CPWR
THE CENTER FOR CONSTRUCTION
RESEARCH AND TRAINING

40-Hour Hazardous Waste Worker

PARTICIPANT MANUAL

Revised February 2026

CPWR

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40-Hour Hazardous Waste Worker Participant Manual

Revised April 2025

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Introduction

CPWR – The Center for Construction Research and Training conducts research and administers specific types of construction health and safety training for members of our consortium partners, and the North American Build Trades Unions (NABTU). Our overriding goal in all the training we deliver is to enable and empower these construction workers to recognize potentially unsafe working conditions, and to identify proper ways to eliminate or control those hazards that make conditions unsafe.

However, this in no way ever relieves the employers from their primary responsibility of providing workers with a safe and healthful workplace.

The Occupational Safety and Health Administration (OSHA) has written regulations (29 CFR 1926.65 and 1910.120) to make sure that workers at hazardous waste sites are properly protected. These regulations require that contractors plan their work carefully, and that they use the right equipment and work methods. A very important part of the OSHA regulation is that workers must be given either forty hours of training with an additional three days of supervised site-specific training for general site workers on a hazardous waste site, or twenty-four hours of training with one day of site-specific training for treatment, storage, and disposal and specialized task workers.

This Hazardous Waste Worker Course, developed by CPWR for the Construction Consortium for Hazardous Waste Worker Training, meets all requirements for the initial twenty-four or forty-hour training. More importantly, it has been designed to meet your needs. The course has been prepared for building trades workers, by building trades workers, and is meant to be taught by experienced tradespeople.

This course will help you to learn about your legal rights and responsibilities, how to recognize and control hazards, how to obtain information about hazardous materials, and how to use and decontaminate respirators and protective clothing. You will also learn about correct work practices, air and medical monitoring, and emergency response.

The CPWR Hazardous Waste Worker Course has been designed to be clear, direct, and to involve you actively in the learning process.

- Learning objectives, found at the beginning of each chapter, tell you what you will be expected to be able to do after you finish the training.
- Brief case studies demonstrate the importance of the information and skills taught.
- The information that you need is stated in clear, non-technical language wherever possible. Technical or unfamiliar concepts are carefully explained.
- Classroom discussions, demonstrations, and activities will involve you actively in the learning process to help you become confident in your ability to use what you learn.
- Hands-on workshops give you the opportunity to practice putting on, wearing, and decontaminating protective equipment.
- Your instructors are always available to explain any material that is not clear.

It is CPWR's goal that every trainee leave the Hazardous Waste Worker Course with the basic skills, knowledge, and confidence that he or she needs to work safely at hazardous waste sites, and that they will be better able to protect themselves on all their jobs. With your active participation, we are confident that we will meet that goal.

Students wearing Level A protective suits experience how difficult it can be to communicate. Here they are receiving instructions for their work assignment in a simulated hazardous waste site.

A CPWR instructor closely monitors not only how well the students accomplish their assigned task, but also observes their safety while wearing this very restrictive equipment.

In addition to class lectures and discussion, students are assigned to solve specific problems in groups, just as they would as part of a work crew.

Students perform both a negative and positive seal check on the respirators they will be using while dressed out in Level B protective clothing. A properly sealed face mask will help protect workers from exposures to hazardous chemicals when they begin work on an actual hazardous waste site.

Students often express amazement at the amount of information they learn in the 40-hour Hazardous Waste Worker class. For many, this class is the first experience they've had that focuses first on their own health and safety.

WARNING

The material was prepared for use by experienced instructors 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 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 procedures, 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 procedures are given in detail.

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 understand how to recognize and respond to alarms at the site and can carry out any role that may be assigned during a response.

For information about further training, consult the training instructor, your company safety and health plan, your company health and safety representative, or your union health and safety representative.

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Chapter 1:
Legal Rights and Responsibilities

The Occupational Safety and Health Administration (OSHA) is responsible for setting and enforcing regulations governing worker safety and health at hazardous waste sites. Other federal and state agencies are responsible for protecting the community, environmental, and transportation system from hazardous materials. Your employer must provide a workplace free from recognized hazards that are causing or likely to cause death or serious physical harm to its employees. Your employer must provide the necessary hazard controls, training, and protective equipment to reduce exposure to hazardous substances. You are responsible for knowing and following the employer's safety rules.

Chapter Objectives:

After completing this module, you will be able to:

1. Identify which government agencies are responsible for aspects of safety, health, and environmental protection.
2. Describe the information you need in OSHA regulations.
3. Discuss your health and safety rights on the job.
4. Identify your health and safety responsibilities.

Introduction

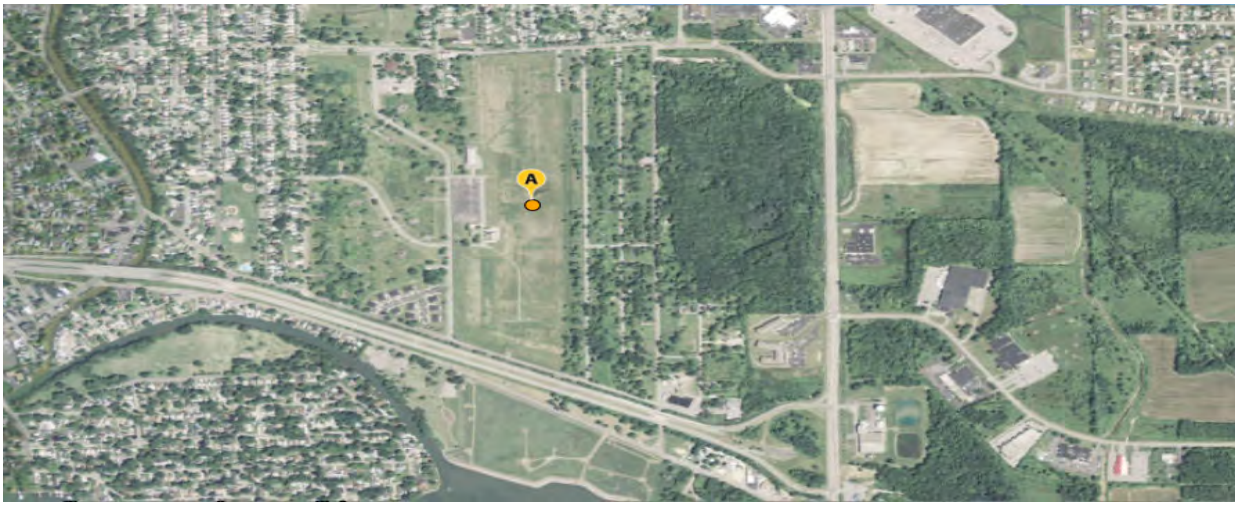
Hazardous waste has been generated for centuries. As mankind learned to process minerals, create dyes, and tan leather, leftover waste products have been affecting workers, the public, and the environment.

During the Industrial Revolution, various hazardous wastes were produced due to rapid industrialization and technological advancements. Factories and machinery used oils for lubrication and cooling. These oils often became contaminated with heavy metals, solvents, and other harmful substances. Toxic inks and dyes from printing and the textile industry were frequently dumped around the printing sites and textile mills. Paint strippers and solvents were being developed to meet industry needs. Early plastics used toxic chemicals such as phenol and formaldehyde.

Disposal of these wastes was not regulated, nor did science understand the true problems of improper disposal. Unused or underutilized land, bogs, marshes, and areas that needed filling around the industrial process were ideal places to dump the contaminated waste from the factories. The prevailing thoughts of the day were out of sight, out of mind.

During World War II, the US Army Corps of Engineers began a nation-wide search for three rural sites that would be suitable to produce the first **nuclear weapons**. After an extensive search, they found three primary locations across the country: Hanford, Washington; Los Alamos, New Mexico; and Oak Ridge, Tennessee. A massive industrial complex was built at Oak Ridge to enrich uranium and eventually serve as the headquarters for the nationwide project. Only six months after breaking ground on the Oak Ridge plutonium pilot plant, an enormous industrial complex for producing plutonium was built at Hanford. In early 1943, a bomb design and development laboratory was set up at Los Alamos, New Mexico.

During the war, waste management took a back seat to more immediate **radiation health and safety** precautions. Given wartime urgency, Manhattan Project leaders in many cases pursued waste management policies that offered interim solutions to a long-term problem that would have to be addressed in peacetime. Furthermore, no formal regulatory standards existed to dictate safe practices at Manhattan Project sites. These policies led to many hazardous waste sites from World War II and the Cold War. The U.S. Department of Energy's (DOE) Office of Environmental Management's (EM) mission is to address the nation's Cold War environmental legacy resulting from decades of nuclear weapons production and government-sponsored nuclear energy research. This legacy includes some of the world's most dangerous radioactive sites with large amounts of radioactive waste, spent nuclear fuel, excess plutonium and uranium, thousands of contaminated facilities, and contaminated soil and groundwater.



Love Canal, located in Niagara Falls, New York, is still one of the worst environmental tragedies in American history. William T. Love's vision was to create a model city powered by a short canal connecting the upper and lower Niagara Rivers. However, economic fluctuations and technological advancements thwarted his dream.

In the 1920s, the abandoned canal became a chemical dumpsite, with the Hooker Chemical Company depositing nearly 22,000 tons of hazardous waste, including polychlorinated biphenyls (PCBs), dioxin, and pesticides. By 1953, the canal was covered with earth and sold to the city for a mere dollar. In the late 1950s, around 100 homes and a school were built on the site. In 1978, the truth emerged: 82 different compounds, including 11 suspected carcinogens, had been leaching upward through the soil. The rotting drum containers released their toxic contents into backyards and basements.

Love Canal is a stark reminder of how not to manage hazardous waste. It revealed the urgent need for regulations and cleanup effort. It led to the creation of the Superfund program, which addresses hazardous waste sites nationwide.

There is no single definition of a hazardous waste site. The contaminants, size of the site, duration of cleanup, and other aspects of hazardous waste sites vary widely. For example, a hazardous waste site could be a military base contaminated with heavy metals, an abandoned industrial facility contaminated with chlorinated solvents, a chemical spill on a highway, or a chemical plant following an explosion.

Just as there is no single definition of a hazardous waste site, there is no one universal cleanup method. In the early days of hazardous waste cleanup, rusty barrels of chemicals were put into new drums and buried again in pits lined with plastic sheets. Tons of contaminated dirt were also dumped over the drums in these “safer” landfills. In 1984, the Environmental Protection Agency (EPA) made it illegal to put hazardous waste in common landfills (the land ban). Since that time, scientists have been coming up with new ways to treat hazardous waste and to clean up water or soil.

In this chapter, we will examine some of the laws and standards that provide protections for workers, the public, and the environment.

Hazardous Waste Legislation

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, also known as Superfund, authorized government money for the cleanup of abandoned hazardous waste sites and compensation to injured victims. In 1986, the Superfund Amendments and Reauthorization Act of 1986 (SARA) continued funding efforts to determine which locations belonged on the National Priority List (NPL). Currently, there are over 1,300 active sites on the NPL, with new sites being proposed and many sites having been deleted. In addition, completed construction for remediation has been reported for over 1,200 sites. In 1986, SARA also mandated that OSHA establish worker safety and health standards for hazardous waste operations, and establish requirements for workers and management. The Hazardous Waste Operations and Emergency Response (HAZWOPER) standard was established in response to SARA. This legislation mandated the Occupational Safety and Health Administration (OSHA) to create regulations that protect workers during hazardous waste operations and emergency responses.

The goal of HAZWOPER is to ensure the safety and wellbeing of workers engaged in cleanup operations at uncontrolled hazardous waste sites and those responding to hazardous substance releases. By providing specific training requirements and guidelines, HAZWOPER equips workers with the necessary knowledge and skills to handle hazardous materials effectively.

The Resource Conservation and Recovery Act (RCRA) is our nation’s primary law governing the disposal of solid and hazardous waste. RCRA was signed into law on October 21, 1976, to address the increasing problems the nation faced from our growing volume of municipal and industrial waste. RCRA was an amendment to the Solid Waste Disposal Act of 1965, which was the first statute that specifically focused on improving solid waste disposal methods.

RCRA gives EPA the authority to control hazardous waste from the “cradle-to-grave.” This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances.

Other Federal Agencies with Hazardous Materials Responsibilities

OSHA is the most important agency for protecting workers on Superfund sites. The following additional government agencies may be involved in hazardous waste operations:

Environmental Protection Agency (EPA)

- Protects our air, land, and water from pollution.
- Regulates the cleanup of hazardous waste sites (Superfund).
- Requires testing of chemicals before they are sold and the disposal of hazardous materials.

Department of Transportation (DOT)

- Regulates the transportation of hazardous materials by land and air.
- Requires labels, placards, manifests, and shipping containers.

United States Coast Guard (USCG)

- Regulates the transportation of hazardous materials on navigable waters.
- Involved in cleaning oil and chemical spills.

Nuclear Regulatory Commission (NRC)

- Regulates community and worker exposure to radiation hazards.

National Institute of Occupational Safety and Health (NIOSH)

- Approves respiratory protection equipment.
- Conducts research.
- Publishes workplace Recommended Exposure Limits (RELs).

Department of Energy (DOE)

- Responsible for controlling hazards to workers and environmental hazards at nuclear weapons sites.

Federal Emergency Management Agency (FEMA)

- Coordinates preperation for, response to, and recovery from disasters.

United States Army Corps of Engineers (USACE)

- Civilian and uniformed personnel provide engineering services.
- Involved in disaster response and recovery.

Occupational Safety and Health Administration (OSHA)

OSHA's purpose is to write and enforce regulations to protect the health and safety of workers, both in general and more specifically in the HAZWOPER Standard.

Your employer has the responsibility to:

Provide a safe and healthy workplace free from recognized hazards that are causing or likely to cause death or serious physical harm. This is Section 5(a)(1) of the OSH Act.

Comply with OSHA Standards:

Both Construction Industry Standards 29 CFR 1926 and General Industry Standards 29 CFR 1910 may be used on a hazardous waste site. If there is a conflict between the two standards, the most protective will be used and enforced.

The employee has the responsibility to:

The employee must follow the employer's safety rules and wear the provided personal protective equipment (PPE). The employees cannot be fined by OSHA for violations but may be disciplined by the employer for violation workplace safety rules. Employees have the responsibility to bring safety and health concerns to the attention of the employer or union. Section 11 (c) of the OSH Act protects the worker from discrimination or harassment for exercising their OSHA Rights.

The employee has the right to:

File a complaint with OSHA over health and safety issues at the worksite and be represented by yourself, union steward, or your appointed representative during an OSHA inspection. You may talk/meet privately with an OSHA inspector.

Be informed of imminent danger. An OSHA compliance officer must inform you of imminent dangers found at the worksite. The compliance officer will also ask the employer to stop the activity until corrective actions can be taken.

Be informed of health hazards and get copies of test results done in the workplace to identify the hazards. You or your representative have the right to documents related to your exposure to the health hazards at the worksite.

Be told about OSHA citations. Notices of OSHA citations must be posted on the worksite where the violation occurred for a period of at least three days or until the hazard is corrected.

Appeal abatement dates for fixing hazards.

Access your medical records. You or your representative have the right to see and copy any medical records about you that the employer has generated. Your employer must keep your medical records for 30 years past your last date of employment. If you are employed less than one year, your employer can maintain your records or give them to you when you leave employment. The Department of Energy (DOE) record retention requirement is 75 years.

OSHA Hazardous Waste Operations and Emergency Response (HAZWOPER)

The OSHA Hazardous Waste Operations and Emergency Response standard is commonly called HAZWOPER. In the construction standards, it is **29 CFR 1926.65** and in general industry standards, it is **29 CFR 1910.120**. The intent of both standards is the same and their contents are similar.

Example:

HAZWOPER (29 CFR 1926.65) **Table of Contents:**

Topic:
Scope, application, and definitions
Safety and health program
Site characterization and analysis
Site control
Training
Medical surveillance
Engineering controls, work practices, and ppe
Monitoring
Informational programs
Handling drums and containers
Decontamination
Emergency response by employees at uncontrolled hazardous waste sites
Illumination
Sanitation at temporary workplaces
New technology programs
Operations under RCRA 1976
Emergency response to hazardous substance releases
Appendix A: Personal protective equipment test methods
Appendix B: General description and discussion of the levels of portion and protective gear
Appendix C: Compliance guidelines
Appendix D: References
Appendix E: Training curriculum guidelines

The HAZWOPER standard was designed to maintain the safety and health of workers at hazardous waste sites and during emergency response (1926.65, paragraph (a)).

The standard covers clean-up required by:

- Local, state, or federal government;
- Voluntary clean-up of hazardous waste sites; and
- Emergency response following the release of hazardous substances — unless the employer can demonstrate that employee exposure to safety and health hazards is unlikely.

A hazardous waste site can include:

- A few buried barrels of chemicals;
- A decommissioned nuclear facility with millions of gallons of liquid hazardous waste;
- Millions of cubic feet of solid hazardous waste;
- Contaminated ground water.

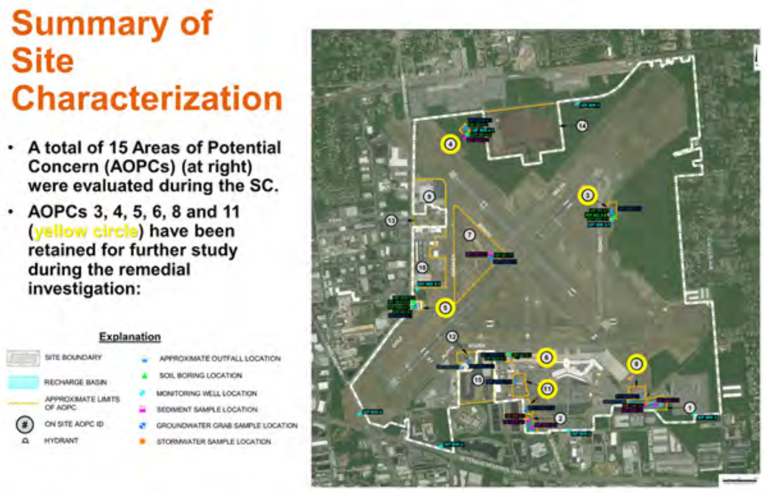
The range of conditions possible at hazardous waste sites makes obtaining site-specific information and providing site-specific plans, procedures, and controls necessary.

Your employer must write and follow a safety and health program (1926.65, paragraph (b)).

The program must identify, evaluate, and control safety and health hazards and provide for emergency response at hazardous waste sites. The written safety and health program must be available to anyone involved with the hazardous waste operation and the site-specific safety and health plan, contained in the program, and must be kept on site. The details about how to do the cleanup must be worked out in advance. The safety and health program will be discussed in detail in further chapters.

Site characterization must be done before cleanup begins on a hazardous waste site (1926.65, paragraph (c)).

Site characterization identifies safety and health hazards, determines the degree of the hazards, and determines the initial requirements for personal protective equipment. Workers who will work on the site must be informed of the results of the site characterization.



Summary of Site Characterization

- A total of 15 Areas of Potential Concern (AOPCs) (at right) were evaluated during the SC.
- AOPCs 3, 4, 5, 6, 8 and 11 (yellow circle) have been retained for further study during the remedial investigation:

A site control program for protecting workers must be implemented before cleanup begins on a hazardous waste site (1926.65, paragraph (d)).

The program must include:					
Site maps	Work zones	Use of a “buddy system”	Site communications	Standard operating procedures	Location of the nearest medical assistance

Working on a hazardous waste site requires initial, on site, and refresher training (1926.65, paragraph (e)).

Training for General Site Workers and Supervisors - 1926.65(e)(3)(i)

This 40-hour training is just one part of the special trainings OSHA requires you to have before you may work on a hazardous waste cleanup site. After you finish this general training, you need three days of actual field experience under the direct supervision of a trained, experienced supervisor. Site specific training for each location is required in addition to the offsite training and field experience. Supervisors and onsite management will need an additional 8 hours of specialized training.

Training for Temporary Site Workers - 1926.65(e)(3)(ii & iii)

Workers who are on a site that has been fully characterized or who are on a site for a specific task, and are unlikely to be exposed above the Permissible Exposure Limit, require 24 hours of training plus 1 day of actual field experience under the direct supervision of a trained, experienced supervisor.

Training for Workers: Treatment, Storage, and Disposal Only - 1926.65(p)(7)

Workers at a Treatment, Storage, and Disposal facility, as defined by 40 CFR 264 and 265, require 24 hours of training plus site-specific training for their respective assignments.

In addition to the above requirements, all workers are required to attend 8 hours of refresher training annually.

OSHA requires employers to provide medical surveillance (exams and tests) before, during, and at the end of a job on a hazardous waste site (1926.65, paragraph (f)).

A medical surveillance program is a required part of the safety and health program. Medical surveillance can indicate that workers will be able to wear the required PPE while working in temperature extremes, that they do not have an illness from chemical exposure on prior jobs, and that they are not sick from being overexposed to chemicals on the current job.

Medical surveillance must be provided by the employer for the following workers:

1. All workers who are or may be exposed to hazardous substances or health hazards at or above the PEL or another published exposure level (if no PEL) for 30 days or more a year;

2. All workers who wear a respirator for 30 days or more a year or as required by 1910.134;
3. All workers who are injured, become ill, or show symptoms due to possible overexposure to hazardous substances from an emergency response or clean-up; and
4. Members of hazardous materials response (HAZMAT) teams.

Note: Medical clearance must be obtained before a respirator is used, even if the respirator will be used for less than 30 days per year.

Employers must make medical examinations available to each employee who falls into one or more of the above categories. Medical exams must be conducted:

1. Before a new job assignment;
2. At a frequency determined by the doctor but not exceeding once every two years;
3. When a job ends, unless the last exam was less than 6 months before;
4. Following signs or symptoms indicating possible overexposure to hazardous substances or health hazards; or
5. Following injury or exposure above the Permissible Exposure Limit or other occupational exposure limit in an emergency situation.

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 must be provided at no cost to the worker, without loss of pay, and at a reasonable time and place. A physician will decide on the content of the examination.

You should explain to the physician the type of work you do, the potential health risks, and the type of protective equipment that you wear on the job. At a minimum, medical exams must include a medical and work history. They should also include a complete physical, lung function test, hearing test, and an EKG for your heart.

Your employer must give the physician:

1. A copy of OSHA’s HAZWOPER standard (29 CFR 1926.65);
2. Your job description;
3. Your current or anticipated exposure levels;
4. A description of personal protective equipment used or to be used;
5. Information from previous examinations that the physician may not have; and
6. Information required by OSHA’s Respiratory Protection standard (29 CFR 1910.134).

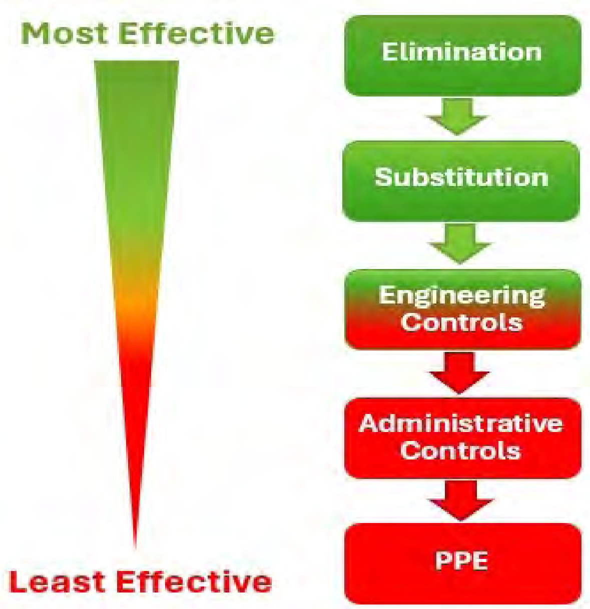
Your employer must give you a copy of the doctor's written report, including:

1. Medical conditions that would make hazardous waste work or respirator use particularly risky for you;
2. Recommended limitations on your assigned work;
3. Results of the exam and tests, if you request them; and
4. A statement that the doctor has told you about the exam results and any conditions that require further examination or treatment.

The report your employer receives from the physician can only discuss findings related to your work. Any medical conditions unrelated to your job must not be revealed to the employer. You have the right to a copy of the physician's full report.

Your employer must keep medical and exposure records for as long as you are employed, plus another 30 years. If you work for your employer for less than a year, they do not have to keep your records provided that they give them to you when you leave. The Department of Energy (DOE) record retention requirement is 75 years.

Controls must be used to protect employees from exposure to hazardous substances and safety and health hazards (1926.65, paragraph (g)).



Controlling exposures to hazards in the workplace is vital to protecting workers. The hierarchy of controls is a way of determining which actions will best control exposures. The hierarchy of controls identifies a preferred order of actions to best control hazardous workplace exposures. Elimination, substitution, and engineering controls are more effective because they control exposures without significant human interaction. Administrative controls and personal protective equipment can also be effective at reducing workers' exposures to hazards.

Moving or opening barrels, drums, and containers can result in injuries and requires special precautions (1926.65, Paragraph (j)).

A 55-gallon metal drum full of gasoline weighs about 400 pounds while the same drum full of bromine will weigh almost 1,500 pounds. It is important to know what is in a drum and how full it is before trying to move it. Dropping a drum can seriously injure a worker. Some chemicals can explode if they are dropped. Spilled chemicals can mix and start a fire or cause an explosion. Employers must write a plan for how they will handle drums to prevent injuries.

Decontamination procedures must be in place before entering areas where potential for exposure to hazardous substances exists (1926.65, Paragraph (k)).

Every time you leave a contaminated work area, you will go through decontamination to make sure you do not track chemicals out of the work area on your work clothes or on your skin. All equipment (even trucks) must go through decontamination.

Photo courtesy of United States Department of Defense (U.S. DoD)

OSHA states that employers must evaluate the danger to employees and the effectiveness of new cleanup technologies (1926.65, Paragraph (o)).

Inventors and scientists are coming up with new ways to clean up hazardous waste all the time. Some methods make the cleanup easier, some reduce worker exposure, and some do both. For example, at some hazardous waste cleanup sites, workers blast thousands of volts of electricity through waste, changing it into a solid. This process, called vitrification, traps the hazardous waste in the rock-like material.

Photo courtesy of U.S. DOE

The employer must write and implement an emergency response plan (1926.65, paragraph (q)).

Things can go wrong during a cleanup. There can be a fire or explosion, workers can be poisoned by gases or hit by a forklift, or large amounts of chemicals can spill. The actions taken in the initial minutes of an emergency are critical. Prompt action and warnings can save lives, minimize physical damage to structures and property, and allow for better resilience. Every site must develop and implement an emergency plan to protect employees.

Photo courtesy of FEMA

Hazard Communication Standard

The OSHA Hazard Communication Standard for Construction (29 CFR 1926.59) requires employers to set up a hazard communication (HazCom) program for the chemicals they bring on site. This standard points you to the General Industry standard 29 CFR 1910.1200. The HazCom standard applies to all hazardous materials that are not hazardous waste. The HazCom standard applies to all hazardous materials that are not hazardous waste. Materials covered by the HazCom program include drum solvents, vehicle maintenance products, and chemicals used to treat waste or chemicals for portable toilets. A copy of this standard can be found on the OSHA website.

Labels and Other Forms of Warning - 1910.1200 (f)

Regulations for labels on incoming containers (not hazardous waste):

- Hazardous chemicals must be labeled with chemical identity, hazard warnings, and name and address of manufacturer.
- Employers must ensure that all containers of hazardous chemicals are labeled (except for portable containers used by a single employee during a single shift).

Safety Data Sheets (SDS) - 1910.1200 (g)

Employers must keep Safety Data Sheets (SDSs) at the work site so that everyone can find information about the dangers of the chemicals they work with and how to protect themselves.

- Manufacturers and distributors must forward SDSs to the purchaser with the first shipment, and with the first shipment after an SDS is updated.
- Employers must get and keep SDSs for each hazardous chemical in their workplace.
- SDSs must be filled out completely and accurately.
- Electronic or paper copies of SDSs must be accessible to workers during all shifts.
- SDSs are not required for hazardous waste found on site, but the hazards and controls for the waste must be determined before cleanup work starts.

Employee Information and Training - 1910.1200 (h)

Employers must train workers on the hazardous chemicals in their work areas at initial assignment and when new hazards are introduced. Training must include the requirements of the OSHA HazCom Standard and how to understand information on labels and SDSs. Workers must be trained on the hazards of the materials used in their areas and how to recognize exposure. Workers must be told the location of the employer’s written hazard communication program, SDSs, and hazardous chemical lists.

Summary: Legal Rights and Responsibilities

The agency in charge of health and safety at work is the Occupational Safety and Health Administration (OSHA). In some states, the U.S. government enforces regulations and in other states, it is the state government.

The OSH Act sets up both employee and employer rights and responsibilities. A major employer responsibility is to provide a workplace free of recognized safety and health hazards likely to cause serious physical harm. A major worker responsibility is to follow proper employer safety rules and to wear personal protective equipment when required.

OSHA regulations important to hazardous waste workers include:

The **Hazardous Waste Operations and Emergency Response (HAZWOPER) Standard (29 CFR 1926.65 for construction or 29 CFR 1910.120 for general industry)**. It protects the safety and health of hazardous waste site workers, and includes:

- Safety and Health Plan that addresses:
  - hazards on site
  - monitoring
  - hazardous waste cleanup plan/work practices
  - personal protective equipment
  - decontamination
  - medical surveillance
  - emergency procedures
- Medical exams (medical surveillance)
- Decontamination – personnel and equipment
- New cleanup methods (new technology)
- Moving barrels of waste (drum handling)
- Training for workers and supervisors
- What to do in an emergency (emergency response plan)

Notes:

Notes:

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Chapter 2:
Health Effects

Chemical, physical, biological, and radiological hazards are found at hazardous waste sites. You need to know how to recognize hazards and the signs and symptoms of exposure in order to protect yourself, others, and the environment. This chapter covers health effects and hazardous properties of chemicals.

Chapter Objectives:

After completing this module, you will be able to:

1. Describe what is meant by the term ‘toxicology’ and how it affects people.
2. Describe the health hazards, both chemical and biological, as they relate to hazardous waste work.
3. Explain the difference between acute and chronic health effects.
4. List and explain the five routes of exposure.
5. Describe the body’s defense system.
6. Explain the body’s reaction to chemical and physical hazards.
7. Describe the different exposure limits and what is meant by the time-weighted average.

Introduction

One of the main concerns when working on a hazardous waste site is the safety and health of the workers. Workers and employers must work together to ensure this. According to OSHA, employers are responsible for providing workers with a safe and healthy workplace, while workers are responsible for following all the employer's safety and health rules, including the proper use of personal protective equipment (PPE).

Hazardous waste sites can be more dangerous than a typical construction job site. They may contain chemical, physical, biological, and radiological hazards. To better protect yourself, others, and the environment, you need to know how to recognize hazards and the signs and symptoms of exposure. This chapter covers the health effects that hazardous waste workers may encounter if they do not protect themselves properly.

Toxicology

Toxicology is the study of poisons and their adverse health effects. Some of the examples of toxic health effects (toxic response) from being exposed to poisons include:

- Nausea, dizziness, and eye, throat, and airway irritation caused by inhaling smoke from your first cigarette.
- Slurred speech, dizziness, nausea, and vomiting caused by too much alcohol.
- Diseases and difficulty breathing caused by years of working with concrete that contains crystalline silica.

Exposures can be brief, occur over many years, or somewhere in between. Adverse health effects may be immediate, not evident for many years, or somewhere in between.

Health Hazards

Health hazards can be the result of exposure to any of these three hazard groups:

- Chemical hazards
- Biological hazards
- Physical hazards

Chemical Hazards

Chemicals hazards are forms of chemicals that include medications, solutions, gases, vapors, aerosols, and particulate matter that are potentially toxic or irritating to the body.

Chemical reaction is a process in which one or more substances, the reactants, are converted to one or more different substances. Substances are either chemical elements or compounds. A chemical reaction between two chemicals may become more dangerous to a worker’s health. An example of this is mixing bleach with ammonia, which produces toxic gases called chloramines. Exposure to chloramine gases can cause coughing, nausea, irritation to the throat, nose, and eyes, and escalate to pneumonia and fluid in the lungs.

Biological Hazards

Biological hazards found on hazardous waste sites are usually related to the presence of infectious waste on the site or related to the physical environment of the hazardous waste site itself. Precautions for biological hazards are similar to those for chemicals – skin and respiratory protection is typically required. You and your coworkers should take special care to ensure that cuts or scrapes are not exposed in any way.

Infectious Waste

Infectious waste normally comes from hospitals and medical laboratories. In the past, such waste was usually discarded with few precautions. Currently, regulations require that infectious waste be disposed of in special red bags. The bags are marked with the international biohazard symbol.

Like chemicals, infectious waste can be scattered throughout an area by wind and water. Special precautions are taken when handing biological waste. Infectious waste is not usually found mixed with industrial waste. However, sludge from sewage treatment plants is the exception. Sludge tends to resemble other chemical waste in appearance.

Wastewater

Wastewater is any water that has been adversely affected by human activity. It comprises liquid waste that is discharged by homes, commercial properties, agriculture, or industry. Such water may contain organic hazards such as bacteria and viruses (pathogens) from animal or human waste, blood, or body parts, as well as chemical or inorganic waste and toxins from oils, detergents, solvents, pesticides, and herbicides, as well as acids or bases.

Bacteria

Bacteria are one-celled living organisms. All bacteria are surrounded by a cell wall. They can reproduce independently and inhabit virtually every environment on earth, including soil, water, hot springs, ice packs, and the bodies of plants and animals.

Fungi

Fungi are plantlike organisms that lack chlorophyll. Many fungi are harmless, such as edible mushrooms, while others cause problems. Some fungi can cause health effects in people. There are over 100,000 species of fungi.

Histoplasmosis is an infection caused by inhaling a fungus called “histoplasma capsulatum.” The Histoplasma fungus is common in soil, especially in soil contaminated by pigeon or bat droppings. The disease is transmitted to humans by airborne fungi spores rising from the soil. Although primarily associated with soil, the fungus has been found in droppings, particularly from bats, alone.

Viruses

A virus is a microscopic organism that infects cells in biological organisms. Viruses are intracellular organisms — they can reproduce only by invading and controlling other cells as they lack the cellular machinery for self-reproduction. They are tiny structures that can only reproduce inside a living cell. Outside of a living cell, a virus is dormant. Once inside, the virus takes over the resources of the host cell and produces more virus particles. Viruses are more similar to mechanized bits of information, or robots, than to animal life. Viruses may be found in biological waste, including wastewater.

Animals, Insects, and Plants

Sometimes animals and insects on a hazardous waste site can play a role in the infection process. For example, rodents at the site can be carriers of the rabies virus. Certain types of ticks carry microorganisms that can cause Rocky Mountain spotted fever and Lyme disease. Mosquitoes spread West Nile Virus. Unlike chemicals, biological hazards contain living organisms that use the human body as a host.

In addition, plants and wildlife present their own natural hazards. Poison ivy, poison oak, and poison sumac can cause severe skin irritation. Depending on the region of the country in which you are working, you may also have to be on the lookout for poisonous reptiles and spiders, such as rattlesnakes, copperhead snakes, and scorpions.

Physical Hazards

A physical hazard is any harmful level of electromagnetic radiation, noise, vibration, temperature, or light. A physical hazard includes any chemicals classified to be one of the following:

- Compressed gas
- Explosive
- Flammable
- Organic peroxide
- Pyrophoric
- Unstable or water reactive

On any jobsite, you have numerous hazards that employers are required to protect you from and to provide you with PPE for as needed. The following is a list of some of the onsite physical hazards:

- Heat stress
- Cold stress
- Ergonomic hazards
- Jobsite hazards

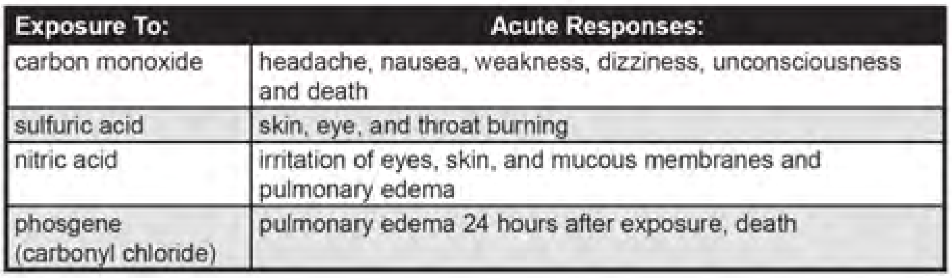
Health Effects

Health effects from being exposed to hazards can be immediate or delayed. These are known as:

- Acute Health Effects
- Chronic Health Effects

Acute health effects usually appear immediately or shortly after, usually within 72 hours of exposure. Acute effects are usually caused by a short-term (acute) exposure. Acute health effects may disappear soon after the exposure ends, or the damage may be permanent.

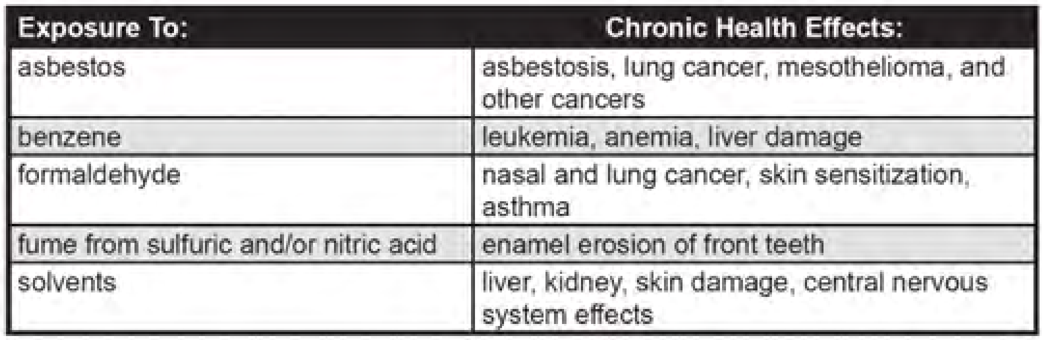
Some examples of acute effects include:



Exposure To:	Acute Responses:
carbon monoxide	headache, nausea, weakness, dizziness, unconsciousness and death
sulfuric acid	skin, eye, and throat burning
nitric acid	irritation of eyes, skin, and mucous membranes and pulmonary edema
phosgene (carbonyl chloride)	pulmonary edema 24 hours after exposure, death

Chronic health effects occur many months or years after exposure and are often the result of long-term, often low-level, exposure to a chemical. With some chemicals, chronic health effects can result from short-term exposures.

You may not notice any effects from exposure to a chemical with chronic health effects for many years. You generally do not feel the damage as it is being done. For example, long-term exposure to asbestos can cause asbestosis, lung cancer, and other cancers, but it does not scratch your throat or give you any early warning that it is dangerous. Some examples of chronic effects include:



Exposure To:	Chronic Health Effects:
asbestos	asbestosis, lung cancer, mesothelioma, and other cancers
benzene	leukemia, anemia, liver damage
formaldehyde	nasal and lung cancer, skin sensitization, asthma
fume from sulfuric and/or nitric acid	enamel erosion of front teeth
solvents	liver, kidney, skin damage, central nervous system effects

Types of Health Effects

Types of health effects include:

- Local: occurs at the point of contact on the body.
- Systemic: occurs at another part of the body other than the point of contact.

Routes of Exposure

Chemicals can affect our bodies in different ways. Most chemicals can enter the body and get into our blood stream by more than one route. Chemicals can also cause extreme damage by just coming in contact with your skin. The toxicity of a chemical may differ depending on how your body was exposed, and it may not be a hazard if it can't get into your body.

The lungs generally offer the least resistance to a chemical entering your body, which is why inhalation is our biggest concern. Inhaling metallic mercury (also known as elemental mercury or quicksilver) is generally more hazardous than ingesting it. This is because 80 percent of inhaled metallic mercury enters the blood through the lungs while less than 0.01 percent of what is ingested enters the blood via the stomach and intestines. Another example would be ingesting large amounts of vitamin D, which can be acutely toxic, but skin contact does not present a hazard because vitamin D is not absorbed through the skin.

The main routes of exposure are:

- Inhalation
- Ingestion
- Absorption
- Contact
- Injection

Inhalation

Inhalation, or breathing in, is the most common way that chemicals get into your body. Inhaling chemicals can do more damage to you because they are absorbed quickly through the lungs and into the bloodstream, where they reach the entire body.

Inhaling small particles and fibers can lead to them ending up deep in the lungs. These particles and fibers can cause diseases or even cancer. For instance, breathing in silica dust can cause silicosis over time and can even lead to lung cancer.

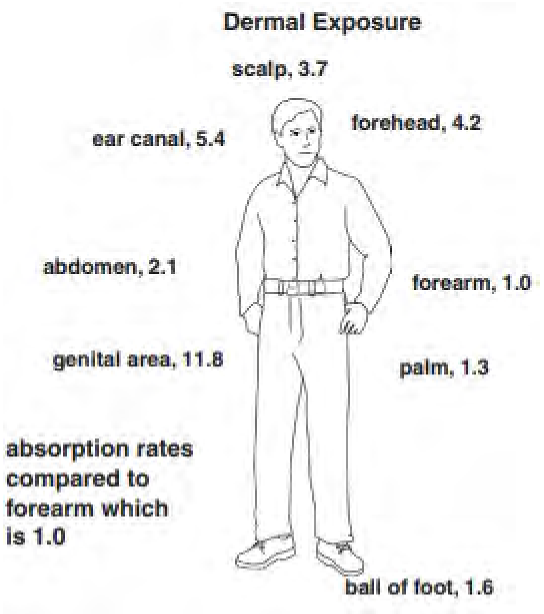
Ingestion

Ingestion is the act of swallowing. It mainly consists of eating and drinking, but ingestion can occur unintentionally by hand to mouth contact, such as smoking. Toxic particles can be ingested when proper hygiene isn't used before a worker eats, drinks, or smokes. Toxic particles are also ingested when you swallow the mucous that has trapped them. The ingestion of toxic particles can lead to tumors in the body and/or cancer in colon, spleen, and other areas of the body.

Absorption

Absorption is a route of entry that may occur through the skin. Absorption can also occur through the gastrointestinal (GI) tract, lungs, and eyes. In hazardous waste work, absorption can happen when a chemical goes through the skin and travels into the body. Many chemicals used in the workplace can damage organs if they penetrate the skin and enter the bloodstream. Examples include pesticides and organic solvents.

Different areas of the body absorb chemicals at different rates. The rate of absorption varies with skin thickness, water content, and fat content. Some chemicals will pass through your skin more quickly if your skin has been exposed to water for an extended period of time (for example, wearing sweaty gloves all day). The rate of absorption will also increase if the skin has been irritated, damaged, punctured, or exposed to chemicals that break down fat in the skin. The relative rate of absorption is compared to a part of the body with a low rate of absorption. This graphic compares the chemical absorption rate of some parts of the body to the absorption rate of the feet. Chemicals may cause allergic or irritant dermatitis following skin contact.



Contact

If your skin comes in contact with some chemicals, they do not get absorbed but can cause serious damage to your skin. There are many acidic and alkaline chemicals that could cause this kind of damage to your dermis.

Injection

Injection occurs when a sharp object, such as a needle, punctures the skin and injects a chemical or a virus into the bloodstream. In some instances, chemicals may enter the body by unintentional injection through the skin. This may occur in hospitals. Once in the bloodstream, chemicals can be transported to any site or organ in the body where they may do internal damage.

Body's Defense Systems

The body does have defense systems to help trap and try to get rid of contaminants. They include:

- Coughing
- Cilia
- Macrophages

Coughing

The body's systems can be sensitive to anything from outside the body. This sensitivity can cause a person to cough, which can get rid of foreign particles from the body and prevent them from getting deep into lungs.

For example, some large particles and fibers can be trapped by the hair in your nose, causing you to cough, which expels the foreign particles from the body.

Cilia

Your body's defense system also has mucous and cilia, which are small, mucous-coated hairs that move upward in a constant wave. The mucous protection starts in your nose/sinuses. The cilia begin in your upper airways, and with their constant movement, they sweep the mucous that has trapped foreign particles. By moving this contaminated mucus upward, it can be prevented from getting into the lungs and eliminated through either coughing or being swallowed (ingested). One thing to be aware of is that smoking can temporarily paralyze the cilia, which allows foreign particles to get past these defenses and deep into your lungs. In order to better protect yourself from chronic health effects, quit smoking immediately.

Macrophages

According to the National Cancer Institute, macrophages are part of the body's immune system, a type of white blood cell that surrounds and kills microorganisms, removes dead cells, and stimulates the action of other immune system cells. Macrophages help to keep small particles from reaching deep into the lungs by digesting them with acids or enzymes. An example of when macrophages are not effective is with asbestos fibers or crystalline silica dust. In these cases, the macrophages cannot digest them and can lead to the development of fibrosis, which is the thickening or scarring of the lung tissue, which can lead to asbestosis or silicosis.

Body’s Reaction to Chemical, Physical, and Biological Hazards

The health effects from chemical and physical hazards include injuries and illnesses, damage to organs, temporary health effects and long-term diseases, minor symptoms to life-threatening conditions, and death. Exposure to biological hazards (blood, bodily fluids, rodent or bird droppings) could cause serious physiological reactions in your body.

A few examples are provided below, and specific types of health effects will be discussed in detail.

Head (nervous system): dizziness, headaches, stress nervousness, irritability, sleeplessness, tremors, speech changes.

Liver and kidneys: damaged while trying to filter the chemicals out of the blood.

Ears: ringing, temporary deafness, hearing loss.

Teeth and Gums: corrosion of enamel, blue/discolored gums.

Eyes: redness, irritation, watering, grainy feeling, welder’s flash.

Nose and Throat: sneezing, coughing, sore throat, nasal cancer.

Chest and Lungs: wheezing, congestion, shortness of breath with mild exercise, flu-like symptoms (metal fume fever).

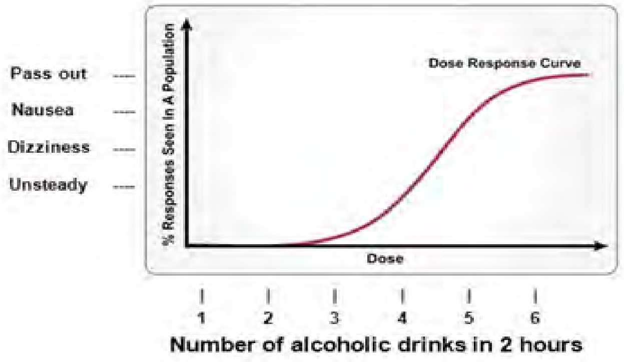
Muscles, Tendons, and Joints: soreness, inflammation, tendinitis.

Reproductive System: miscarriage, irregularities in menstruation, damage to fetus or chromosomes, low sperm count, sterility.

Stomach and Intestines (gastrointestinal tract): vomiting, diarrhea.

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

The following is an example of the dose response curve to show how people respond to toxic chemicals. A higher dose means a greater response from the body. The following example shows how people respond to a number of alcoholic drinks in two hours.



Several factors influence each person's response to a certain dose, or amount, of a chemical. This is true whether the chemical is the alcohol we drink, the medicine we take, or a solvent used at work.

Factors that affect an individual's response to a toxic chemical include:

- Body weight
- Occupation
- Physical and health condition
- Exposure to other chemicals (now or in the past)
- Gender
- Heredity factors
- Age
- Lifestyle (smoking, nutrition)

The body processes chemicals in three ways, they include:

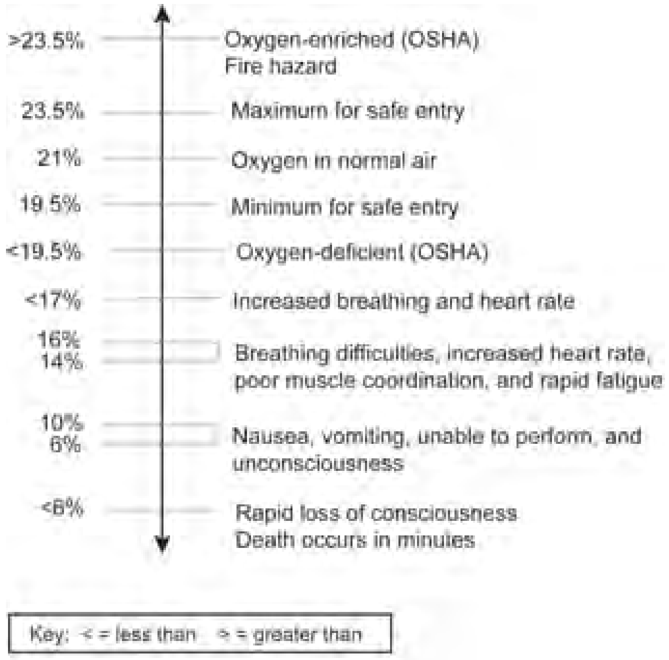
1. **Metabolize** (break down) the chemical into a form that is more easily separated and removed from the body. Most chemicals are metabolized in the liver, but other organs, including the lungs, kidneys, skin, stomach, and intestines can be involved in metabolizing chemicals too. Often the chemical is altered to be more water soluble (easier to excrete) and less toxic.
2. **Excrete** the chemical or the byproducts of its metabolism in urine, feces, sweat, exhaled air, or hair.
3. **Store** the chemical byproducts of its metabolism in the bones, fat, or other tissues. Lead is an example of a material that can be stored in your body.

Chemicals are often classified by how they harm us. The following are classes of chemical hazards:

Asphyxiants

Asphyxiants are chemicals that interfere with getting oxygen to body tissues and can cause suffocation. There are two kinds of asphyxiants: simple asphyxiants and chemical asphyxiants.

1. **Simple Asphyxiants:** Simple asphyxiants take the place of (displace) oxygen in the air so there is less oxygen available to be brought into the body. There are many simple asphyxiants that may be found on construction and hazardous waste sites. Carbon dioxide, ethane, helium, hydrogen, methane, neon, krypton, acetylene, nitrous oxide, argon, propane, and nitrogen are simple asphyxiants.



An atmosphere with less than 19.5 percent oxygen by volume is considered oxygen deficient and immediately dangerous to life and health. The health effects experienced depend on the duration of oxygen deficiency, work rate, breathing rate, temperature, health, and age. Adverse health effects, such as reduced reaction times, may begin at 19 percent oxygen but may not be immediately noticeable or recognized. These percentages are for measurements taken at sea level — adjustments must be made for higher elevations.

2. **Chemical Asphyxiants**: Chemical asphyxiants reduce your body's ability to provide oxygen to its tissues, even when there is plenty of oxygen in the air. Carbon monoxide is an example that attaches to your red blood cells 250 times more strongly than oxygen. The red blood cells are necessary to keep our bodies properly oxygenated.

Chemical asphyxiants can interfere with the following:

- Oxygen getting into your blood
- Oxygen being transported to body tissues
- Oxygen being taken up by tissues
- A combination of the three

Even at low levels or following brief exposures, chemical asphyxiants can cause collapse, unconsciousness, and death. Hydrogen cyanide, hydrogen sulfide, and methylene chloride are other examples of chemical asphyxiants that you might encounter on a jobsite.

Irritants

An irritant causes inflammation through direct contact with the skin, eyes, nose, mouth, or respiratory system. Irritants can also be allergens.

Two types of irritants are:

1. **Respiratory Tract Irritants:** Respiratory tract irritants can cause injury to the nose, mouth, throat, and lungs. Inhaled irritants can harm any part of the respiratory tract, but their water solubility determines where they will do the most damage. Materials that are more water-soluble (e.g., ammonia, formaldehyde, and sulfur dioxide) affect mainly the upper respiratory tract as they come in contact with moist tissues in the nose and throat. Less water-soluble materials (e.g., nitrogen dioxide and phosgene) act deeper in the lungs (lower respiratory tract).

   Chlorine (Cl) and ozone (O3) are examples of chemicals that often affect both the upper and lower respiratory tract. Respiratory tract irritation can be relatively minor, such as a tightening of the chest or bronchitis. But it may also be very serious, as in the case of pulmonary edema (fluid in the lungs), and cause death.

2. **Skin Irritants:** Skin irritants can cause redness, itching, and drying of the skin, which is known as contact dermatitis. Organic solvents and detergents are examples of skin irritants. Some acids, such as sulfuric acid, are irritants at low concentrations but can cause burns and destroy tissue at higher concentrations.

Sensitizers

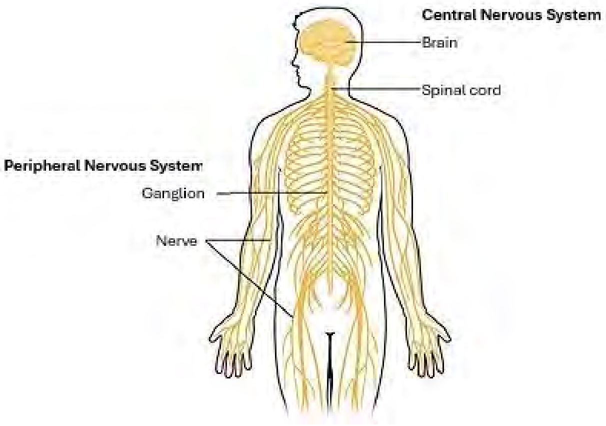
A sensitizer is a chemical that can cause an allergic reaction in the body. After repeated exposures to chemicals known as allergic sensitizers, some people become allergic and develop a reaction to even small exposures to those chemicals. Allergic sensitizers generally affect the skin and respiratory tract, and the reaction may get worse with each exposure. The symptoms are often similar to those caused by irritants, but they can occur at locations other than where the chemical came in contact with the body. An example of such symptoms is asthma (inflammation and narrowing of the airways in the lungs) following skin contact with isocyanates. As with irritants, the response can be very serious and may even cause death.

Sensitizers include toluene, isocyanates, formaldehydes, phenol resins, epoxy resins, chromium, and nickel.

Toxins

A toxin is a substance that can be poisonous or cause negative health effects. Any chemical can be toxic or harmful under certain conditions.

1. **Systemic Toxins:** affect body systems other than the ones they come into contact with. This is different from local health effects, such as skin irritation or burns from contact with an acid, which occur at the point of contact with the chemical. An example of systemic toxicity is the central nervous system (brain) depression caused by exposure to alcohol. Potassium cyanide is a systemic toxicant in that it affects virtually every cell and organ in the body by interfering with the cell's ability to use oxygen. Chemicals can also cause local health effects such as irritation at the site of contact (skin, eyes, and lungs).
2. **Blood System Toxins:** damage blood cells or interfere with blood cell formation by damaging our bone marrow. Examples include benzene, methylene chloride, arsine, phosphorus, and naphthalene.
3. **Nervous System (Neuro) Toxins:** damage the central nervous system (brain) or peripheral nervous system. Symptoms include dullness, muscle tremors, restlessness, convulsions, loss of memory, epilepsy, and loss of muscle coordination. Examples include mercury, insecticides, hexachlorophene, and lead.



4. **Liver (Hepato) Toxins:** cause liver damage and produce symptoms including jaundice and liver enlargement. Examples include alcohols, carbon tetrachloride, and nitrosamines.
5. **Kidney (Renal or Nephro) Toxins:** damage the kidneys. Examples include halogenated hydrocarbons, heavy metals, and ethylene glycol.
6. **Reproductive Toxins:** damage the reproductive cells (egg and sperm) or interfere with their formation. Examples include DBCP, lead, cadmium, cellosolve, and vinyl chloride.

Carcinogens

Carcinogens cause cancer and must be listed on an SDS if the chemical is listed in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest edition) or found to be a potential carcinogen by OSHA. Cancer is the uncontrolled growth of malignant (harmful) cells at any site in the body. Cancer can take 20 to 30 years after exposure to develop. Carcinogens include crystalline silica, vinyl chloride, asbestos, methylene chloride, toluene-2, and 4-diisocyanate.

Teratogens

Teratogens cause birth defects in a developing fetus. Many teratogens can affect the fetus even before the woman knows she is pregnant. Examples include thalidomide, anesthetic gases, methyl ethyl ketone (MEK), xylene, methylene chloride, lead, methyl mercury, cigarette smoke, and ionizing radiation.

Mutagens

Mutagens cause a change (mutation) in your genetic material. Mutation of the reproductive cells may cause birth defects in future children. Mutation of other cells in the body may cause cancer. Many mutagens are also carcinogens. Examples of mutagens include ethylene oxide (a sterilizing chemical used in hospitals), benzene, hydrazine, and ionizing radiation.

Physical Hazards

Physical hazards are workplace agents, factors, or circumstances that can cause damage to the body. A physical hazard can also include many chemicals classified as one of the following:

- Compressed gas
- Explosive
- Flammable
- Organic peroxide
- Pyrophoric
- Unstable or water reactive

Physical hazards include:

- Heat stress
- Cold stress
- Noise
- Ergonomic hazards

Heat Stress

Workers who are exposed to extreme heat or work in hot environments may be at risk of heat stress. Exposure to heat stress can result in occupational illnesses and injuries. Heat stress can result in heat rash, heat cramps, heat exhaustion, and heat stroke.

Workers at risk of heat stress include outdoor workers and workers in hot environments such as firefighters, construction workers, hazardous waste workers, miners, and others. Because of the added stress of wearing PPE, hazardous waste workers are susceptible to heat stress.

Heat Rash

Heat rash is a skin irritation caused by excessive sweating during hot, humid weather. Symptoms include red clusters of pimples or small blisters. A heat rash usually appears on the neck, upper chest, groin, under the breasts, and in elbow creases.

Workers experiencing heat rash should:

- Work in a cooler, less humid environment, if possible.
- Keep the rash area dry.
- Apply powder to increase comfort.
- Do not use ointments and creams
- Shower daily
- Wear clean clothing

Heat Cramps

Heat cramps usually affect workers who sweat a lot during strenuous activity. This sweating depletes the body's salt, mineral, and fluid levels. Low salt levels in muscles cause painful cramps. Heat cramps may also be a symptom of heat exhaustion.

Symptoms of heat cramps include muscle cramps, pain, or spasms in the abdomen, arms, and legs.

Workers with heat cramps should:

- Drink water and have a snack or a drink that replaces carbohydrates and electrolytes (such as sports drinks) every 15 to 20 minutes
- Avoid salt tablets
- Get medical help if the worker starts cramping and has any of the following:
  - Has heart problems
  - Is on a low sodium diet
  - Has cramps that do not subside within one hour

Heat Exhaustion

Heat exhaustion is the body's response to an excessive loss of fluids, minerals, and salt, usually through excessive sweating.

Heat exhaustion is most likely to affect:

- The elderly
- People with high blood pressure
- Those working in a hot environment

Symptoms of heat exhaustion include:

- Headache
- Nausea
- Dizziness
- Weakness
- Irritability
- Thirst
- Heavy sweating
- Elevated body temperature
- Cold clammy skin
- Decreased urine output

Treat a worker who has heat exhaustion by doing the following:

- Have someone stay with the worker
- Remove the worker from the hot area and give liquids to drink
- Remove unnecessary clothing, including shoes and socks
- Cool the worker with cold compresses or have the worker wash their head, face, and neck with cold water
- Encourage frequent sips of cool water

Heat Stroke

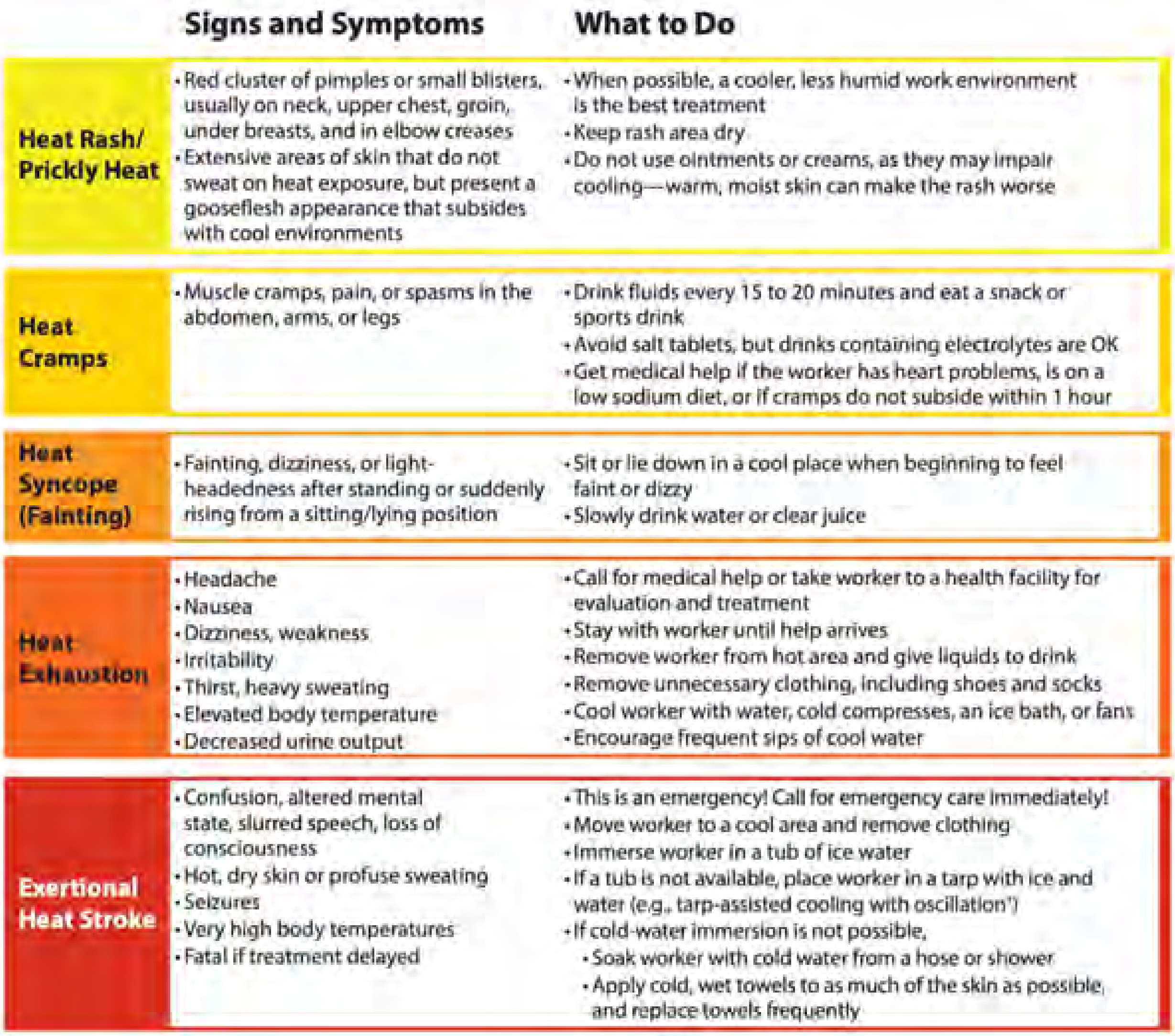
Heat stroke is the most serious heat-related illness. It occurs when the body can no longer control its temperature. The body's temperature rises rapidly, the sweating mechanism fails, and the body is unable to cool down through evaporation. When heat stroke occurs, the body temperature can rise to 106°F or higher within 10 to 15 minutes. Heat stroke can cause permanent disability or death if the person does not receive emergency treatment.

Symptoms of heat stroke include:

- Confusion, altered mental status, slurred speech
- Loss of consciousness (coma)
- Red, hot, dry skin
- Lack of sweating
- Seizures
- Very high body temperature
- Fatal if treatment is delayed

Take the following steps to treat a worker with heat stroke:

- Call 911 for emergency medical care
- Stay with the worker until emergency medical services arrive
- Move the worker to a shaded, cool area and remove outer clothing
- Cool the worker quickly, using the following methods:
    - With a cold water or ice bath, if possible
    - Wet the skin
    - Place cold, wet cloths on the skin
    - Place cold wet cloths or ice on the head, neck, armpits, and groin
    - Soak clothing with cool water
    - Circulate the air around the worker to speed cooling



	Signs and Symptoms	What to Do
Heat Rash/ Prickly Heat	• Red cluster of pimples or small blisters, usually on neck, upper chest, groin, under breasts, and in elbow creases • Extensive areas of skin that do not sweat on heat exposure, but present a gooseflesh appearance that subsides with cool environments	• When possible, a cooler, less humid work environment is the best treatment • Keep rash area dry • Do not use ointments or creams, as they may impair cooling—warm, moist skin can make the rash worse
Heat Cramps	• Muscle cramps, pain, or spasms in the abdomen, arms, or legs	• Drink fluids every 15 to 20 minutes and eat a snack or sports drink • Avoid salt tablets, but drinks containing electrolytes are OK • Get medical help if the worker has heart problems, is on a low sodium diet, or if cramps do not subside within 1 hour
Heat Syncope (Fainting)	• Fainting, dizziness, or light-headedness after standing or suddenly rising from a sitting/lying position	• Sit or lie down in a cool place when beginning to feel faint or dizzy • Slowly drink water or clear juice
Heat Exhaustion	• Headache • Nausea • Dizziness, weakness • Irritability • Thirst, heavy sweating • Elevated body temperature • Decreased urine output	• Call for medical help or take worker to a health facility for evaluation and treatment • Stay with worker until help arrives • Remove worker from hot area and give liquids to drink • Remove unnecessary clothing, including shoes and socks • Cool worker with water, cold compresses, an ice bath, or fans • Encourage frequent sips of cool water

Exertional Heat Stroke	• Confusion, altered mental state, slurred speech, loss of consciousness
	• Hot, dry skin or profuse sweating
	• Seizures
	• Very high body temperatures
	• Fatal if treatment delayed
		• This is an emergency! Call for emergency care immediately!
		• Move worker to a cool area and remove clothing
		• Immerse worker in a tub of ice water
		• If a tub is not available, place worker in a tarp with ice and water (e.g., tarp-assisted cooling with oscillation")
		• If cold-water immersion is not possible,
		  • Soak worker with cold water from a hose or shower
		  • Apply cold, wet towels to as much of the skin as possible, and replace towels frequently

Cold Stress

Workers who are exposed to extreme cold or work in cold environments may be at risk of cold stress. Extreme cold weather is a dangerous situation that can lead to health emergencies in susceptible people, such as those without shelter, outdoor workers, and those who work in an area that is poorly insulated or without heat.

What constitutes cold stress, and its effects, can vary across different areas of the country. In regions unaccustomed to winter weather, near freezing temperatures are considered factors for cold stress. Whenever temperatures drop below normal and as wind speed increases, heat can leave your body more rapidly. These weather-related conditions may lead to serious health problems. Types of cold-related illnesses include hypothermia, frostbite, trench foot, and chilblains.

Hypothermia

When exposed to cold temperatures, your body begins to lose heat faster than it is produced. Prolonged exposure to cold will eventually use up your body's stored energy. The result is hypothermia, or abnormally low body temperature. A body temperature that is too low affects the brain, making you unable to think clearly or function effectively. This makes hypothermia particularly dangerous because a person may not know it is happening and will not realize they need to do anything about it.

Symptoms of hypothermia can vary depending on how long you have been exposed to the cold temperatures.

Mild Hypothermia: your core body temperature is 90-95°F. Symptoms may include the following:

- Shivering and chattering teeth
- Feeling exhausted
- Slow movements and reactions
- Feeling sleepy
- Weak pulse
- Faster-than-normal heart rate
- Fast breathing
- Pale skin color
- Confusion
- Excessive peeing

Moderate Hypothermia: your core body temperature is 82-90°F. Symptoms may include the following:

- Slowdown in breathing and heart rate
- Speech is garbled
- Trouble thinking straight
- Hallucinations
- Less shivering
- Bluish color on lips, fingers, and skin
- Muscle stiffness
- Abnormal heart rhythm
- Low blood pressure
- Loss of consciousness takes this to a medical emergency and 911 needs to be called

Severe Hypothermia: your core body temperature is lower than 82°F. This level is considered a medical emergency and calling 911 would be appropriate. Symptoms may include the following:

- No more shivering (a sign that your heat regulation systems are not working)
- Low blood pressure
- Loss of consciousness
- No reflexes
- Fluid in lungs
- Unable to move voluntarily
- Combative
- Low amount of pee
- Heart stops beating
- Possible coma or death

Take the following steps to treat a worker with hypothermia:

- Alert the supervisor and request medical assistance.
- Move the victim into a warm room or shelter. Protect the person against wind, drafts, and further heat loss.
- Remove their wet clothing.
- Warm the center of their body first—chest, neck, head, and groin—using an electric blanket, if available, or use skin-to-skin contact under loose, dry layers of blankets, clothing, towels, or sheets.
- Provide warm beverages as they may help increase the body temperature, but DO NOT give alcoholic beverages. Do not try to give beverages to an unconscious person.
- After their body temperature has increased, keep the victim dry and wrapped in a warm blanket, including the head and neck.
- If the victim has no pulse, begin cardiopulmonary resuscitation (CPR) and call 911.

Frostbite

Frostbite is an injury to the body that is caused by freezing. Frostbite causes a loss of feeling and color in the affected areas. It most often affects the nose, ears, cheeks, chin, fingers, or toes. Frostbite can permanently damage body tissues, and severe cases can lead to amputation. In extremely cold temperatures, the risk of frostbite is increased in workers with reduced blood circulation and among workers who are not dressed properly.

Symptoms of frostbite include:

- Reduced blood flow to hands and feet (fingers or toes can freeze)
- Numbness
- Tingling or stinging
- Aching
- Bluish or pale, waxy skin

Workers suffering from frostbite should:

- Get into a warm room as soon as possible.
- Unless absolutely necessary, do not walk on frostbitten feet or toes—this increases the damage.
- Immerse the affected area in cold to barely warm, but not hot water (the temperature should be comfortable to the touch for unaffected parts of the body).
- Warm the affected area using body heat—for example, the heat of an armpit can be used to warm frostbitten fingers.
- Do not rub or massage the frostbitten area, doing so may cause more damage.
- Do not use a heating pad, heat lamp, or the heat of a stove, fireplace, or radiator for warming. Affected areas are numb and can be easily burned due to the nerve endings being affected by the cold/frozen tissue.

Trench Foot

Trench foot, also known as immersion foot, is an injury of the feet resulting from prolonged exposure to wet and cold conditions. Trench foot can occur at temperatures as high as 60°F if the feet are constantly wet. Injury occurs because wet feet lose heat 25 times faster than dry feet. Therefore, to prevent heat loss, the body constricts blood vessels to shut down circulation in the feet. Skin tissue begins to die because of lack of oxygen and nutrients and due to the buildup of toxic products.

Symptoms of trench foot include:

- Reddening of the skin
- Numbness
- Leg cramps
- Swelling
- Tingling pain
- Blisters or ulcers
- Bleeding under the skin
- Skin separating from the underlying small blood vessels
- If left untreated, gangrene (the foot may turn dark purple, blue, or gray)

Workers suffering from trench foot should:

- Remove shoes or boots and wet socks.
- Dry their feet, socks, and boots.
- Avoid walking on their feet, as this may cause tissue damage.

Chilblains

Chilblains are caused by the repeated exposure of skin to temperatures just above freezing to as high as 60°F. The cold exposure causes damage to the small blood vessels that supply the skin. This damage is permanent, and the redness and itching will return with additional exposure. The redness and itching typically occurs on cheeks, ears, fingers, and feet.

Symptoms of chilblains include:

- Redness
- Itching
- Possible blistering
- Inflammation
- Possible ulceration in severe cases

Workers suffering from chilblains should:

- Avoid scratching.
- Slowly warm the skin.
- Use corticosteroid creams to relieve itching and swelling.
- Keep blisters and ulcers clean and covered.

Noise

It is important for everyone to understand how occupational hearing loss can occur and how it can be prevented. Occupational hearing loss can occur when you are exposed to loud noise or ototoxic chemicals while at work.

- Noise is considered loud (hazardous) when it reaches 85 A-weighted decibels (dBA) or higher. A-weighted decibels are a scale for measuring noise. Hazardous noise can cause both hearing loss and tinnitus.
- Tinnitus is an annoying buzzing, rushing, or ringing noise in your ears or in your head that does not go away.
- Exposure to certain chemicals can cause damage to different parts of the ear, meaning they are ototoxic. Exposure to ototoxic chemicals can cause hearing loss and make the ears more sensitive to the harmful effects of noise. About 10 million workers are exposed to solvents and an unknown number are exposed to other ototoxicants.

The most common cause of hearing loss is exposure to loud noises. It is called Noise-Induced Hearing Loss and can be caused by a one-time exposure to a loud sound like an explosion (acute exposure) or by repeated exposure to sounds over 85 decibels for an extended period of time (chronic exposure).

Many construction workers lose their hearing at a young age, it is not just a problem for older workers. In fact, construction workers experience hearing loss at a younger age than the general population. According to NIOSH, the average 25-year-old construction worker has the hearing of a 50-year-old.

Signs of hearing loss include:

- Having difficulty hearing when there is background noise.
- Thinking people are mumbling when they talk to you.
- Needing to ask others to repeat themselves often.
- Turning up the radio in your vehicle at the end of the day.

Often, those close to you will notice that you have hearing trouble before you notice it yourself.

Ergonomics

Construction is one of the most hazardous industries in the United States. Some of the most common construction injuries are the result of job demands that push the human body beyond its natural limits.

Workers who must often lift, stoop, kneel, twist, grip, stretch, reach overhead, or work in other awkward positions to do a job are at risk of developing a work-related musculoskeletal disorder (WMSD) such as back problems, carpal tunnel syndrome, and tendonitis, to name a few. From 2021 to 2022, the rate of injuries resulting in one or more days away from work was 1.1 times higher among construction workers compared to those in all industries (13.9 versus 12.6 per 10,000 full-time workers). During this period, there were 19,460 back injuries among construction workers that resulted in one or more days away from work.

From 2021 to 2022, 6.6% or 33,240 work-related musculoskeletal disorder (MSD) injuries resulted with one or more days away from work occurred among construction workers.

Some solutions to reduce ergonomic issues include:

- Changing materials or work processes
- Changing tools and/or equipment
- Changing work rules and providing training

Occupational Exposure Limits

OSHA, NIOSH, and ACGIH are all organizations who want workers to be safe in any environment they work in. All three agencies have established Occupational Exposure Limits (OEL). Some OELs are legally enforceable, and some are recommendations for protective levels around the hazards we have been discussing. Exposure limits describe the maximum amount or concentration of chemical you can be exposed to.

Permissible Exposure Limits (PELs)

Permissible Exposure Limits (PELs) are legally enforceable exposure levels established by OSHA. PELs are regulatory limits on the amount or concentration of a substance in the air that a worker can be exposed to without incurring the risk of adverse health effects. They may also contain a skin designation. OSHA PELs are based on an eight-hour time weighted average (TWA) exposure.

Employers must try to implement the Hierarchy of Controls to eliminate or prevent an employee's exposure to any chemical or physical hazard. It would be best if the employers can create a work environment that keeps the employee below the established PELs. Even though they try to keep exposures below the PELs, they may have to provide the proper PPE for the employee's protection. NIOSH and non-governmental agencies (such as the American Conference of Governmental Industrial Hygienists) also establish limits, but these recommendations are not legally enforceable.

Threshold Limit Values (TLVs)

Threshold Limit Values (TLVs) are recommended exposure limits set by the American Conference of Governmental Industrial Hygienists (ACGIH), a private, non-governmental organization. In general, TLVs are NOT legally enforceable. Contractors on Department of Energy (DOE) sites are required to meet the 2016 TLVs when they are more protective (lower) than the OSHA PELs. TLVs are reviewed and updated annually and are usually more protective of human health than PELs.

Recommended Exposure Levels (RELs)

Recommended Exposure Levels (RELs) are set by NIOSH and are NOT legally enforceable. RELs are usually more protective of human health than PELs. Most PELs and TLVs are defined as average exposures over an eight-hour work shift. RELs are set for 10-hour days so they don't need to be adjusted when working 10-hour days. Some PELs, TLVs, and RELs have a "skin" notation, which means that the material is readily absorbed through the skin.

Short-Term Exposure Limits (STELs)

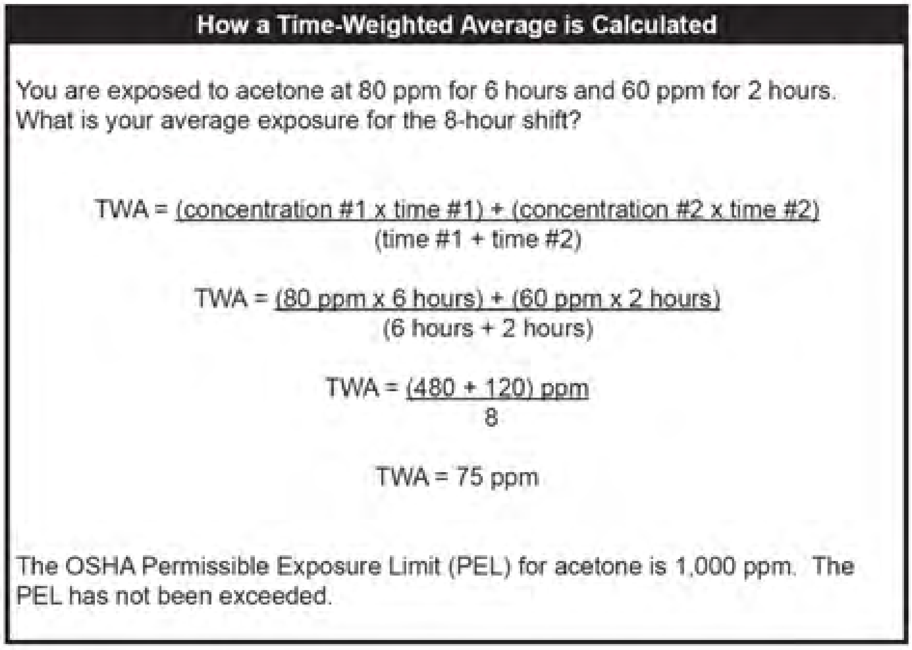
Short-Term Exposure Limits (STELs) are a maximum average concentration to which a person may be exposed for a short period of time, usually 15 minutes. It is legally enforceable if set by OSHA. NIOSH and ACGIH also have recommended STELs for some chemicals.

Ceiling Limit

The ceiling limit is an exposure level that must NOT be exceeded at any time. It is legally enforceable if set by OSHA.

Time-Weighted Average (TWA)

The time-weighted average (TWA) is an employee's average airborne exposure during any eight-hour work shift of a 40-hour work week that shall not be exceeded.



How a Time-Weighted Average is Calculated

You are exposed to acetone at 80 ppm for 6 hours and 60 ppm for 2 hours. What is your average exposure for the 8-hour shift?

$$\text{TWA} = \frac{(\text{concentration \#1} \times \text{time \#1}) + (\text{concentration \#2} \times \text{time \#2})}{(\text{time \#1} + \text{time \#2})}$$

$$\text{TWA} = \frac{(80\text{ ppm} \times 6\text{ hours}) + (60\text{ ppm} \times 2\text{ hours})}{(6\text{ hours} + 2\text{ hours})}$$

$$\text{TWA} = \frac{(480 + 120)\text{ ppm}}{8}$$

$$\text{TWA} = 75\text{ ppm}$$

The OSHA Permissible Exposure Limit (PEL) for acetone is 1,000 ppm. The PEL has not been exceeded.

OSHA's eight-hour TWA PEL is the level of exposure established as the highest level of exposure an employee may be exposed to without incurring the risk of adverse health effects.

OSHA PELs are eight-hour TWAs and are expressed as either mg/m^3 or ppm. There are also shorter TWAs. Short-Term Exposure Limits (STELs) are TWAs that are averaged over a 15-minute period.

Exposure to all chemicals in a mixture must be considered, especially if the health effects of the chemicals are similar. For example, if you work on a hazardous waste site cleaning up acetone, xylene, and toluene, it is important to consider your exposure to all three because they all affect the central nervous system.

The following is an example to show how to combine exposures to chemicals that have similar effects. Air monitoring shows that acetone levels are at 500 ppm, xylene levels are at 50 ppm, and toluene levels are at 100 ppm.

$$\frac{\text{TWA acetone}}{\text{PEL acetone}} + \frac{\text{TWA xylene}}{\text{PEL xylene}} + \frac{\text{TWA toluene}}{\text{PEL toluene}} =$$

$$\frac{500\text{ ppm}}{1{,}000\text{ ppm}} + \frac{50\text{ ppm}}{100\text{ ppm}} + \frac{100\text{ ppm}}{200\text{ ppm}} =$$

$$\frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \mathbf{1.5}$$

In this example, the result was 1.5, meaning that additional controls to reduce exposure are needed.

Some exposures can be measured in blood, urine, or exhaled breath. This is called biological monitoring and would be required by OSHA for certain exposures.

Examples include:

Substance:	***Measured In:***
Lead	Blood
Carbon Monoxide	Breath or Blood
N-Hexane	Breath or Urine
Parathion (Pesticide)	Urine
Perchloroethylene	Blood, Urine, or Breath

Summary: Health Effects

Toxicology is the study of poisons and their adverse health effects. Adverse health effects may be immediate, not evident for many years, or somewhere in between.

Chemicals hazards are forms of chemicals that include medications, solutions, gases, vapors, aerosols, and particulate matter that are potentially toxic or irritating to the body.

Biological hazards are disease-producing agents (pathogens) that can be transmitted to individuals through various routes of exposure. Examples of biological hazards include blood, bodily fluids, and fecal material.

Acute health effects usually appear immediately or shortly after, usually within 72 hours of exposure. Acute effects are usually caused by short-term (acute) exposure. Acute health effects may disappear soon after the exposure ends, or the damage may be permanent.

Chronic health effects occur many months or years after exposure and are often the result of long-term, often low-level, exposure to a chemical. With some chemicals, chronic health effects can result from short-term exposures.

Inhalation, or breathing in, is the most common way that chemicals get into your body.

Ingestion is the act of swallowing. It mainly consists of eating and drinking, but ingestion can occur unintentionally by hand to mouth contact, such as when smoking.

Absorption is a route of entry that may occur through the skin. Absorption can also occur through the GI tract, lungs, and eyes. In hazardous waste work, absorption can happen when a chemical goes through the skin and travels into the body.

Contact is NOT a route of entry but can cause serious damage to your skin and possibly muscles.

Injection occurs when a sharp object, such as a needle or pressurized system, punctures the skin and injects a chemical or a virus into the bloodstream.

The body’s defense systems include coughing, cilia, and macrophages (the body’s immune system).

The resulting health effects from chemical and physical hazards include injuries and illnesses, damage to organs, temporary health effects and long-term diseases, minor symptoms to life-threatening conditions, and death.

Chemical classes that harm people include asphyxiants, system toxins, liver toxins, carcinogens, irritants, blood system toxins, kidney toxins, teratogens, sensitizers, nervous system toxins, reproductive toxins, and mutagens.

Heat stress can result in heat rash, heat cramps, heat exhaustion, and heat stroke.

Exposure limits describe the maximum amount or concentration of chemical you can be exposed to. The term occupational exposure limit (OEL) is a term that includes all workplace exposure limits.

PELs are set by OSHA and are the only legally enforceable exposure limit.

RELs are set by NIOSH and some RELs are more protective than the PEL.

TLVs are set by the ACGIH and are more protective than the PELs.

The time-weighted average (TWA) is an employee’s average airborne exposure in any eight-hour work shift of a 40-hour work week that shall not be exceeded.

The eight-hour TWA PEL is the level of exposure established as the highest level of exposure an employee may be exposed to without incurring the risk of adverse health effects.

Notes:

CPWR

Chapter 3:
Hazardous Chemical Information

There are several different systems used to identify materials and their hazards. Identification information is included on labels attached to small containers (drums, packages, boxes) and placards attached to large containers (trailers, rail cars, tanks). Safety Data Sheets must be available for chemicals used on the job.

Chapter Objectives:

After completing this module, you will be able to:

1. List the three states of chemicals.
2. Explain information on the physical properties and characteristics of hazardous chemicals.
3. Describe and demonstrate how to use the NIOSH Pocket Guide (NPG).
4. Describe the Department of Transportation (DOT) labels and placards.
5. Describe the NFPA 704 system used for labeling storage vessels, containers, buildings, and rooms at hazardous waste facilities and businesses that use chemicals.
6. Demonstrate the ability to look up information about a chemical on an SDS.

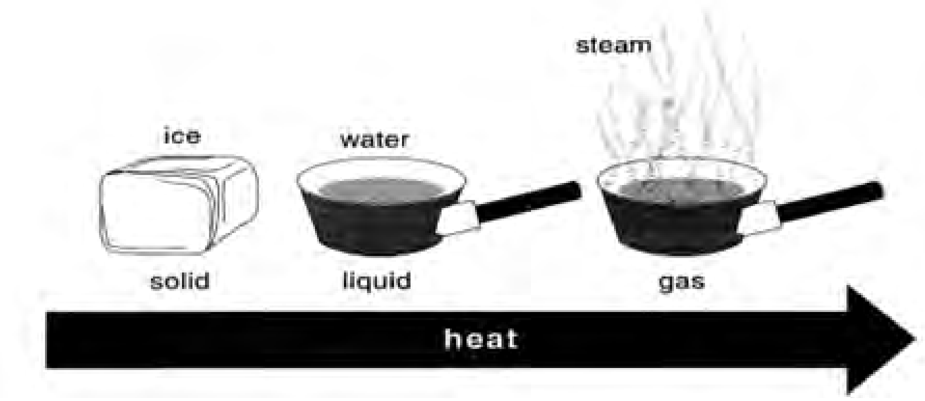
Properties of Chemicals

How chemicals act depends upon their physical and chemical properties. Understanding how chemicals behave can help you anticipate the hazards. The following properties of chemicals are explained below:

1. Freezing Point
2. Melting Point
3. Boiling Point
4. Sublimation
5. Corrosive (pH)
6. Solubility
7. Specific Gravity
8. Viscosity
9. Relative Gas Density (Vapor Density)
10. Vapor Pressure
11. Flammability
12. Flash Point
13. Oxidizer
14. Explosive Limits
15. Combustible Dust
16. Incompatibles
17. Nanoparticles
18. Molecular Weight

Chemicals can exist in three states:

Solids - have fixed volume, shape, and are not compressible.
Liquids - have a fixed volume, can change shape based on the container, and are compressible.
Gas/Vapor - have undefined volume, undefined shape (expand to fill the container), and are compressible.



We often use the terms gas and vapor interchangeably because they behave similarly, but they are slightly different:

- **Vapor** is a gas that is normally a liquid or solid at room temperature. When a liquid evaporates, it produces vapors. Some solids, such as iodine and carbon dioxide, are capable of subliming (going directly from a solid to a gas) at atmospheric pressure and room temperature. Thus, such solids also have significant vapor pressures under these conditions.
- **Gases** are like solids and liquids—they are everywhere. Common gases include oxygen and carbon dioxide—you cannot see them because they are colorless, but they are there in the air we breathe. They are made up of very small molecules that are really spread out.

Knowing what phase a chemical is in (solid, liquid, or gas) is important for understanding its associated risk.

Example: A solid block of lead cannot harm you unless you swallow it or grind it into small particles and inhale it. However, if it is heated, the lead will turn into a liquid which can burn you. If heated more, the lead will turn into a fume that can be inhaled. The state of the substance affects the type of hazards (burn or health effects from lead exposure) and the degree of the hazards (it is easier to be exposed to lead fumes than a lead block).

Freezing Point

Temperature at which a liquid becomes a solid.
Example: Water left in your freezer (less than 32°F) changes to a solid (ice).

Melting Point

Temperature at which a solid becomes a liquid.
Example: Ice (solid water) left at any temperature above 32°F changes to a liquid (water).

- Tin: 449°F
- Lead: 620°F
- Copper: 1,985°F
- Iron: 2,800°F

Boiling Point

The temperature where a liquid rapidly changes into a vapor. At this temperature, the vapor pressure of the liquid is equal to atmospheric pressure.
Example:

- PCBs: 617 to 691°F
- Water: 212°F
- Acetone: 133°F
- Chlorine: -29°F

Sublimation
The process by which certain solids become gases (sublime) without ever being a liquid.
Example: Dry ice (CO_2) changes from a solid to a gas at temperatures above -109°F.

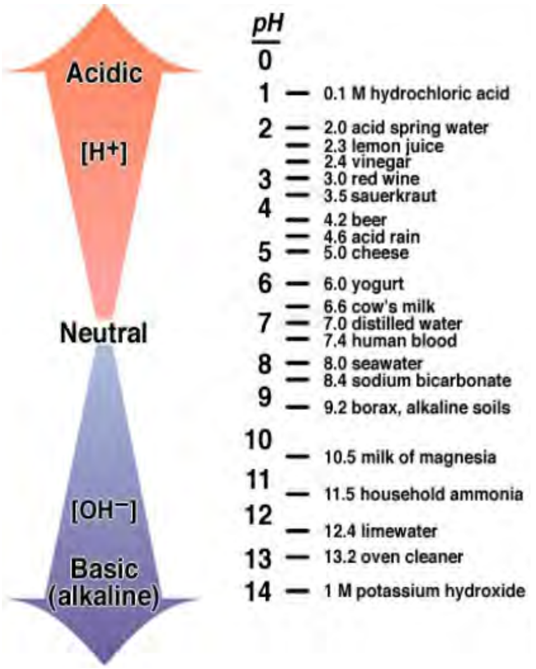
Important: If you know the freezing, melting, sublimation, and boiling points, you can then figure out the form or state a compound will be in at the temperature you are working in.

Corrosive
A chemical that can damage skin, eyes, other tissues, metal, and other solids. pH is a measure of how strong an acid or base a substance is. A pH of 1 is very acidic; a pH of 14 is very alkaline. A pH of 7 is neutral—neither acid nor base. A change in pH of one unit (for example, from 3 to 4) represents a 10-fold change in acidity or alkalinity. For example, strong acids (low pH) and bases (high pH) are corrosive. pH stands for the potential of hydrogen.
Example:

Corrosive Acids:	**Corrosive Bases:**
Sulfuric Acid (Oleum)	Sodium Hydroxide
Nitric Acid	Lime
Hydrochloric (Muriatic) Acid	Sodium Hydroxide (Lye or Caustic Soda)

Important: Corrosives are health hazards and must be stored in glass or special plastics.

Chemicals with high and low pH values will cause burns and irritate the eyes, nose, and lungs. Waste materials with a pH of less than 2 or greater than 12 are legally defined as hazardous.



The next set of properties associated with chemicals is how they will act when they are released into the air or mixed with water.

Knowing a material's chemical properties can help you to understand where it is most likely to go in the air and water. This information is important in determining where to do air monitoring and how to protect the environment.

Solubility
The ability of a substance to solute, that is, to form a solution with another substance, the solvent.
Example: Methylene chloride has a solubility of 2% in water. This means that up to 2 grams of methylene chloride can be dissolved in 100 grams of water.

Substance:	**Solubility in Water:**
Acetone	100%
Methylene Chloride	2%
Toluene	0.07%
PCBs	Insoluble

Specific Gravity (Sp. Gr.)
The density of a liquid compared to water (water = 1). If the specific gravity is less than one, the chemical tends to float. If the specific gravity is greater than one, the chemical tends to sink. If the water is moving, then the chemicals will mix.
Example:

	Sp. Gr.
• Toluene	0.87
• Methylene Chloride	1.33
• PCB	1.39
• Light Diesel Oil	0.86

Important: By quantifying buoyancy, specific gravity helps you determine where a chemical spilled in water is likely to be found (floating on the surface or sunk to the bottom) and to identify clean-up methods (like pillows or booms on the surface).
The specific gravity of water is 1.

Specific gravity less than 1
(floats)

Specific gravity greater than 1
(sinks)

Viscosity

The measure of a fluid's resistance to flow, which decreases as temperature increases and is independent of pressure (except at very high pressure).

Example:

Chemicals with High Viscosity:	Chemicals with Low Viscosity:
Polymers	Alcohols
Heavy Oils	Gasoline
Lubricating Grease	

Important: The viscosity of a substance impacts how quickly it will spread if spilled.

Relative Gas Density (RGasD)

Also known as vapor density, Relative Gas Density is the weight of a vapor or gas compared to an equal volume of dry air at the same temperature and pressure. Relative gas density is unitless. Air has a relative gas density (RGasD) of 1.

- If RGasD is greater than 1.0, the vapor or gas is heavier than air and tends to concentrate in low places.
- If RGasD is less than 1.0, the vapor or gas tends to rise.

Example:

Substance:	**RGasD**:
Carbon Monoxide	0.97
Air	1.0
Methylene Chloride	2.90
Gasoline	3.79

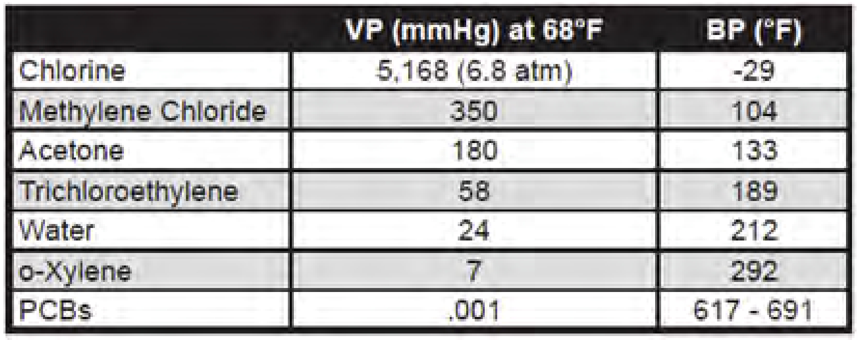
Important: RGasD tells you where to expect and monitor for released gases and vapors. Any air movement will mix gases and vapors, so you cannot assume that an area is safe based on relative gas density.

Vapor Pressure (VP)

A measure of a liquid's ability to evaporate or give off vapor. The higher the VP, the faster a liquid will become a vapor. Vapor pressure is measured in millimeters of mercury (mmHg). One atmosphere of pressure (1 atm) equals 760 mmHg. Any chemical with a VP of 760 mmHg or more will be, or change to, a gas at room temperature.

Liquids release some vapor all the time but chemicals with high vapor pressures release a large amount of vapor at room temperature. Vapor pressure increases as the temperature increases.

The boiling point is the temperature where the vapor pressure of the liquid is as high as atmospheric pressure, and a lot more vapor is released. A chemical with a high boiling point will have a low vapor pressure—it needs more heat to become a vapor. The lower the boiling point, the higher the vapor pressure will be.
Example:

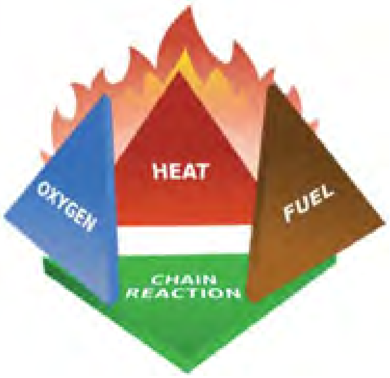


	VP (mmHg) at 68°F	BP (°F)
Chlorine	5,168 (6.8 atm)	-29
Methylene Chloride	350	104
Acetone	180	133
Trichloroethylene	58	189
Water	24	212
o-Xylene	7	292
PCBs	.001	617 - 691

Important: A sealed vessel containing a chemical with a high vapor pressure is more likely to become pressurized and explode as the temperature rises.

Flammability
A measure of how quickly a specific material is capable of catching fire and burning. It indicates the ease with which a material can ignite and the intensity with which it burns once it catches fire. Highly flammable materials must be treated with extra care, as they can combust quickly.

Important: For a fire to burn, there must be a proper combination of four things: fuel, oxygen, heat (above the ignition temperature), and a chain reaction. For example, even if you have enough fuel, enough oxygen, and an ignition source, there is no fire without a chain reaction producing enough heat to sustain the fire. Likewise, with enough fuel and an ignition source, but too little oxygen, there is no fire. These four items make up the fire tetrahedron.



To put out a fire, you must remove one of the four elements shown in the fire tetrahedron.

Chain reaction was added to the classic fire triangle because enough heat must be produced to sustain the fire (reaction). Think about holding the flame of a cigarette lighter beneath a 2 x 4 for a second. There is heat, oxygen, and fuel, but no chain reaction. If the 2 x 4 was ground into sawdust, the reaction would go forward because the ratios were right.

- Fire is a rapid chemical process that produces heat and light.
- An explosion is a rapid chemical process that produces heat and light and violent expansion of gases.

Flash Point (Fl. P.)

The lowest temperature at which a liquid will give off enough vapor to form an ignitable mixture with air near the surface of the liquid if there is a source of ignition. Liquids do not burn, vapors burn.

Example:

Substance:	**Flash Point:**	**OSHA**:
Gasoline	- 45°F	Category 2
Acetone	0°F	Category 2
Methylethyl Ketone	16°F	Category 2
Toluene	40°F	Category 2
Turpentine	95°F	Category 3
Stoddard Solvent	102-110°F	Category 3
Diesel	126-205°F	Category 3
Cresol	187°F	Category 4

Explanation of Flammable Categories of Liquids

The flash point and the boiling point are used to classify the relative fire hazards of liquids. OSHA (29 CFR 1910.106) defines a flammable liquid as any liquid having a flashpoint at or below 199.4°F and divides them into four categories based on the following:

- **Category 1**: includes liquids having flashpoints below 73.4°F and having a boiling point at or below 95°F.
- **Category 2**: includes liquids having flashpoints below 73.4°F and having a boiling point above 95°F.
- **Category 3**: includes liquids having flashpoints at or above 73.4°F and at or below 140°F (60°C). When a Category 3 liquid with a flashpoint at or above 100°F is heated for use to within 30°F of its flashpoint, it shall be handled following the requirements for a Category 3 liquid with a flashpoint below 100°F.
- **Category 4**: includes liquids having flashpoints above 140°F and at or below 199.4°F. When a Category 4 flammable liquid is heated for use to within 30°F of its flashpoint, it shall be handled following the requirements for a Category 3 liquid with a flashpoint at or above 100°F.

When liquid with a flashpoint greater than 199.4°F is heated for use to within 30°F of its flashpoint, it shall be handled following the requirements for a Category 4 flammable liquid.

Oxidizer
A chemical that can start or promote the burning of other materials.
Example:

- Perchloric Acid
- Ozone
- Hydrogen Peroxide
- Household Bleach
- Peroxides
- Chlorine

Important: Oxidizers can react chemically with fuels and can start fires or explosions. Store oxidizers away from flammables.

Explosive Limits
The concentration or percentage of a gas/vapor in the air that could result in an explosion if an ignition source is present.

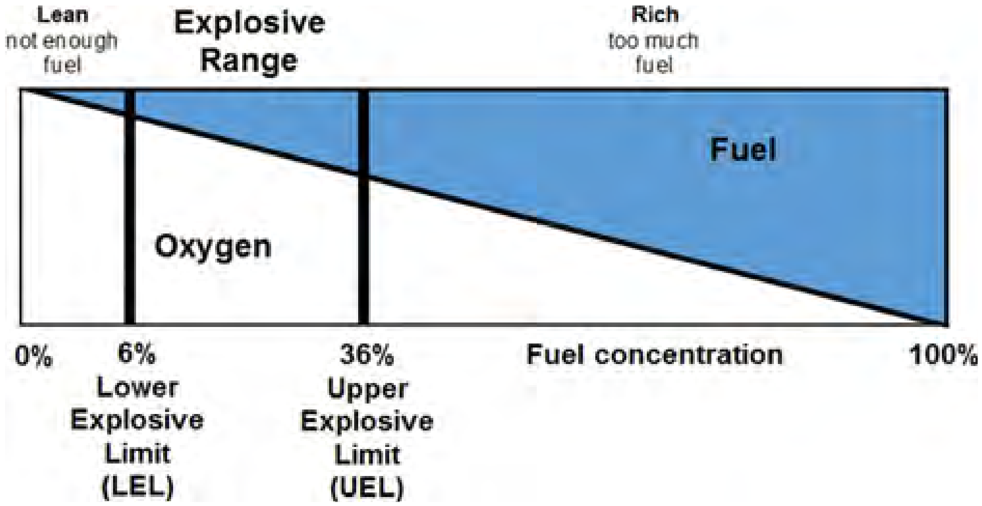
- **Lower Explosive Limit (LEL)** is the lowest concentration (% in air) of a substance that will burn if ignited. Concentrations below the LEL are "too lean" or not enough gas to ignite.
- **Upper Explosive Limit (UEL)** is the maximum concentration (% in air) of a substance that will burn if ignited. Concentrations above the UEL are "too rich" or there is too much gas to ignite.

The explosive range of a flammable gas is the concentration of the substance in air and if the percentage is between the LEL and UEL. In this range, the substance will readily ignite if an ignition source is present.

Important: Evacuate the area if the concentration of a flammable vapor or gas is greater than 10 percent of the LEL. Do not enter or stay in an area that is above 10 percent of the LEL unless you are trained and properly equipped.

Concentrations above the UEL are not safe because the concentration can quickly drop into the explosive range when air is added or mixed and the high concentration creates an oxygen-deficient atmosphere.

The concentration of flammable gases and vapors can change rapidly, so constant air monitoring is essential. Methyl alcohol's (also known as methanol) explosive range is between 6 and 36 percent and is illustrated below.



Combustible Dust
A finely divided particulate solid that presents a flash fire hazard or explosion hazard when suspended in air.

Important: Many construction activities and potential work locations can be filled with different types of dust and, unfortunately, some of them can be combustible.

The ease of ignition and the severity of a combustible dust explosion is influenced by:

- Particle size
- Moisture content
- Ambient humidity
- Oxygen available for combustion
- Shape of dust particles
- Concentration of dust in the air

Five conditions are necessary for an explosion or fire from combustible dust:

1. Oxygen
2. Combustible dust
3. Dispersion/Ideal dust concentration
4. Confinement of the dust cloud
5. Ignition source

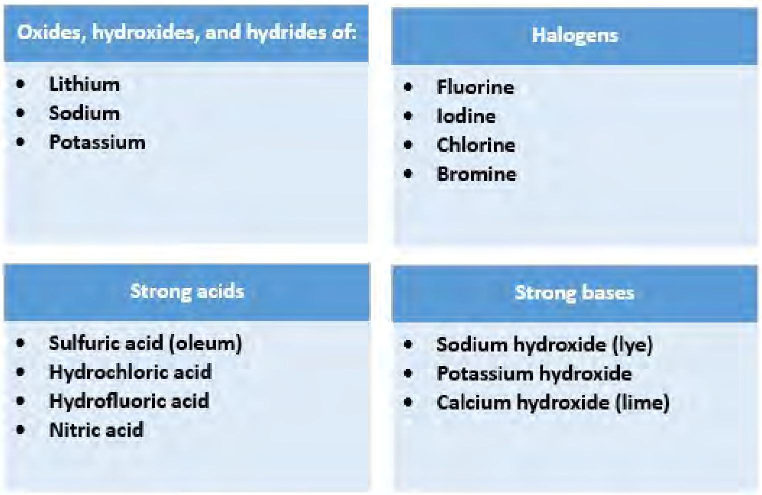
Incompatibilities
Chemicals react violently when they come in contact with each other, which may result in fires, explosions, and/or toxic gas release.

Important: Incompatible chemicals must be prevented from coming into contact with each other. Store containers of incompatible chemicals away from each other so that they do not come into contact if the containers leak or rupture.

When strong acids and bases (alkalis) are mixed, heat and spattering occur and can damage the eyes and skin. Acids added to cyanides produce hydrogen cyanide gas, which can cause death.

Water-reactive chemicals can create heat, spattering, and toxic fumes upon contact with water.

Examples:



Oxides, hydroxides, and hydrides of:

- Lithium
- Sodium
- Potassium

Halogens

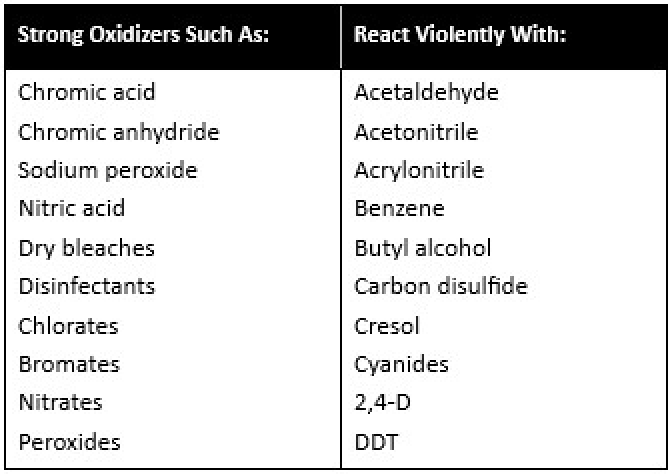
- Fluorine
- Iodine
- Chlorine
- Bromine

Strong acids

- Sulfuric acid (oleum)
- Hydrochloric acid
- Hydrofluoric acid
- Nitric acid

Strong bases

- Sodium hydroxide (lye)
- Potassium hydroxide
- Calcium hydroxide (lime)



Strong Oxidizers Such As:	React Violently With:
Chromic acid	Acetaldehyde
Chromic anhydride	Acetonitrile
Sodium peroxide	Acrylonitrile
Nitric acid	Benzene
Dry bleaches	Butyl alcohol
Disinfectants	Carbon disulfide
Chlorates	Cresol
Bromates	Cyanides
Nitrates	2,4-D
Peroxides	DDT

*__Note__: Do not store these chemicals near each other.

Nanoparticles

Nanoparticles exist in nature and can be created and used for their unique properties.

Materials engineered to be nanoscale are often referred to as engineered nanomaterials (ENMs) and can take on unique optical, magnetic, electrical, and other properties. These emergent properties have the potential for great impacts in electronics, medicine, and other fields but there is concern for potential health effects.

Nanoparticles must have at least one dimension that is less than 100 nanometers. Carbon nanotubes are 100,000 times smaller than a human hair. Little is known about the health effects of nanoparticles.

Nanoparticles can enter the body through inhalation, ingestion, and dermal exposure. They are small enough to pass from the blood to the brain. The health effects of nanoparticles can be different than the health effects of larger particles of the same material.

NIOSH, CPWR, and others are evaluating the potential for exposure to nanoparticles.

Molecular Weight

The molecular weight (MW) of air can be used to see if a substance is lighter or heavier than air. Air has a molecular weight of 28.96 g/mol (grams per mole mass) or 29. This means that any substance that has a MW greater than 29 is heavier than air and will sink in low lying areas. Any substance with a MW less than 29 will rise.

You can divide the MW of a chemical by 29 and that will equal the vapor density. Air has a vapor density of 1, so anything over 1 will sink and anything lighter than 1 will rise.

NIOSH Pocket Guide

The NIOSH Pocket Guide (NPG) is a guide to chemical hazards that informs workers, employers, and occupational health professionals about workplace chemicals and their hazards. The NPG includes 677 chemicals. The information in the pocket guide includes chemical structures or formulas, identification codes, synonyms, exposure limits, chemical and physical properties, incompatibles and reactivities, measuring methods, respirator selections, signs and symptoms, and procedures for emergency treatment.

The NPG is available for downloading as a PDF on the NIOSH website. You can find it here: https://www.cdc.gov/niosh/npg/

The same website offers an application that can be downloaded directly to your electronic devices.

Department of Transportation (DOT) System Placards and Labels

Department of Transportation (DOT) Labels and Placards are diamond-shaped and use numbers, symbols, and colors to warn about hazards. These labels and placards must be posted on large portable tanks, tank trucks, and rail cars. The four-digit ID number that identifies the chemical is listed in the DOT Emergency Response Guidebook and the NIOSH Pocket Guide.

Some labels and placards identify specific chemicals, like this one for toluene (1294).

Other labels give the hazard symbol and UN hazard class number only, not the specific chemical. The four-digit ID number may be found on a nearby panel.

The following are examples of symbols used to represent UN Hazard Classes and Divisions. Note that some substances may fall into more than one Hazard Class or Division and some placards only indicate Class while others are more specific and indicate the Division Number.

Hazard Class Number and Name	
	1 - Explosives
	2 - Gases
	3 - Flammable and Combustible Liquids
	4 - Flammable Solids; Spontaneously combustible materials; and dangerous when wet materials/water-reactive substances
	5 - Oxidizers and Organic Peroxides 5.1 - Oxidizing Substances
	6 - Toxic/Poisonous Substances and Infectious Substances
	7 - Radioactive Materials
	8 - Corrosive
	9 - Miscellaneous Hazardous Materials

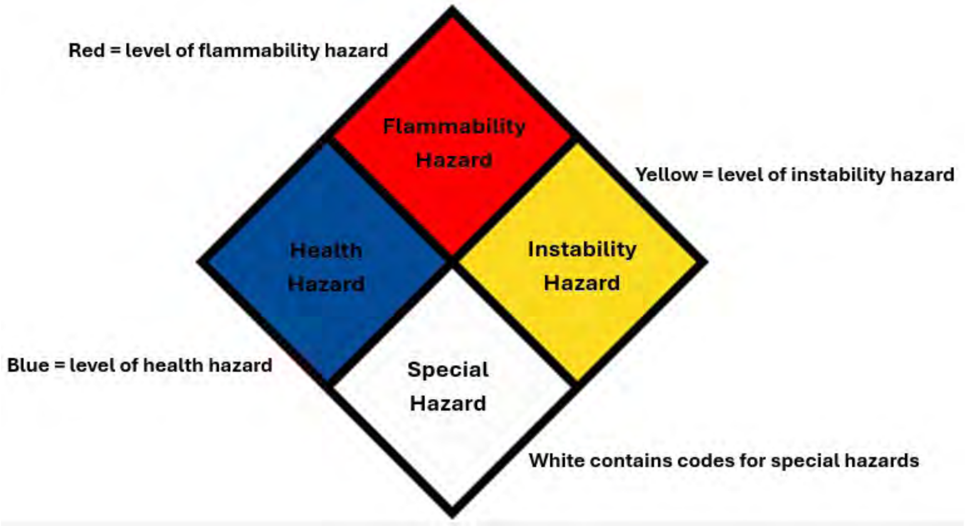
NFPA 704

The National Fire Protection Association (NFPA) 704 (Standard System for the Identification of the Hazards of Materials for Emergency Response) is a standard maintained by the National Fire Protection Association. The standard describes a system to help emergency personnel quickly and easily identify the short-term hazards posed by nearby hazardous materials during a fire, spill, or similar emergency. The NFPA 704 only applies when a federal, state, or local regulation or code requires its use. NFPA 704 does not specify when a container, tank, or facility must be labeled, rather it specifies how to label when another code, standard, or an Authority Having Jurisdiction, (such as the local fire department) requires such labeling. The standard applies to industrial, commercial, and institutional facilities that manufacture, process, use, or store hazardous materials. It does not apply to transportation.

The NFPA 704 system may be used to label storage vessels, containers, buildings, and rooms at hazardous waste facilities and businesses that use chemicals. Some facilities use this system throughout their departments and put the NFPA label on all hazardous materials. The facility's hazard communication training should inform the worker if this warning system is being used at the work site.

The system uses numbers and symbols in four divisions of a color-coded diamond to convey the hazard information. A number in any of the colored sections indicates the level or potential severity of the hazard.

- Blue: identifies the level of a health risk.
- Red: indicates the level of flammability.
- Yellow: indicates the level of instability or chemical reactivity of the chemical.
- White: contains codes for special hazards for the responders to be aware of.



Health, flammability, and instability hazards are rated on a scale from 0 (minimal hazard) to 4 (severe hazard). The NFPA diamond does not name individual chemicals and usually represents the maximum rating in each category for chemicals in the area. In areas with few chemicals, there may be a labeled NFPA diamond for each chemical.

Color	Hazard	Risk (For All Hazards)	
Red	Flammability	4	Severe
Blue	Health Risk	3	
Yellow	Instability (Chemical Reactivity)	2	
		1	
		0	Minimal

The special hazard codes that could be found in the white section of the NFPA diamond may contain symbols that give more information about the chemical. There are three special hazard symbols defined in the NFPA 704 standard. Local fire jurisdictions may choose to include other symbols not defined by NFPA based on hazards in their area.

OX
- **Oxidizer.** May make combustion without an air supply possible and greatly increase the rate of combustion/fire.

SA
- **Simple asphyxiant.** Use is limited to nitrogen, helium, neon, argon, krypton, and xenon.

~~W~~
- **Reacts violently or explosively with water.**

At a minimum, the NFPA hazard diamonds should be posted at the following locations:

- The two exterior walls of a facility.
- Access to a facility, room, or area.
- Each principal means of access to an exterior storage area.
- Storage tanks or vessels.

Since the NFPA hazard diamonds are intended to quickly provide hazard information to emergency responders, the placards should be visible where the responders are likely to enter. If there are numerous areas where the responders could enter, then there should be numerous placards.

NFPA placards allow emergency responders to determine if they should enter and what, if any, specialty equipment should be used, procedures followed, or precautions taken during the first moments of an emergency response.

While not defined in the NFPA standard, infectious and radioactive materials may be indicated in the special hazard section of NFPA diamonds.

One of the most common types of packaged biological waste is infectious waste from hospitals and other healthcare facilities. This type of waste should be in boxes, plastic containers, or red plastic bags marked on all sides with the infectious materials symbol shown below.

Infectious Materials Symbol

Examples of infectious materials include used needles and syringes, soiled bandages, test tubes, and disposable vials. Less frequently encountered biological hazards include biological research materials.

Radioactive sources are used in industry and medicine, and radioactive waste comes from energy and weapons production. Do not work with or around radiation hazards unless you have had the training to do so and have the proper personal protective equipment (PPE) and equipment.

Radiation Symbol

Radiation hazards should be covered in the Standard Operating Procedures (SOPs) for your work site. **All forms of radiation should be considered very hazardous.**

TREAT THEM WITH RESPECT!

Labels and Safety Data Sheets (SDS)

The OSHA Hazard Communication Standard (29 CFR 1926.59 or 29 CFR 1910.1200) requires employers to have a hazard communication (HazCom) program, label chemical containers, and keep Safety Data Sheets (SDS) for each hazardous chemical used in their workplace.

Employees must be told the location of the employer's written hazard communication program, SDSs, and hazardous chemical lists. If you do not know where SDSs are kept on your job, you should ask your supervisor first, your employer next, and then the general contractor or the subcontractors.

OSHA's Hazard Communication standard is written to be consistent with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

OSHA's use of the GHS helps to ensure a consistent way of classifying hazards and communicating the information to workers. The Hazard Communication standard gives workers the right to understand the chemical hazards associated with their jobs.

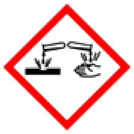
OSHA requires that labels contain these elements:

1. **Product Identifier:** the name, code, or batch number used to identify hazardous chemicals.
2. **Supplier Identification:** includes the name, address, and telephone number of the chemical manufacturer, importer, or other responsible party.
3. **Signal Words:** are used to indicate the relative level of severity of the hazard and alert the reader to a potential hazard on the label. "Danger" is used for the more severe hazards, while "warning" is used for the less severe.
4. **Hazard Statement:** describes the nature of the hazard(s) of a chemical, including, where appropriate, the degree of hazard, and is based on the chemical's class and category.
5. **Precautionary Statement:** describes recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to hazardous chemicals or improper storage or handling.
6. **Hazard Pictograms:** a composition that may include a symbol plus other graphic elements, such as a border, background pattern, or color that is intended to convey specific information about the hazards of a chemical.

The label producer may provide any supplementary information that it determines is helpful. Such information may include hazards not otherwise classified, directions for use, PPE pictograms, expiration dates, and fill dates. This section must also identify the percentage of ingredient(s) of unknown acute toxicity when it is present in a concentration of 21 percent and the classification is not based on testing the mixture (product) as a whole.

There are nine pictograms that may be found on labels and SDS:

The chart on the following page depicts the pictogram name, the pictogram itself, and the hazards/types of chemicals.

Pictogram Name	Pictogram	Hazards/Types of Chemicals
Flame		Flammables, Self-Reactives, Pyrophorics, Self-Heating, Emits Flammable Gas, Organic Peroxides
Flame Over Circle		Oxidizers
Exploding Bomb		Explosives, Self-Reactives, Organic Peroxides
Corrosion		Skin Corrosion/Burns, Eye Damage, Corrosive to Metals
Gas Cylinder		Gases under pressure
Health Hazard		Carcinogen, Respiratory Sensitizer, Reproductive Toxicity, Target Organ Toxicity, Mutagenicity, Aspiration Toxicity
Exclamation		Irritant (skin and eye), Skin (dermal) Sensitizer, Acute Toxicity (harmful), Narcotic Effects, Respiratory Tract Irritation
Skull and Crossbones		Acute Toxicity (severe)
Environmental Pollutant		Aquatic Toxicity, Part of GHS, but not 1910.1200. OSHA does not have jurisdiction over environmental matters

Important: If you pour anything into a container, it must be labeled unless you are going to use it within the work shift and control it. Employers can go beyond the minimum standard and require labeling for all containers.

Safety Data Sheets (SDSs)

Safety Data Sheets (SDSs) are an important information source on hazardous chemicals. Manufacturers and distributors must forward SDSs to the purchaser with the first shipment, and with the first shipment after an SDS is updated. Whenever the employer receives a new or revised SDS that could impact your health, you must be informed within 30 days after receipt. Your employer must maintain SDSs for all hazardous chemicals used on the job. SDSs do not apply to hazardous waste. You can, however, find information on hazardous waste in shipping papers, manifest forms, and waste profile sheets.

SDSs must contain the following 16 sections in the specified order.

Sections 1-8 contain general information:

1. Identification
2. Hazard(s) Identification
3. Composition, information on ingredients
4. First-aid measures
5. Fire-fighting measures
6. Accidental release measures
7. Handling and storage
8. Exposure controls and personal protection

Sections 9-11 and 16 contain other technical and scientific information:

9. Physical and Chemical properties
10. Stability and Reactivity
11. Toxicological information

16. Other Information

Sections 12-15 are not mandatory:

12. Ecological information
13. Disposal considerations
14. Transport information
15. Regulatory information

The SDS must contain headings for sections 12-15 to be consistent with the GHS, but OSHA will not/cannot enforce the content of these sections because they are within the jurisdiction of other agencies.

The following is the minimum information needed on an SDS by section:

Section 1: Identification
- Product identifier
- Other means of identification
- Recommended use of the chemical and restrictions on use
- Supplier’s details (including name, address, phone number, etc.)
- Emergency phone number

Section 2: Hazard(s) Identification
- Classification of the substance/mixture and any national or regional information
- Label elements and precautionary statements
- Other hazards not otherwise classified

Section 3: Composition/Information on Ingredients
- Chemical identity
- Common name, synonyms, etc.
- CAS number, EC number, etc.
- Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance

Section 4: First-aid Measures
- Description of necessary measures, subdivided according to the different routes of exposure, (e.g. inhalation, skin and eye contact, and ingestion)
- Most important symptoms/effects, acute and delayed
- Indication of immediate medical attention and special treatment needed, if necessary

Section 5: Fire-fighting Measures
- Suitable (and unsuitable) extinguishing media
- Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products)
- Special protective equipment and precautions for firefighters

Section 6: Accidental Release Measures
- Personal precautions, protective equipment, and emergency procedures
- Environmental precautions
- Methods and materials for containment and cleaning up

Section 7: Handling and Storage
- Precautions for safe handling
- Conditions for safe storage, including any incompatibilities

Section 8: Exposure Controls/Personal Protection
- Control parameters, e.g., occupational exposure limit values or biological limit values
- Appropriate engineering controls
- Individual protection measures, such as personal protective equipment

Section 9: Physical and Chemical Properties
- Appearance (physical state, color, etc.)
- Odor
- Odor threshold
- pH
- Melting point/freezing point
- Initial boiling point and boiling range
- Flash point
- Evaporation rate
- Flammability (solid, gas)
- Upper/lower flammability or explosive limits
- Vapor pressure
- Vapor density
- Relative density
- Solubility(ies)
- Partition coefficient: n-octanol/water
- Autoignition temperature
- Decomposition temperature
- Viscosity

Section 10: Stability and Reactivity
- Chemical stability
- Possibility of hazardous reactions
- Conditions to avoid (e.g., static discharge, shock, or vibration)
- Incompatible materials
- Hazardous decomposition products

Section 11: Toxicological Information
- Concise but complete and comprehensible description of the various toxicological (health) effects and the available data used to identify those effects, including information on the likely routes of exposure (inhalation, ingestion, skin and eye contact)
- Symptoms related to the physical, chemical, and toxicological characteristics
- Delayed and immediate effects and also chronic effects from short and long-term exposure
- Numerical measures of toxicity (such as acute toxicity estimates)

Section 12: Ecological Information
- Ecotoxicity (aquatic and terrestrial, where available)
- Persistence and degradability
- Bioaccumulative potential
- Mobility in soil
- Other adverse effects

Section 13: Disposal Considerations
- Description of waste residues and information on their safe handling and methods of disposal, including the disposal of any contaminated packaging

Section 14: Transport Information
- UN number
- UN proper shipping name
- Transport Hazard class(es)
- Packing group, if applicable
- Special precautions that a user needs to be aware of or needs to comply with in connection with transport or conveyance either within or outside their premises

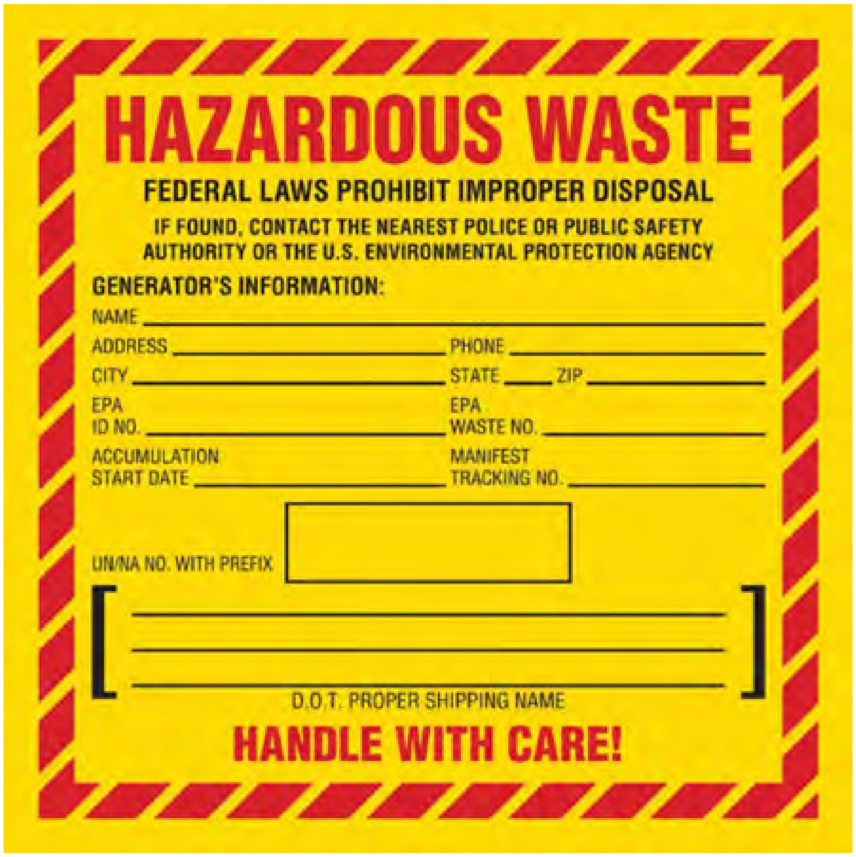
Section 15: Regulatory Information
- Safety, health, and environmental regulations specific to the product in question

Section 16: Other
- Indicates when the SDS was prepared or when the last known revision was made.
- May also state where the changes have been made to the previous version.

Other Forms of Hazardous Materials Documentation

The EPA requires that hazardous waste be labeled during transit. An example of a hazardous waste label is shown below. Information on the label must include:

- Generator's name and address.
- DOT proper shipping name.
- EPA identification number.
- Accumulation start date



HAZARDOUS WASTE

FEDERAL LAWS PROHIBIT IMPROPER DISPOSAL

IF FOUND, CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERATOR'S INFORMATION:

NAME
ADDRESS
PHONE
CITY
STATE
ZIP
EPA ID NO.
EPA WASTE NO.
ACCUMULATION START DATE
MANIFEST TRACKING NO.
UN/NA NO. WITH PREFIX
D.O.T. PROPER SHIPPING NAME

HANDLE WITH CARE!

The DOT requires that truck drivers carry a bill of lading or waste manifest (shipping papers) containing the following information for all hazardous materials:

- Shipper's name and address
- Receiver's name and address
- Description of hazardous material (identification number, proper shipping name, hazard class, and packing group)
- Emergency response information
- DOT hazard classification information
- Quantity of material shipped to the location

The EPA requires that hazardous waste be accompanied by a manifest to track it from the cradle-to-grave. The manifest has a number of copies that are given to the generator, the transporter, and site characterization workers. Hazardous waste manifests must include:

- 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

Although the SDS, shipping papers, manifest forms, and waste profile sheets contain important information, they have several limitations, which include:

- Information may be incomplete or inaccurate
- Information may not apply to the site or specific use
- Information may be too general
- SDS may not be current

It is important that you read these documents before there is an emergency. It is a good practice to call the emergency number on the SDS to get clean-up response and emergency information before there is an emergency.

Unions, employers, trade groups, state governments, and other organizations may also provide sources of information.

Summary: Hazardous Chemical Information

Chemicals exist in three states: solids, liquids, and gas/vapors.
Vapor is a gas that is normally a liquid or solid at room temperature.
You cannot see gases because they are colorless, but they are there in the air we breathe.

Chemical Properties:

- **Freezing Point:** Temperature at which a liquid becomes a solid.
- **Melting Point:** Temperature at which a solid becomes a liquid.
- **Boiling Point:** The temperature where a liquid rapidly changes into vapor or gas.
- **Sublimation:** The process by which certain solids become gases (sublime) without ever being a liquid.
- **Corrosive:** A chemical that can damage skin, eyes, other tissues, metal, and other solids.
- **Solubility:** The ability of a substance to be dissolved in a solvent (often water).
- **Specific Gravity (Sp. Gr.):** The density of a liquid compared to water (water = 1).
- **Viscosity:** The measure of a fluid’s resistance to flow.
- **Relative Gas Density (RGasD):** Also known as vapor density, it is the weight of a vapor or gas compared to an equal volume of dry air at the same temperature and pressure (air = 1).
- **Vapor Pressure (VP):** A measure of a liquid’s ability to evaporate or give off vapor.
- **Flammability:** A measure of how quickly a specific material is capable of catching fire and burning. There are four different flammable categories.
- **Flash Point (Fl. P.):** The lowest temperature at which a liquid will give off enough vapor to form an ignitable mixture with air near the surface of the liquid if there is a source of ignition.
- **Oxidizer:** A chemical that can start or promote the burning of other materials.
- **Explosive Limits:** The concentration or percentage of a gas/vapor in the air that could result in an explosion if an ignition source is present.
- **Lower Explosive Limit (LEL):** The lowest concentration (% in air) of a substance that will burn if ignited.
- **Upper Explosive Limit (UEL):** The maximum concentration (% in air) of a substance that will burn if ignited.
- **Combustible Dust:** A finely divided particulate solid that presents a flash fire hazard or explosion hazard when suspended in air.
- **Incompatibilities:** Chemicals that react violently when they come into contact with one another and may result in fires, explosions, and/or toxic gas release.

NIOSH Pocket Guide: a guide to chemical hazards.
DOT Labels and Placards: Must be posted on large portable tanks, tank trucks, and rail cars.
NFPA Label: May be used to label storage vessels, containers, buildings, and rooms at hazardous waste facilities and businesses that use chemicals.
GHS Required Labels: Help ensure a consistent way of classifying hazards and communicating the information to workers.
Nine Pictograms found on labels.
Safety Data Sheets (SDSs): An important information source on hazardous chemicals and there are 16 required sections of an SDS.

The EPA requires hazardous waste labeling for transport and disposal. Some localities use the NFPA diamond, which shows health (blue), fire (red), instability (yellow), and special (white) hazards.

Safety Data Sheets may be on site for some waste and must be on site for all products used in cleanup. The SDS tells you what chemicals are in the product, chemical information, health and physical hazards, exposure limits, personal protective equipment, first aid, and spill precautions.

Every shipment of hazardous waste that leaves the cleanup site must have a form called a manifest that indicates what the waste is and where it comes from.

Before you start work on a cleanup site, your employer should have received waste profile sheets, information about waste from a laboratory. These are a source of information about the chemical and physical properties of the waste.

Labels, SDSs, manifests, shipping papers, and waste profile sheets can be valuable sources of information for the contractor and the worker.

Notes:

Notes:

CPWR

Chapter 4:
Monitoring and Sampling

Monitoring and sampling are necessary to determine the identity or type of a substance and the amount of a substance. This information will be used to determine if workers can enter an area, what personal protective equipment they should wear, whether further cleanup is needed, and if the waste can be mixed. The concentration of hazardous substances can be measured in a short time with direct-reading or real-time instruments, or the substance/sample may be collected and sent to a laboratory for analysis.

Chapter Objectives:

After completing this module, you will be able to:

1. Describe situations where monitoring and sampling is needed.
2. Explain the advantage and disadvantage of monitoring and sampling methods.
3. Describe different types of monitoring and sampling.
4. Identify issues with the way monitoring and sampling is being conducted at your job.

Monitoring and sampling are two different methods to determine the identity or type of a substance and the amount of the substance. Monitoring uses electronic devices to provide real-time readings of substances in the air. Sampling involves collecting a substance over a period of time in a container that is then sent to a laboratory for analysis to identify and quantify specific substances.

Monitoring and sampling are very important because they:

- Identify what and where the dangers are on the hazardous waste site.
- Determine how much hazardous material is present.
- Determine the extent and conditions of worker exposures.
- Assist in the selection personal protective equipment (PPE) (suit, gloves, respirator, etc.) and other controls.
- Aid in planning work activities and methods (for example, using water sprayers).
- Determine if special equipment and tools are needed.
- Determine whether employees need medical surveillance or exams.
- Create a record of exposure.
- Determine potential for community exposure.

Monitoring must be performed whenever employees may be exposed to hazardous substances. The monitoring results are important and vital information used in selecting PPE and other controls. Airborne exposures are very complex and can change considerably over the course of a day or a project.

An industrial hygienist, site health and safety professional, or other knowledgeable person must set up a monitoring plan, which is a required component of the Safety and Health Plan. It must indicate the frequency and type of monitoring. Monitoring must be conducted more frequently, or continuously, when conditions are more hazardous and more likely to change (for example, confined spaces, Immediately Dangerous to Life or Health (IDLH) conditions, or flammable atmospheres).

Monitoring includes all employees who may be exposed to hazardous concentrations of chemicals and conditions but should focus on the employees likely to have the highest exposures first. When worker overexposures have been identified, the monitoring program must be expanded to identify all overexposed workers.

Exposures may change and monitoring must be repeated if:

1. Work begins in a different area of the site
2. Work activities or tasks change

3. Materials being handled change
4. Monitoring results indicate that exposures may have changed
5. Excessive contamination in the work area
6. Weather conditions change

Monitoring can determine the presence or concentration of:

1. Oxygen
2. Explosive/flammable gases and vapors
3. Toxic chemicals
4. Radiation
5. Noise
6. Heat stress
7. Biological hazards

Monitoring and sampling can be classified in 3 basic categories:

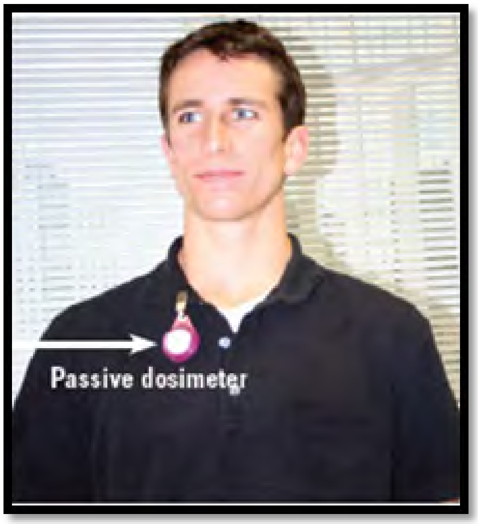
1. Personal
2. Area
3. Bulk/Surface

Personal monitoring and sampling are performed to evaluate the level of exposure to hazardous materials workers face in the workplace. It is an evaluation that consists of measuring the hazard through personal monitoring and/or sampling. Personal monitoring for atmospheric hazards is conducted in the breathing zone of a worker and determines a specific worker's exposure over a set course of time. Usually that is over an eight-hour work period and OSHA has established legally enforceable Permissible Exposure Limits (PEL's) that are based on an eight-hour Time Weighted Average (TWA).

Personal sampling is the most accurate measurement of exposure because the sampling device goes where you go and collects air from your breathing zone. This is why personal sampling is used to compare actual worker exposures to Occupational Exposure Limits (OELs) whenever possible. OELs may be legally enforceable or contain recommendations that are not legally enforceable. OELs set by NIOSH and ACGIH are not generally enforceable.

Personal samples are usually collected by placing a battery-operated air pump on the person's belt and clipping a collection tube or filter cassette in their breathing zone (near the collar). Air from the breathing zone is pulled into the collection device where the contaminants are trapped. The collection device, or the filter in it, is sent to a laboratory for analysis on the day they are collected.

NIOSH and OSHA methods require calibration of personal air sampling pumps before and after each use. Calibration should be performed with the same type of filter or sampling media that will be used during monitoring. Primary calibration devices, such as a bubble burette, a spirometer, or electronic bubble meter, are the most accurate and preferred. Rotameters are a less expensive and less accurate calibration device and may be acceptable for field calibration in some cases.



Passive dosimeters (diffusion monitor) are another type of personal monitoring that is done with small badges in your breathing zone. The badges are clipped to the collar and collect contaminants as air passes over them without using a pump.

They can only be used once and must be either sent to a lab for analysis or show a distinct color change on the testing disk.

Area monitoring and sampling is not used to determine a specific worker's exposure, but more of an indication of what hazards might be getting into the surrounding community.

This type of monitoring/sampling is often used to:

- Measure background concentrations in the air prior to the start of work
- Trigger alarms if concentrations get too high on the jobsite
- Assess the effectiveness of controls
- Determine if the methods being used are protecting the community effectively.

Bulk/surface monitoring/sampling are used to determine how much of a hazardous substance is present:

- In water or liquids
- In soil
- In waste
- On surfaces
- In materials

Bulk sampling of material is the main source of information for site characterization, and it identifies hazardous contents. It is important/vital for determining work plans, necessary controls, PPE, and proper disposal. The whole site and health plan is based on the site characterization:

- What hazards, both chemical and physical, are on the site?
- How much contamination is on the site?

The presence of a hazardous substance can indicate the potential for exposure but should not be used to estimate worker exposure.

Wipe sampling shows which surfaces are contaminated. A piece of cloth or other material is wiped across a known area (often 100 cm_2) of the surface and then submitted to a laboratory for analysis. Wipe sampling for lead is common in homes believed to have older paint. Department of Energy facilities use wipe sampling for beryllium and other metals.

Personal, area, and bulk/surface sampling can be accomplished by sending a sample to a lab for analysis or using real-time direct read monitoring devices.

Monitoring and Sampling Advantages and Limitations

There are many different monitoring methods and each approach may answer different questions and have different advantages and limitations. Many methods are not as accurate or quick as we would like them to be and no single instrument or method can detect all chemicals, but proper monitoring can provide information to help protect workers' health. Using the wrong method or instrument may expose workers to an unsafe work environment.

There is often more than one sampling method for a hazardous substance. Collecting lead-based paint chips and sending them to a laboratory is accurate but using an X-ray fluorescent (XRF) instrument is much quicker and does not damage the surface.

Sampling should be planned with the laboratory's input. The laboratory must be qualified and accredited to perform the analysis you are requesting. The final limitation is that you generally need to know what chemical or chemicals might be present before you sample so that you can select the right method.

The time required to receive the results is a major weakness of personal sampling methods that require laboratory analysis:

- Samples are submitted the day they are collected
- Lab has designated time for analysis (48 to 96 hours)
- Employers must post result in 5 to 7 days

It may take 1-14 days to receive the results from a laboratory and that may be too long to wait for some decisions. Also, these samples provide no information about ceiling exposures during the hours they were collected.

Samples of groundwater and water from wells, ponds, and streams are usually sent to a lab to identify chemicals or any type of contaminants.

Soil samples from varying depths are usually sent to a lab for analysis and can indicate the extent of the contamination (concentration), how deep it is, and the boundaries/ extent of the contaminated area.

A glass cylinder called a "thief" or a "coliwasa" is inserted into a waste drum or tank and used to collect/capture a sample. Some basic tests may be performed on site with colorimetric strips, but the sample is often bottled and sent to a lab for analysis. Compatibility testing is performed by a laboratory and can determine whether the hazardous materials can be safely mixed with other like chemicals on the site. The U.S. EPA, Army Corp of Engineers, and other groups have developed compatibility software programs.

Real-time or direct read monitoring provides an immediate measurement of the concentration of the contaminants. The instrument, equipment, or method used depends on the potential hazards present.

Advantages of real-time monitoring include:

- Results are immediate (seconds to minutes)
- Relatively inexpensive (starting at a few hundred dollars)
- Relatively easy to do with proper training
- Can be used to ensure safe entry into confined spaces

Disadvantages of real-time monitoring include:

- Concentration range limited—may not be able to detect high enough or low enough levels of toxins.
- Most monitors cannot identify an unknown contaminant or distinguish one from another.
- Must be calibrated and maintained on a regular basis, based on the manufacturer's recommendations.
- Background levels and other chemicals can give false readings (cross-sensitivity).
- Common instruments only have a few sensors.

Real-time Monitoring
Real-time monitoring can be used to measure:

- Oxygen
- Explosive/flammable gases and vapors
- Toxic chemicals
- Radiation
- Noise
- Others

When used for confined space entry, real-time measurements must be taken in the following order to ensure accuracy and safety:

- Oxygen (19.5%-23.5%)
- Flammable (less than 10% LEL)
- Potential toxic substances (below IDLH or above the PEL, depending on the exact situation)

Oxygen meters measure the percentage of oxygen in the air. Normal breathing air contains approximately 20.9 percent oxygen. Air that contains less than 19.5 percent oxygen is oxygen deficient. The oxygen in confined spaces such as tanks, pits, silos, pipelines, vaults, and sewers are often oxygen deficient.

OSHA requires Supplied-Air Respirators (SAR) (with escape bottle) or Self-Contained Breathing Apparatus (SCBA) respiratory protection in atmospheres with less than 19.5% oxygen.

An atmosphere is oxygen enriched if it contains more than 23.5 percent oxygen. Oxygen enrichment makes it easier for flammable and combustible substances to burn and increases the risk of fire or explosion.

Keep in mind that:

- Temperature, pressure, and carbon dioxide can all affect readings
- Instruments must be calibrated and checked regularly
- Instruments must be bump tested (calibration check) daily, prior to use
- Users must be trained

Flammable and explosive chemicals are detected by combustible gas meters called Combustible Gas Indicators or CGI and reported as a percentage of the lower explosive limit (% LEL). These instruments are useful for confined space entry. The alarms on the meters/monitors will ring at 10 percent of the LEL, which indicates there is an atmosphere with potential for fire/explosion.

Keep in mind that CGIs:

- Must be bump tested (calibration check) by trained personnel before each shift
- Require periodic calibrations
- Do not respond the same to all gases and vapors
- Need a minimal amount of oxygen to work properly
- Users must be trained
- Must be allowed enough time for contaminants to reach the instrument through the length of tubing used

Combustible gas indicators are often manufactured to include other sensors to monitor such things as oxygen, flammable gases, and two or four toxic gases, such as hydrogen sulfide, methane, carbon monoxide, ammonia, chlorine, etc. These monitors are often called multi-gas/4 gas/6 gas monitors/detectors.

Other real-time instruments are available for hazardous chemicals:

- Photoionization detectors
- Flame ionization detectors

Photoionization Detectors (PID)

A photoionization detector (PID) is a direct-reading instrument used to measure the presence of volatile organic compounds (VOCs), which are any chemical compounds that possess significant vapor pressures and can have serious effects on a worker's health. Ultraviolet light is used to ionize the molecules that pass through the equipment. This 'excites' the molecules, which causes them to lose electrons, and they become positively and negatively charged ions. These ions generate electric current. The stronger the current, the greater the concentration of VOCs in the air.

Flame Ionization Detectors (FID)

The flame ionization detector (FID) is a portable direct-reading instrument used to detect organic compounds. It is a type of organic vapor analyzer (OVA). Organic compounds are chemical compounds containing carbon, such as toluene and benzene.

An FID can operate in two modes:
1. Survey mode
2. Gas chromatograph (GC) mode

In survey mode, the FID detects the total concentration of organic compounds in the tested atmosphere (total ppm). In GC mode, it detects and measures individual components (that is, benzene, xylene, toluene), with detection limits that can be as low as a few parts per million. To get accurate and effective readings, qualified persons must be thoroughly trained in the FID's operation, limitations, and data interpretation.

Portable Gas Chromatographs/Mass Spectrometry (GC/MS)

Portable Gas Chromatographs/Mass Spectrometry (GC/MS) have emerged as indispensable tools for on- the-go detection and identification of volatile compounds. These compact devices empower first responders, environmental scientists, and safety professionals to swiftly assess hazardous substances in the field. These units are now as light as thirty pounds and have a nine-hour battery life. This allows for detection of unknowns previously requiring samples to be sent to the lab. Portable gas chromatographs are compact analytical instruments that combine gas chromatography with mass spectrometry.

Gas chromatography (GC): This separation technique allows for the analysis of complex mixtures by separating individual components based on their volatility and affinity for a stationary phase. The sample is vaporized, injected into a column, and then separated into its constituent compounds.

Mass spectrometry (MS): MS identifies and quantifies compounds by measuring their mass-to-charge ratio. It provides information about the molecular structure and fragmentation patterns of the separated compounds.

Portable GC/MS units are revolutionizing chemical analysis by bringing the lab to the field. They are still expensive ($60,000-$150,000). As technology advances, the prices and weights will come down. Their accuracy, speed, and versatility continue to improve, making them indispensable tools for safeguarding workers and public health and safety.

Colorimetric Detector

A colorimetric detector tube is a glass tube filled with a solid material that changes color when it reacts with certain chemicals. A hand-operated or battery- powered pump is used to pull a specific volume of air through the tube and the contaminant reacts with the chemical in the tube, producing a stain proportional in length to the concentration of the contaminant. Drager, Sensidyne, and others manufacture colorimetric detector tubes for dozens of contaminants or types of contaminants (example: alcohols).

The instructions are important and different for every type of colorimetric tube.

Pumps for colorimetric tubes are for single or multiple tubes and are manual or battery operated.

Colorimetric tubes are relatively easy to use, inexpensive, and quick. There are limitations to the usefulness of colorimetric detector tubes:

- They cannot be used to reliably identify chemicals
- Each tube is specific to a chemical or a small range of chemicals
- Similar chemicals may produce a color change (interference)
- Pump must be checked for leaks and calibrated
- Tubes have a limited shelf life (always check expiration date before use)
- User must read the correct scale on the tubes
- User must follow specific pump-stroke requirements
- Results can be off by as much as +/- 25%
- Results may be affected by temperature and humidity
- The results may not be clear

Radiation Detectors
No single instrument can measure all forms of radiation accurately. With different accessories, radiation detectors can be used to detect alpha particles, beta radiation, gamma rays, and x-rays. Workers on sites with ionizing radiation may be required to wear badges (dosimeters) that measure doses over many days. On sites where radiation sources are present, a specific monitoring program should be in place that describes monitoring devices, the type of hazard, and control methods.

Air Speed
Instruments to measure air velocity (speed) are useful for confined space entry ventilation requirements. Once you know the flow capacity of the blowers and verify the velocity, you can use calculations or charts that come with blowers to determine air flow rate or how much air is being moved per hour. This is important when determining how long to ventilate a space before entry.

Noise
Sound level meters (SLMs) are direct reading instruments that measure how loud noise is in decibels (dB). Most instruments use the A scale (dBA), which mimics how the ear responds to noise.

With SLMs, keep in mind that:

- They require calibration before and after each use.
- The battery must be checked before each use.
- They do not record data, and the display must be viewed constantly during use.
- They require training for proper use.

Personal noise dosimeters also measure sound level, but they record data over a period of time. These instruments are worn by the employee during the entire shift and used to determine the employee's eight-hour TWA exposure.

Temperature
Heat stress monitors measure heat stress index, black globe temperature, air temperature, and relative humidity.

The presence of biological hazards such as molds, bacteria, viruses, and certain parasites will affect PPE selection, as well as decontamination and disposal procedures. Specialists must be brought in to investigate and evaluate biological hazards

Worker Responsibilities
If you are asked to wear a sampling device:

- Be sure the monitor is positioned properly within your breathing zone.
- Notify your supervisor, safety, or industrial hygiene personnel if any problems occur.
- Use your rights provided by OSHA's Access to Employee Exposure and Medical Records Standard (1926.33) to request the results of tests in writing.
- Compare the results with OSHA PELs, NIOSH RELs, and ACGIH TLVs.
- Keep the results. If you become ill, the information may be helpful to your doctor.
- Ask for assistance if you do not know what the results mean.

Site management and health and safety personnel are responsible for selecting appropriate monitoring equipment. Manufacturers are often the best source of information about equipment uses, capabilities, and limitations. Some general considerations when selecting monitoring equipment:

- Instruments used in potentially flammable or explosive atmospheres must be intrinsically safe (incapable of creating sparks or heat that could ignite an explosive or flammable atmosphere).
- Most direct-reading instruments and sampling methods are designed to measure only one contaminant or group of contaminants and may experience interference from others.
- No instrument or monitoring method can measure all toxic substances.
- Make sure instruments are designed for the conditions (temperature, humidity, etc.) they will be used in.
- Users must be allowed to practice regularly.

Monitoring Measurements

The concentration or amount of gases and vapors is often measured in:

- parts per million (ppm) or
- parts per billion (ppb)

Parts per million (ppm) means the number of parts of one substance per million parts of another substance. 1 ppm is equivalent to 1 inch in 16 miles or 1 drop of ink in 14 gallons of water.

- 100% = 1,000,000 ppm
- 10% = 100,000 ppm
- 1% = 10,000 ppm
- 0.1% = 1,000 ppm

Parts per billion (ppb) is 1,000 times smaller than ppm, so:
1 ppb would be the equivalent of 1 inch in 16,000 miles or 1 drop of ink in 14,000 gallons of water.

Concentration of particulates is usually measured in weight per volume of air and is measured in:

- mg/m^3 – milligrams per cubic meter of air
- µg/m^3 – micrograms per cubic meter of air

mg/m^3 means milligrams of a substance in each cubic meter of air.

- A cubic meter (m^3) = 1 meter long, 1 meter high, and 1 meter deep.
- The volume of a blue public mailbox is approximately one cubic meter and 1 million times larger than a cubic centimeter.

Concentration is different from weight because 5 mg/m^3 is not 5 milligrams of arsenic, it is 5 milligrams of arsenic in every cubic meter of air.

These units are commonly used for concentrations of silica dust, metal fumes, or other particles in the air. For example, one crushed aspirin in a cubic meter of air is 325 mg/m^3. The Action Level for Lead Exposures is 30 µg/m^3 and the PEL is 50 µg/m^3.

Another monitoring result, commonly found during asbestos or fiberglass exposures, is f/cc, which means the number of fibers in each cubic centimeter of air. In the asbestos standard (29 CFR 1926.1101), OSHA defines a fiber as the "particulate form of asbestos, 5 micrometers or longer, with a length-to-diameter ratio of at least 3 to1."

- Cubic centimeter (cc or cm^2) is another common metric unit of volume.
- A cubic centimeter: 1 centimeter long,1 centimeter high, and 1 centimeter deep.
- A sugar cube is approximately one cubic centimeter.

For many chemicals, the NIOSH Pocket Guide lists a conversion factor from ppm into mg/m^3.

Micrograms (µg), milligrams (mg), grams (g), and kilograms (kg) are metric units of mass or weight. A grain of sugar weighs approximately 1 milligram. A gram is one thousand (1,000) milligrams and approximately the mass of a dollar bill or a paper clip.

A kilogram is one million (1,000,000) milligrams and about 2.2 U.S. pounds.

2.2 pounds = 1 kg = 1,000 g = 1,000,000 mg = 1,000,000,000 µg

1 gram (g) = Weight of a dollar bill

Or

Weight of 1 Packet of Sweet 'N Low

Summary: Monitoring and Sampling

Personal monitoring/sampling tells you what levels of chemicals workers are exposed to. Your employer will use monitoring/sampling results to choose the right engineering controls and personal protective equipment.

Oxygen-deficient and oxygen-enriched atmospheres, fire and explosion hazards, toxic chemicals, biological hazards, and radioactivity can all be monitored at the site.

Personal and area sampling is used to measure the amount of a toxic chemical in the air that a worker and the community is exposed to. Usually, these samples must be sent to a laboratory for analysis.

Real-time instruments give you an immediate measurement of contaminants in the air. Direct-reading instruments may be used for personal or area monitoring. They can measure flammable gases and vapors, oxygen, and toxic gases and vapors.

The air in a confined space must be tested with direct-reading instruments in this order: oxygen (19.5%-23.5%), flammable (less than 10% LEL), and then potential toxic substances (below IDLH or above the PEL, depending on the exact situation) before you enter and periodically while workers are inside. If the oxygen level is low or high, or if the meter is not properly calibrated, combustible gas levels (% LEL) will not be accurate. If the oxygen level is less than 19.5% or the combustible gas indicator reads at 10% of the LEL, leave the area immediately and alert your supervisor.

OSHA requires employers to do everything they can to keep exposure to air contaminants below the PELs. Personal monitoring is required to ensure exposures are below PELs and provides the most accurate information on a worker’s exposure. Personal monitoring is usually accomplished by having the worker wear a small pump that collects an air sample in the breathing zone. A full-shift eight-hour TWA is calculated from the results and compared to occupational exposure limits (PELs, RELs, or TLVs). It may take a day to a couple of weeks to get the results back from the lab and they provide no information about periods of high (peak) exposures during the shift.

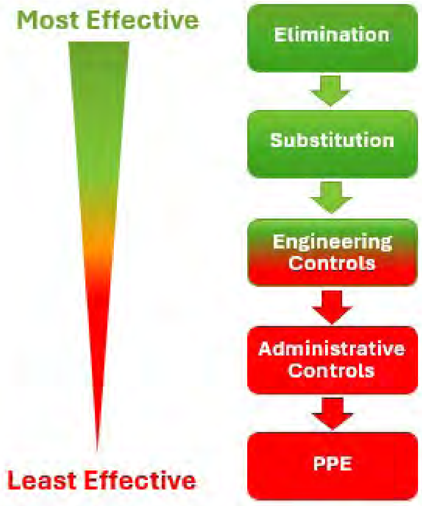
ppm – parts per million
ppb – parts per billion
mg/m^3 – milligrams per cubic meter of air
µg/m^3 – micrograms per cubic meter of air
cm^3 – cubic centimeter

Notes:

CPWR

Chapter 5:
Personal Protective Equipment (PPE)

Eliminating hazards or using engineering and administrative controls may not always be feasible on hazardous waste sites. Personal protective equipment (PPE) is required by OSHA and the EPA for all contractors working on hazardous waste sites when other controls cannot provide adequate protection. PPE shields or isolates the wearer from the chemical, physical, radiological, and biological hazards at hazardous waste sites. Careful selection and use of PPE can protect the respiratory system, skin, eyes, ears, hands, feet, and head.



Chapter Objectives:

After completing this module, you will be able to:

1. Identify if the proper PPE has been selected for the hazard.
2. Properly don and doff your PPE.
3. Inspect, clean, and store your PPE.
4. Describe the four ensemble levels that may be used when doing hazardous waste work.
5. Explain the difference between a qualitative and a quantitative fit test.
6. Demonstrate the User Seal Check.

Personal Protective Equipment (PPE) Program

A written personal protective equipment (PPE) program is required by OSHA as part of the employer's safety and health program and site-specific safety and health plan. The selected PPE must be capable of protecting employees from known and potential hazards. The PPE program must address:

1. Selection, based on site-specific hazards
2. Use and limitations
3. Work task duration
4. Maintenance and storage
5. Decontamination and disposal
6. Training and proper fitting
7. Putting on and taking off equipment
8. Inspection procedures
9. Evaluation of the effectiveness of the PPE program
10. Limitations during temperature extremes, heat stress, and other appropriate medical considerations

The preliminary site evaluation should provide enough information to select the appropriate PPE. When information on hazards is inadequate, OSHA mandates a high level of skin and respirator protection, along with the use of special equipment to monitor the air.

OSHA addresses PPE in 29 CFR 1926 Subpart E and 29 CFR 1910 Subpart I.

Standard Title	Construction Standard	General Industry Standard
General Requirements	1926.95	1910.132
Foot Protection	1926.96	1910.136
Head Protection	1926.100	1910.135
Hearing Protection	1926.101	1910.95
Eye and Face Protection	1926.102	1910.133
Respiratory Protection	1926.103	1910.134
Safety Belts, Lifelines and Lanyards	1926.104	
Hand Protection		1910.138

Section I – Respiratory Protection

Respiratory protection is required at hazardous waste sites when engineering or administrative controls cannot provide adequate protection. This section outlines the types of respiratory protection and their use and limitations.

Respirators can provide protection from chemical and particulate (dusts, fumes, mists, fibers) exposures (including some radioactive and biological materials) and oxygen deficient atmospheres. The respiratory protection standards for general industry (29 CFR 1910.134) and construction (29 CFR 1926.103) are identical.

OSHA's respiratory protection standards require employers to develop a site-specific written respiratory protection program if workers are required to wear respirators. When voluntary use of respirators is permitted, employers are required to have a written program sufficient to control the potential hazards associated with the use of the respirator.

The respiratory protection program must be written, have a designated administrator, and address:

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

Employers must provide medical evaluations to determine employees' ability to use a respirator before fit testing and use. Medical clearance to use a respirator is determined by a physician or other licensed health care professional (PLHCP). The PLHCP uses a questionnaire and, if necessary, a follow-up medical examination, to determine if you are at risk for adverse health effects from the added stress of a respirator. If you answer "yes" to specific questions on the questionnaire, you must then get tests or a physical exam. The medical clearance is repeated if you have health problems, change the type of respirator you use, or the workplace changes.

The PLHCP must be told what your job involves. Your employer keeps a copy of the medical clearance report with your other workplace records. The report must be limited to your ability to wear a respirator.

Medical conditions that could keep you from wearing a respirator include:

- Lung disease
- Claustrophobia (fear of small spaces)
- Severe high blood pressure
- Heart disease
- Punctured eardrum

Selecting the correct respirator for the hazard is the responsibility of the program administrator or other qualified personnel. Choosing the wrong respirator may be life threatening. All respirators must be approved by the National Institute for Occupational Safety and Health (NIOSH). Procedures for selecting respirators must be part of your employer's written program. To select the correct respirator, a qualified person must first test the air and know:

- The percentage of oxygen in the air.
- The hazardous substances workers may be exposed to.
- The concentration of the substances in the air.
- Permissible Exposure Limits (PELs) for the substances.
- The likelihood of Immediately Dangerous to Life or Health (IDLH) conditions.
- If the contaminants are hazardous to skin and eyes.

Air monitoring and direct reading instruments are used to identify the substances in the air and determine their concentrations.

The concentration of each hazardous substance must be compared to its PEL or another more protective occupational exposure limit.

An atmosphere with less than 19.5 percent oxygen by volume is considered oxygen deficient and immediately dangerous to life and health. The health effects experienced depend on duration of the oxygen deficiency, work rate, breathing rate, temperature, health, and age. Adverse health effects, such as reduced reaction times, may begin at 19 percent oxygen but may not be immediately noticeable or recognized. These percentages are for measurements taken at sea level—adjustments must be made for higher elevations.

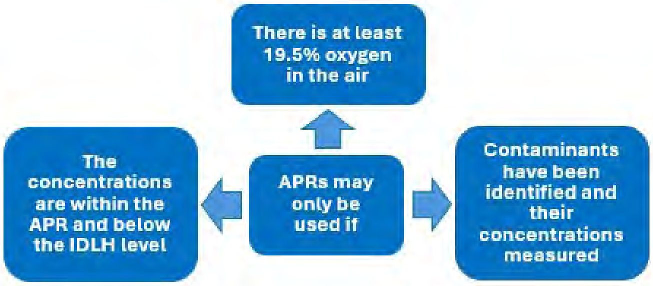
There are two main types of respirators, each with several subtypes:

1. **Air-purifying respirators (APRs)** remove contaminants from the air before it is inhaled.
2. **Atmosphere-supplying respirators** supply clean breathing air from a source independent of the work area. There are two types of atmosphere-supplying respirators:
   - **Supplied-air respirators (SARs)** or airline respirators supply air through an airline from a tank or compressor to the wearer.
   - **Self-contained breathing apparatus (SCBA)** supplies the air from a tank on the wearer’s back.

SCBA: full-face, positive-pressure, pressure demand 30 minute unit

Air-Purifying Respirators

Air-purifying respirators (APRs) can provide protection from particulates and some gases and vapors. They work by filtering air before it is inhaled. APRs include half mask filtering facepieces, half mask elastomerics, full facepiece elastomerics, and powered-air purifying respirators (PAPRs). Elastomeric means a polymer plastic that stretches. Most APRs consist of a facepiece with one or two filter cartridges through which the air enters, an exhalation (out) valve near the chin, and two straps. The most widely used on hazardous waste sites are full facepiece elastomeric APRs. Respirators and masks that are not approved by NIOSH should never be used for respiratory protection on a hazardous waste site or other jobs.



Filtering Facepiece

Filtering facepieces are disposable respirators that can be used in certain situations but can never be used on certain jobs, like an asbestos abatement project, as they do not protect against the microscopic fibers that may pass right through it. With this type of respirator, the facepiece itself is the filter, which is a low-efficient particulate filter, not a High Efficiency Particulate Air (HEPA) filter. Some filtering facepieces have an exhalation valve. The N95 is the most common type of filtering facepiece.

Half-mask respirators and disposable filtering facepiece respirators have an APF of 10, so they only provide one-fifth the respiratory protection of full facepiece APRs. Unlike full facepiece respirators, half-mask APRs do not provide eye protection. Half mask filtering facepieces consist of a filtering medium that makes up the entire facepiece and, in some cases, an exhalation valve. Filtering facepiece respirators do not provide protection from gases or vapors but are permitted for particles as long as they provide sufficient protection for the concentration present. Remember, APRs must not be used when the oxygen content is less than 19.5 percent.

Half-Mask Air-Purifying Respirator

Filtering Facepiece Air-Purifying Respirator

Full facepiece APRs have an APF of 50 and provide eye protection. They protect against particulates and some gases and vapors by filtering air before it is inhaled. Air enters through the filters/cartridge(s), which is selected to remove dusts, particles, chemical vapors and gases, or some combination of these, and exits through a valve. Workers who wear glasses will need a special kit to prevent the temples (side pieces) of the glasses from letting air leak in around the sides of the mask.

Typical Full Facepiece Air-Purifying Respirator

Negative vs Positive Pressure Respirators

A negative pressure respirator means any tight-fitting respirator in which the air pressure inside the facepiece is negative during inhalation with respect to the ambient air pressure outside the respirator. This means that as workers breath in air is pulled toward the respirator, so if there are any gaps in the seal of the respirator, contaminants can enter inside the facepiece rather than being filtered before entering. For this reason, it is essential that a worker has a proper fit when wearing the respirator.

A positive pressure respirator means the pressure inside the respiratory inlet covering of the respirator exceeds the ambient air outside the respirator. In other words, positive pressure prevents contaminants from entering the facepiece because air will blow out from the facepiece if there are any gaps that may be there when there isn't a good seal.

Air-purifying and Atmosphere-supplying Respirators

Another type of APR is the **powered air-purifying respirator (PAPR)**, which uses a blower to force air through the filters or cartridges and into the mask. PAPRs consist of a hood or helmet, facepiece, filter or cartridge, power source, and a blower. APF for PAPRs are 50 with a half mask, 1,000 with a full facepiece, and 25 with a helmet, hood, or loose-fitting facepiece. PAPRs with a helmet or hood can be given an APF of 1,000 with evidence from the manufacturer. PAPRs can only be used in environments where there is enough oxygen. If an employee has medical condition that prevents the use of a negative pressure respirator, then the employer must provide a PAPR [1910.134(e)(6)(ii)].

Two types of air purifiers (cleaners) are used with APRs.

1. Filters or air purifying elements remove dusts, particles, mists, and fumes (tiny metal particles) from air.
2. Chemical cartridges use a filter, sorbent, or catalyst, or a combination of these to remove vapors and gases from air. Materials used as sorbents include activated charcoal, silica gel, and specific chemicals that will capture gases and vapors.

Procedures for selecting filters and cartridges must be part of your employer's written program. Filters and cartridges are chosen based on the contaminants, the concentration of the contaminants, and, to a lesser extent, the size of the particles. For example, welding often produces both fumes and gases and may require a combination cartridge with both a filter and a chemical cartridge. In some instances, cartridges to protect you from a chemical are not available or have short service life and it is not possible or practical to use an APR.

Filters, canisters, and cartridges are labeled, and identification is color-coded.

Color Assigned to Canister, Cartridge, or Filter (ANSI Z88.7-2010)

Contaminants	Color Assigned
Acid gases	White
Organic vapors	**Brown/Black**[7]
Ammonia gas	Green
Ammonia & methylamine gas	Green
Carbon monoxide gas	Blue
Acid gases & organic vapors	**Yellow**
Acid gases, ammonia, and organic vapors	Brown
Organic vapors, chlorine, chlorine dioxide, hydrogen chloride, hydrogen fluoride, sulfur dioxide, formaldehyde, hydrogen sulfide (escape only), ammonia, methylamine	Pale Brown (Tan)
Acid gases, ammonia, carbon monoxide, and organic vapors	Red
Other vapors and gases or combinations not listed above	Olive
Any Particulates – High Efficiency (HE), for PAPRs only	**Purple/Magenta**
Any Particulates – P100	**Purple/Magenta**[8]
Any Particulates – P95, P99, R95, R99, R100	**Orange**[9]
Any Particulates free of oil – N95, N99, or N100	**Teal**[10]

[7] Organic vapor cartridges may be brown following changes to ANSI Z88.7 in 2010.

[8] Particulate filters housed within a container, and which do not have replaceable filter media, shall be color- coded as above. Particulate filters not housed within a container and which have a NIOSH filter class designation (N95, P95, etc.) on the filter do not need to be color-coded.

[9] An orange stripe or indicator shall be used to identify P class particulate filters, except P100, in combination with any vapor or gas canister or cartridge if the filter is housed within a container and the NIOSH filter class designation is not visible on the filter.

[10] A teal stripe indicator shall be used to identity N class particulate filters in combination with any vapor or gas canister or cartridge if the filter is housed within a container and the NIOSH filter class designation is not visible on the filter.

NIOSH has nine filter classes for non-powered respirators and they are based on three levels of filter efficiency and three levels of resistance to degradation from oil mist.

	Resistance to Oil		
Minimum Efficiency	**N (not oil resistant)**	**R (oil resistant)**	**P (oil proof)**
95%	N95	R95	P95
99%	N99	R99	P99
99.97%	P100	R100	P100

How do you know when your cartridge or filter needs to be changed?

Your employer’s written program must include a change schedule for cartridges for gases and vapors [1910.134(d)(3)(iii)(B)(2)], unless the cartridge has an end-of- service-life indicator (ESLI), which is an indicator that changes color when the cartridge is no longer effective. The frequency with which cartridges need to be changed depends on the chemical(s), their concentrations, the chemical’s boiling points, the temperature and humidity of the air, and your rate of work or breathing. Some cartridges will only last for minutes while others may be effective for many hours. It is considered a best practice to replace gas and vapor cartridges at the beginning of each shift and some substance-specific OSHA standards (e.g. benzene and formaldehyde) require this even if the end of the cartridge’s service life has not been reached. Odor, taste, and irritation cannot be used in place of a change schedule or ESLI, but you must leave the work area and change your cartridges if you detect a taste or smell in your respirator. You cannot rely on smell, taste, or irritation because they may not occur until you’ve already been exposed. If your sense of smell is weakened, you may be working with a useless cartridge and not even know it. When a particulate filter becomes “loaded,” it becomes difficult to breathe through and must be changed. Cartridges and filters must also be changed when recommended by the manufacturer or when they become damaged or wet.

Atmosphere-Supplying Respirators (ASRs)

Unlike an air-purifying respirator, atmosphere-supplying respirators (ASRs) provide clean breathing air from a source outside the area that workers are in. There are three types of ASRs. They are:

- Supplied-Air Respirators (SAR): Airline
- Self-Contained Breathing Apparatus (SCBA): Tank worn by the worker
- Combination SAR/SCBA: Includes an airline and backup SCBA tank

Supplied-Air Respirators (SAR)

SARs are connected by an airline hose to a free-standing cylinder, an air compressor, or a system supplying breathing air through a building. They are also known as airline respirators. At a minimum, the breathing air used must meet the requirements for Grade D breathing air. Although they are lightweight in comparison to an SCBA unit and can be used for long, continuous periods, they can limit the user's mobility by the length of the airline hose. The hose cannot exceed 300' in length. Also, the hose can get tangled, caught up on something, or even cut. A SAR cannot be used in an IDLH atmosphere, oxygen deficient, or an atmosphere of unknown contaminants without the use of an escape SCBA (which is typically a small, 5-minute bottle).

SARs deliver air to the user in three different regulators (Modes). They are:

- Continuous-Flow: Maintains airflow at all times.
- Demand-Flow: Gives the user air when the user demands it (inhales). This will cause negative pressure in the facepiece during inhalation, which provides the same protection as a full-face APR when used with a full-facepiece. These are commonly used with a mouthpiece for SCUBA diving.
- Pressure-Demand: Gives the user continuous airflow, which maintains positive pressure in the facepiece and gives additional air when the user demands it (inhales). Pressure demand is the preferred choice for maximum protection because if leakage occurs, the airflow from the facepiece should be directed outward and away from the user.

SARs are available in configurations with hoods and helmets as well as tight-fitting facepieces.

Self-Contained Breathing Apparatus (SCBA)

SCBAs are equipped with their own breathing air supply. Because of the portable air cylinder (tank), unrestricted movement is an advantage over an SAR. Disadvantages include they are heavier for the user and the length of service life. They usually use a 30-minute bottle, which doesn't last the same amount of time for all users. Length can depend on how many PSI of air they are filled with and the users' breathing habits and work tasks.

SCBAs categorized as open-circuit and closed-circuit devices can be used for entry into and escape from atmospheres that are considered IDLH, oxygen deficient, or areas of unknown concentrations.

Open-Circuit SCBAs

Open-circuit SCBAs are usually equipped with a full facepiece and contain their own breathing air supply in a pressurized cylinder that is worn on the back of the user. Typically, this is the type of respirator worn by firefighters. These respirators exhaust exhaled air into the atmosphere instead of recirculation it. Since there is no recirculation of breathing air, the service life of the open-circuit SCBA is usually shorter than a closed-circuit device.

As is with the SAR, regulators used with SCBAs can be used in either demand or pressure demand flow. SCBAs in demand flow cannot be used in IDLH atmospheres.

Closed-Circuit SCBAs

Closed-circuit SCBAs are also known as a 'rebreather'. The breathing gas is recycled after going through a process to remove the exhaled carbon dioxide (CO_2) and replace the oxygen consumed by the user. Closed-circuit SCBAs are approved for both entry and escape or escape only. Entry and escape devices have a duration of one to four hours. They are designed for use in IDLH and oxygen deficient atmospheres, such as confined space rescues.

Escape only closed-circuit SCBAs, known as closed-circuit escape respirators (CCERs), are used in certain work settings during emergencies to allow workers to escape from IDLH or oxygen-deficient environments. The duration of CCERs depends on the total amount of oxygen available to the user (capacity) and the oxygen consumption rate. They are also known as self-contained self-rescuers (SCSRs) in the mining community and as emergency escape breathing devices (EEBDs) in other industries. The SCSR is similar in design to the entry and escape closed-circuit SCBAs but is considerably smaller and with less weight. Because it is an escape-only device, this type of CCER can only be used for up to one hour.

Combination SAR/SCBA

A combination SAR/SCBA incorporates a backup self-contained air supply. The self-contained portion of the device is only used when the primary air supply falls or becomes interrupted. Typically, the self-contained air supply is small, since it only needs to supply enough air to allow a worker to escape from a hazardous environment when the SAR airline becomes cut or compromised in another way. When used with an escape, a SAR can be used in an IDLH atmosphere.

An assigned protection factor (APF) indicates the level of respiratory protection that a class of respirators can be expected to provide to employees when used as part of an effective respiratory protection program. A lower APF means the respirator does not provide as much protection. For example, a full facepiece air-purifying respirator has an OSHA APF of 50 and an SCBA in positive pressure mode has an APF of 10,000.

The full facepiece air-purifying respirator will let more contaminant into your facepiece and provide less protection than the SCBA will.

OSHA Assigned Protection Factors[5]

Type of respirator [1, 2]	Quarter mask	Half mask	Full facepiece	Helmet / hood	Loose-fitting facepiece
Air-Purifying Respirator	5	[3]10	50		
Powered Air-Purifying Respirator (PAPR)		50	1,000	[4]25/1,000	25
Supplied-Air Respirator (SAR) or Airline Respirator				[4]25/1,000	25
• Demand mode		10	50		
• Continuous flow mode		50	1,000		
• Pressure-demand or other positive-pressure mode		50	1,000		
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	

1. Employers may select respirators assigned for use in higher workplace concentrations of a hazardous substance for use at lower concentrations of that substance, or when required respirator use is independent of concentration.
2. The assigned protection factors in Table 1 are only effective when the employer implements a continuing, effective respirator program as required by this section (29 CFR 1910.134), including training, fit testing, maintenance, and use requirements.
3. This APF category includes filtering facepieces and half masks with elastomeric facepieces.
4. The employer must have evidence provided by the respirator manufacturer that testing of these respirators demonstrates performance at a level of protection of 1,000 or greater to receive an APF of 1,000. This level of performance can best be demonstrated by performing a Workplace Protection Factor or Simulated Workplace Protection Factor study or equivalent testing. Absent such testing, all other PAPRs and SARs with helmets/hoods are to be treated as loose-fitting facepiece respirators, and receive an APF of 25.
5. These APFs do not apply to respirators used solely for escape. For escape respirators used in association with specific substances covered by 29 CFR 1910 subpart Z, employers must refer to the appropriate substance-specific standards in that subpart. Escape respirators for other IDLH atmospheres are specified by 29 CFR 1910.134 (d)(2)(ii).

Maximum Use Concentration (MUC) means the maximum atmospheric concentration of a hazardous substance from which an employee can be expected to be protected when wearing a respirator. MUC is determined by a respirator's APF multiplied by the OSHA PEL (or another exposure limit) for a chemical. The MUC is for a specific chemical and type of respirator and does not take the filter or cartridge into account.

Air-purifying respirators cannot be used at IDLH concentrations even when the MUC is greater than the IDLH concentration. In this situation, you must use a respirator, such as a SCBA, specifically listed for IDLH conditions.

Use the following formula to calculate maximum use concentration:

MUC = APF X OSHA PEL

Here is an example:

You were given a half-face air-purifying respirator for work on a site with napthalene. The OSHA PEL for napthalene is 10 ppm. What is the maximum use concentration (MUC) in this scenario?

MUC = APF of 10 X 10 ppm

MUC = 100 ppm naphthalene with a half-face air-purifying respirator

If naphthalene concentrations may exceed 100 ppm, then your employer must provide you with respirator with a higher APF.

If you know the concentration at your worksite, you can also use a respirator's assigned protection factor to determine the maximum concentration of a chemical you are likely to be exposed to while wearing that respirator. You need to make sure that the concentration inside your respirator is below the OSHA PEL for the chemical. Use the following formula to do this.

$$\frac{\text{concentration of chemical in the work area}}{\text{Respirator's APF}} = \text{Concentration of chemical in the respirator}$$

Here is an example:

The OSHA PEL for o-xylene is 100 ppm. You are working in an atmosphere where the concentration of o-xylene is 800 ppm. Which of the two respirators below would you rather have to protect you against the chemical?

A half-face air-purifying respirator with an assigned protection factor of 10?	A full facepiece air-purifying respirator with an assigned protection factor of 50?
$\frac{\text{800 ppm}}{\text{APF of 10}}$ = 80 ppm maximum concentration inside your respirator	$\frac{\text{800 ppm}}{\text{APF of 50}}$ = 16 ppm maximum concentration inside your respirator
Less Protective	**More Protective**

A properly fitted full facepiece air-purifying respirator protects your eyes and provides five times more protection than a half-face air-purifying respirator.

Compressors

Compressors used to supply breathing air must meet special requirements. These compressors must be equipped with in-line, air-purifying sorbent beds and filters that are maintained and replaced or refurbished per the manufacturer's instructions. The compressor's exhaust must not contaminate the air it supplies. To avoid contamination of the supplied air, locate compressor air intakes in a contaminant-free area. Compressed breathing air must meet or exceed the following criteria for Grade D breathing as described in ANSI/CGA G-7.1-1989:

- Oxygen content of 19.5 - 23.5%
- Hydrocarbon (condensed) content of 5 mg/m_3 or less
- CO content of 10 ppm or less
- CO_2 content of 1,000 ppm or less
- Lack of noticeable odor

IDLH Respiratory Use

Sometimes workers need to go into areas that are immediately dangerous to life or health (IDLH). SCBA and SARs with an escape bottle are the most protective forms of respiratory protection and the only types allowed in IDLH conditions. Whenever SCBAs or SARs are used in these areas, there must be a trained worker outside who is in constant contact with the workers inside. Provisions must be made for rescue.

Positive pressure SCBAs or SARs with an escape bottle must be used when:

- Oxygen content of the air is less than 19.5%;
- Contaminants and/or its concentration are unknown;
- Concentration of the contaminant is IDLH or above the concentration safely handled by a less protective respirator; and
- There is an emergency including any of the above conditions.

Respirator Fit

Respirators must fit properly, be worn correctly, cleaned, stored, and maintained to provide the level of respiratory protection indicated by the assigned protection factor.

A tight-fitting respirator will protect you only if it seals against your face. Faces come in different sizes, and so do respirators. The purpose of fit testing is to find the manufacturer/size combination that offers you the best protection. OSHA’s respiratory protection standard requires that users of tight-fitting respirators be fit-tested.

Weight loss or gain, scars, dentures, dental work, or facial injury can change the way the respirator seals to your face and require another fit test.

Facial hair prevents the respirator from sealing to your face and wearing or fit testing a tight-fitting respirator is not allowed when facial hair may interfere with the face-to-facepiece seal.

The OSHA Respiratory Protection Standards state:

“The employer shall not permit respirators with tight-fitting face-pieces to be worn by employees who have (A) facial hair that comes between the sealing surfaces of the face-piece and the face . . . or (B) any condition that interferes with the face-to-face-piece seal.”

OSHA states that there cannot be any facial hair between the skin and the facepiece when you use a respirator that relies upon a good face-to-face-piece seal. This includes any tight-fitting (as opposed to helmet or loose-fitting hood) positive pressure respirators.

Even heavy stubble can prevent a good face-to-face-piece seal. Studies clearly show that facial hair will reduce the protection provided by respirators, particularly negative-pressure respirators. Twelve out of 14 studies reviewed showed that leakage increased 20 to 1,000 times when respirator wearers had facial hair (Stobbe, 1988). Rules about facial hair must be part of your employer's written program.

Inspection

Respirators should be inspected before and after each use and, if not used, at least monthly. Most construction workers are responsible for doing this themselves. Even if someone else is assigned to inspect your respirator, it is a good idea to check for yourself. Procedures for inspecting, maintaining, and storing respirators must be part of your employer's written program. Your employer's policy may include more frequent inspections.

Inspection for all respirators should include:

1. Checking the condition of the facepiece and all of its parts.
2. Checking the headbands to make sure that they can be tightened to provide a good fit.

Inspection for SCBAs and SARs should include:

1. Checking the hoses and the points where the hose attaches to the facepiece and to the air tank.
2. Checking the head and tank harnesses for cracks, tears, or other defects.
3. Checking the regulator according to the manufacturer's directions.
4. Checking the air tanks or compressor for damage.
5. Reporting defects or unusual conditions immediately.

Employers must provide each user with a respirator that is clean, sanitary, and in good working order. Employers must ensure that respirators are cleaned and disinfected using the procedures in 1910.134 Appendix B-2 or equivalent procedures recommended by the respirator manufacturer.

It is a good practice to clean and disinfect respirators after every use. OSHA states that respirators must be cleaned and disinfected:

- as often as necessary to maintain sanitary conditions when used by one person
- before being worn by different individuals when issued to more than one employee
- and after each use for respirators used for emergencies, fit testing, or training

Cleaning and disinfecting for all respirators should include:

1. Inspecting each piece
2. Washing/disinfecting the respirator components following the manufacturer's instructions
3. Hand-drying with a clean, lint-free cloth or air-drying
4. Reinspecting the pieces as they are put back together
5. Storing away from dust, sunlight, heat, extreme cold, high humidity, and chemicals

Cleaning and disinfecting for SCBAs and SARs should include:

1. Removing the air tank or hoses
2. Inspecting each piece
3. Washing/disinfecting the facepiece, hose, and harness following the manufacturer's instructions with disinfectant soap and water
4. Hand-drying with a clean, lint-free cloth or air-drying
5. Do not submerge SCBAs in water
6. Follow the manufacturer's specialized instructions

If you find something wrong with your respirator, do not try to fix it yourself. Find out who is authorized to do repairs in your site-specific respiratory protection program.

Fit Testing

Workers must be fit tested with the same make, model, style, and size of respirator that will be used. Fit testing can be either qualitative (subjective) or quantitative (objective measurement with a computer), depending on the respirator. Procedures for fit tests must be part of your employer's written program.

Qualitative and quantitative fit testing are used to determine the size and model of respirator that best fits the wearer and demonstrates that your face-to-facepiece seal is adequate. These tests must be repeated at least annually, or whenever changes in your physical condition may affect the respirator fit, to ensure a proper fit and your employer must keep a record of the tests.

Qualitative Fit Testing

Purpose: Determine whether the seal between the respirator's facepiece and the wearer's face is adequate.

Method: While wearing a respirator, you are exposed to a test substance that is an irritant (smoke), has a strong odor (banana

oil), or has a sweet or bitter taste (saccharine or Bitrex). The test is repeated while you complete seven activities (normal breathing, deep breathing, turning your head, moving your head, talking, bending over, and normal breathing) that may affect fit. These activities are performed for one minute each except for grimacing (smiling or frowning), which is done for 15 seconds. If you smell, taste, or detect the substance, then your respirator does not fit well and will not protect you.

Requirements: The qualitative methods are OSHA-approved and can be used to fit test tight-fitting respirators as required by 1910.134. These tests can only be used for APRs with an APF of 10 or less. Positive pressure atmosphere-supplying respirators and PAPRs that pass the QLFT fit test may be used at the higher protection factors assigned to these respirators.

Disadvantages: Qualitative fit testing depends on your senses. Passing or failing is subjective and determined by the respirator user. Having a poor sense of smell or taste or not following the method may cause you to believe you are protected when you aren't.

Some of the test substances can irritate the eyes or cause coughing. NIOSH recommends against fit testing with irritant smoke because of the associated health risks.

Fit testing is often done in an "ideal" environment that does not reflect real working conditions. Test conditions will not show how a respirator will fit in extreme temperatures or during hard physical work.

Quantitative Fit Testing

Purpose: Measure the effectiveness of a respirator in keeping contaminants from entering the facepiece during a fit test. Quantitative fit tests provide a fit factor to indicate whether the seal between the respirator's facepiece and the wearer's face is adequate. Fit factor means a quantitative estimate of the fit of a particular respirator to a specific individual and typically estimates the ratio of the concentration of a substance in room air to its concentration inside the respirator when worn.

Method: A probe is added to the respirator facepiece or between the filter and the facepiece. Then an instrument is used to measure particles or air pressure inside and outside the mask. The most common method measures the number of particles in the room and in the respirator mask, compares the two numbers, and calculates a fit factor. The test is repeated while you complete eight activities (normal breathing, deep breathing, turning your head, moving your head, talking grimmacing, bending over, and normal breathing) that may affect fit. The test provides an average fit factor for the seven one-minute activities.

Requirements: Quantitative fit testing is required by OSHA for all negative pressure respirators with an APF greater than 10 and is a good practice for all respirators. The quantitative fit test must indicate a fit factor of at least 100 for half mask respirators and at least 500 for full facepiece respirators or the respirator cannot be used.

Disadvantages: The equipment is more expensive to purchase than the equipment required for qualitative fit testing.

Respirator User Seal Checks

A positive-pressure and/or negative-pressure user seal check must be done each time you put on a respirator. These quick checks ensure that the respirator is properly seated on and sealed to your face but do not replace initial or annual fit testing.

Positive-Pressure (Exhale) User Seal Check

Method: Cover the exhalation (out) valve with your hand and blow out gently. The facepiece should expand but not break the seal. Adjust the respirator to eliminate leaks if necessary and repeat the process. For a positive pressure respirator, after the air supply is attached, simply hold your breath. You should not hear any air leaking from the mask.

Negative-Pressure (Inhale) User Seal Check

Method: For an APR, place your hands or latex gloves over cartridges and inhale. For an SCBA or SAR, disconnect the hose at the regulator, cover the end of the hose and inhale. Hold your breath for 10 seconds and check to see that no outside air leaks into the facepiece. Adjust the respirator to eliminate leaks if necessary and repeat the process.

Positive-pressure and negative-pressure user seal checks can be done quickly and easily in the field.

Section II – Chemical Protective Clothing (CPC)

After other controls have been used to the extent feasible, PPE provides an important barrier between chemicals or other hazards and your body. Although it cannot eliminate exposures, PPE can reduce exposures when properly selected and worn.

Chemical protective clothing (CPC) is a type of PPE and protects employees from chemical and physical hazards. CPC is an important part of a hazardous waste site worker's protective equipment.

Chemical protective clothing includes suits, foot covers, boots, gloves, and hoods that are made of special materials. These materials are chemical-resistant, which means they act as a barrier to keep chemicals from coming into contact with your skin. It is critical to select CPC that is designed to protect against the specific chemicals on your site. Otherwise, you might not be protected, even when you think you are.

CPC, and other PPE, must be selected based on potential exposures and explained in the safety and health plan. For example, totally encapsulating suits may be required for moving leaking drums, whereas non-encapsulating suits may be okay for operating a remote (robot) drum handler. The level of protection provided must be reevaluated as additional site information is gained.

Suits, respirators, gloves, and chemical protective steel-toed boots are always worn together in an ensemble, or combination. PPE ensembles are selected based on the respiratory and skin risks of the job. OSHA describes PPE ensembles as Level A, Level B, Level C, and Level D, in Appendix B of the HAZWOPER standard.

PPE Ensemble Level	Respiratory Risk	Skin Risk
A	High	High
B	High	Moderate
C	Moderate	Moderate
D	Low / None	Low / None

Chemical protective suits are of two general types, totally-encapsulating or non-encapsulating.

1. Totally-encapsulating chemical-protective (TECP) suit: Provides head-to-toe coverage to protect the wearer from chemicals. These "moon suits" have special seams and zippers to prevent chemicals from leaking into the suit. They are gas/vapor-tight and have exhalation valves. TECPs are used when the highest levels of skin and respiratory protection are needed. These suits have a face shield that is part of the hood.
2. Non-encapsulating chemical-protective (NECP) suit: Provides good protection from chemicals and may or may not have face shields. These suits are not totally encapsulating, are not vapor tight, and do not have exhalation valves. They provide less skin protection than vapor-tight suits. These suits are used when less skin protection is needed. The hood can either be part of the suit or detached.

Disposable suits, which provide limited protection from chemicals, can be used alone or in conjunction with these chemical-protective suits.

Level A provides the highest level of skin, respiratory, and eye protection that can be worn by a hazardous waste site worker.

The following constitute Level A equipment and may be used as appropriate:

1. NIOSH-approved positive pressure, full face piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator (SAR) with escape SCBA.
2. Totally-encapsulating chemical-protective (TECP) suit.
3. Built-in outer chemical-resistant gloves and separate inner chemical-resistant gloves.
4. Chemical-resistant boots with steel toe and shank.
5. Disposable protective suit, gloves, and boots (worn outside the Level A suit to protect the expensive suit).*
6. Coveralls.*
7. Hard hat (under suit).*
8. Long underwear (to absorb sweat).*

* Optional depending on conditions

Note: With SAR, the suit must be properly equipped with a pass-through air-line connection, called an air-line egress.

Level A should be worn when:

1. The identified substances require the highest level of protection for the skin, eyes, and respiratory system.
2. There is potential for splash, hand or foot immersion, or other skin contact with substances that may harm or be absorbed through the skin.
3. Working in confined, poorly ventilated areas, and the chemicals present or their concentrations are unknown.

Level B provides the highest level of respiratory protection, but a lesser degree of skin and eye protection than Level A. Level B is the minimum acceptable level for initial entry.

The following constitute Level B equipment and may be used as appropriate:

1. NIOSH-approved positive pressure, full face piece self-contained breathing apparatus (SCBA), or positive pressure supplied air respirator (SAR) with escape SCBA.
2. Non-encapsulating chemical-protective (NECP) suit. Hooded chemical-resistant clothing (overalls and long-sleeved jacket; coveralls; one or two-piece chemical-splash suit; disposable chemical-resistant overalls) - not vapor tight.
3. Inner and outer chemical-resistant gloves.
4. Chemical-resistant boots (outer) with steel toe and shank.
5. Boot covers: outer, chemical-resistant (disposable).
6. Disposable protective suit or coveralls and gloves (worn outside the Level B suit to protect the expensive suit and gloves).*
7. Hard hat.*
8. Face shield. *
9. Long underwear (to absorb sweat).*

* Optional depending on conditions

Level B should be worn when:

1. The type and concentration of substances in the air have been identified and require a high level of respiratory protection, but less skin protection.
2. The atmosphere contains less than 19.5 percent oxygen.
3. Incompletely identified vapors or gases are present but not suspected of containing high levels of chemicals harmful to skin or capable of being absorbed through the skin.

Note: This involves atmospheres with IDLH concentrations of specific substances that present severe inhalation hazards and do not represent a severe skin hazard, or do not meet the criteria for the use of air-purifying respirators.

Level C provides less respiratory protection than Levels A and B and less skin protection than A. It may or may not provide the same skin protection as Level B, depending on the type of suit worn.

The following constitute Level C equipment and may be used as appropriate:

1. NIOSH-approved air-purifying respirator (APR), full face or half-mask.
2. Hooded chemical-resistant clothing (overalls; two-piece chemical-splash suit; disposable chemical-resistant overalls).
3. Inner and outer chemical-resistant gloves.
4. Coveralls.*
5. Chemical-resistant boots (outer) with steel toe and shank.*
6. Boot covers: outer, chemical-resistant (disposable).*
7. Hard hat.*
8. Escape mask.*
9. Face shield.*

* Optional depending on conditions

Level C should be worn when:

1. The types and concentrations of airborne substances are known and there is at least 19.5% oxygen in the air;
2. A sufficient APR is available and all criteria for use have been met; and
3. Direct contact with the hazardous substance will not harm the skin or be absorbed through the skin.

Level D provides no respiratory protection and little or no skin protection. It is for people who work outside of the hazardous waste area. Level D protection is typically worn by workers involved with support activities such as equipment supply, maintenance, or off-site vehicle operation. Level D is similar to “typical work clothes” except for chemical-resistant boots with steel shank.

The following constitute Level D equipment and may be used as appropriate:

1. Coveralls (work clothing).
2. Chemical-resistant boots or shoes with steel toe and shank.
3. Hard hat.*
4. Gloves.*
5. Outer, chemical-resistant boots (disposable).*
6. Safety glasses or chemical splash goggles.*
7. Face shield.*
8. Escape mask.*

* Optional depending on conditions

Level D should be worn when:

1. The atmosphere contains no known hazards; and
2. The work will not involve getting chemicals on the skin or inhaling hazardous levels of any chemicals.

Remember, CPC ensembles must be selected based on the level of respiratory and skin protection required. Combinations of personal protective equipment other than those described for Levels A, B, C, and D protection may be more appropriate and may be used to provide the proper level of protection.

CPC Ensemble Level	Respirators	Skin Protection	Protection From
A	SCBA or SAR*	TECP suit, chemical-resistant gloves & boots	High respiratory and skin hazards and unknowns
B	SCBA or SAR*	NECP suit, chemical-resistant gloves & boots	High or unknown respiratory and moderate skin hazards
C	APR or PAPR	NECP suit, chemical-resistant gloves	Moderate respiratory and skin hazards
D	None	Optional gloves	No respiratory hazards and minimal skin hazard

* with escape SCBA.

CPC Selection Guidelines

Chemical resistance: Different materials are resistant to different chemicals. Even water can break down some materials. CPC must provide protection against the chemicals likely to be at the site. This is true for whole-body as well as hand and foot protection.

Durability: In addition to exposure to chemicals, CPC will be subject to stretching and contact with rough surfaces and sharp objects. CPC must be durable enough to be used without being torn, punctured, or abraded.

Resistance to temperature extremes: Heat and cold can often damage 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. Always check the manufacturer's information about temperature damage.

Ability to be cleaned: Clothing must either be decontaminated or disposed of after each use.

Cost: CPC is expensive, but buying less expensive, inferior products which do not adequately protect employees can be more expensive in the long run due to increased medical costs and lost work time.

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 can make gripping difficult and lead to other hazards.

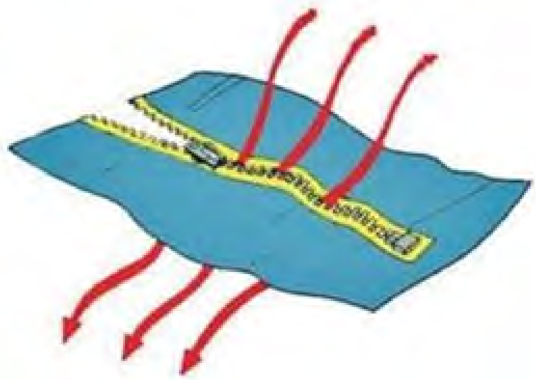
Heat stress and thermal comfort: CPC's contribution to workers' heat stress must be considered, monitored, controlled, and balanced against the need to provide protection from chemicals.

Size: CPC should be available in a variety of sizes to accommodate different sized workers. Suits that are too small will tear easily and provide no protection. Suits that are too large will make walking and working difficult. Safety boots that are too big will result in a tripping hazard and reduced comfort. Gloves that don't fit well make using equipment difficult and dangerous.

Chemical protective clothing’s ability to protect us depends on:

- Contact time
- Concentration
- Presence of chemical mixtures
- Temperature
- Size of the contaminant molecules and pore size of the CPC material
- Physical state (solid, liquid, gas) of the chemical contaminants

Penetration is the movement of a chemical through openings in CPC. Zippers, stitched seams, abrasions, punctures, tears, or other openings in the CPC material can contribute to penetration.



Degradation is the physical deterioration of the protective material, which reduces chemical resistance. High temperature, sunlight, inappropriate storage environments, and chemical exposure can contribute to degradation. Signs of degradation are not always visible and include discoloration, blistering, brittleness, softening, cracking, swelling, and shrinking.

Permeation is the movement of a chemical through a protective material on a molecular level (invisible). Breakthrough time is the amount of time required for a chemical to permeate, or pass through, a material.

Measured Breakthrough Time	Performance Level
10-30 min.	Level 1
30-60 min.	Level 2
60-120 min.	Level 3
120-240 min.	Level 4
240-480 min.	Level 5
>480 min.	Level 6

Materials used to make most PPE and suits do not “breathe,” causing rapid heat and moisture build-up inside the PPE. Wearing PPE makes it difficult for the body to cool itself and adds to heat stress. This leads to discomfort and possibly heat-related illnesses including:

- Heat exhaustion
- Heat cramps
- Heat rash
- Heat stroke

The safety and health plan should address preventing heat-related illnesses with procedures for:

- Monitoring forecasts and weather conditions
- Acclimatizing workers to working in a hot work environment
- Implementing a work-rest schedule
- Providing water and shade and ensuring they are used
- Identifying and responding to heat-related illnesses

Wearing cool suits and vests while wearing protective clothing keeps workers cool.

Photo 1: Vest and a frozen H_2O bottle
Photo 2: Bottle carrier (r), pump priming bulb (m), and battery pack (l)
Photo 3: Front view of the Cool Suit vest & sternum strap

Inspection, Maintenance, Storage, and Limitations

It is important to **inspect** CPC for evidence of chemical or physical damage. Instructions for inspection, maintenance, and storage should be in the site safety and health plan.

CPC should always be inspected when it is:

1. Received from the distributor
2. Issued to workers
3. Put into storage
4. Taken out of storage
5. Used in training
6. Used for work or an emergency response
7. Received following maintenance or repair

An inspection checklist should be developed for each item. CPC inspection checklists should consider:

1. Weakness in zipper or valve seals
2. Cuts, holes, tears, swelling, and abrasions in seams of fabric
3. Signs of contamination such as discolorations or visible stickiness
4. Signs of malfunctioning exhaust valves
5. Improper storage

Note: CPC may be contaminated even though it does not appear discolored.

Proper **maintenance** and **storage** can prevent problems with CPC and prolong the life of the equipment. SOPs should describe storage before the CPC is issued to the wearer, as well as post-use storage. Check the manufacturer's data, as most CPC has a shelf life.

Chemical-protective clothing has limitations:

1. Fully encapsulating suits make communication very difficult. It is important to establish other ways to communicate. Learn the alarm and hand signals used on your site. Two-way radios, portable radios, or radios with a microphone and speaker combination attached to the full-face respirator are recommended. Remember, all radios must be intrinsically safe when working in a potentially explosive atmosphere.
2. Most suits restrict movement and increase clumsiness, especially when climbing, working in tight areas, or using hand tools.
3. PPE, especially TECPs, increases heat stress and the risk of heat-related illnesses.
4. Heat stroke is a serious threat. Watch for signs of dizziness, nausea, and lack of perspiration, especially at temperatures over 70°F.
5. Disposable boot covers may be slippery. Use caution to prevent slips and falls.
6. Suit-to-boots and suit-to-glove joints on Level B and Level C suits should be taped. Fold the end of the tape back under to make a tab for easy removal (see image to the right). Use special care when removing tape as adhesive tape can damage the suit material.

7. Goggles and eye/face protection may become clouded due to moisture from breathing. When wearing Level A, you may want to keep a cloth inside the suit to wipe fog off the inside of the face shield.
8. Kneeling can contaminate and tear the suit.
9. Seams are weak points, especially in disposable suits. Be careful not to strain and split them. If this occurs, report the incident and follow the appropriate SOP.
10. Use caution when suits are worn in potential fire areas. Most suits do not offer fire protection and may increase the possibility of injury because they melt. If a fire occurs, get out of the area. Special fire-retardant suits may be worn over your CPC, but this makes movement more difficult and greatly increases heat stress.

Other Protective Clothing and Equipment

The situation and potential exposures determine the PPE needed. For example, chemical-resistant gloves, face shield/goggles, and aprons can be used with Level D when there are no respiratory hazards present but some skin hazards exist.

A number of operations at hazardous waste sites result in substantial noise exposure and require the use of hearing protection. When required, a hearing conservation program must be implemented (29 CFR 1926.52 and 29 CFR 1910.95). The employer must provide a selection of hearing protection for you to choose from (29 CFR 1926.101 and 29 CFR 1910.95).

Summary: Personal Protective Equipment (PPE)

Personal protective equipment (PPE) includes respirators, chemical-resistant suits, steel-toed boots, gloves, hard hats, and hearing protection. PPE is required by OSHA regulations and protects workers from:

- Chemical contact with skin and eyes
- Noise
- Respiratory hazards
- Sharp objects underfoot
- Falling objects

Respirator Protection

Respirators prevent toxic materials from entering your body through your lungs. When respirators are required, your employer must have a written respiratory protection program. You must complete a respirator medical evaluation (questionnaire) and/or exam and receive medical clearance from a physician or other licensed health care professional before your fit test.

Selecting the right respirator and filter or cartridge can be a matter of life or death. Special considerations in the use of respirators include facial hair, eyeglasses, communication, and use in IDLH atmospheres (such as low oxygen or chlorine leaks).

A respirator that filters the air is an air-purifying respirator or APR. These may be filtering facepiece respirators or elastomeric (rubber) respirators with cartridges or filters. Elastomeric respirators have a facepiece, straps, an exhalation (out) valve, and one or two filters or cartridges where the air enters. Filters remove dust and particulates, cartridges remove vapors and gases, and some hazards require filters and cartridges to be used together. Your employer must have a change schedule unless the cartridge has an end of service life indicator (ESLI). An APR can only be used if there is enough oxygen in the air.

Situations where you must **not** use an air-purifying respirator (APR) include:

- Not enough oxygen (less than 19.5%)
- The chemicals or concentrations of chemicals are not known
- Levels of hazardous substances in the air are above the maximum use concentration for the respirator and chemical
- Atmosphere is immediately dangerous to life and health (IDLH)
- Skin hazards where you must wear a fully-encapsulating suit

Atmosphere-supplying respirators include self-contained breathing apparatus (SCBA) and supplied-air respirators (SARs).

SCBA are the type of respirator firefighters use most often. They can be used in areas with low oxygen, high levels of chemicals, very toxic chemicals, or fires.
SCBAs have a facepiece, a 30-60 minute tank of air, a pressure gauge, a low-pressure alarm, a regulator, and a safety or bypass valve for use during regulator failure.

SARs, also known as airline respirators, have a long hose that supplies air. The long hose must be protected from chemicals and cuts. If SARs are used in IDLH situations or for unknown concentrations, a small bottle of air for escape must also be worn.

Chemical Protective Clothing

Chemical protective clothing and other PPE expose wearers to heat stress because heat, moisture, and air do not move through them well, or at all. Heat stress can lead to symptoms including severe fatigue, nausea, chills, dizziness, confusion and heat-related illnesses including heat exhaustion, fainting, heat cramps, heat rash, and heat stroke. Anyone experiencing these symptoms or suspected of having these conditions should receive immediate medical attention.

Suits are made of many different kinds of materials, including butyl, neoprene, and polyethylene. No one material can stop all chemicals. All chemicals will eventually soak through the material (permeate), move through the seams (penetrate), or damage the material (degrade).

Suits, respirators, several pairs of gloves, and chemical protective steel-toed boots are always worn together in an ensemble. The PPE ensemble used must be selected based on the respiratory and skin hazards present or anticipated.

Level A is for gases, mists, or vapors that may burn the skin or chemical spills that can soak through the skin. It provides the most protection and includes:

- an SCBA (or supplied-air respirator with escape unit)
- a gas-tight, totally-encapsulating chemical-protective suit with gloves and foot coverings built in

Level B is for high levels of gases or small spills of chemicals that can soak through the skin. It includes:

- an SCBA (or supplied-air with escape unit)
- a full-body chemical-protective suit that is not gas-tight
- gloves and boots

Level C is for known, low levels of gases, dusts, or spills of chemicals that cannot soak through the skin. It includes:

- an air-purifying respirator (APR)
- hooded, chemical-resistant clothing
- gloves and boots

PPE must be properly cared for, maintained, inspected, and stored. Wearers should know the uses and limitations of PPE. Written programs about selection, care, and use of PPE should be included in or referenced in the safety and health plan.

Notes:

Chapter 6:
Work Practices and Site Control

The Occupational Safety and Health Administration (OSHA) is responsible for setting and enforcing regulations governing worker safety and health hazards at hazardous waste sites. Other federal and state agencies are responsible for protecting the community, environmental, and transportation systems from hazardous materials. Your employer must provide a workplace free from recognized hazards that are causing or likely to cause death or serious physical harm to its employees. Your employer must provide the necessary hazard control training and protective equipment to reduce exposure to hazardous substances. You are responsible for knowing and following the employer safety rules.

Workers’ exposures to hazards at a waste site are controlled using engineering and administrative controls and personal protective equipment (PPE), in that order. Engineering controls are the most effective way to reduce workers’ exposure. Personal protective equipment does not control the source of exposure, but it can reduce the amount of substance reaching the body.

Chapter Objectives:

After completing this module, you will be able to:

1. Explain why site characterization is necessary and how it is accomplished.
2. Describe what the requirements are for a Site Safety and Health Plan.
3. Discuss the different work zones that will need to be established on a Hazardous Waste Worksite.
4. Explain what is required for medical surveillance and why it is important.

There is no single definition of a hazardous waste site. The contaminants, size of the site, duration of cleanup, and other aspects of hazardous waste sites vary widely. For example, a hazardous waste site could be a military base contaminated with heavy metals, an abandoned industrial facility contaminated with chlorinated solvents, the cleanup after a chemical spill on a highway, or a chemical plant following an explosion.

Characterization

Site characterization and analysis identify the safety and health hazards on a hazardous waste site so that they can be controlled.

Experts must determine:

1. What chemicals are hazardous waste at the site.
2. How much of each hazardous substance is on the site.
3. Chemical and physical properties of hazardous substances.
4. Safety and health hazards on the site.
5. Appropriate controls, including personal protective equipment (PPE), to protect employees from hazards.

Hazardous waste site characterization and analysis requirements can be divided into seven parts.

1. Information required prior to entry.
2. Personal protective equipment.
3. Preliminary evaluation.
4. Hazard identification.
5. Monitoring.
6. Risk identification.
7. Worker notification.

Required Information

Before workers can enter the site, the following information must be obtained:

1. Location and approximate size of the site.
2. Description of the task to be performed.
3. Time required to do the task.
4. Site layout and accessibility by air and roads.
5. Safety and health hazards that are expected to be at the site.
6. Pathways of movement of hazardous substances.
7. Capabilities of emergency response teams.
8. Expected hazardous substances and their chemical and physical properties.

Personal Protective Equipment

Personal protective equipment (PPE) must be provided for workers engaged in the site entry to perform the preliminary onsite evaluation. If this initial survey cannot establish airborne concentrations, all employees must use a high level of protective gear rated Level B or higher (see Chapter 5). Once further information on hazards is available, the PPE will be reevaluated by health and safety specialists and adjusted to be either more or less protective.

Preliminary Evaluation: History and Background

The preliminary site evaluation determines the level of protection to be worn by the entry team. Information is obtained prior to the initial entry through observations and monitoring from the perimeter, interviews, and a review of records, safety data sheets, and other documents regarding materials at the site.

After the preliminary evaluation, the entry and backup teams evaluate the site-specific characteristics to identify existing hazards and to help select the appropriate engineering controls and personal protective equipment for the tasks to be performed. Until contaminant concentrations are known, Level B is the minimum level of PPE required for entry and backup teams.

Hazard Identification: A List of Dangers

Hazard identification documents all conditions that may cause death or serious harm, including those that may pose inhalation or skin absorption hazards that are immediately dangerous to life or health (IDLH). Hazards include, but are not limited to, confined spaces, potentially explosive or flammable situations, and other construction hazards.

Some of the dangers on hazardous waste sites are the same as on regular construction jobs, and some of them are different. Even the simplest task can become hazardous while wearing a respirator and other PPE.

Monitoring: Air, Chemical, and Hazard Sampling

Monitoring must be conducted during the initial entry when the site evaluation shows the potential for IDLH conditions or ionizing radiation, or the evaluation provides insufficient information to eliminate the possibility of these conditions. Hazardous levels of ionizing radiation are measured with direct read instruments. Direct reading instruments are also used to identify IDLH conditions such as flammable or explosive atmospheres, oxygen deficiency, and toxic substances.

In addition to the monitoring required for initial entry, periodic monitoring is required when there is a possibility that exposure may exceed the Permissible Exposure Limits (PELs). Additional monitoring may be required when work begins in a different area, when work involves new contaminants, when different tasks are performed, or when working with obvious contamination.

Risk Identification: How Great of a Danger?

Once hazards are identified, the risk associated with the hazards must be determined. Employees must be informed of any risks, including:

- Exposures exceeding OSHA PELs or other occupational exposure limits recommended by NIOSH or the ACGIH.
- IDLH concentrations.
- Sources of skin and eye irritation or absorption.
- Explosion and flammability risk.
- Oxygen deficiency or enrichment.

Worker Notification

Before work begins, each site worker must be told about the substances known or expected to be present on the site. The employer must make information including chemical and physical properties and health effects available to workers so they understand the hazards of doing their job.

Work areas and site maps should show the lay of the land, prevailing wind direction, drainage, and the location of buildings, containers, impoundments, pits, ponds, and tanks. Site maps are helpful for planning PPE use, assigning personnel to work zones, and identifying evacuation routes. A site map should be modified during work to reflect the changes in activities. Computer software or clear overlays can be used to help prevent the information from cluttering the map.

Most hazardous waste sites have three work zones: exclusion, contamination reduction, and support.

The hazards, potential for exposure, and level of PPE needed are different for each zone. These zones are used to control the spread of hazardous substances, restrict the number of people in high-risk areas, and ensure that people in each area have appropriate training and PPE. You may hear each zone called several different names.

The **exclusion zone**, or commonly referred to as the Hot Zone, is a contaminated area and presents a high potential for exposure to hazards. Personnel working in this area wear the highest level of PPE on the site. Workers must be decontaminated every time they leave the hot zone.

Activities performed in the hot zone include:

- Site characterization (e.g. mapping, photographing, sampling)
- Installation of wells for groundwater monitoring or treatment
- Clean up work such as drum movement and staging

The boundary between the hot zone and the contamination reduction zone is called the hot line. It must be clearly marked by lines or hazard tape or enclosed with physical barriers such as chains, fences, or ropes.

The **contamination reduction zone**, or warm zone, is between the hot and support zones and where decontamination activities take place. The site safety officer, personal decontamination station operator, and emergency response personnel are usually stationed in the contamination reduction zone. Equipment, supplies, and workers' rest areas are also located here. The contamination reduction zone contains the decontamination line. The decontamination line is made up of a series of stations and arranged to decrease contamination. Personal protective equipment and clothing are removed, and decontamination procedures take place in the contamination reduction zone to prevent the transfer of hazardous substances to cleaner areas. There are often two decontamination lines: one for the workers and, if necessary, one for heavy equipment, tools, and machinery. Decontamination will be discussed in detail in Chapter 8.

The contamination control line is the boundary between the support and the warm zone. Everything located outside the contamination control line is in the support zone.

The **support zone**, or cold zone, is free of contamination and personnel should have no exposure. The command post supervisor, project team leader, and support field team members are usually stationed in the support zone. The location of the support zone is chosen for accessibility, resources, visibility, wind direction, and distance.

Hazardous waste workers must always use the **buddy system** and work in teams of two or more. The buddy system requires teams of workers to watch out for each other's safety and health.

A buddy provides assistance, observes their partner for signs of chemical exposure or heat stress, periodically checks the partner's PPE, and notifies the command post supervisor if help is needed.

The buddy should maintain line-of-sight contact and communication with others and the command post supervisor. Workers must make sure that the selected communication system is understood before entering the exclusion zone. PPE is required on the site. Workers must be decontaminated every time they leave the exclusion zone.

Communication systems must be established prior to the start of work so the team members can alert each other to emergencies, pass along safety information, initiate changes in work tasks, and maintain site control. The system must address communication with individuals on the site and at other locations. Internal communication systems include two-way radios, walkie-talkies, audio and visual alarms, hand signals, and cell phones. External communication systems include telephone, email, text messaging, radios, audio, and visual alarms, including sirens, horns, flags or pennants, and strobe or other flashing lights. Any communication device that is electric or electronic must be intrinsically safe. Site-specific training on communication and warning systems is required. Some common hand signals are described below.

This is an example of a basic communication plan:

Channel 2 has been designated as the radio frequency for personnel in the exclusion zone. All other on-site communications will be on channel 3.

Personnel in the exclusion zone should remain in constant radio communication or within sight of the project team leader. Any failure of radio communication requires an evaluation of whether personnel should leave the exclusion zone.

A horn blast is the emergency signal to indicate that all personnel should leave the exclusion zone. In addition, a loudspeaker is available if required.

The following hand signals will be used in case of failure of radio communications:

- Hand gripping throat = Out of air, cannot breathe
- Grip partner’s wrist or hands around the waist = Leave area immediately
- Hands on top of head = Need assistance
- Thumbs up = OK, I’m All right

Telephone communication to the command post should be established as soon as possible. The phone number is 555-867-5309.

Nearby medical facilities must be identified before cleanup begins on a hazardous waste site. The facility should be made aware of the cleanup activities and procedures for requesting medical assistance. All employees must be informed of the location of the medical facility and how to notify them in the event of an emergency or when treatment is needed. The location of the nearest prepared medical facility and notification procedures must be included in the site control plan.

Safety and Health Program

Establishing a safety and health program at the job site is one of the most effective ways of protecting the most valuable asset: the workers. Safety and health programs foster a proactive approach to "finding and fixing" job site hazards before they can cause injury or illness. Rather than reacting to an incident, management and workers collaborate to identify and solve issues before they occur. This collaboration builds trust, enhances communication, and leads to other improvements.

There are seven core elements of an effective safety and health program:

1. Management Leadership: Top management demonstrates its commitment to eliminating hazards and to continuously improving workplace safety and health, communicates that commitment to workers, and sets program expectations and responsibilities. Managers at all levels make safety and health a core organizational value, establish safety and health goals and objectives, provide adequate resources and support for the program, and set a good example.
2. Worker Participation: Workers and their representatives are involved in all aspects of the program—including setting goals, identifying and reporting hazards, investigating incidents, and tracking progress. All workers, including contractors and temporary workers, understand their roles and responsibilities under the program and what they need to do to effectively carry them out. Workers are encouraged and have means to communicate openly with management and to report safety and health concerns or suggest improvements, without fear of retaliation. Any potential barriers or obstacles to worker participation in the program (for example, language, lack of information, or disincentives) are removed or addressed.
3. Hazard Identification and Assessment: Procedures are put in place to continually identify workplace hazards and evaluate risks. Safety and health hazards from routine, nonroutine, and emergency situations are identified and assessed. An initial assessment of existing hazards, exposures, and control measures is followed by periodic inspections and reassessments, to identify new hazards. Any incidents are investigated with the goal of identifying the root causes. Identified hazards are prioritized for control.
4. Hazard Prevention and Control: Employers and workers cooperate to identify and select methods for eliminating, preventing, or controlling workplace hazards. Controls are selected according to a hierarchy that uses engineering solutions first, followed by safe work practices, administrative controls, and finally personal protective equipment (PPE). A plan is developed that ensures controls are implemented, interim protection is provided, progress is tracked, and the effectiveness of controls is verified.

5. Education and Training: All workers are trained to understand how the program works and how to carry out the responsibilities assigned to them under the program. Employers, managers, and supervisors receive training on safety concepts and their responsibility for protecting workers' rights and responding to workers' reports and concerns. All workers are trained to recognize workplace hazards and to understand the control measures that have been implemented.
6. Program Evaluation and Improvement: Control measures are periodically evaluated for effectiveness. Processes are established to monitor program performance, verify program implementation, and identify program shortcomings and opportunities for improvement. Necessary actions are taken to improve the program and overall safety and health performance.
7. Communication and Coordination for Employers on Multiemployer Worksites: General contractors, contractors, and staffing agencies commit to providing the same level of safety and health protection to all employees. General contractors, contractors, subcontractors, and staffing agencies communicate the hazards present at the worksite and the hazards that work of contract workers may create on site. General contractors establish specifications and qualifications for contractors and staffing agencies. Prior to beginning work, general contractors, contractors, and staffing agencies coordinate on work planning and scheduling to identify and resolve any conflicts that could impact safety or health.

The OSHA 29 CFR 1910.120 standard requires employers to develop and implement a written safety and health program. The written program shall include the following elements:

1. An organizational structure for the operation.
2. A comprehensive work plan.
3. The site-specific safety and health plan.
4. The safety and health training program.
5. The medical surveillance program.
6. The standard operating procedures for safety and health.
7. Any connection between the general safety and health program and site-specific activities.

Contractors and Subcontractor Responsibilities

An employer who retains contractor or subcontractor services for work and hazardous waste operations shall inform those contractors, subcontractors, or the representatives of the site emergency response procedures and any potential fire, explosion, or health hazards, as well as of tanks or other hazards of the hazardous waste operation that have been identified by the employer, including those identified in the employer's information program.

Program Availability
The written safety and health program shall be made available to any contractor or subcontractor or the representative who will be involved with the hazardous waste operation; to employees; to employee-designated representatives; to OSHA personnel, and to the personnel of other federal, state, or local agencies with regulatory authority over the site.

The organizational structure section of the program must describe lines of authority, responsibilities of supervisors and employees, and communication between all personnel involved in the cleanup operation.

The comprehensive work plan must include activities, logistics, and use of resources. The comprehensive work plan should be reviewed during the site-specific training period. The site-specific work plan must include specific details about:

- The task(s) to be done.
- How they will be done.
- Who will do them.
- What equipment and resources will be needed.
- What training will be needed.
- What medical test will be needed.

Site-Specific Safety and Health Plans

The site-specific safety and health plan addresses the hazards during each phase of the cleanup and the procedures and controls required to protect workers. To the extent possible, the plan should be detailed enough to avoid language that is generic or requires interpretation. The site-specific safety and health plan should be used as a planning guide before site work begins and as a reference tool throughout the site work. When new information is obtained during the inspections, the plan should be updated.

Each of the following topics must be covered:

- Safety and health hazard analysis for each task or operation
- Employee training
- Personal protective equipment
- Medical surveillance
- Air monitoring
- Site control
- Decontamination
- Emergency response
- Confined space entry
- Spill containment

A safety and health hazard analysis is a technique that focuses on job tasks as a way to identify hazards before they occur. It focuses on the relationship between the worker, the task, the tools, and the work environment. Ideally, after you identify uncontrolled hazards, you will take steps to eliminate or reduce them to an acceptable risk level.

Under the OSHA HAZWOPER standard, training must be provided for all hazardous waste workers who are exposed to hazardous substances, health hazards, or safety hazards. Supervisors and management responsible for the site must also receive training.

General site workers must have a minimum of 40 hours of instruction and a minimum of three days actual field experience under the direct supervision of a trained, experienced supervisor. Supervisors are required to complete the 40-hour general program, three days of actual field experience, and an additional eight-hours of training designed for managers. Treatment, storage, and disposal facility workers and workers on site for a specialized operation must have a minimum of 24-hours of instruction and a minimum of one day of actual field experience.

Eight hours of refresher training is required every year for all site workers and supervisors. Workers who will assist in the emergency response activities must receive additional, emergency response specific training.

The medical surveillance program must provide for monitoring of workers' health before, during employment, and at the end of employment. The medical surveillance program must be provided 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 other published exposure level for 30 days or more a year.
- All employees who wear a respirator for 30 days or more a year or as required by 1910.134.
- All employees who are injured, become ill, or show symptoms due to overexposure to hazardous substances from an emergency response or clean up.
- Members of hazardous materials response teams.

Note: Medical clearance must be obtained before using a respirator.

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 or place. A physician will decide on the content of the examination.

Medical exams must be conducted:

- Before a new job assignment;
- At least once a year unless a physician determines that a longer period, up to two years, is appropriate;
- More than once a year if the doctor decides it is necessary;
- When a job ends; and
- If an employee has symptoms that may have been caused by exposure to hazardous substances or if the employee was injured or exposed to above the PEL or other occupational exposure limit in an emergency.

Your employer must give the physician:

- A copy of OSHA's HAZWOPER standard.
- Your job description and exposures.
- Your current or anticipated exposure levels.
- A description of personal protective equipment used or to be used.
- Information from previous examinations that the physician may not have.
- Information required by the respirator standard.

Your employer must give you a copy of the physician's written opinion, including:

- Medical conditions that could make hazardous waste work or respirator use particularly risky to you.
- Recommended limitations on your assigned work.
- Results of the exam and test if you request them.
- A statement that the doctor has told you about the exam results and any conditions that require further examination or treatment.

The report your employer gets from the physician can discuss only findings related to your work. Any medical conditions unrelated to your job must not be revealed to the employer. You have the right to request and be given a copy of the physician's full report. Your employer must keep medical and exposure records for as long as you are employed plus another 30 years. If you work for your employer for less than a year, they do not have to keep your records if they give them to you when you leave. The Department of Energy (DOE) record retention requirement is 75 years.

Cleanup Methods and Technology

Cleaning up hazardous waste sites is a complex, multi-phase process. Cleanup methods can include:

Free Product Recovery: pump pools of waste out of the ground. The waste must be treated with one of the methods below or the chemical may be purified and reused.

Filtration: filter out solid hazardous waste from the water with sand beds or other filters.

Incineration: burn hazardous waste in a high temperature incinerator.

Solidification: waste mixed with cement and ashes to turn it into a solid block that can be buried in a regular landfill.

Chemical Decontamination: wash buildings or pipes or treat waste with chemicals to remove, transform, or neutralize the contaminant. The resulting solution may need to be treated with one of the above methods before disposal.

Mechanical Decontamination: scrap, blast, or grind buildings to remove chemicals. Sometimes special peel off coatings are used. The dust and debris must be treated with one of the above methods.

Dismantling: cut machines or building components apart with saws, cutters, grinders, torches, explosives, or water jets. Dust must be treated with one of the above methods.

These treatment methods can cause serious health and safety problems without the proper precautions and controls.

New technologies must be evaluated before they are used 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.

Summary: Work Practices and Site Control

The safety and health plan is a written document that includes site-specific information designed to identify, evaluate, and control exposures to hazards. The plan must include: organizational structure on the site; a comprehensive work plan; a site-specific safety and health plan; standard operating procedures (SOPs); safety and health training; a medical surveillance and exam program; and any information necessary to link the overall company plan to the site-specific plan.

Hazard control procedures must be written and put in place before workers enter the site. These procedures must include a site map, work zones, buddy system, site communication (routine and emergency, hand signals, alarms, etc.), standard operating procedures, and identifying the nearest appropriate medical facility.

Special work methods are needed to protect worker safety and health. Carefully planned, detailed written work instructions called standard operating procedures (SOPs) tell you how to do the work safely. SOPs lay out work practices needed to protect worker safety and health. At each hazardous waste site, workers must be trained on the SOPs that relate to their work.

Sampling or moving drums is one of the most dangerous jobs you can do. Extra precautions must be taken before moving or sampling any drums that are damaged, leaking, unstable, or have any crystals around the edge. Keep absorbents and overpack drums handy any time you move a drum in case there is a spill or leak.

General site workers must receive at least 40 hours of off-site training before entering the site and three days of on-site training before beginning work. TSD and specialized workers must receive 24 hours of training with one day of site-specific training. Supervisors receive an additional eight hours of off-site training. All employees attend an additional eight-hour refresher training course each year.

Every site is divided into three areas: an exclusion zone or “hot zone” (chemical cleanup), contamination reduction zone or “warm zone” (buffer & decon), and a support zone or “cold zone” (support & rescue) to ensure proper PPE, minimize exposure, and keep chemicals from spreading outside the work area. The zones are set up depending on monitoring results and the layout of the site.

Notes:

CPWR

Chapter 7:
Standard Operating Procedures (SOPs)

Safe work practices are vitally important to protect the workers' safety and health. Standard operating procedures (SOPs) are written instructions for safe work practices. Safe work practices can minimize exposure for workers, the environment, and nearby communities. Each site's SOP contains written instructions for safe work practices.

Chapter Objectives:

After completing this module, you will be able to:

1. Explain the five approaches to controlling hazards.
2. Identify drum handling procedures through SOPs.
3. Identify unsafe work practices in hazardous waste sites.
4. Identify potential confined spaces.

Standard Operating Procedures

Standard operating procedures (SOPs) are uniform instructions for doing a specific job. Learning the safety SOPs is a major part of the preparation when working with hazardous waste. They exist to protect worker safety and to maintain the control and safety of the site. SOPs must be developed to minimize employee contact with hazardous chemicals.

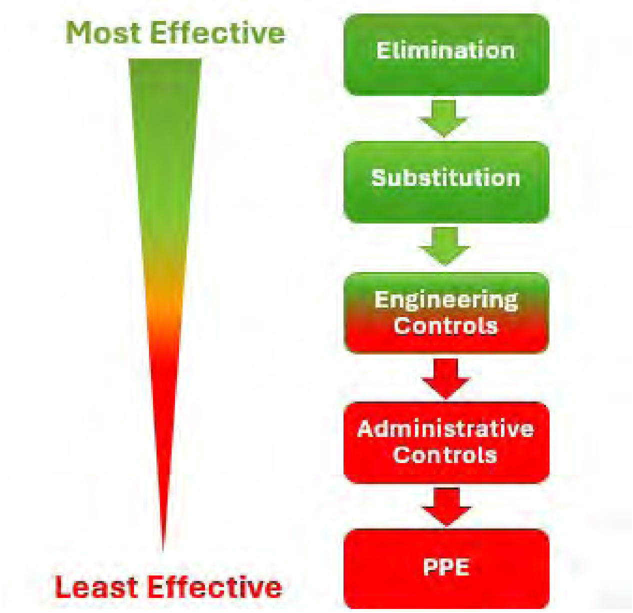
The major consideration in developing SOPs for a hazardous waste site is the health and safety of site personnel. Work must be done efficiently and in a way that protects you, the surrounding environment, and the residents of the community.

The right equipment, trained personnel, and SOPs help reduce the possibility of harm to site personnel. For SOPs to be effective, they must be as follows:

- Written in advance. Developing and writing safe, practical SOPs is difficult when responding to an actual situation.
- Based on the best available information, operational principles, and technical guidance.
- Field tested, reviewed, and revised when necessary by competent safety professionals.
- Used for training and periodic retraining of personnel.

Hazard Control

The hierarchy of controls is a method of identifying and ranking safeguards to protect workers from hazards. They are arranged from the most to least effective. Often, you'll need to combine control methods to best protect workers. For example, a local exhaust system (an engineering control) requires training, periodic inspections, and preventive maintenance (administrative controls). You will also need to consider feasibility. From most effective to least effective, the five approaches to hazard control are:



1. Elimination removes the hazard from the workplace
2. Substitution replaces the hazard with a less hazardous alternative
3. Engineering controls prevent hazards from reaching the worker
4. Administrative controls use work practices, training, procedures, and scheduling to reduce exposure
5. Personal protective equipment (PPE) is worn by workers to prevent the hazard from reaching the worker

Elimination

Eliminating hazards is an effective control but is often difficult, especially on hazardous waste sites.

Substitution

The second most effective method of controlling a hazard is substitution. This involves replacing a hazardous material, ingredient, or piece of equipment with a less dangerous one. The idea is to replace an occupational risk with something that has no risk or very little risk.

Engineering Controls

These are usually the most reliable ways to control hazards that cannot be eliminated. Engineered controls such as remotely operated drum punchers, ventilation of confined spaces, and sealed cabs on earth-moving equipment control the hazard to prevent exposure.

Negative air unit

Administrative Controls

Administrative controls use policies and work practices to reduce worker exposure to hazards and must be written before the work begins. They may include a scheduling system to limit time in a workspace or access to the space. Examples of administrative controls include industrial hygiene monitoring programs, medical surveillance programs, confined space entry permits, lock-out procedures, training, work practices, and limiting exposure time. Administrative controls can be less reliable than elimination or engineering controls because they require workers to know and follow procedures.

Personal Protective Equipment

Personal protective equipment (PPE) is the last resort and must be used to reduce worker exposure when the hazard cannot be eliminated or controlled with engineering or administrative controls. Personal protective equipment includes respirators, gloves, steel-toed boots, chemical-protective suits, and face shields. PPE is discussed in more detail in Chapter 5.

There are many hazards on a hazardous waste site that require controls that are not related directly to the waste site and will require site-specific training. In this section, we will discuss some of the hazards below that may require SOPs for the hazardous waste site:

- Drum Handling, Storage, and Sampling Procedures
- Spill Control
- Fire Prevention
- Electrical Safety
- Soil Excavation
- Equipment and Vehicle Operation
- Ladder and Scaffolding Use
- Heat and Cold
- Radiation
- Confined Spaces

Drum Handling, Storage, and Sampling Procedures

Unidentified drums can be dangerous and should be inspected, sampled, and handled by experts. If you discover a drum, report it immediately to your supervisor. Assume that a drum or container is hazardous until tested. Do not rely on outdated or questionable drum markings or labels alone to identify hazards.

Special instruments or probes should be used to detect buried drums. Drums that may contain radioactive waste must not be handled until specially-trained personnel can assess the hazards.

Only workers trained to do so should move drums. They should use remote handling equipment whenever possible. Fire-extinguishing equipment must be on hand and ready to use. They will move the contents of deteriorated drums to clean drums when they cannot fix the drums. The clean container must meet DOT, OSHA, and EPA requirements.

OSHA lists minimum special handling precautions that must be taken if a container is known or suspected of holding shock-sensitive waste [29 CFR 1926.65(j)(5)]. You should assume that a container of packaged laboratory waste contains shock sensitive or explosive material until the contents have been characterized.

OSHA also lists special requirements for handling drums with mixed waste from laboratories, which are called lab packs [1926.65(j)(6)].

These requirements include:

- Lab packs are only opened when necessary.
- Only persons with the knowledge to inspect, classify, and segregate the contents of a lab pack may open it.
- Unless the contents are otherwise identified, handle as shock-sensitive waste (especially if you see crystals on any container).

Even if your job does not involve drum handling, you may work near large numbers of drums containing known or unknown chemicals.

Use the chart below, to figure out what type of material is supposed to be in a drum.

Type of Drum	Construction	Contents
Closed-top*	Metal (unlined)	Non-corrosive products in liquid form
Closed-top	Plastic or composite (plastic inside metal or lined cardboard)	Corrosive liquids (acids or bases)
Open-top	Metal (unlined)	Non-corrosive solids or sludges
Open-top**	Plastic (lined)	Corrosive solids or sludges
Special	Stainless steel, nickel, and Monel TM	Extremely hazardous materials
Overpack - large outside drum with a leaking drum inside	Metal or plastic	Any leaking drums listed
Closed-top drums with fittings	Fittings for pressurizing with inert gas	Reactive, flammable, or explosive liquids
Open-top	Plastic or metal	Lab packs of a variety of potentially dangerous and incompatible materials

*Closed-top drums are sealed and have small openings (bungs) in the top.

**Open-top drums have removable lids and may or may not have bungs.

The number of staging areas should be kept to a minimum. This allows acceptable access and exit routes to be maintained for loading and shipping. Drum sampling requires specific precautions and is usually carried out by trained engineers or technicians. The drum sampling SOPs must be included in the Safety and Health Plan.

If any of the following conditions exist, the drum should not be sampled until special precautions are taken:

1. A bulging top warns of pressure build-up within the drum
2. Damaged or dented drums could also mean a buildup of pressure
3. Vapors or mists coming from the drum, usually near the bunghole
4. Obvious Leaks

These sampling safe work practices should be included in the drum sampling SOP:

1. Drum tops should be covered with plastic sheeting to avoid worker contact.
2. Never stand on drums, use ladders and platforms to reach stacked drums.
3. Do not lean over drums to reach the one being sampled.
4. Dispose of or decontaminate sampling equipment according to the sampling plan.

Spill Control

Your site must have a spill control plan that describes actions to take if either a minor or major spill occurs. Depending on the chemical, the spill control plan may include:

Containment:

- **Plugging**: The leaking container is plugged to prevent or limit further release. Common plugging materials include wood, soap, rags, and commercial products. Plug materials must be compatible with the chemical that is leaking.
- **Patching**: A patch is applied over the leaking area. Patching materials include rubber, patching mud, and tape. Patching materials must be compatible with the chemical that is leaking.
- **Over packing**: Placing a leaking container into a larger compatible container to contain the contents.

Confinement keeps the spill in a defined area and includes:

- **Diking**: Dikes may be built around the perimeter of the leak with sand, earth, straw, sorbent, or other materials. The diking material must be compatible with the spilled material. Plastic sheeting can be used as an additional barrier.
- **Blocking**: Drains, ditches, or storm sewers should be covered and blocked to prevent run-off of spilled materials. This blocking can be done with a sorbent pad,

a 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.

- **Absorption**: Run-off can be absorbed with dirt, sand, soda ash, sawdust, wood chips, peat moss, vermiculite, foam, or other materials. The sorbent must be compatible with the spill. For example, wood chips and an acid can start a fire.
- **Collection**: Run-off can also be collected in containers such as drums or buckets.

Staging means placing drums with similar contents alongside each other. This is one step toward remedial action. When staging drums, place them no more than two wide with an aisle between them. This allows access to all drums without standing on or leaning over them.

Activities in staging areas may include:

- Opening and sampling the contents
- Holding and storing until test results for the contents return
- Bulking or mixing compatible materials
- Loading and shipping

If drums are stored on pallets:

- Store only compatible substances on the same or adjacent pallets
- Use only intact pallets without broken or damaged boards
- Set drums squarely on pallets and band drums together if possible
- Place drums with labels and numbers facing outward
- They may be placed no more than 2 high and 2 wide with an aisle in between

Drum inspections should be conducted daily, or according to the site SOP, to look for:

- Leaking
- Swelling or bulging
- Rust or other signs of deterioration
- Exterior corrosion or crystallization
- Damage

Report these or other identified conditions to the supervisor.

Opening drums puts workers at serious risk and should be done with a remote drum punch or other remotely operated equipment if possible. OSHA 29 CFR 1926.65(j)(2) requires certain procedures for opening drums or containers. Anyone who opens drums must use non-sparking and intrinsically-safe tools and grounding may be necessary.

Ponds and lagoons store large volumes of waste materials and may also be used for treating waste materials. The hazards around ponds and lagoons may include:

1. Drowning
2. Corrosive and toxic gases, vapors, and liquids
3. Unstable walking surfaces

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

1. Safety equipment such as life jackets, safety belts, or lifelines when working close to unguarded areas
2. Chemical protective equipment to prevent skin contact and inhalation of chemicals
3. Limiting access and keep barricades secure
4. Training workers

Fire Prevention

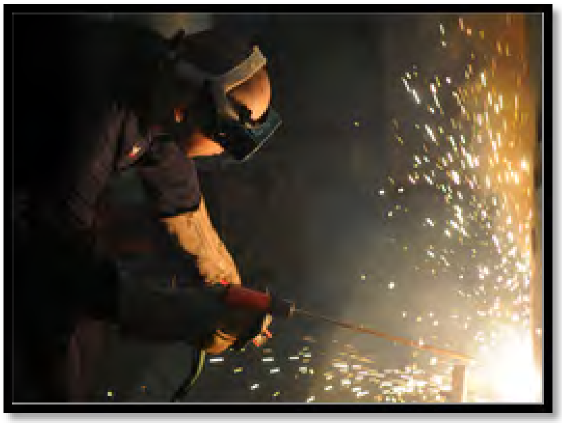
Fire and explosions are serious hazards on hazardous waste sites. These incidents can lead to unplanned releases and exposures to workers and the public. Flammable materials, incompatible and unstable chemicals, and other fuel sources are present at many sites. Equipment, hot work, and other ignition sources can trigger a fire or explosion.

Fire prevention and control should be addressed in the site plan. Constant vigilance is needed to keep the hazard low. Below are some of the items to consider:

1. Train employees in hazard recognition of flammables and ignition sources.
2. Locate firefighting equipment in strategic areas.
3. Maintain supplies of firefighting equipment and media.

4. Train fire brigade crews and provide adequate practice time.
5. Conduct fire drills and evacuations.
6. Conduct frequent fire safety inspections.
7. Post evacuation routes.
8. Provide for proper storage of compressed gases and flammable chemicals.
9. Provide non-sparking tools and intrinsically-safe radios, equipment, and power tools as needed.

Hot Work Permits: cutting, grinding, and welding are common activities at hazardous waste sites and require hot work permits. OSHA's Subpart J – Welding and Cutting provides minimum safety requirements for all cutting and welding activities. Hot work SOPs should include a permit system.



Electrical Safety

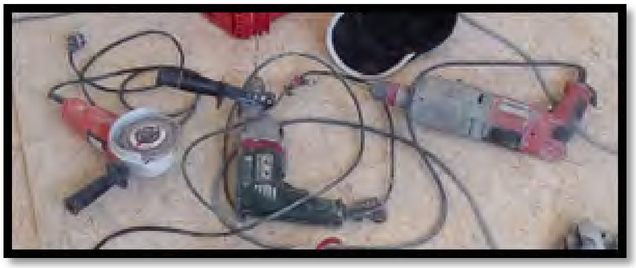
Electrical safety is a major concern on hazardous waste sites and needs to be addressed in the site safety and health plan.

Contact with overhead lines, energized equipment, and live lines are the most common hazards. Controls include maintaining minimum clearances (20' for cranes and overhead power lines). Charts in the crane and electrical standards provide guidance based on voltage. Lockout-tagout procedures are used for servicing equipment and isolating spaces.

Temporary power and wet locations can be protected with ground fault circuit interrupters (GFCI), assured grounding programs, and double-insulated tools.

Power tool use should be incorporated into site-specific SOPs. Power tools can spread contamination around the site if not cleaned and maintained.

- Use GFCIs when working with power tools
- Use non-sparking or intrinsically-safe tools around flammables
- Guards and safety devices are to remain in place and operable
- Electric tools should be UL listed, double insulated, or grounded
- Inspect frequently
- Decontaminate after each use and then return to proper storage



Soil Excavation

Every shovelful or bucket of soil that is excavated may contain or expose a contaminant. Burying industrial waste has long been a common practice. Even today we are injecting waste into deep wells. Spills or releases may contaminate the soil. Floods and moving water can transport and deposit waste into the soil.

The soil excavation SOP should address at least these questions:

1. What is the contaminant?
2. What are the physical properties of the soil?
3. What is needed to prevent collapse or cave-in?
4. How much needs to be removed? (tonnage/cubic feet)
5. What equipment is needed to excavate and load soil?
6. Will personal or area air monitoring be needed?
7. What PPE is needed?

SOPs should include these or similar provisions:

- At a minimum, soil excavation SOPs must comply with OSHA 1926 Subpart P Excavations
- Shoring or sloping used at 5‘ and greater depths
- Access and egress (ladder) with no more than 25’ of travel
- Utilities must be located before excavation
- Atmospheric monitoring provided if oxygen-deficient or hazardous atmosphere exists or could exist in excavations 4’ or more in depth
- Excavate clean soils first, then contaminated soil. This limits the spread of contamination by equipment
- Set up a soil stockpile area

- Bermed and plastic lined to contain soil from movement
- A method to cover the stockpile in the event of bad weather
- Safe work platforms and catwalks when lining and tarping truck beds and pits
- Take adequate soil samples to determine if all contamination has been removed
- Decontamination procedures for all equipment before clean restoration begins

Equipment and Vehicle Operation

Being struck by and caught between are two of the most common hazards of working around equipment and vehicles. Noise, PPE, and other site hazards may interfere with a worker's ability to avoid struck by or caught between incidents. On a hazardous waste site, there are additional issues to consider when developing SOPs. Here are a few.

1. All equipment must stay in the Exclusion Zone until decontaminated.
2. Maintenance, repair, and refueling are an ongoing process.
3. Decontamination must be available for both maintenance vehicles and retrieval equipment if the repairs cannot be made in the Exclusion Zone.
4. Mechanics and service people must be qualified to be in the Exclusion Zone if the equipment cannot be removed for service.
5. Always check vehicles entering and exiting the site for leaks. This helps prevent the spread of contamination and prevents the possible mixing of incompatible materials.
6. Workers must wear highly visible vests or clothing.
7. Protective clothing and respirators may limit the vision and hearing of operators and workers. Reaction times may get slower. Workers should stay clear of overhead loads and out of the swing radius of the equipment.

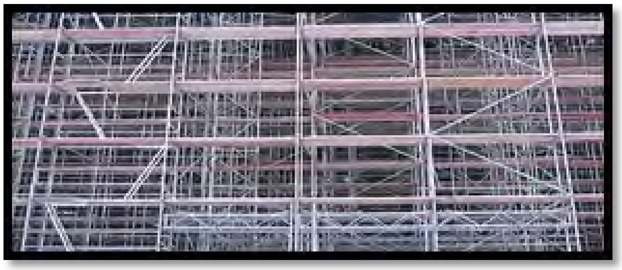
Ladders and Scaffolding

Falls are the number one hazard when working on construction sites. Many employers are moving away from ladder use and using mobile elevated work platforms (MEWP) and scaffolding. MEWPs and scaffolding have guardrail systems to prevent the workers from falling. MEWPs are being manufactured in many configurations to get the worker to where the tasks are.

Ladder fall injuries represent a substantial public health burden of preventable injuries for workers. Falls remain a leading cause of unintentional injury and deaths nationwide, and 43 percent of fatal falls in the last decade have involved a ladder. It is essential to choose the right ladder type to prevent serious injuries from a collapsing ladder. Ladders are for moving from a lower level to a higher level and should not be used as a continuous work platform.

Here are a few things to consider if you are using a ladder on a hazardous waste site:

1. Wooden ladders should not be used on hazardous waste sites as they may absorb contaminants
2. Three points of contact while climbing
3. Place the ladder at a 4 to 1 ratio.
4. Extend 36” above the landing platform
5. Secure the ladder from movement as necessary



Falls are the number one hazard when working on scaffolds. Getting on and off the scaffold at the access point at the work level is a common place for the falls to take place. Electrocution and collapse are other hazards that scaffold SOPs should address.

Some items workers on scaffolding should be aware of:

1. Scaffolds should support their weight and 4 times the intended load.
2. Guardrails or personal fall arrest shall be provided for workers at 10 ft.
3. Scaffolds shall be plumb and level, braced at a height-to-base ratio of 4 to 1.
4. Supported scaffolds must rest on baseplates and mud sills or other firm foundations.
5. Platforms must be fully planked.

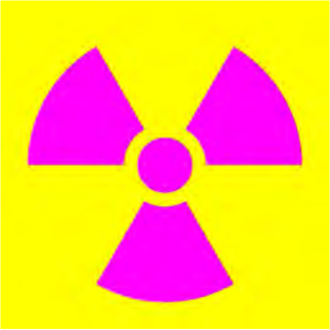
Mobile elevated work platforms are part of the OSHA scaffold standard. Tip overs, electrocution, and caught-between are some of the hazards operators must be trained on for each piece of equipment used. Operating manuals must be located on the platform. Other personnel must be trained in operating the ground controls in case of control failure on the platform.

Heat and Cold

Heat and cold stress are large hazards on hazardous waste sites due to PPE requirements. New personnel should be evaluated and allowed to be acclimated to working in extreme temperatures or elevations. This involves a work rest/rotation until the new personnel can assume full duties. Warm clothing for cold work may be provided as PPE or cooling vests in hot environments.

Radiation

This is NOT a RADWORKER course! If you see this symbol on your worksite, LEAVE the area unless you have been specifically trained to deal with the hazards of radiation.



Confined Space Entry

Every year, approximately one hundred workers in the United States die in confined spaces and several thousand are injured. About one-third of confined space fatalities are would-be rescuers. In many confined space fatalities, employers did not have a written confined space program or a confined space permit system.

According to OSHA, for a location to be considered a confined space, it must have these three defining properties:

1. Is large enough and so configured that a worker can bodily enter it;
2. Has limited or restricted means for entry and exit; and
3. Is not designed for continuous worker occupancy.

Confined spaces found at hazardous waste sites include:

- Ditches, culverts, and ravines
- Incinerators and scrubbers
- Tank trucks and rail cars
- Vaults and silos
- Sewer systems with manhole entrance

Permit-required confined spaces (PRCS) are confined spaces with at least one of the following additional hazards:

1. Hazardous atmosphere (or the potential for one)
2. Material that could engulf a person. The material could be stored in the space (for example, grain) or enter the space through pipes (such as water or chemicals)
3. A shape (tapers, slopes, or converges) that could trap or asphyxiate someone
4. Any other recognized serious safety or health hazard

Confined spaces do not always look dangerous. It may even be hard to recognize that a particular space is a confined space. For example, settling tanks and excavations are confined spaces even though they are open on top.

The potential hazards of confined spaces can become life-threatening conditions very quickly. Lack of ventilation can allow toxic gases and vapors to accumulate. Materials stored in the space or brought in through pipes can instantaneously engulf entrants. Energy sources that are not locked out can be turned on by people outside the space. All potential hazards must be evaluated and controlled before work inside the space begins.

A large portion of confined space deaths are due to atmospheric hazards (toxic gases or vapors, asphyxiants, flammable or explosive atmospheres). The trouble is that you can't see atmospheric (air) hazards. You can't see when there is too little (less than 19.5% oxygen) or too much oxygen (greater than 23.5%) in the air. Nor can you see toxic or flammable gases or vapors that accumulate in confined spaces (except for very rare cases).

What causes oxygen deficiency?

1. Other gases in the confined space can displace the oxygen in the air
2. Activities such as welding and burning can "use up" oxygen in the confined space
3. Chemical reactions such as rusting, or the drying of certain paints and cement can also "use up" the oxygen

Toxic, flammable, or explosive gases or vapors may be present in a confined space or introduced by work activities. The immediate hazards that could impair your ability to leave a space are the greatest concern. These hazards include central nervous system effects from solvents and chemical residues, asphyxiation from carbon monoxide or hydrogen sulfide, and fire or explosion of gasoline or solvents.

Monitor the inside of a confined space before entering the space and while inside.

Collect the initial air sample through a sampling probe inserted into the space.

Ventilation can be used to bring air into a space and eliminate hazards from oxygen deficiency and gases and vapors that are toxic, flammable, and explosive.

Note: Using welding or medical oxygen to "ventilate" a space can cause oxygen levels to become dangerously high (greater than 23.5%).

Remember:

1. Always monitor to find the oxygen and chemical content of air in a confined space.
2. Do not operate heaters or motors in confined spaces without special precautions to limit carbon monoxide and other contaminants in exhaust.
3. Rust, drying paint, cement, or caulking can increase the chances of oxygen deficiency.
4. Welding or burning inside confined spaces presents major hazards and requires special precautions as well as special hot work permits.

All confined space SOPs should comply with OSHA's confined spaces standard (29 CFR 1910.146 for General Industry and 29 CFR 1926 Subpart AA for Construction) and permits must include the required elements. This should be the case even if the space is not a permit-required confined space.

A permit-required confined space permit must include:

1. Name of the space that is going to be entered.
2. Why the space needs to be entered (description of the work to be done).
3. The date, and length of time the permit is good for.
4. Names and/or identification of the authorized entrants.
5. Names of the attendants who will remain outside the space.
6. Name of the entry supervisor - a space for the initials / signature of the supervisor who originally authorized entry.
7. The hazards of the space.
8. Means of detecting an increase in atmospheric hazard levels.
9. How the space will be isolated (for example, purged, ventilated, inerted, blanked and blinded, locked-out), and how hazards will be eliminated or controlled.
10. The conditions that must exist for entry to begin.
11. Air monitoring results and the name(s) or initials of the people who did the monitoring. The permit must also show when the tests were done.
12. Who to call for emergencies and rescue and how to contact them.
13. How entrants and attendants will communicate with each other.

14. All the equipment that must be provided to comply with the standard. This includes alarms and monitoring, personal protective, communication, and rescue equipment.
15. Any other information that is needed to ensure worker safety during confined space entry.
16. Other permits, such as hot work permits, are needed for the work to be done.

Summary: Standard Operating Procedures (SOPs)

There are five approaches to hazard control at hazardous waste sites:

1. Elimination removes the hazard from the workplace.
2. Substitution replaces the hazard with a less hazardous alternative.
3. Engineering controls, such as ventilation, prevent the hazard from reaching the worker.
4. Administrative controls use work practices, training, and scheduling to reduce exposure.
5. Personal protective equipment (PPE) worn by workers to prevent the hazard from reaching the worker.

Elimination and substitution are difficult to implement on hazardous waste sites but most cleanup jobs will use the other three methods. PPE should always be the last resort.

The safety and health plan is a written document that includes site-specific information designed to identify, evaluate, and control exposures to hazards. The plan must include organizational structure on the site; a comprehensive work plan; a site-specific safety and health plan; standard operating procedures (SOPs); safety and health training; a medical surveillance and exam program; and any information necessary to link the overall company plan to the site-specific plan.

Special work methods are needed to protect worker safety and health. Carefully planned, detailed written work instructions called standard operating procedures (SOPs) tell you how to do the work safely. SOPs document work practices that are needed to protect worker safety and health. At each hazardous waste site, workers must be trained on the SOPs that relate to their work.

Sampling or moving drums is one of the most dangerous jobs you can do. Extra precautions must be taken before moving or sampling any drums that are damaged, leaking, unstable, or have any crystals around the edge. Keep absorbents and overpack drums handy any time you move a drum in case there is a spill or leak.

Confined space entry on hazardous waste sites increases the risk of exposure or injury to workers. The employer needs to assign a competent person to identify and evaluate confined spaces on the worksite. Confined spaces are large enough to bodily enter, have limited access and egress, and are not designed for continual human occupancy.

Notes:

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CPWR

Chapter 8:
Decontamination

Decontamination (decon) is the process of removing contaminants from personnel and equipment to protect yourself, your fellow workers, your family, and the community. It may also include neutralizing contaminants by chemical means. Proper disposal is an important part of decontamination.

Chapter Objectives:

After completing this module, you will be able to:

1. Demonstrate proper decontamination of your personal protective equipment and tools based on the simulated hazards during training.
2. Identify the steps of the decontamination process.

Decontamination

Decontamination, also known as ‘decon’, is necessary to prevent worker exposure and the spread of hazardous substances beyond the worksite. Decontamination is the process of removing or neutralizing contaminants that have collected on you or your personal protective equipment (PPE) and your tools and equipment. Decontamination is vital to everyone’s health and safety at a hazardous waste site—including those in the surrounding community who do not want to see contaminants move from the site into their area. Without proper decontamination, there is potential for exposure.

Decontamination Plan

The decontamination procedures are described in the employer’s site safety and health plan. The site safety and health plan should state when, where, and how decontamination will occur. Certain conditions will dictate where decontamination will take place, and these places may change throughout the day or week. For instance, the location for decontamination may change during the day depending on wind conditions. This is because the contaminated area should be upwind from where decontamination will take place.

The decontamination plan must contain the following information:

1. A description of the location and layout of decontamination stations.
2. A list of the decontamination equipment and supplies needed (for example, water, scrubbing-brushes).
3. PPE to be worn by decontamination workers.
4. Specific decontamination procedures for substances that may be encountered on the site.
5. Methods for preventing contamination of clean areas.
6. Procedures for minimizing worker contact with contaminants during removal of PPE.
7. Safe disposal methods for clothing and equipment that are not completely decontaminated.
8. All wastewater, neutralizing chemicals, etc. created during decon must be collected, treated, and disposed of properly. This is always a high priority.
9. A plan for the evaluation and revisions of the plan whenever the type of PPE changes, the site conditions change, or the site hazards are reassessed based on new information.

Decontamination Procedures

Proper decontamination procedures must:

1. Be communicated to workers and implemented before workers or equipment enter the hazardous waste site.

2. Protect workers and the environment from hazardous substances or contaminated equipment.
3. Prevent continued permeation of the hazardous substance into PPE, other equipment, and tools and degradation that could result.
4. Prevent the mixing of incompatible substances.
5. Prevent the uncontrolled transfer of contaminants to the home, community, and to workers in clean areas.
6. Be monitored by the safety and health supervisor and revised as necessary.

PPE Practices

It is important to reduce the need for decontamination by minimizing contamination and contact with hazardous substances. Standard operating procedures (SOP) should establish practices that minimize exposure and maximize worker protection.

For example, these PPE practices can minimize worker exposure:

1. Inspect PPE before each use to ensure it is in good condition.
2. Close zippers, buttons, and snaps fully on PPE.
3. Tuck inner gloves under the suit's sleeves and outer gloves over the suit's sleeves.
4. Wear a third pair of tough outer gloves over the sleeves.
5. Tuck boots under the legs of outer clothing.
6. Wear hoods over the respirator harness.
7. Tape and tab all joints (if tape adhesive is compatible with suit materials) to help prevent contaminants from getting inside gloves, boots, and jackets.

Proper work practices can help reduce the amount of contamination and the need for decontamination. Examples of good work practices include:

- Following SOPs that minimize contact with hazardous substances.
- Not kneeling or walking through puddles or areas of obvious contamination.
- Properly disposing of decontamination equipment and solvents.

- Using remotely controlled equipment, such as drum grapplers, to sample, handle, and open drums.
- Covering monitoring and sampling instruments with plastic bags.
- Wearing disposable outer garments and using disposable equipment whenever possible.

Decontamination Zones

Protective clothing, tools, and equipment must be decontaminated, cleaned, maintained, or replaced as often as necessary to protect the workers. You must remove and discard contaminated clothing and PPE that cannot be decontaminated because it is permeable and/or not chemically resistant.

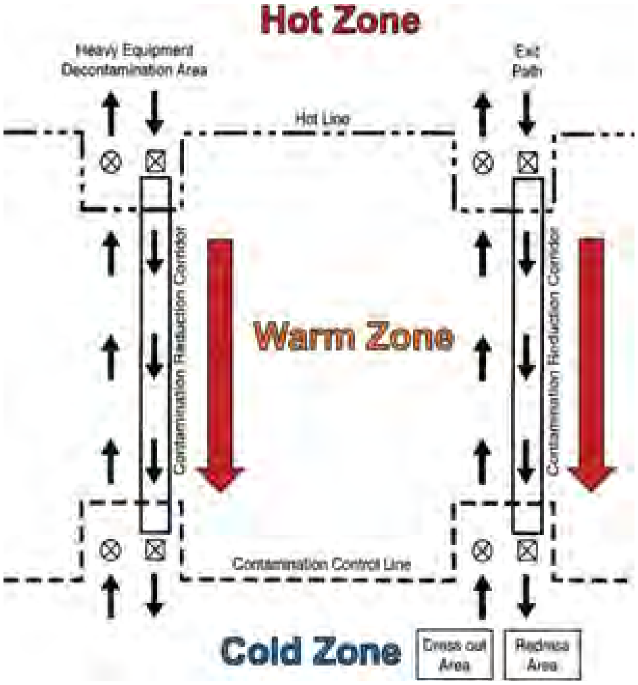
The decon line must be set up and operational before anyone starts work in the Exclusion Zone, commonly known as the Hot Zone.

Decontamination must occur:

- When PPE or clothing becomes contaminated;
- Before personnel go from an Exclusion Zone to a Support Zone;
- Before workers eat, drink, smoke, or use restroom facilities; and
- Before tools, equipment, or vehicles leave the site.

Decon Line

Decontamination takes place as you leave the Exclusion Zone and pass through a series of wash stations in the Contamination Reduction Zone (CRZ). This area is called the decontamination line or the decon line. The decontamination line is made up of a series of stations that reduce contamination. The stations are arranged in order of decreasing contamination, preferably in a straight line. Most decontamination activities take place in the Contamination Reduction Zone but gross decontamination may take place in the Exclusion Zone. The only way out of the Exclusion Zone must be through the decon line.



Adapted from: Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, DHHS 85-115 NIOSH, OSHA, U.S. Coast Guard, EPA.

Exclusion Zone

The Exclusion Zone, also known as the “Hot Zone”, is the actual contaminated area where work takes place. Hazards are present in the Exclusion Zone. The “Hot Line” is the outer boundary of the Exclusion Zone and should be clearly marked with hazard tape, signs, or ropes.

Contamination Reduction Zone

Decontamination activities occur in the Contamination Reduction Zone, also known as the “Warm Zone”. Protective equipment and clothing are removed to prevent the transfer of hazardous substances to cleaner areas. Tools and equipment will also be decontaminated in the Contamination Reduction Zone.

Support Zone

The Support Zone, commonly called the Cold Zone, is free of contamination. If necessary, workers who have been in the Exclusion Zone receive a medical exam in the Support Zone (for example, heat stress monitoring). The Support Zone contains the administrative and other support personnel who keep the zones running smoothly.

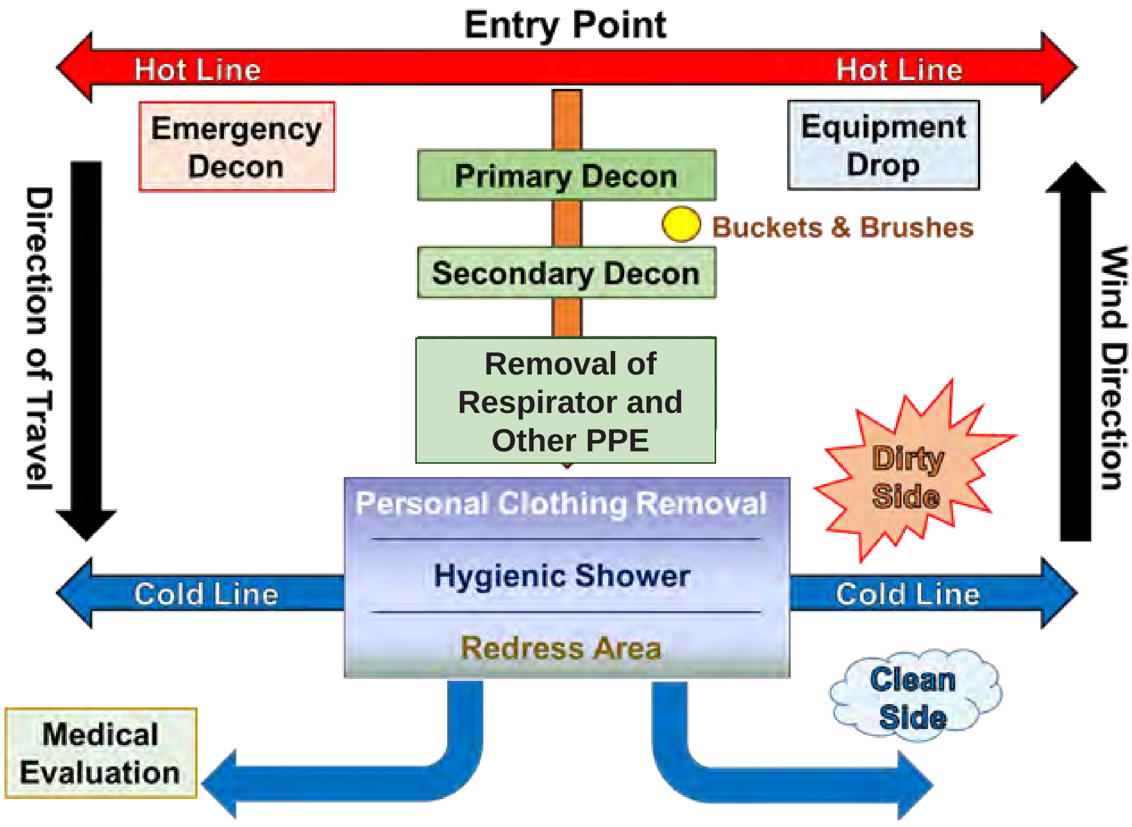
Personnel decontamination must occur before workers enter clean areas. Workers in suits and respirators may be assigned to the decon line to scrub and rinse personal protective equipment and help you take it off. Outer, more heavily contaminated items, such as boots, gloves, and suits should be decontaminated and removed first. Less contaminated items, for example inner boots and gloves, are removed next. You must go through decon every time you leave the Exclusion Zone.

Decontamination Stations

The number of stations, their configuration, and the procedures at each station is site-specific and will vary with the nature (type of chemicals) and extent (amount or concentration) of the contamination. On most decon lines, you will stand in a tub and your suit gloves and outer boots will be scrubbed with brushes and a compatible cleaner. Then you will step into two other tubs in succession, one for a full-body wash and the last tub for a rinse. You will take off your outer boots, inner gloves, and then your suit, carefully rolling them inside out so you do not get chemicals from the outside of the suit on your skin. You take off your respirator last. Some decon lines are very long and complicated and some are short but the basic process is always the same.

See the sample decontamination line diagram shown below.

Decontamination begins as you exit the Exclusion Zone and ends before you enter the Support Zone. All personnel, clothing, tools, equipment, and sample containers leaving contaminated areas must be decontaminated.



Decontamination Process

The process of decontamination uses one or more methods to remove or neutralize hazardous substances. The decon methods must be site-specific. Just as no one pair of gloves will protect you from every chemical, no single decon method will remove all types of contamination.

1. Contaminants may be removed by washing and rinsing, dissolving contaminants in a solvent (water, alcohol, dilute acid, etc.), wiping, scrubbing, scraping, evaporating, heating, freezing, melting, or adsorption/absorption (with powdered lime or kitty litter).
2. Contaminants may be neutralized or inactivated by using a weak acid or base, chemical detoxification (making the hazardous substance less toxic), or disinfecting or sterilizing equipment with chemical disinfectants, heat, or steam.
3. Particulates (dust) that cling to PPE, tools, and equipment may become trapped in small openings, such as the weave of the fabric, can be removed with water or a liquid rinse. Surfactants, such as detergent, improve the effectiveness of washing and rinsing by making the contaminants dissolve more readily into a solvent and reducing the ability of contaminants to stick to surfaces. Multiple

rinses with clean solutions will remove more contaminants than a single rinse with the same volume of solution.

4. Volatile liquid contaminants can be removed from protective clothing, tools, or equipment by evaporation followed by a water rinse. Make sure that you wear an appropriate respirator or use other protection from the vaporized chemicals.
5. Chemicals, heat, and radiation may be used as disinfectants to kill some microorganisms such as bacteria and viruses. Disposable PPE is recommended for use with infectious agents. All tools and equipment that cannot be decontaminated, such as wooden handles, and any contaminated cleaning solutions must be disposed of properly.
6. It is important to select and follow proper decon procedures. The methods used must be compatible with the clothing, tools, and equipment being cleaned and capable of removing the contaminant without creating hazardous byproducts. Decontamination through chemical neutralization requires careful planning and training.
7. Decontamination of tools and equipment prevents deterioration of the tool and equipment and controls the spread of hazardous substances. The specific decontamination procedure depends on the tool and equipment and the hazardous substance.
8. Contaminated monitoring equipment requires special cleaning. EPA regional laboratories or the manufacturer can provide information on proper decontamination methods.
9. Metal tools should be decontaminated, as appropriate, by chemical or physical means. Wooden tools and tools with wooden handles are difficult to decontaminate because they absorb chemicals.
10. The safety and health plan must detail the methods for decontaminating all respirators. Certain parts of contaminated SCBAs and other respirators, 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. Regulators must be maintained according to the manufacturer’s recommendations.
11. Contaminated wash and rinse solutions must be contained and properly disposed of to prevent pollution and the spread of contamination. Tools used in the Exclusion Zone must not be removed from the Exclusion Zone unless they have been decontaminated. Contaminated clothing, tools, buckets, brushes, etc. must be secured in drums or other containers and properly labeled. The spent decon solutions and runoff must be transferred to properly labeled drums and disposed.

12. Workers at the start of the decon line (toward the Exclusion Zone) will need more protection from contaminants than workers at the end of the decon line. Decon workers should wear the same level of PPE as Exclusion Zone workers or no more than one level of protection lower. Decon workers must never wear less than Level C protection. The safety and health plan should specify the level of PPE to be worn by workers at all positions on the decon line.

    - Level A workers entering decon are met by level A or B;
    - Level B workers entering decon are met by level B or C;
    - Level C workers entering decon are met by level C.

Decon is intended to protect workers, the community, and the environment.

Health and Safety Risks

To reduce health and safety risks during decontamination in the Contamination Reduction Zone:

- Make sure that decontamination solutions are compatible with the hazardous substances being removed to prevent a reaction, which could produce an explosion, heat, or toxic products.

- Make sure there are enough decon workers to help each person through the line.
- Provide hand-holds while boots are being washed or boot covers removed.
- Use “gripper” decals or other methods of increasing traction to reduce the likelihood of slips on plastic sheeting and slippery surfaces.
- Provide benches or chairs (not wooden unless they will be disposed of after the job) for personnel to sit on at stations where boots or suits are removed.
- Be sure all work areas are adequately decontaminated and cleaned.
- Prevent unauthorized employees from removing protective clothing, tools, or equipment from change rooms.

How do you know if decontamination was effective?

In most cases, there will not be an on-the-spot test to assure total decontamination. How do you know if decontamination was effective?

- You can inspect decontaminated items to make sure there are no visible signs of contamination.
- Wipe samples can be collected from decontaminated equipment and sent to a lab for analysis.
- PPE can be sent to a lab to be analyzed for the presence of contamination.
- Collecting and analyzing the water from the final rinse can also help to determine the effectiveness of decontamination.

Summary: Decontamination

Decontamination is important to prevent worker exposure and the spread of hazardous substances beyond the site. Proper procedures must be developed before a clean-up job begins. Remove contamination from personnel and expensive tools and equipment such as SCBAs and air monitors. Properly dispose of PPE and less expensive equipment that cannot be decontaminated.

The decontamination line is a series of stations organized in a specific sequence. The stations are arranged in order of decreasing contamination and to have the most efficient decontamination. Decontamination reduces levels of contamination on personnel, PPE, tools, and equipment until acceptable levels of the contaminant are present. Anything that cannot be decontaminated or packaged for reuse must be disposed of. The decon line must be set up and ready to go before anyone enters the Exclusion Zone.

During the development of the decontamination plan, work zones must be established to control the spread of contaminants.

There are three zones:

1. The Exclusion Zone or “Hot Zone” is the work area. Only personnel in proper PPE should be in the Exclusion Zone.
2. The Contamination Reduction Zone or “Warm Zone” is the area where decontamination occurs. Decon workers usually wear PPE equal to, or one level less than, clean-up workers.
3. The Support Zone or “Cold Zone” is the area for support personnel. There are no hazardous waste materials in the Support Zone.

Methods for decontamination depend on the PPE, tools, equipment, and the hazardous substances at the site and include:

- Rinsing or dissolving.
- Scraping, brushing, and wiping.
- Evaporation, then rinsing.
- Washing with soap and water.
- Chemical disinfection or neutralization.
- A combination of the above.

Decon workers must be decontaminated before they leave the decon line. All decon tools and equipment must be properly decontaminated or disposed of properly.

Notes:

CPWR

Chapter 9:
Emergency Response

Site management must provide a detailed Standard Operating Procedure for emergencies, including fire, explosion, spills, or other situations that cannot be handled by workers on site. The site safety and health plan is required by 29 CFR 1926.65 and includes a section on Emergency Response. Knowing what to do during an emergency and practicing it beforehand helps workers protect their safety and health.

Chapter Objectives:

After completing this module, you will be able to:

1. Define what an emergency response is.
2. List examples of waste-related emergencies and examples of non-waste-related emergencies.
3. Explain a hazardous waste clean-up worker's role during emergency response.
4. Explain a HAZMAT team's role in an emergency response.
5. Explain OSHA's requirements for a written, site-specific emergency response plan (ERP).
6. Identify the components of an emergency response plan.

What is an Emergency Response?

According to OSHA, emergency response or responding to emergencies means a response effort by employees from outside the immediate release area or by other designated responders (i.e., mutual-aid groups, local fire departments, etc.) to an occurrence that results, or is likely to result, in an uncontrolled release of a chemical hazardous substance. An emergency response can also be for a physical or medical emergency.

Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, are not considered to be emergency responses within the scope of the OSHA standard. Responses to releases of hazardous substances where there is no potential safety or health hazard (i.e., fire, explosion, or chemical exposure) are not considered to be emergency responses.

If a worker detects a spill or release, they should immediately notify their supervisor. The supervisor will decide whether outside help is required. For example, a spill of 100 milliliters (3 ounces) of acetone can be cleaned up by workers in the area and is unlikely to result in safety or health hazards. The most common emergencies at hazardous waste sites are spills, fires, and explosions.

HAZMAT Team

Site characterization and analysis is the starting point of any safety and health plan, knowing what and how much hazardous material is present. Knowing the status and capabilities of emergency response teams that would provide assistance to this potentially hazardous waste clean-up site and who would assist employees at the time of an emergency is an important component of an emergency response plan. These emergency response teams are known as a hazardous materials (HAZMAT) response team.

The HAZMAT team is:

- An organized group of employees and may include a team that is established by fire departments, local, regional, or state governments.
- Designated by the employer.
- Expected to perform work to stabilize and control leaks or spills of hazardous substances.
- Required to approach the hazardous substance in some situations.
- Not the same as a fire brigade.

A HAZMAT team responds to potential releases of hazardous substances to control or stabilize an incident. A HAZMAT team may be a separate component of a fire brigade or fire department.

Emergency Response Plan (ERP)

Emergencies that may occur on a hazardous waste site can include hazardous waste related emergencies and non-hazardous waste emergencies. The following are some examples of both types of emergencies:

Hazardous waste emergencies can include:

- Fires/explosions
- Damaged containers
- Leaks/spills
- Radioactive materials
- Toxic vapor release
- Chemical reactivity (incompatibles mixed together)

Non-hazardous waste emergencies can include:

- Slips, trips, and falls
- Heat stress
- PPE failure

- Electrocution
- Other emergencies that can happen on any typical construction site

In accordance with 1926.65(b)(4)(ii)(H), employers must develop and implement an emergency response plan (ERP) as part of the site-specific safety and health program. The ERP must be designed to handle anticipated emergencies and be put in place prior to the start of clean-up work. The plan shall be in writing and available for inspection and copying by workers, their representatives, and OSHA personnel.

The emergency response plan must be consistent with the disaster, fire, and/or other emergency response plans of local, state, and federal agencies. The elements of the plan include:

- Evacuation routes and procedures, including safe distances and places of refuge
- Pre-emergency planning and coordination with outside parties
- Emergency recognition and prevention
- Personnel roles, lines of authority, training, and communication
- Site security and control
- Rescue, medical treatment, and first aid
- Decontamination, PPE, and emergency equipment
- Post emergency review and follow-up

In addition to these elements for the ERP, the following elements must be included or also addressed:

- Site topography, layout, and prevailing weather conditions.
- Procedures for reporting incidents to local, state, and federal governmental agencies.

The emergency response plan shall be a separate section of the site safety and health plan.

Employers who evacuate their workers from the danger area and prohibit them from assisting in an emergency are not required to have an ERP. Instead, these employers must provide an emergency action plan that meets the requirements of 1926.35 or 1910.38. Employers must ensure that workers are trained and equipped to assist or conduct emergency cleanup activities.

The ERP must be reviewed periodically. If site conditions have changed or new information is available concerning hazards, the employer must update the ERP.
The emergency response plan must be rehearsed regularly as a part of the overall training for site operations. Make sure you know where to go and what to do before an emergency occurs. When it happens, it is too late to read the plan.

In a medical emergency, remove any victim out of the Exclusion Zone, do an emergency decon of the victim, and remove any contaminated PPE. Inform responding medical personnel what has happened and the potential chemicals the victim might have been exposed to. If it is a life-threatening emergency, decon can wait.

First aid training is not typically included in the 40-hour Site Worker mandated by 1926.65. However, first aid considerations and emergency medical treatment are required components of the site safety and health plan. Personnel designated to provide first aid require advanced training and are necessary for emergency response.

Alarm System

An employee alarm system shall be installed to:

- Notify employees of an emergency situation.
- Stop work activities if necessary.
- Lower background noise in order to speed communication.
- Begin emergency procedures.

The alarm system must produce a signal (noise, light, etc.) that can be perceived by all affected workers. All alarms must be distinct and recognized as signaling a specific action. The employer shall ensure that all components of the alarm system are approved for the work site and operating properly.

The alarm system must be tested at least every two months. The system must be operational at all times and during repairs or maintenance, a back-up system must be operational. Maintenance work must be done by trained personnel only.

During site-specific training, the employer must explain the alarm system and how to report an emergency. Emergency telephone numbers must be posted near the telephone or in obvious locations.

If you observe a life-threatening situation, it is your responsibility to:

1. Activate the alarm system.
2. Notify the supervisor or emergency coordinator.
3. Carry out your designated activities.

Post emergency response is the portion of a response performed after the immediate threats have been stabilized or eliminated and clean-up has begun. If these activities are performed by the workers who were a part of the initial emergency response, then they are not considered post emergency response.

Summary: Emergency Response

An emergency is any sudden or unexpected event requiring outside help.

Emergency response workers need sufficient training before they may respond to an emergency incident. This course does not qualify you as an emergency response worker.

The HAZMAT team is an emergency response team that provides assistance to hazardous waste clean-up employees at the time of an emergency.

The emergency response plan (ERP) is a written plan that is put into action before clean-up work begins.

The plan must be site-specific, and it must be available for workers to copy or read.

Workers may be able to clean up small spills on site without outside help. For large spills or medical emergencies, you will need to get out and call for trained help.

In a medical emergency, get the victim out of the Exclusion Zone, decon as completely as you can, wipe off and remove PPE, and tell medical personnel what has happened.

Employees who are engaged in responding to hazardous emergency situations at hazardous waste clean-up sites that may expose them to hazardous substances must be trained in how to respond to such expected emergencies.

Alarm systems must produce a signal (noise, light, etc.) that can be perceived by all affected workers.

Work sites must be properly equipped to respond to emergencies. Telephones, horns, fire extinguishers, spill control equipment, and other equipment are needed when responding to incidents and alerting employees.

Notes:

CPWR

Abbreviations and Acronyms; Glossary; and OSHA Regional Offices:

ABBREVIATIONS and ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ACM	Asbestos Containing Material
ANSI	American National Standards Institute
APF	Assigned Protection Factor
APR	Air-Purifying Respirator
atm	Atmosphere, a measure of pressure.
BP	Boiling Point
°C	Celsius, Centigrade; International temperature scale in which boiling is 100°C and freezing is 0°C.
CAS	Chemical Abstracts Service
cfm	Cubic Feet per Minute
CFR	Code of Federal Regulations
CGI	Combustible Gas Indicator
C	Ceiling Limit
cm	Centimeter (measure of length, 1 cm = 0.394 in)
cm^2	Square Centimeter
cm^3 or cc	Cubic Centimeter
CNS	Central Nervous System
CPC	Chemical-Protective Clothing
CPR	Cardiopulmonary Resuscitation
CRC	Contamination Reduction Corridor

CRZ	Contamination Reduction Zone
dB	Decibels (measure of sound intensity)
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EL	Excursion Limit
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
ESLI	End-of-service-life Indicator
f	Fiber
FID	Flame Ionization Detector
Fl. P. or FP	Flash Point
FRZ	Freezing Point for liquids and gases
g	Gram
GFI or GFCI	Ground Fault (Circuit) Interrupter
HEPA	High Efficiency Particulate Air
IARC	International Agency for Research on Cancer
IDLH	Immediately Dangerous to Life or Health
IP	Ionization Potential
l	Liter
LEL	Lower Explosive Limit

LFL	Lower Flammable Limit
m	Meter
m^2	Square Meter
m^3	Cubic Meter
mg	Milligram
mil	a measure of thickness
ml	Milliliter
mm	Millimeter
mmHg	Millimeters of mercury
MP or MLT	Melting Point
MUC	Maximum Use Concentration
MW	Molecular Weight
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
NPL	National Priority List
NOAEL	No-observed-adverse-effect-level
ORM	Other Regulated Material
OSHA	Occupational Safety and Health Administration
PAPR	Powered Air-Purifying Respirator
PCB	Polychlorinated Biphenyl
PEL	Permissible Exposure Limit (OSHA)

PF	Protection Factor
PID	Photoionization Detector (monitor)
PPE	Personal Protective Equipment
ppm	Parts Per Million
PRCS	Permit-Required Confined Space
psi	Pounds Per Square Inch
REL	Recommended Exposure Limit (NIOSH)
SAR	Supplied-air Respirator
SCBA	Self-Contained Breathing Apparatus
SDS	Safety Data Sheet
SG	Specific Gravity
SOL	Solubility in Water
SOP	Standard Operating Procedure
Sp. Gr. or SG	Specific Gravity
STEL	Short-Term Exposure Limit
TLV	Threshold Limit Value
TLV-C	Threshold Limit Value—Ceiling
TLV-STEL	Threshold Limit Value—Short-Term Exposure Limit
TSDF	Treatment, Storage, and Disposal Facility
TWA	Time-Weighted Average
UEL	Upper Explosive Limit

UFL	Upper Flammable Limit
µg	Microgram (millionth of a gram)
µm	Micron or Micrometer (1/1000 mm or 0.001 mm)
USCG	U.S. Coast Guard
VOC	Volatile Organic Compound
VD	Vapor Density (air = 1)
VP	Vapor Pressure (air = 760 mmHg)

GLOSSARY

A

Absorption—a route of entry into the body by which chemicals are absorbed through the skin.

Acid—a chemical with a pH between 1 and 6.9 with the strongest acids having the lowest pH. Acids are sour, turn litmus red and can cause skin or tissue damage (pH goes from 1-14).

Acute effect—an adverse health effect which develops rapidly. Common acute effects include dizziness, headache, difficulty breathing, eye and throat irritation.

Additive effect—one in which the combined effect of two chemicals is equal to the sum of the agents acting alone.

Administrative controls—work and personnel practices that reduce exposure to chemical and physical hazards.

Adsorbent—a substance that holds other substances. Adsorbents such as activated carbon are used to remove odors and vapors.

Air-purifying respirator—protective mask with absorbent filters that remove toxic materials from the air.

Alkali—a base: any chemical with a pH above 7 and up to 14. Alkalis are bitter and turn litmus paper blue.

Alpha particle—positively charged radioactive particle capable of traveling only a few inches in air. Although it cannot penetrate the skin it does a lot of damage if it gets into the body.

Alveoli—the small air spaces deep in the lung where oxygen goes into the blood.

American Conference of Governmental Industrial Hygienists (ACGIH)—A private organization that develops and publishes recommended occupational exposure limits (see TLV).

Anhydrous—inorganic compound that does not contain water.

Asphyxiant—a vapor or gas which can cause unconsciousness or death by suffocation (lack of oxygen). Asphyxiation is a major hazard of confined spaces.

B

Base—see alkali

Beta particle—a radiation particle which can cause skin burns and harm if inside the body. Beta particles can be stopped by a thin sheet of metal.

Boiling point—temperature at which a liquid changes to a vapor.

Buddy system—a safety measure where workers, especially those exposed to hazards work in pairs.

C

Carcinogen—a substance which can cause cancer.

CAS Number—a unique number assigned to a chemical by the Chemical Abstract Service.

Catalyst—a substance that speeds up a chemical reaction.

cm^3 (cc)—cubic centimeter, a metric measurement (cm x cm x cm) about the size of a sugar cube.

Ceiling (C)—the maximum allowable exposure limit for an airborne substance, not to be exceeded during the shift.

Central Nervous System (CNS)—The brain and the spinal cord.

Chemical cartridge—a filtering device which is attached to an air-purifying respirator.

Chemical-resistant material—prevents chemicals from penetrating through your clothes to your skin.

Chronic effect—an adverse health effect which develops slowly over a long period of time.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)—The “Superfund” law administered by the EPA, regulates clean-up of hazardous waste.

Concentration—the amount of one material in another, i.e. the amount of a chemical vapor in air.

Confined space— has limited or restricted means for entry or exit, is large enough for workers to enter and perform certain jobs and is not designed for continuous occupancy.

Corrosive—a liquid or solid that eats away another material or skin. Both acids and bases (alkalis) are corrosive.

D

Decibels—a unit of measurement of noise levels.

Decomposition—the breakdown of a material by heat, chemical reaction, decay, or other processes.

Decontamination—the chemical or physical process of reducing and preventing the spread of contamination from persons and equipment.

Decontamination line—a line set up with stations for decontamination procedures between the Exclusion Zone and the Support Zone.

Degradation—process which diminishes or destroys protective properties of chemical protective clothing.

Department of Transportation (DOT)—Government agency that regulates shipments and transfer of hazardous materials.

Dermatitis—redness or irritation of the skin often caused by chemical exposures.

Dilution—method of reducing the concentration of a contaminant, generally in air or water by adding more air or water.

Dose—the quantity of a chemical taken into the body.

Dose response—the relationship between the amount of the chemical and the severity of response in humans or animals.

E

Emergency response plan—A written plan detailing actions and personnel responsibilities during chemical emergencies.

Engineering control—substitution, isolation, and ventilation methods used to reduce the level of the contaminant at the source.

Environmental Protection Agency (EPA)—federal agency concerned with the quality of the air, water, and land.

Evaporation rate—how fast a liquid becomes a vapor

Exclusion Zone —The Hot Zone or contaminated area.

Exposure—the concentration of a material in the air to which a worker can come into contact. Usually, exposure is measured within the worker's breathing zone.

F

Flammable—The ability of a material to ignite and burn. According to OSHA, flammable liquids have a flash point of not more than 199.4°F.

Flash Point—the temperature at which a liquid will give off enough vapors that they will burn if ignited.

G

Gram (g)—a metric unit of weight. 454g = 1 pound.

H

Hazardous material—A chemical which is either flammable, corrosive, reactive or toxic.

Hazardous Waste Operations and Emergency Response (HAZWOPER)—OSHA standard which was developed to protect hazardous waste personnel and emergency responders.

Hazards—the properties of a material that may cause injury or death by contact, inhalation, or ingestion.

HAZCOM—OSHA Hazard Communication Standard (1910.1200).

Heat exhaustion—prolonged exposure to intense heat exceeds the body's ability to cool down, causing excessive sweating and sodium deficiency.

Heat stroke—a life-threatening condition requiring medical attention in which the body is unable to sweat; skin is hot and dry.

Heavy metals—the major toxic metals, for example; mercury and arsenic.

Hematotoxin—toxic to the blood or organs where blood is made. "Hem-" or "Hema-" or "Hemo-" has to do with blood, as with "hemolysis," which means bursting blood cells.

Hepatotoxin—toxic to the liver. "Hep-" or "Hepat-" has to do with the liver, as in "hepatitis," which means swelling of the liver, usually caused by a germ (virus or bacteria), but can also be caused by some chemicals.

I

Immediately Dangerous to Life or Health (IDLH)—According to the OSHA Respiratory Protection Standard, "an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere."

Incident Command System (ICS)—an organized system of personnel and delegation of responsibilities which controls the response to an emergency.

Incident commander—person in charge of on-site management of all activities at a hazardous materials emergency.

Incompatible chemicals—chemicals which produce a negative reaction when mixed.

Ingestion—taking a substance in through the mouth.

Inhalation—Breathing in substances (usually as gas, vapor, fume, mist, or dust). The most common route of entry for workplace chemical exposures.

Irritant—a substance which causes an inflammatory response when brought into contact with the eyes, skin, or respiratory system.

Isolation—method of decontamination in which contaminated equipment and materials are bagged or covered and set aside, usually for subsequent shipment to an approved landfill for disposal.

L

Latency—the time interval between exposure to a substance and the development of a disease.

Lock-out—a procedure to prevent energy from reaching equipment being serviced or repaired. Energy source is locked out and the equipment tagged off.

Lower explosive limit or **Lower flammable limit**—the lowest concentration (percentage of the substance in air) that will burn when an ignition source is present.

M

m—meter; a metric unit of length equal to about 39 inches

m^3—cubic meter-a measure of volume, close to a yard X a yard X a yard.

Manifest form—required by EPA to track hazardous wastes.

Melting point—the temperature at which a solid substance changes to a liquid state.

Metabolism—the chemical reactions that go on in the body to maintain life.

Milligrams per cubic meter (mg/m^3)—unit of measurement which is a weight per unit volume of air.

Monitoring—measuring concentrations of substances in the workplace.

Mutagen—a substance which can change the genetic material (DNA) in a living cell.

N

National Fire Protection Association (NFPA)—produces fire standards and the four-color diamond used on labels to indicate hazard.

National Institute for Environmental Health Sciences (NIEHS)—a federal agency responsible for issues related to the environment.

National Institute for Occupational Safety and Health (NIOSH)—The federal occupational health and safety research agency.

Neurotoxin—a substance which is toxic to the brain and nerves.

Neutralization—method of decontamination in which a chemical is mixed with another chemical to lessen the hazards.

Nuclear Regulatory Commission (NRC)—a federal agency responsible for community and worker protection from radiation hazards.

O

Occupational Safety and Health Administration (OSHA)—a federal unit responsible for creating and enforcing occupational safety and health regulations.

Oxidation—a reaction in which a substance combines with oxygen, rusting is an example of oxidation.

Oxidizer—a substance that gives up oxygen readily.

Oxygen-deficient—air which contains less than 19.5% oxygen.

Oxygen-enriched—air containing more than 23.5% oxygen.

P

Parts per million (ppm)—a volume measure of chemical concentration. For example one part of chemical in a million parts of air.

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

Permeation—process by which a chemical dissolves in or moves through a protective clothing material on a molecular level.

Permissible Exposure Limit (PEL)— set and enforced by OSHA is the highest concentration of a substance to which a person can be legally exposed during a typical weekday.

pH—measures acidity/alkalinity of substances and ranges from 1 to 14. Strong bases are closer to 14, strong acids closer to 1 water, pH 7, is neutral.

Physical agent—light, heat, cold, noise, radiation, vibration, etc. which affect health and safety.

Pulmonary toxin—a substance which is toxic to the lungs.

Q

Qualitative fit-test—measures effectiveness of a respirator by exposing wearer to a test atmosphere containing an irritating or smelly substance. Wearer should not be able to detect the substance.

Quantitative fit test—measures effectiveness of a respirator in preventing substance from entering the facepiece while wearer is in a test chamber. Concentration of substance is measured inside the facepiece of the respirator.

R

Rad—A measure of radiation energy absorbed by the body.

Reactivity—tendency of a substance to undergo chemical reaction with the release of energy.

REM (Roentgen Equivalent Man)—A unit used to measure the dose equivalent, which combines the amount of energy (from any type of ionizing radiation that is deposited in human tissue), along with the medical effects of the given type of radiation.

Renal—pertaining to the kidney.

Residual volume (RV)—the amount of air remaining in the lung after breathing out.

Risk—the chance of injury or loss.

Route of Entry—how material gets into the body: inhaled, ingested, through skin or eye contact absorption.

S

Safety Data Sheet (SDS)—chemical information sheet required by OSHA's Hazard Communication Standard. Lists health effects, chemical properties, emergency response actions, reactivity data, control measures, safe handling procedures, etc.

Self-Contained Breathing Apparatus (SCBA)—a supplied-air respirator with an air tank carried on wearer's back.

Sensitizer—a substance which on first exposure causes little or no reaction but which on repeated exposure may cause a marked serious allergic response.

Short-Term Exposure Limit (STEL)—the maximum concentration of a chemical a worker can be exposed to during a 15-minute period, set by OSHA.

Solubility (in water)—a measure of how much of a material will dissolve in water.

Sorbent—a material designed to trap and hold gases and vapors, either by absorption or adsorption.

Stability—ability of a material to remain unchanged. A material is considered stable if it remains in the same form under expected and reasonable conditions of storage or use.

Standard Operating Procedures (SOP)—written descriptions of tasks and activities to be followed during work.

Support Zone (cold zone)—area where administrative and support functions not requiring respiratory protective equipment are performed.

Synergistic Effect—a combined effect of two or more substances which is greater than the sum of the effect of each.

Systemic—relating to the whole body

T

Teratogen—a substance which can cause birth defects in a developing fetus.

Threshold—the lowest dose or exposure to a chemical at which a specific effect is observed.

Threshold Limit Value (TLV)—A concentration limit similar to the OSHA PEL. TLVs are set by ACGIH and not legally enforceable.

Time-Weighted Average (TWA)—measurement to determine the worker's average exposure to a substance over a typical 8-hour work shift. OSHA PELs are time weighted averages.

Toxicity—Ability of a chemical to cause health damage.

U

United Nations Identification Number (UN Number)—A number used internationally to identify a hazardous material.

United States Coast Guard (USCG)—concerned with the transportation of hazardous materials on navigable waterways.

Upper Explosive Limit or **Upper Flammable Limit** (UEL/UFL)—The highest concentration (percentage of the substance in air) that will burn when an ignition source is present. At higher concentration, the mixture is too "rich" to burn.

V

Vapor—gaseous form of a substance normally in the liquid or solid state at room temperature.

Vapor density—the weight of a vapor or gas compared to air. Materials lighter than air have vapor densities less than 1.0. Materials heavier than air have vapor densities greater than 1.0. Also called Relative Gas Density or RGasD.

Vapor pressure—indicates the tendency of a liquid to evaporate into the air. Normal air has a vapor pressure of 760 mmHg at sea level (less at higher elevations).

Ventilation—means controlling a hazardous atmosphere using continuous forced-air mechanical systems.

Viscosity—resistance to flow.

OSHA REGIONAL OFFICES

NOTE: In case of a workplace fatality, explosion, emergency call OSHA at 1-800-321-6742.

Boston Regional Office:
CT, ME, MA, NH, RI, VT
JFK Federal Bldg.
25 New Sudbury Street Rm. E340
Boston, MA 02203
Phone: (617) 565–9860
Fax: (617) 565–9827

New York City Regional Office:
NJ, NY, PR, VI
Federal Building
201 Varick St., Rm. 670
New York, NY 10014
Phone: (212) 337–2378
Fax: (212) 337–2371

Philadelphia Regional Office:
DE, DC, MD, PA, VA, WV
U.S. Department of Labor
1835 Market Street Mailstop OSHA-RO/19
Philadelphia, PA 19103
Phone: (215) 861-4900
Fax: (215) 861-4904

Atlanta Regional Office:
FL, GA, NC, SC
Sanm Nunn Atlanta Federal Center
61 Forsyth St., SW Room 6T50
Atlanta, GA 30303
Phone: (678) 237-0400
Fax: (678) 237-0447

Chicago Regional Office:
IN, IL, MI, MN, OH, WI
John C. Kluczynski Federal Building
230 S. Dearborn St., Rm. 3244
Chicago, IL 60604
Phone: (312) 353–2220
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Dallas Regional Office:
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A. Maceo Smith Federal Building
525 Griffin St., Rm. 602
Dallas, TX 75202
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IA, KS, MO, NE
2300 Main Street, Suite 10030
Kansas City, MO 64108
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Fax: (816) 283-0547

Denver Regional Office:
CO, MT, ND, SD, UT, WY
Cesar Chavez Memorial Building
1244 Speer Blvd., Suite 551
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Phone: (720) 264-6550
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San Francisco Regional Office:
AZ, CA, NV, ID, OR, WA, AK
American Samoa, Guam,
Northern Mariana Islands
San Francisco Federal Building
90 7th Street, Suite 2650
San Francisco, CA 94103
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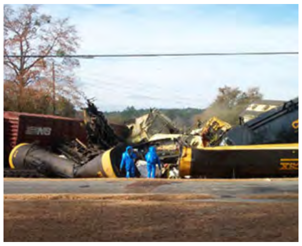
Fax: (415) 625-2534

Birmingham Regional Office:
FL, AL, MS, LA, AR, TN, KY
Medical Forum Building
950 22nd Street North, Rm 1050
Birmingham, AL 35203
Phone: (205) 421-9390



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