical hazards
- Sparks causing fire or explosion
- Spread of contamination

Specific SOPs should be in place for use of specific power equipment on-site. The following general guidelines should be incorporated into site-specific SOPs for power tool use:

- Use pneumatic-powered equipment whenever possible to reduce electric shock hazard potential
- Check that safety pins or other restrainers are in place when using pneumatic equipment
- When using electrical equipment, follow OSHA requirements for grounding and/or ground fault circuit interrupter (G.F.C.I.) circuit breaker
- Use non-sparking, explosion-proof equipment near flammable and combustible material
- Do not use heat and spark-producing tools (grinders, torches) near flammable or combustible material without adequate testing and other precautions
- Keep guards and other safety devices in place and operational at all times
- Use appropriate personal protective equipment (PPE), and ensure that it does not become entangled in moving parts or ignited by power tools
- Inspect tools before each use to ensure they are in good operating condition
- Use the proper tool for the job
- Decontaminate tools after each use, and return them to proper storage

Loading and Unloading

Back injuries or other strains may occur during loading or unloading procedures. Training in use of proper equipment and lifting techniques will help prevent this type of injury.

Loading and Off-Loading Procedure for Drums and Other Containers

Before working near motor vehicles, make certain you verify and correct as needed that:

- Wheel chocks are in place
- Dock board is secured in place
- Container restraints (load wrappers, binders, or chains) are in proper place. Be careful when removing them, because they may puncture the drums or strike you in the face or mouth.

When moving drums and other containers, follow these procedures:

- Use proper equipment, such as drum cart, forklift, or similar equipment
- Use a drum cart, verifying that the drum is securely attached, and tip slowly while watching for leakage
- Place container in proper storage area, segregating containers as directed
- Report any problems such as leaks, bulging drums, or discolored packaging immediately
- If slings are to be used for off-loading containers such as transformers, be sure the weight is within the hoist and sling load limits and that the slings are in good condition. Always inspect the sling before each use.

Bulk Transfer

Bulking is the transfer of compatible wastes to bulk containers, vacuum trucks, or tank trucks for transport to another area of the site or off-site for treatment, storage, or disposal. Bulking waste increases the efficiency of transportation, reduces hazards to workers who would otherwise have to handle drums many times, and reduces the potential of physical injury. Liquid wastes are transferred from drums or other vessels by pumps or vacuums properly bonded/grounded and rated for the material being transferred. Pump-hose connections, lines, and valves must be inspected prior to transfer. Hoses used to transfer liquid wastes must be handled carefully, because residual substances may remain inside and could contact workers, spill on the ground, or cause a reaction with incompatible chemicals.

Unloading Problems – Material Will Not Flow

- Valve will not connect – may be incorrect hook-up locations. Check with supervisor
- Check whether internal and external valves are open
- Check for proper venting
- Check for accumulation of solids on bottom of tanker blocking or plugging tanker valves

Bulking is permitted only after the individual materials have been thoroughly characterized.

Procedures for Disconnecting Vessel to Which Material Was Pumped

- Check through hatch or inspection panel to see if vessel is empty
- Place drip pan under hose connector
- Close all valves
- Loosen hose connection, draining any material into a drip pan
- Place unloading hose in proper location, connecting capping or other means as required
- Unhook ground lead
- Secure hatch, valve caps, etc. on vessel
- In the event of equipment failure, overflow, or other emergency, follow emergency procedures

Loading Procedures

Loading procedures must be undertaken with care to prevent exposure of workers to the contents of containers, limit spread of contaminations, and reduce physical injury. The following activities should be included in an SOP as appropriate.

Preliminary Procedures for Vehicle Loading:

- Verify integrity of container(s)
- Inspect tankers for evidence of damage, leaks, and remaining contents
- Inspect bulk solid containers for evidence of damage, weak places, and sealed tailgates
- Inspect drums for evidence of damage, leaks, tight lids and bungs, proper gaskets, and labels
- Install a liner in container or transport vehicle as required. Plastic sheeting or straw is commonly used with solids to prevent leakage and ease off-

loading of solid materials. Plastic sheeting (Visqueen[a]) is used to line trailers hauling drums in case of leakage.
- Position vehicle for loading and set brake
- Chock wheels if loading drums in trailers or filling tankers

General Vehicle Loading Procedures:

- Do not overfill or overload
- Monitor loading in case of problems
- Monitor condition of material and containers being loaded for leaks, discoloration, or other unusual conditions
- Record volume being loaded
- Operate bulk tank valves, connecting hoses and transfer pumps
- Operate loading equipment (e.g., front-end loader, forklift, or similar equipment)
- Transfer drums to transport vehicle
- Prepare for transport by completing paperwork, (e.g., verify volume, weight, and similar information). Sign and remove copies.
- Perform final inspection of vehicle for placards, caps in place, traps on, no leakage, cargo braced, and similar procedures
- Use mechanical equipment, when possible

Procedure for Preparing Vehicles to Leave the Site:

Procedures must be followed to prevent contamination from leaving the site. Vehicle preparation may include the following steps:

- Secure openings by locking tailgates, installing valve caps, securing hatch, or closing doors
- Check for drips and spills. Clean up or contain as described in the SOP
- Direct the vehicle to wash area if decontamination is required
- Wheel wash may be required for vehicles that entered active sites

Excavation

Excavation activities are frequently performed at hazardous waste sites. Whether conducted as part of the initial site preparation or part of site remediation, all soil excavation must be shored and sloped to prevent accidental collapse. (See OSHA 29 CFR 1926 Subpart P)

Actual excavation is only one part of a Soil Excavation Plan, however. The plan is needed to document adequately the methods used to determine the nature of the soil and coordinate soil removal.

Contaminated soil must be characterized, and the amount of soil estimated; it will then be excavated and disposed of or treated and replaced.

The means of handling soil removal must be determined by:

- Will the soil be dug to full depth in one pass or in several?
- Which direction will work progress?
- Will additional work, such as shoring, be needed?
- Which angle of repose will be appropriate?

Decide what equipment for excavating and loading soil will be appropriate:

- Can equipment excavate to the depth required?
- Can loading equipment clear the sides to make a clean dump into trucks?

Coordination of movement of employees, equipment, and material must be conducted in order to accommodate access point, stockpile location, and decontamination activities. The plan may be implemented as follows:

- Identify and physically mark the areas of soil to be removed with stakes, spray paint lines, or similar means on-site.
- Have the utility company check the area for underground service lines and pipes. Consult pipeline maps as well.
- Physically mark routes and areas that equipment is to use when moving contaminated soil on, off, or around the excavation, the loading area, truck lining and tarping area, and similar areas.
- Set up soil loading and/or stockpile area with:
    - Bermed, plastic-lined area to hold soil
    - A method to cover the pile in case of rain
    - Catwalk, platforms, or other means from which to work when lining and tarping trucks
    - Portable scales or access to nearby scales for accurate payload determination for shipping manifest
- Set up decontamination area for equipment and/or trucks moving off-site.
- Excavation should progress from clean to dirty areas to avoid spread of contamination.
- The depth of excavation should be monitored periodically to ensure removal is being done per plan.

- When excavation reaches the required depth, soil samples are to be taken to determine if the excavation is clean. Ideally, sampling and analysis will be done quickly enough that if the area is not clean enough, additional excavation can be done before equipment is out of the area.
- When excavation, sampling, and analysis are completed and show that the area is clean, site restoration can begin.
- All equipment that was used for removal and will be used for restoration must be decontaminated before beginning restoration.
- Install backfill, venting, cover, and cap as required.

Additional points to consider include the following:

- The number of personnel in the area of equipment movement should be minimized. All equipment should be equipped with horn and back-up alarm to increase personnel awareness of their presence.
- Truck drivers bringing material to the site and truck drivers picking up loads at the site must remain in and with their trucks at all times.
- The possibility exists of a dump truck rolling over during dumping, especially if a load hangs in the bed. All personnel must remain well clear of trucks during dumping.
- Excavations in excess of 5 feet in depth in stable soil must be shored or laid back in accordance with OSHA Construction Standard 29 CFR, 1926.651. Unstable soils must be shored or laid back at lesser depths to prevent cave-in.
- Barricades should be installed around the excavation to prevent personnel from falling into it.

More than 5,000 workers are seriously injured and 100 die every year in slides and cave-ins.

Motorized Equipment and Vehicle Operation

Equipment and vehicle operation is covered by OSHA 29 CFR 1926, Subpart O.

Heavy Equipment

Extensive training in the use of the different “rigs” is required before a worker is assigned to become an operator. Experienced operators need to become familiar with the differences in driving and operating their equipment when wearing Level A or B PPE due to motion and visibility restrictions. Characteristics of levels of protection will be discussed in the Personal Protective Equipment chapter of this guide.

The following should be part of an SOP describing heavy equipment operation:

- Whenever the equipment is parked, the parking brake must be set
- Equipment parked on inclines must have wheels chocked and parking brake set
- Equipment should be fueled before the start of work whenever possible to reduce the risk of fire if fuel is spilled
- Breathing air cylinders must be positioned to prevent valve and regulator damage during operation
- Cylinders must be securely attached to equipment
- All equipment taken into the Hot Zone (contaminated area) must remain in that zone until decontaminated
- Operators working in Level B must be able to access and connect the equipment air system without the use of the 5-minute escape system. This may be done by:
    - Using a longer-duration, NIOSH-approved SCBA unit for entry and egress, modified to fit the vehicle
    - Having operator park equipment at edge of Hot Zone and use egress to decontaminate and enter support area. A long decontamination procedure may require airline hook-up in decontamination area.
    - Use airline from support area to access and egress, switching airline at equipment. An assistant will be required to take out and return the airline.

Motor Vehicles

Automobiles, pick-up trucks, and forklifts may be in use at a site. Proper operation will minimize the spread of contamination and reduce the potential for accidents.

General Requirements for Motor Vehicles (off-highway use only)

All vehicles in use should be checked at the beginning of each shift to ensure that the following parts, equipment, and accessories are in safe operating condition and free of apparent damage that could cause failure while in use:

- Service brakes (including trailer brake connection, fluid level, etc.)
- Parking system (hand brake)
- Emergency stopping system (brakes)
- Tires
- Horn

- Steering mechanism
- Coupling device
- Seat belts
- Operating controls
- Safety devices (back-up alarms, fire extinguisher, mirrors, etc.)
- Lights, reflectors
- Windshield wipers
- Defrosters

All defects shall be corrected before the vehicle is placed in service.

Only trained and qualified personnel authorized by the company shall operate equipment. Operators who have not previously operated equipment while using PPE should familiarize themselves with the restriction the PPE imposes before operating in close proximity of people or other critical situations. Prior to operating each day, operators should inspect their equipment for failures and defects.

When operating vehicles equipped with the Roll Over Protection System (ROPS), workers must wear seat belts for the system to be effective. When leaving a machine, operators should step to the ground instead of jumping from the equipment because of extra hazards due to PPE. Blades, buckets, or other similar devices should be lowered to the ground and the engine shut down before leaving the equipment. Because the contaminant level may rise suddenly, operators must be prepared to shut down and immediately leave the area when signaled to do so. Care should be taken that all waste goes into the transport vehicle. Spillage on the side of trucks may require that they be decontaminated before leaving the site.

It is important to remember that when people are working in a group:

- A signal person should be designated. The signal person will provide when-to-move signals to the operator to avoid confusion and unexpected movement.
- All personnel in the area of the equipment should remain in view of the operator at all times.
- All personnel in the area of the equipment should remain out of the “swing area” and path of the equipment, unless the operator knows they are there.

Equipment is to be used only for its intended purpose and must not be overloaded or abused. Equipment must not be used to carry passengers unless it

is equipped with seats to do so. Equipment should operate up-wind from the site whenever possible.

Ladder and Scaffolding Use

Ladders and scaffolding may be used on the site to access vessel entry ports or in disassembly operations at facilities being decontaminated.

Ladder safety is described in OSHA Construction Standard 29 CFR 1926.450. Extra care should be taken when climbing ladders while wearing PPE due to restriction of motion and visibility. All fixed or existing ladders should be carefully inspected for deterioration of parts and attachments before use.

Scaffolding requirements are found in OSHA Construction Standard 29 CFR 1926.451. Extra care should be taken when working on scaffolds in PPE due to restriction of motion and visibility. Aerial lifts such as extendible boom platforms, serial ladders, articulated boom platforms, vertical towers, and their combinations should be used in place of scaffolds whenever possible and practical, in accordance with OSHA 29 CFR 1926.556.

Exercise - Design an SOG

In this exercise, you will design an SOG for a work practice that may take place at a hazardous waste site. See Exercise Guide.

Other Considerations

Adequate lighting and sanitation facilities must be available if the work activities are to be performed in a safe and healthful manner. Specific requirements for hazardous waste sites are described below.

Illumination

At minimum, work and rest areas must be illuminated to the levels listed in the table below (29 CFR 1910.120 [m]).

Foot Candles	Area or Operations
3	Excavation and waste areas, access-ways, active storage areas, loading platforms, refueling and field maintenance areas
5	General site areas
5	Indoors: warehouses, corridors, hallways
5	Tunnels: shafts and general underground work areas. (Exception: minimum of 10 foot-candles is required at tunnel and shaft heading during drilling mucking, and scaling.)
10	General shops: mechanical and electrical equipment rooms, active storerooms, barracks
30	First aid stations, infirmaries, and offices

The health and safety supervisor should have a meter to assess lighting, as needed.

Sanitation at Temporary Workplaces

Water: An adequate supply of drinking (potable) water must be provided at the site. If portable containers are used to dispense drinking water, they must be tightly closed and equipped with a tap; it is not permissible to dip from a common container. The container must be clearly marked and never used for another purpose. If single-use cups are supplied, they must be kept sanitary prior to use and disposed of in provided trash cans.

If water unfit for drinking (non-potable) is available at the site for firefighting or other purposes, the water lines and hose connections must be clearly marked to indicate that it not to be used for drinking, washing, or cooking. Systems shall be designed to prevent any potential cross-connection with a potable source.

Toilet Facilities: Toilet facilities with doors and inside locks must be provided for employees, unless employees are part of a mobile work crew having transportation available to nearby toilets. Hazardous waste sites without sewers must be provided with chemical, recirculating, combustion, or flush toilets, unless they are prohibited by local codes. At least one toilet facility must be available at temporary field conditions. For other work sites, a minimum of one facility should be available for 20 or fewer employees, one toilet seat and one urinal per 40 employees for 20–200 employees, and one toilet seat and one urinal per 50 employees for more than 200 employees.

Food Handling: All employee food services must meet all laws and ordinances of the areas where they are located.

Sleeping Quarters: Temporary sleeping quarters must be heated, ventilated, and lighted.

Washing Facilities and Showers

Employers must provide nearby washing facilities. They shall be located in areas under the control of the employer where exposure levels are below the PEL and published exposure levels. The facilities shall be sufficient to ensure that employees can remove hazardous materials from themselves.

When work will continue for six months or longer, showers and change rooms for all employees exposed to hazardous substances and health hazards must be provided, consistent with the following regulations:

Showers must be provided in accordance with OSHA 29 CFR 1910.141(d)(3).

Change rooms must have two separate areas, one for removal and storage of clean clothes and one for the removal and storage of work clothing. Change rooms must meet the requirements of 29 CFR 1910.141(e).

Showers and change rooms must be located in areas where exposures are below the PEL and published exposure levels. If this is not possible, then a ventilation and supplied-air system must be provided to reduce exposures to the required level.

Employers must ensure that all employees shower at the end of the work shift and when leaving the site.

Summary – Work Practices

Written work practice plans help protect worker safety and health and limit offsite contamination. Detailed descriptions are included in the Plan at each site.

Elements of the written work practice may include

- Title Page or Title Block – identification of the activity, date and approvals
- Table of Contents
- Definitions of any specialized or unfamiliar terms
- Purpose, including any applicable standards or regulations
- Scope – what is covered and, if necessary, what is not covered
  - Emergency conditions
- Personnel – who completes the work and who else must approve or take part in the activity
  - Qualifications
  - Required Training
- Equipment and/or materials needed
  - PPE
  - Forms/checklists
- Procedures or steps
  - Air/Water/Soil/Surface Monitoring
  - Conditions to be aware of during the work

At the site, the written document is a Standard Operating Procedure.

At each hazardous waste site, employees must be trained in the specific SOPs that are relevant to their duties.

Hazard Control

Exposure to hazards at a waste site is controlled by using the hierarchy of controls. The best approach is to eliminate the hazard; if this cannot be done, then engineering and administrative controls are implemented. When other controls are not feasible, personal protective equipment (PPE) is used to prevent exposure. This chapter is an introduction to hazard control.

Chapter Objectives

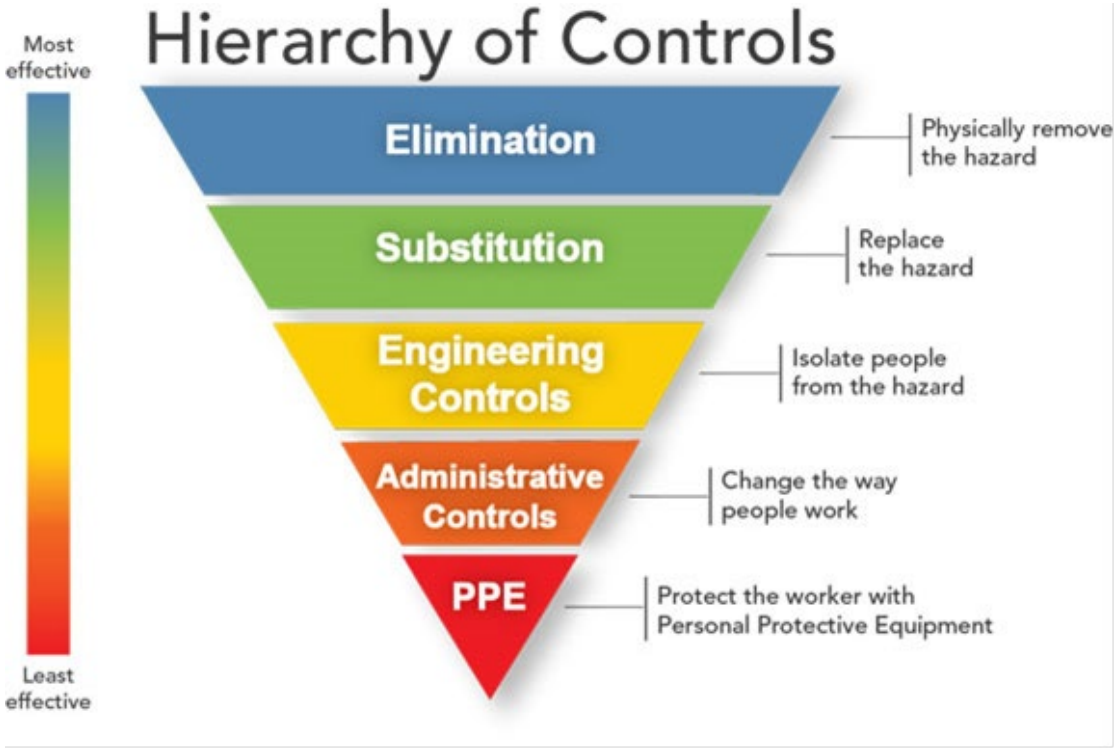
When you have completed this chapter, you will be better able to:

- Identify types of hazard control that can be used at a hazardous waste site
- List the elements of a HAZWOPER Safety and Health Program
- Identify topics that must be included in the site-specific Safety and Health Plan, referred to in OSHA resources as Health and Safety Plan (HASP)
- Implement controls for hazards identified during a simulated site activity

Types of Hazard Control

Hierarchy of Controls

The hierarchy of controls refers to the preferred methods of hazard control. Traditionally, in order from most-preferred to least-preferred, they are:



Source: https://www.cdc.gov/niosh/topics/hierarchy/default.html

On a hazardous waste site it is not possible to eliminate all hazards. However, a range of controls can be employed.

Elimination

Disconnecting power at an abandon building at the waste site (eliminating electrical hazards) is one example. Eradication of poisonous plants, and venomous snakes are additional examples.

Substitution

Using a 'green' pesticide made from household chemicals to eradicate poison ivy is one example. Using soap and water instead of a solvent-based liquid for hand cleaning is another example of substitution.

Modify

When confined space entry activities are changed to use work practices that do not require personnel to enter the space, the procedure has been modified.

Sending a robot to collect soil samples potentially contaminated with radioactive sludge is a modification (compared with sending a person).

Contain

Enclosing a noisy operation is an example of containing the hazard. When a dusty material transfer operation cannot be controlled, moving the operator to an isolated control area contains the hazard in an unoccupied workspace.

Ventilate

Removing solvent vapors with mechanical exhaust at a transfer point of liquids containing a toxic solvent is an example of ventilation.

Work Practice Change

Adding a sign-off during excavation to ensure that trenching has been done according to guidelines is a change in the work practice.

Personal Protective Equipment

When the above controls are not possible, personal protective equipment is used. For example, Level B is required to protect from solvent-contaminated soil during drum staging.

Hazard controls are further defined as Engineering or Administrative.

When engineering controls are used to control hazards, a piece of technology is used to reduce exposure. Examples include having an air-conditioned cab on a piece of earth-moving equipment to reduce employee heat exposure, a remote drum-puncturing rig, and shielding of radiation or explosion exposures. The purpose of remote drum puncturing and shielding is to reduce the level of exposure to the worker(s), minimize the release of the contaminant or hazard at the source, reducing the need for or level of decontamination. When use of confined space entry is the only way of accomplishing a task, a ventilation fan is used to provide fresh breathing air inside the confined space, helping to reduce the risk. Ventilation is a commonly used engineering control.

Administrative controls are policies and practices written before the work begins to minimize exposure to chemical and physical hazards. Examples include industrial hygiene monitoring programs, medical surveillance programs, confined space entry and hot-work permits and policies, and lock-out procedures. Other examples are work plans limiting the duration of exposure (e.g., to noise

and radiation), developing a written plan describing the maintenance of protective clothing, and implementing specific work practices which reduce or prevent exposure. All of these controls are described in site-specific Standard Operating Procedures (SOPs).

Safety and Health Program

Potential or identified hazards at a site and methods to control them must be described in writing. Training for limit the effects of known or anticipated hazards at each site is conducted after this introductory training and covers the Safety and Health Program. Details about this important resource are in the next section.

The Safety and Health Program (as required per OSHA 29 CFR 1910.120[b]) is a written document which describes:

- An organizational structure
- A comprehensive workplan
- A site-specific Safety and Health Plan
- The safety and health training program
- The medical surveillance program
- The standard operating procedures for safety and health. (general content of several included in this program)
- Any necessary interface between general and site-specific programs. (especially used if company has remediation activities at multiple sites)

The program is developed to identify, evaluate, and control safety and health hazards and provide for emergency response at hazardous waste sites. Copies of the written plan must be located at the work site where workers, contractors, sub-contractor representatives, and government personnel can have access. Programs already written as part of other required safety and health efforts may be referenced in the Safety and Health Program.

The importance of the first five of these topics is described below.

Organizational Structure

Knowing the responsibilities of each person at the site is essential for carrying out the work effectively and resolving unexpected circumstances quickly. The organizational structure must be written and included in site-specific training. A

general supervisor has the overall responsibility to conduct the clean-up activities. The safety and health supervisor develops and implements the site Safety and Health Plan and verifies compliance. Responsibilities of all other site workers are described, as well as lines of authority, responsibility, and communication.

The organizational structure is reviewed periodically and updated as necessary. Each site will differ, so site-specific training is needed whenever there is a change in work location.

Comprehensive Workplan

At each site, a comprehensive workplan must be developed to address activities, logistics, and use of resources. Topics from the comprehensive workplan shall be discussed/reviewed during the site-specific training. Included in the work plan are written descriptions of:

- Normal procedures
- Clean-up activities
- Task objectives and procedures
- Personnel requirements for carrying out the activities
- Training program
- Required informational programs about the nature, level and degree of exposure likely as a result of hazardous waste operations
- Medical surveillance requirements

Site-Specific Safety and Health Plan (referred to in OSHA resources as the Health and Safety Plan or HASP)

This series of written documents covers the hazards during each phase of the work and the procedures required to protect employees. Each of the following topics must be addressed:

- Safety and health risk or hazard analysis for each task or operation
- Employee training
- Personal protective equipment
- Medical surveillance requirements
- Air monitoring protocol
- Site control
- Decontamination
- Emergency response plan (ERP)

- Confined space entry
- Spill-containment program

The site-specific Safety and Health Plan provides for pre-entry briefings to be held prior to initiating any site activity, and at other times as necessary to ensure that employees are knowledgeable of the site Safety and Health Plan and that this plan is being followed. Site characterization and analysis work is required to prepare and update the site-specific Safety and Health Plan.

The site-specific Safety and Health Plan should be used as a planning guide before any site work begins. It should also be used as a reference tool throughout the site work to ensure employees' awareness of the plan and company compliance with it. As information on the site is obtained during periodic site inspections, relevant sections of the plan should be updated by the safety and health supervisor or another person knowledgeable in safety and health.

The general requirements for most of the programs listed above are covered in separate sections of this program. Training, Medical Surveillance, Site control and Spill-containment are described below.

Safety and Health Training Program

Under the OSHA standard 29 CFR 1910.120(e) training must be provided for all employees regularly working at a site who are exposed to hazardous substances, health hazards or safety hazards; this requirement is met by the general 40-hour program. Supervisors and managers responsible for the site must receive both the general 40-hour and an 8-hour site supervisory training. Occasional site workers are required to complete 24 hours of training. The durations are minimum hours of training.

Occasional site workers will also receive a minimum of one day of on-site training on the specifics of the location where the work will be conducted, and the methods to control any hazards. Additional on-site training may include such topics as Hazard Communication, specialized training for working around radioactive materials, DOT regulations, OSHA construction hazards, emergency response and first aid.

Medical Surveillance Program

Medical surveillance (29 CFR 1910.120(f)) is a required part of the Workplan and the Safety and Health Program. It is essential to assess and monitor worker

health and fitness both prior to and during employment, provide emergency and other treatment as needed, and retain accurate records for future reference. The medical surveillance programs should be instituted by the employer for the following employees:

- All employees who are or may be exposed to hazardous substances or health hazards at or above the PEL or above another published exposure level (if there is no PEL) for 30 days or more a year
- All employees who wear a respirator for 30 days or more a year.
- All employees who are injured due to an overexposure from an emergency incident involving hazardous substances or health hazards
- Members of official hazardous materials response teams

Medical examinations and consultations for anyone who is covered by these four categories are provided by the employer. Medical exams must be conducted:

- Prior to a new job assignment (pre-placement or reassessment)
- At least once every year but not less often than every two years
- At the termination of a job
- If an employee exhibits signs or symptoms which may have resulted from exposure hazardous substances during an emergency incident, or if the employee has been injured or exposed above the PEL or published exposure level in an emergency
- More than once a year if the physician determines that an increased frequency is medically necessary

All medical examinations and procedures must be performed by or under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine. The exam is provided without cost to the employee, without loss of pay and at a reasonable time and place. The content of the examination or consultation will be determined by the physician. Because the physician may not understand the details of the work assignment, it is important to explain the type of work, potential health risks, and type of protective equipment (RPE, CPC, other) that will be used. Prior to the exam appointment, the employer should provide: a copy of the HAZWOPER standard, and for each employee job and exposure descriptions, current or anticipated exposure levels, PPE that will be used, any information from previous examinations not readily available to the physician, information needed for medical clearance for respirator use (if appropriate).

Examination and consultations may include, but are not limited to:

- Medical and work history
- Physical exam
- Pulmonary function test
- Hearing test
- Electrocardiogram (EKG)

The employer pays for all mandatory medical surveillance examinations or consultations.

The employer will obtain the following from the physician and provide it to the employee:

- Physician's opinion relative to the employment (findings not relevant to employment are not provided to the employer)
- Physician's recommended limitations to the assigned work
- Results of medical examination and tests requested by the employer
- A statement that the employee has been informed by the physician of the examination results and any conditions that require further examination or treatment

The employee has a right to request and be given a copy of the full report. It should be kept in a safe place or forwarded to your family physician as part of your medical record.

The employer must keep records of medical exams and exposure records for the duration of the worker's employment plus 30 years thereafter. The records must include name, social security number, physician report, employee reports of health effects related to exposure, exposure monitoring results and information provided to the physician by the employer.

SOPs

Any written SOPs not included in other parts of the written documents are placed here. It may be useful to include a full listing of SOPs and where each can be found in this section of the Program.

Interface between general and site-specific programs

The XYZ Remedation Enterprises Inc manages site cleanup operations across several states. General Health and Safety SOPs are in the Corporate Manual;

site-specific SOPs are included in this Program or referenced to other Plans implemented on-site.

Health and Safety Plan Element - Site Control
EXAMPLE – Guidance for Training Purposes

Site Control

In order to protect personnel working at site characterization surveys, a site control program must be implemented. According to OSHA 29 CFR 1910.120(d), minimum components of a site control program are:

- Site maps
- Work zones
- "Buddy system"
- Site communication, including means for emergency alert
- Standard operating procedures or safe work practices
- Identification of the nearest medical assistance

The purpose of this program is to control employee exposure before actual clean-up work begins. Many elements are also part of routine clean-up operations.

Site Maps

A site map is a graphic representation of topographic features; prevailing wind direction; drainage; and the location of buildings, containers, impoundments, pits, ponds, and tanks. Site maps are helpful for planning activities related to PPE, assigning personnel to work zones, identifying problem areas and access and evacuation routes, and reviewing conditions at the daily safety and health briefing of the field team. A site map is designated before site entry and should be modified during site work to reflect changes in activities.

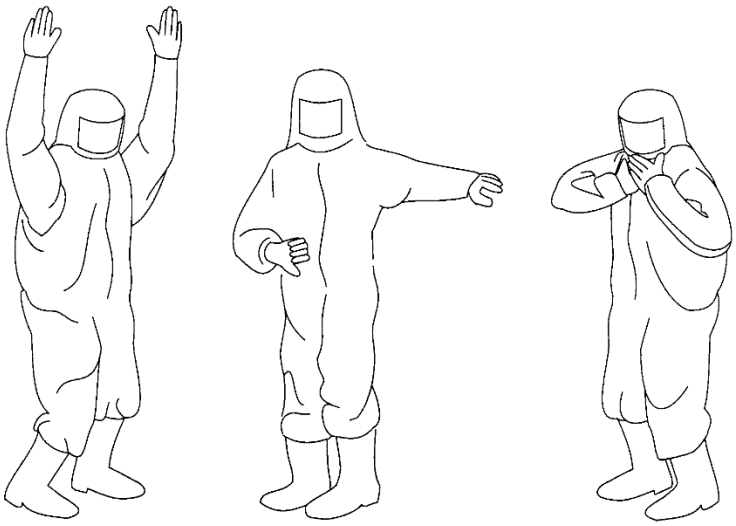
Work Zones

Hazardous waste sites should be divided into as many different zones as needed to reduce accidental spread of toxins from a contaminated area to a clean area, reduce the number of personnel authorized in high-risk areas, delineate required levels of protection to be worn, and plan emergency evacuation routes. Most areas will have at least three zones. These zones are named differently depending upon the site, as discussed in the Decontamination chapter.

Buddy System

The “buddy system” is a protective procedure requiring workers to perform in pairs or within close proximity of one another in order to safeguard one another’s safety and health. A buddy provides assistance, observes his/her partner for signs of chemical or heat exposure, periodically checks the integrity of the partner’s protective clothing, and notifies the command post or others if emergency help is needed. Buddies should work in line-of-sight or be provided devices for communication with each other and the command post. When wearing protective clothing, workers must make sure that hand signals are understood. Some common hand signals are shown below.

Common Hand Signals



In trouble; need help getting out of suit.

Task cannot be completed with remaining air.

Out of air

Site Communication

Communication systems need to be established to alert team members to emergencies, pass along safety information (e.g., time available in air cylinder), initiate changes in work tasks, and maintain site control. Communication systems used at a work site are referred to as internal and external systems. Internal systems consist of visual cues such as hand signals, lights, flags, and flares and audio cues such as bells, sirens, whistles, or compressed-air horns. External

communication systems such as telephones or radios are useful but may be limited when static electricity or protective clothing interfere with good communication or pose a safety hazard. At each site, workers are trained to use both communication systems.

Emergency Alerting

Employees must be knowledgeable of emergency systems' alerting horns or other warning systems. Actual methods used at each site may differ. Site-specific training is required.

Site Characterization and Analysis

Site characterization and analysis (29 CFR 1910.120(c)) provides information needed to identify site hazards and select worker protection methods. Site characterization is a detailed process which includes a preliminary evaluation, hazard identification, personal protective equipment, monitoring, risk identification, and employee notification. Conditions must be constantly monitored after site characterization to detect changes in the work areas.

Preliminary Evaluation

Preliminary evaluation of a site's characteristics must be done by a qualified person prior to site entry in order to select proper protection for the entry team. Information is obtained away from the site through interviews, existing records, perimeter reconnaissance, and manufacturer's safety data sheets (SDSs) or other documents regarding materials at the site.

Immediately after the initial site entry, a more detailed evaluation of the site-specific characteristics must be performed to identify existing site hazards and aid further in the selection of the appropriate engineering controls and personal protective equipment for the tasks to be performed. These surveys are done by at least four people – an entry team and back-up. The table on the next page lists some general site hazards to consider when approaching and working at the site.

Hazard Identification

Hazard identification includes documenting all suspected conditions that may pose IDLH inhalation or skin absorption hazards, as well as other potentially dangerous or lethal conditions. Hazards may include:

- Confined spaces (including trenches and low spots)
- Potentially explosive or flammable situations
- Visible vapor clouds
- Areas having biological indicators such as dead animals or vegetation

The following information must be obtained to the extent available before employees enter a site:

- Location and approximate size of the site
- Description of the response activity and/or the job task to be performed
- Duration of the planned employee activity
- Site topography and accessibility by air and roads
- Safety and health hazards expected at the site
- Pathways for hazardous substance dispersion
- Present status and capabilities of emergency response teams that would provide assistance to hazardous waste clean-up site employees at the time of an emergency
- Expected hazardous substances and their health hazards and chemical and physical properties

Potential Site Hazards

Biological • Bacteria (salmonella) • Fungal Virus (Hepatitis B) • Parasite (ticks, chiggers, mites) • Plant (Poison Ivy) • Animal (bears, rodents, wild dogs) • Reptiles (snakes)	Chemical • Acids • Bases (caustics) • Gases • Liquids • Solids • Vapors • Dusts, mists • Fumes
Physical • Ponds, lagoons • Confined spaces, trenches • Electricity • Slips, trips and falls • Ladders • Struck-by hazards • Vehicles, heavy equip. • Steam • Ergonomic injuries • Noise • Radiation • Fall from heights • Temperature extremes • Equipment maintenance	Psychological • Claustrophobia (fear of closed or narrow spaces) • Acrophobia (fear of heights) • Monotonous jobs • Disorientation in PPE • Sexual harassment

Personal Protective Equipment

Personal protective equipment must be provided for workers engaged in initial site entry. The specific program will be designed to keep inhalation hazards below published guidelines and control all other anticipated safety hazards.

When the preliminary site evaluation does not produce the type of information that can be used to predict airborne concentrations, Level B protection (see the chapter on PPE) must be used at a minimum. Employees will have an escape bottle, as appropriate. Instrumentation to detect IDLH situations will be used.

Once further information on the hazards is available, the protective equipment will be re-evaluated by the health and safety specialist and adjusted to be more appropriate.

Monitoring

Monitoring must be conducted during the initial site entry when the site evaluation reveals the potential presence of an IDLH condition, ionizing radiation, or insufficient information. The following steps are required:

- Monitoring for hazardous levels of ionizing radiation with direct-reading instruments
- Monitoring the air for IDLH, combustible or explosive atmospheres, oxygen deficiency, or toxic substances with direct-reading instruments
- Visually observing for signs of potential IDLH or other dangerous conditions
- Implementing an ongoing air monitoring program after the start-up of operations

Risk Identification

Once the presence and concentrations of specific hazardous substances and health hazards have been established, the risks associated with these substances shall be identified. Employees who will be working on the site shall be informed of any risks that have been identified, including as a minimum:

- Exposures exceeding exposure limits
- IDLH concentrations
- Potential skin absorption and irritation sources
- Potential eye irritation sources
- Explosion and flammability ranges
- Oxygen deficiency

Notification

Notification of the chemical, physical, and toxic properties of all substances known or expected to be present at the site must be made to each employee who may be affected by the hazard. Employee notification must be completed before their work activities begin.

New Technologies

The hazardous waste field is constantly changing as new methods of working with and treating hazardous wastes become available; similarly, better methods of employee protection are being developed.

As part of the Safety and Health Program, the employer must develop and implement an SOP for introducing effective new technologies and equipment.

For example, if robots are introduced to manipulate waste containers, a site-specific SOP would include operator instructions training, troubleshooting, maintenance, decon methods, and emergency recognition and alerting. Evaluation is done to assess the effectiveness of the new approach before it is implemented at the site on a large scale. Data from the manufacturer or supplier may be included in the evaluation. The process and all data must be available to OSHA.

Working with Local Fire/Emergency Personnel

The Local Emergency Planning Committee (LEPC) can facilitate development of the emergency response plan (ERP) and contact with the local fire and emergency personnel. It is essential for site management to communicate clearly with the local fire and emergency groups to ensure that the location of potentially hazardous chemical situations is known to all groups. There must be preplanning discussions and/or drills of the role of each group in the potential emergencies which could occur at the facility. Plant management must take the lead in maintaining communication between the groups.

Hazardous Chemical Reporting

Under the Emergency Planning and Community Right-to-Know Act (EPCRA), facilities must submit Safety Data Sheets (SDSs) for certain chemicals, or lists of those chemicals, to the state emergency response commission (SERC), LEPC, and local fire departments. The SDS will contain information on fire and explosion hazards, health hazards, protective equipment, and other subjects critical to emergency response efforts.

Facilities must also submit hazardous chemical inventory forms for the chemicals covered by the law to the SERC, LEPC, and local fire departments.

A Tier I inventory must be submitted to the SERC, LEPC, and fire department. The Tier I inventory provides quantity, hazard, location, and storage information on general categories of substances. Because it provides general information only, it is only useful as a screening tool.

A Tier II Inventory must be provided upon request of the SERC, LEPC, or fire department. This form provides much more specific and useful information on substances used, stored, or produced at the facility. A Tier II inventory can be submitted by the facility instead of a Tier I. The Tier II form may be helpful in writing pre-plans for sites within the fire department's jurisdiction.

Emergency Release Notification

Facilities must immediately notify the SERC and LEPC of any accidental releases of "Extremely Hazardous Substances" that are above reportable quantities. They must also provide written follow-up reports on actions taken and medical effects that could be caused by the release. Although the LEPC is not required to notify the fire department in the event of such a release, a good emergency response plan will provide for such notification. You should contact your local LEPC for additional states' laws which might be applicable.

Enforcement

The U.S. Environmental Protection Agency is responsible for enforcing hazardous waste regulations. The EPA may assess civil and administrative penalties of up to $74,552 per day when hazardous waste storage, management or disposal requirements are violated. Some states have enacted similar requirements and do their own enforcement.

The SERC, LEPC, or state and local governments may begin legal actions against facilities that fail to comply with this law. Citizens may also file lawsuits against facilities, the SERC, and the EPA for failure to meet legal requirements.

Exercise - Hazard Control

Discuss in a small group what some of the hazards might be on a hazardous waste site and some possible methods of controlling each hazard. Record your ideas on the worksheet. One member of the group should be prepared to report back to the class. See Exercise Guide.

Summary – Hazard Control

Site characterization and analysis are important and continuous parts of hazard control. They are conducted before and during site work to assess health and safety risks and determine ways to control hazards and contamination. Only qualified people should conduct such investigative work.

Administrative controls usually consist of written programs or plans which are implemented to prevent harmful situations. Engineering controls include substitution, isolation, and ventilation. Use of personal protective equipment is another method of limiting exposure.

Elements of a site Safety and Health Program are listed in 29 CFR 1910.120(b). The elements include: the organizational structure, comprehensive work plan, site-specific Safety and Health Plan, standard operating procedures (SOPs), safety and health training, medical surveillance program, and any information necessary to link the overall company to the site-specific plan.

The Safety and Health Plan, referred to by OSHA as the Health and Safety Plan (HASP), is a written document which includes site-specific information designed to identify, evaluate, and control exposures to hazards. The HASP is part of the Safety and Health Program.

Hazard control procedures are to be planned and implemented before personnel enter the site. The site control program must include site map, work zones, buddy system, site communication procedures for routine and emergency situations, standard operating procedures, and identification of the nearest medical facility.

Emergency Response

Pre-planning of actions to be taken by employees is required to protect life and property. This must be developed and implemented prior to beginning remediation work. As the work progresses, the ERP may be updated as conditions at the site change.

Adequate planning and practice limits/prevents damage to health and property should an emergency occur.

Chapter Objectives

When you have completed this chapter, you will be better able to:

- Identify required elements in an Emergency Response Plan
- Identify the differences between an Emergency Response Plan and an Emergency Action Plan
- Identify the roles of key positions in the Incident Command System

Emergencies

A hazardous materials emergency is a spill or release that cannot be controlled as part of pre-emergency planning, the *threat* of a spill or release is determined and included. The most common types of chemical emergencies at waste sites are spills. Other emergencies may occur that do not involve hazardous materials. These include severe weather, workplace violence, or confined space rescue.

Notify your supervisor whenever a spill or release is detected. With your input, the supervisor will decide whether outside help is required. The following questions should be considered:

- Do you know the extent of the spill or release?
- Do you know the nature and type of material spilled or released?
- Have you participated in training specifically to respond to this type and quantity of spilled/ released material?

Your supervisor will determine whether the situation is an emergency or if non-emergency containment procedures might be appropriate.

Always follow the site-specific notification instructions you have been given during the on-site training.

Site personnel must determine if there will be an internal response or if all workers will evacuate. For any internal response, an Emergency Response Plan is required as part of hazard control in the site-specific Safety and Health Plan; for evacuation, an Emergency Action Plan is required and is referenced in the Safety and Health Plan. Training on either emergency plan is needed.

The requirements of an ERP and EAP are detailed below.

Emergency Response Plan (ERP, 29 CFR 1910.120)

An Emergency Response Plan (ERP) is required at all hazardous waste sites, The ERP must be in writing and available at the site. It must be developed and practiced before an emergency occurs that requires a response. The ERP should be a living document that is revised at least annually based on experiences during response efforts, as well as new processes that are added, new hazard information that becomes available, or changes in the level of response by site personnel.

The specific topics which must be covered in the ERP (29 CFR 1910.120(l)(2)) are:

- Pre-emergency planning
- Personnel roles, lines of authority, training, and communication
- Emergency recognition and prevention
- Safe distances and places of refuge
- Site security and control
- Evacuation routes and procedures
- Decontamination procedures which are not included in the Safety and Health Plan
- Emergency medical treatment and first aid procedures
- Emergency alerting and response procedures
- Critique of response and follow-up
- PPE and emergency equipment

Response to an emergency incident requires a structured approach to ensure health and safety of all involved, efficient use of resources and appropriate follow up. The response operation can be small and managed by properly training in-plant personnel or may require outside assistance from the immediate area (e.g.,

fire service) or a larger area (e.g., State EPA) or federal involvement (e.g., US Coast Guard). The structures described by the Federal Emergency Management Administration (FEMA) in the National Incident Management System are flexible to address these contingencies. https://training.fema.gov/nims/

On-site personnel who will provide emergency medical treatment of First Aid require specialized training for those certifications.

The employee alerting system enables workers to be recognize an emergency situation and to take the action(s) described in the ERP. The system may require reductions in background noise in order to speed communication and to begin emergency procedures. See OSHA 29 CFR 1910.165.

The ERP must be available for review and copying upon request by employees, their representatives, and personnel from OSHA and other relevant agencies.

Emergency Action Plan (EAP, 29 CFR 1910.38)

An Emergency Action Plan (EAP) is required at any workplace where management has decided that workers will evacuate when a hazardous materials or other emergency occurs, and the response will be conducted by outside personnel. At some sites, both an ERP and an EAP may be in place for different parts of the operation.

The following must be in the EAP, as shown in 29 CFR 1910.38(a)(2):

- Emergency escape procedures and emergency route assignments
- Procedures to be followed by employees who remain to operate critical plant operations before they evacuate
- A procedure to account for all employees after the emergency evacuation has been completed
- Rescue and medical duties for those employees who are to perform them
- Preferred means of reporting fires or other emergencies
- Names or regular job titles of persons or departments who can be contacted for further information or explanation of duties under the plan

If the decision has been made to evacuate and rely on outside responders, an EAP is required.

An employer using an EAP must have and maintain an employee alarm system. The employee alarm system must use a distinctive signal for each purpose and comply with the requirements in 29 CFR 1910.165.

The employer must designate and train employees to assist in a safe and orderly evacuation of other employees. A full listing of functions is in the workplace specific EAP. OSHA guidance in developing an EAP is shown here: https://www.osha.gov/SLTC/etools/evacuation/implementation.html.

The EAP must be in writing at the worksite and available to workers if there are more than 10 employees; for smaller workplaces, the plan can be transmitted verbally. The EAP is reviewed with each worker when hired, newly assigned or there is a change in the plan.

An EAP is an evacuation plan, not a response plan.

The employer must review the emergency action plan with each employee covered by the plan when the plan is developed or the employee is assigned initially to a job, when the employee's responsibilities under the plan change and when the plan is changed.

The EAP must be in writing, kept in the workplace, and available to employees for review. For an employer with 10 or fewer employees only, the EAP may be communicated orally to employees.

Employee Alerting Systems - ERP or EAP

Both the ERP and EAP require use of alerting systems.

In order to alert all employees to the presence of an emergency situation, an alarm system must be in place. The alarm system must produce a signal (noise, light, etc.) that can be perceived by all employees in the affected area of the site. All alarms must be distinct and recognized as signaling a specific action.

The procedure for reporting an emergency is part of the site-specific training. When telephones are used to report, emergency telephone numbers must be posted near them or in conspicuous locations. If another communication system is used, the emergency message will have priority over all other messages transmitted. All manually- operated warning systems used to supplement the alarm must be unobstructed, conspicuous, and readily accessible for use. The employer shall ensure that all components of the alarm system are approved for the work site and operating properly. After use (for testing or alarm), the system

must be returned to normal operation as soon as possible by the employer. Back-up parts or systems must be available as appropriate.

The system must be tested at least every two months. If several methods are available to activate the system, a different method must be used for each successive test. The system must be operational at all times, unless it is undergoing repairs or maintenance. Maintenance work must be done by trained personnel.

Communication is the Key

NIMS was established to improve communication among public sector responders and those seeking assistance by using a uniform set of terms.

- An ERP should include NIMS terms
- Training must include NIMS terms
- Training coordination with outside responders is detailed in the ERP

Private sector employers are not required to use NIMS, but use may facilitate communication with responders who likely include public sector employees.

NIMS-trained personnel, such as local fire department responders, may assist at work sites covered by an EAP.

- Plan for communication by meeting with responders BEFORE an incident
- Update responders when changes are made to the EAP
- Train with outside personnel included in the EAP

If you have an EAP, **it is critical** that outside personnel who may be called to the workplace be aware of your terminology, and you of theirs.

ERP or EAP - communicate **in advance** with responders who may assist when the plan is activated; if possible do drills or tabletop exercises with responders.

When an emergency occurs, the priorities are, in order:

1. Life
2. Stabilization of the incident
3. Property

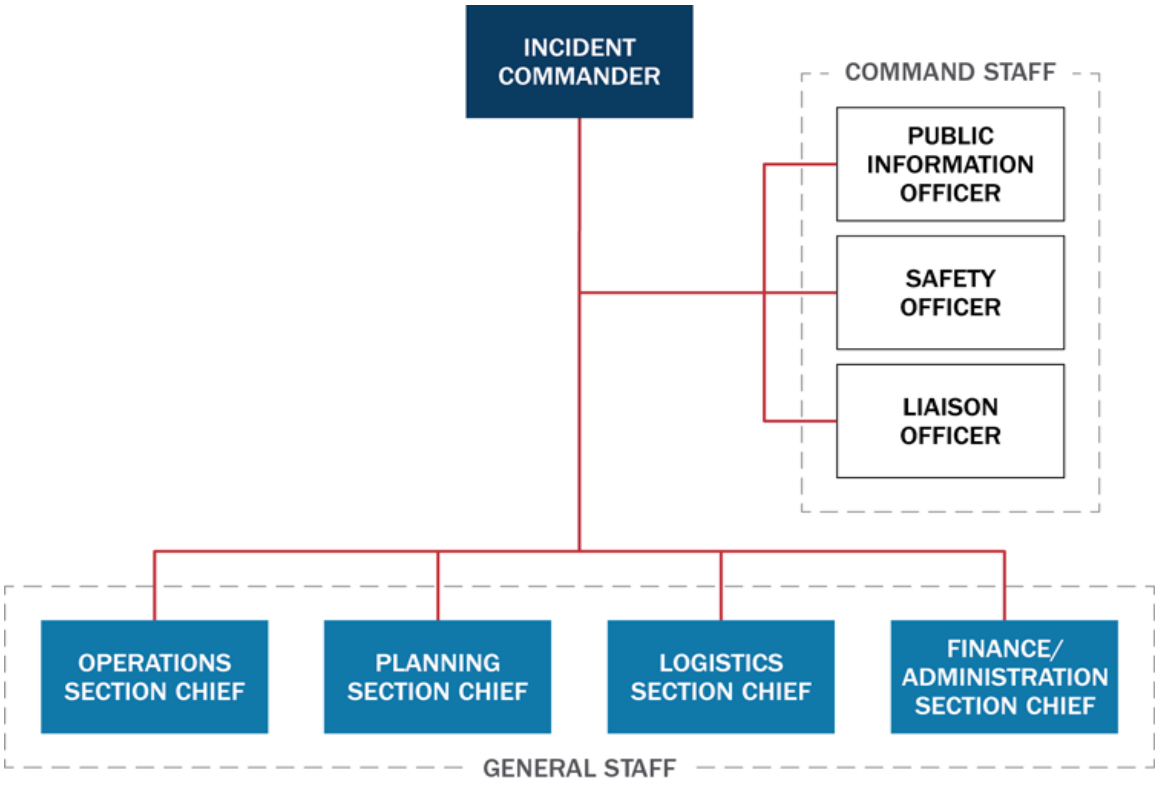
Make sure you know where to go and what to do before an emergency occurs.

When it happens, it's too late to read the plan!

Incident Command System

The Incident Command System (ICS) illustrates an organizational structure for incident management that coordinates the procedures, personnel, equipment, facilities and communication.

An example of the structure of a response team follows, using the standard terms in the National Incident Management System (NIMS). This system was promoted after the 9/11 attack where the need for uniform terminology was identified as essential to ensure effective communication between parties.



Source: https://www.fema.gov/sites/default/files/2020-07/fema_nims_doctrine-2017.pdf

Key functions of the Incident Commander (person in charge of a response), and response team members in the Command Staff and General Staff are shown below: (reference under figure above).

Incident Commander – (The person in charge who oversees all aspects of the response)

Functions:

- Establishes a single Incident Command Post (ICP) for the incident
- Establishes consolidated incident objectives, priorities, and strategic guidance, and updating them every operational period
- Selects a single section chief for each position on the General Staff needed based on current incident priorities
- Establishes a single system for ordering resources
- Approves a consolidated Incident Action Plan (IAP) for each operational period
- Establishes procedures for joint decision making and documentation
- Captures lessons learned and best practices

Command Staff (see figure above)

Public Information Officer (PIO)

Functions:

- Interface with public, media and/or other agencies with information needs
- Gathers, verifies, coordinates and disseminates information to both internal and external parties
- Monitors the media and other sources and provides information to relevant components of the responders
- Releases accurate information concerning the incident after it is cleared by the Incident Commander

Safety Officer

Functions:

- Reports directly to the Incident Commander
- Monitors incident operations
- Advises the IC on health and safety matters of incident personnel
- Establishes the systems and procedures to assess, communicate and mitigate hazardous environments
    - Developing and maintaining the Safety Plan
    - Coordinating safety efforts
    - Implementing measures to promote safety
- Stops or prevents unsafe acts

Liaison Officer

Functions:

- IC's point of contact for representatives from agencies such as fire and law enforcement or other jurisdictions
- Receives input from outside groups to Maintains communication between outside agencies and in-house response
- Point of contact to facilitate coordination of assisting or cooperating agencies or jurisdictions

General Staff (see figure above)

Operations Section, led by Section Chief

Functions:

- Section Chief appointed by the IC; assigned personnel may change as the incident evolves

- Directing management of tactical activities to achieve objectives established by the IC
- Developing and implementing strategies and tactics to achieve incident objectives
- Section Chief organizes the group to meet the needs, maintain manageable span of control and optimize use of resources
- Supporting Action Plan development for each part of the response

Planning Section, led by Section Chief

Functions:

- Collect, evaluate and disseminate incident information to the IC or other personnel
- Prepare status reports, display information, maintain the status of resources
- Facilitate the incident action planning process and prepare the incident Plan sing input from other sections and command staff and IC guidance
- Facilitate incident planning meetings
- Record status of resources and anticipated needs
- Collecting, organizing, displaying and disseminating status information and analyzing the situation as it changes
- Planning for the orderly, safe and efficient demobilization of resources
- Collecting, recording and safeguarding incident documents

Logistic Section, led by Section Chief

Functions:

- Ordering, receiving, storing/housing and processing incident-related resources
- Providing ground transportation during an incident, maintaining and supplying vehicles, keeping vehicles usage records and developing incident traffic plans
- Setting up, maintaining, securing and demobilizing incident facilities
- Determining food and water needs, including ordering food, providing

cooking facilities, maintaining food service areas and managing food security and safety (in cooperation with the Safety Officer)
- Maintaining an incident Communications Plan and acquiring, setting up, issuing, maintaining and accounting for communications and IT equipment
- Providing medical services to incident personnel

Finance/Administration Section, led by Section Chief

Functions:

- Tracking costs, analyzing cost data, making estimates and recommending cost savings measures
- Analyzing, reporting and recording financial concerns resulting from property damage, responder injuries or fatalities at the incident
- Managing financial matters concerning leases and vendor contracts
- Managing administrative databases and spreadsheets for analysis and decision making
- Recording time for incident personnel and leased equipment

Additional functions may be integrated into the ICS. For example, in a response that could involve criminal activity, an Intelligence/Investigations Section might be activated by the IC. The basic ICS structure is flexible and can be scaled for more complex incidents, including events that involve multiple geographical or governmental jurisdictions or take place in more than one location.

Unified Command

When multiple jurisdictions or agencies are involved in a response, the use of Unified Command enables those in charge of each authority to jointly manage and direct response activities through a common set of incident objectives, strategies and a single Incident Action Plan (IAP). In Unified Command, there is not a single Incident Commander, rather each participating partner maintains authority, responsibility and accountability for its personnel and other resources. Each member of the Unified Command assumes responsibility to inform other members of the Unified Command of activities.

Exercise – What should be done?

In this exercise, you will use a Mock Safety and Health Plan (for training purposes only) to identify appropriate actions for several scenarios. See Exercise Guide.

Summary – Emergency Response

Potential unintentional or unexpected spills or releases at a hazardous waste site may occur and require preparation through pre-planning and practice.

Emergency response actions follow predetermined plans that have specified content:

- Emergency Response Plan (ERP) for on-site response using an Incident Command System (ICS)
- Emergency Action Plan (EAP) for evacuation

An alerting system is used to inform everyone on site of an emergency condition.

The training required for all workers is detailed in the written plans.

Closing and Program Evaluation

Thank you for participating in this program.

This is an opportunity to ask any questions you may have, or to discuss how the knowledge and skills learned can be used at work. Were all of your initial questions answered?

Please take the next 10 minutes to complete the program evaluation forms. These are important for improving the program. The Midwest Consortium does take your comments seriously and has made changes in content and the skill exercises based on feedback. Your comments are anonymous.

We hope to see you at another Midwest Consortium program in the future.

Appendix – bridge to 40H

Introduction

Welcome to the 16-Hour bridge to 40H. Completing these 16-hours will allow individuals who have already completed the 24-hour Hazardous Waste Worker course to upgrade their training to the 40-hour Hazardous Waste Worker course. Note that prior to starting full-time site work, 3 days of on-site field training with a supervisor are required to familiarize you with site-specific plans, potential exposures and work practices. Note that any participant who will participate in a hands-on exercise involving donning/doffing of supplied air respiratory protection must be evaluated by a health care professional using the fitness-for-training exam.

There will be some review of important concepts but much of the 16-hours will focus on hands-on exercises to develop the skills needed for hazardous site work.

Exercise – Respiratory Protection Lab

In this exercise, you will become familiar with SCBAs, APRs, egress units and equipment cleaning and inspection procedures. See Exercise Guide.

Exercise - PPE Lab

This lab will give you the opportunity to practice donning and doffing different levels of CPC, and to inspect it. See Exercise Guide.

Exercise - Work Practices Lab

In this lab, you will participate in work practices that may take place at a hazardous waste site. See Exercise Guide.

Exercise – Suit Up and Decon

During this lab, you will have an opportunity to inspect, don and doff PPE and participate in decon. See Exercise Guide.

Bringing it all Together

During this session, you look at simulated hazardous waste site work activities and prepare for working at various locations on the site in PPE, as you would during remediation activities.

Please practice the tasks (without PPE) and ask questions, including about safe work practices, the added stress of doing the activity in PPE and information resources that may be helpful in hazard assessment or identifying best practices

Site Simulation

The Site Simulation is a series of exercises designed to familiarize each program participant with the good work practices used at a hazardous waste site. At a simulated site, each trainee will don, doff and decontaminate respiratory and other personal protective equipment. During the simulation, a site set up with the various work zones, pairs of trainees utilizing the Buddy System will participate in specific tasks such as segregating, overpacking, handling, identifying and sampling drums and decontaminating tools and equipment (or other tasks relevant to future work).

After the simulation, a critique of the simulation will be conducted.

A Skills Performance Checklist is provided to document your activities. See Exercise Guide.