MWC

MIDWEST CONSORTIUM FOR HAZARDOUS WASTE WORKER TRAINING

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# 40 Hour Program
# Technician-level Emergency Responder
# Participant Guide

**Acknowledgments**

The Midwest Consortium developed this course for emergency responders under cooperative agreement number U45 ES 06184 from the National Institute of Environmental Health Sciences. We encourage you to comment on these materials. Please give your suggestions to those leading the program in which you are now enrolled.

**Warning**



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

**Disclaimer**

The Occupational Safety and Health Administration (OSHA) standard to help ensure health and safety during emergency response activities requires specific training for members of the response team, depending upon the duties to be performed. This program is intended to assist the employer in meeting the requirements of the Technician-Level responder at industrial sites. Employees trained at this level are trained to approach the point of release of the hazardous material and stop or reduce the flow. According to the regulation 29 CFR 1910.120(q)(6)(iii):

Hazardous materials technicians are individuals who respond to releases or potential releases for the purpose of stopping the release. They assume a more aggressive role than a first responder at the operations level in that they will approach the point of release to plug, patch or otherwise stop the release of a hazardous substance.

Additional training may be required to perform specialized tasks following a response activity or as the potential hazards change at the facility. In addition, annual refresher training is required by OSHA for all emergency responders.

Content was updated September 8, 2023 and all web links are active as of that date; if you find an error, please inform the facilitator so that it can be updated.

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# Course Introduction

Welcome to the 40-hour Technician program, a training program required in the Occupational Safety and Health Administration standard often referred to as HAZWOPER. This acronym stands for:

| | |
|---|---|
| HAZ | HAZardous |
| W | Waste |
| OP | OPerations and |
| E | Emergency |
| R | Response |

You are participating in this training program because you are or will be assigned Technician-Level emergency response duties. That is, if a release should occur at your facility or during your municipal or other duties, you may be expected to approach the point of the release and stop the release following practices and procedures described in a written document resulting from preplanning.

During this program you will learn skills to avoid exposure as you prepare to participate in responses to potential spills or releases.

Specific exercises include:

- Using references to assess hazards
- Identifying hazard control measures
- Implementing standard operating procedures
- Selecting and using provided protective equipment donning/doffing protective equipment
- Using monitoring equipment to identify hazards
- Working within the Incident Command System
- Performing control, containment, or confinement of a release
- Setting up decontamination procedures
- Participating in termination activities

The skills will be applied during an emergency scenario.

When you finish, you will be better able to:

- Recognize hazards
- Contain a release
- Minimize exposure to hazardous materials
- Prevent the spread of contaminants
- Describe practices to reduce potential emergencies
- Implement the emergency response plan (ERP)
- Play a role in the Incident Command System (ICS)

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

- Respiratory protective equipment
- Chemical protective clothing
- Information resources
- Monitoring equipment
- Plans, including a model emergency response plan

Each day includes time for review. Throughout the program, you are urged to ask questions. If an instructor does not have the answer to your question, it may be covered later during the week or it may be posted for response in a later part of the program. For example, a question on Day 1 about an air sampler would likely be deferred to the Day 3 monitoring session.

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

| Get the Most from Training |
|---|
| Ask questions |
| Participate in small group discussions |
| Put your hands on equipment and tools |
| Use resources |
| Learn from experiences of others |

During this introductory session, you will:

- Use a local example to identify or illustrate response hazards
- Complete a pretest

The goal is to use work practices to minimize exposures.

## Recent Releases

Your facilitator will introduce one or more recent hazmat responses in the Midwest. What information or skills would have been useful to the responders?

## Summary – Program Introduction

The overall goals of the program were reviewed:

- Recognize hazards
- Contain a release
- Minimize exposure to hazardous materials
- Prevent the spread of contaminants
- Describe practices to reduce potential emergencies
- Implement the emergency response plan (ERP)
- Play a role in the Incident Command System (ICS)

By reviewing a local example, the need for training prior to a response was illustrated.

# Introduction to HAZWOPER

## Emergency Response

Your job in emergency response builds on your previous work experience and health and safety training. Your experience is important and when shared will add value to everyone taking or teaching this course. By learning to use resources throughout this program, you will be able to find answers to questions that arise after the training program ends.

During this introductory session, you will:

- Describe previous work experience
- Review the format of HAZWOPER
- Review definitions of Hazardous Material and emergency
- Discuss advantages of response organization
- Contribute to a list of chemicals of interest

The goal is to use good work practices to minimize exposures.

## Previous Experience You Bring to Training

Learn by sharing your expertise.

Everyone is urged to describe experiences related to HAZWOPER emergency response. Examples of the types of experiences are listed below such as experience with:

- Construction
- Chemicals
- Hazards and hazardous situations
- Use of respirators and protective clothing
- Other levels of emergency response training

Also:

- What is your current employment?
- Why you are taking the class?
- What do you hope to learn during the class?
- How will you use this 40-hour training?

## The Format of HAZWOPER

The standard commonly called HAZWOPER, or 29 CFR 1910.120, is the major federal regulation designed to safeguard the safety and health of workers responding to a chemical release and handling and disposing of hazardous materials. The standard is enforced by the Occupational Safety and Health Administration (OSHA); in some states, Federal OSHA has jurisdiction and in other states, state government has set up a state plan. Who covers HAZWOPER where you work?

Paragraphs in the standard are identified with numbers and letters to make it easier to locate the information, similarly to how library books are numbered. For example, the specific requirements for training of technician-level responders are found in section 29 CFR 1910.120 (q)(6)(iii). In the illustration below, see how to interpret the numbering of the paragraph.

| Requirements for Hazardous Materials Emergency Responder Training | |
| --- | --- |
| **29 CFR 1910.120** | |
| 29 = | OSHA regulations are located in Title 29 |
| CFR = | *Code of Federal Regulations* is the title of the government publication |
| 1910 = | Part number 1910 covers General Industry |
| .120 = | Section number 120 covers hazardous waste operations and emergency response |
| (q)(6)(iii) = | The paragraph describes training for each level of emergency responder |

This will be covered more later in this program (see agenda distributed by facilitator).

## What is a Hazardous Substance? What is an Emergency?

There are various definitions of 'hazardous substance' found in laws and regulations.

Find the definition of 'hazardous substance' in the Definitions section of HAZWOPER.

OSHA defines 'hazardous substance' in 29 CFR 1910.120(a)(3) by reference to several lists:

Section 103(14) of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (42 U.S.C. 9601)

Any substance listed by the U.S. Department of Transportation as hazardous materials under 49 CFR 172.101 and appendices

Waste or combination of wastes as defined in 40CFR261.3, or substances defined as hazardous wastes in 49 CFR 171.8.

And this broad statement: "Any biologic agent and other disease-causing agent which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any person, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations in such persons or their offspring."

The following, less technical definition may be helpful: A **hazardous substance/material** may cause damage to people, property, or the environment.

Why this broad definition? Some hazards affect the environment or are transmitted through the environment to a responder. And property damage may result from contact with the hazardous material or a fire.

A good, non-legal benchmark: When in doubt, treat any release as hazardous!

OSHA defines a HAZWOPER Emergency Response as:

> **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 which results, or is likely to result, in an uncontrolled release of a hazardous substance.
>
> 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 this 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.

Why does this definition support that everyone should be trained?

Because of training…
- Essential information is reported
- Appropriate decisions can be made regarding actions
- Exposures to humans and environment are minimized
- Responders use appropriate PPE and work practices

## How is a Response Organized?

Think about the local example discussed earlier, and your experience. Discuss several ways that an organized response might limit exposures to personnel and the environment. The procedures used to determine if a response is needed and for any response are described in the Emergency Response Plan (ERP). (In this program, you may use a 'for training only' Plan)

OSHA 29 CFR 1910.120(q)(2) is a list of elements that must be included in the ERP:

- Pre-emergency planning and coordination with outside parties
- Personnel roles, lines of authority, training, and communication
- Emergency recognition and prevention
- Safe distances and places of refuge
- Site security and control
- Evacuation routes and procedures
- Decontamination
- Emergency medical treatment and First Aid
- Emergency alerting and response procedures
- Critique of response and follow-up
- Personal protective equipment and emergency equipment

The Incident Command System (ICS) will be covered later in the program.

## Exercise: Make a List

Are there specific hazards or exposures that you want to learn about? In your small group, make a list of hazards of interest on the form in the Exercise Manual.

This information will be used to tailor the course to the needs and skills of participants. During a report back, your facilitator will note items you want to learn about and specific chemicals or hazards of interest and post the lists on the wall. The instructor will refer back to these lists regularly during the week.

## Summary – Introduction to HAZWOPER Emergency Response

- A hazardous material is any substance that may cause damage to people, property, or the environment.
- Training in safe emergency response practices will reduce the chances of harm to people or property.
- The procedures used to determine that a response is needed and for the response are described in the Emergency Response Plan (ERP).
- Employers are required to develop an Emergency Response Plan to prepare for potential hazardous materials incidents if employees are to respond.
- Emergency incidents are spills or releases of hazardous materials into the workplace of environment, or the threat of such spills or releases. Spills or releases can occur on land, in the air, or in water.

# Chemical Properties

Many types of chemicals may be found in industry or along transportation routes. Responders who can recognize and describe the properties of chemicals are better able to reduce exposures and avoid injury or illness.

## Chapter Objectives

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

- Describe the importance of basic chemical terms
- Identify the factors needed for fire or explosion
- Demonstrate an ability to find properties of chemicals using resources

# Chemical Properties

In this section, some basic chemical terms and properties are illustrated; these properties are used to better characterize risk to health or the environment.

**Important Terms:**

**Chemistry** is the study of the properties of chemicals and the changes that occur when different materials are mixed, heated, and/or exposed to extreme pressure or temperature.

**Element:** Chemicals are made from 111 elements (atoms), 91 of which are naturally occurring on Earth and 20 of which are man-made. Each of the elements is described in their simplest form, the atom. About three-fourths of the elements are classified as metals. Some examples are:

| | | | | | |
|---|---|---|---|---|---|
| Aluminum | (Al) | Lead | (Pb) | Potassium | (K) |
| Cadmium | (Cd) | Manganese | (Mn) | Sodium | (Na) |
| Chromium | (Cr) | Mercury | (Hg) | Tin | (Sn) |
| Copper | (Cu) | Nickel | (Ni) | Uranium | (U) |
| Gold | (Au) | Platinum | (Pt) | Zinc | (Zn) |
| Iron | (Fe) | | | | |

Less than one-fourth of the elements combine with metals. Some examples are:

| | | | | | |
|---|---|---|---|---|---|
| Bromine | (Br) | Hydrogen | (H) | Oxygen | (O) |
| Chlorine | (Cl) | Iodine | (I) | Sulfur | (S) |
| Fluorine | (F) | Nitrogen | (N) | | |

**Chemical:** Elements are the basic building blocks of chemical compounds. A combination of two or more elements is called a chemical compound. Chemicals are generally divided into two broad categories, inorganic and organic.

Inorganic Chemical: Generally, inorganic compounds do not contain carbon, as in the examples shown below.

| | |
|---|---|
| Asbestos (hydrated silicate) | Sodium Hydroxide (NaOH) |
| Hydrochloric acid (HCl) | Sulfuric Acid ($H_2SO_4$) |
| Silica ($SiO_2$) | Water ($H_2O$) |

But there are exceptions, such as Carbon Monoxide (CO).

Organic Chemical Compounds: Compounds that contain carbon (C) are generally classified as organic compounds. Many solvents are organic. Petroleum, coal, and oils are made of organic chemical compounds. Some organic compounds are:

Benzene ($C_6H_6$) Ethyl alcohol ($CH_3CH_2OH$)

Carbon tetrachloride ($CCl_4$) Glucose ($C_6H_{12}O_6$)

Chloroform ($CHCl_3$) Methyl alcohol ($CH_3OH$)

Methylene chloride ($CH_2Cl_2$)

Chemicals may be identified on a label or in company data files by the Chemical Abstracts Service (CAS) name, a synonym, a trade name, or a manufacturer name. Product literature and other resources often show all names.

Many properties of a chemical depend on temperature and pressure. The conditions at which the property was measured will be stated as NTP or STP.

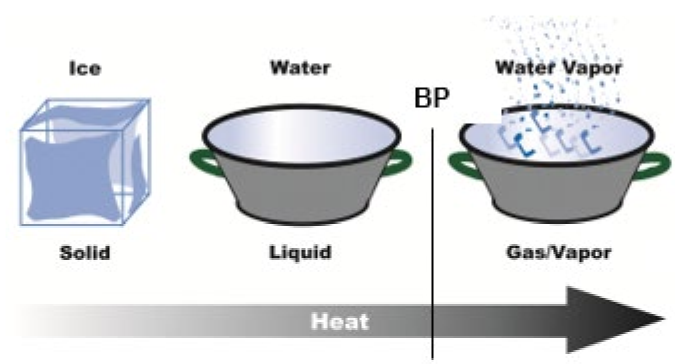
**NTP**: Normal Temperature and Pressure (room conditions) 68ºF or 20ºC; 1 atmosphere or 760 mmHg

**STP**: Standard Temperature and Pressure 32ºF or 0ºC, 1 atmosphere or 760 mmHg

**Selected Chemical Properties Defined and Illustrated**

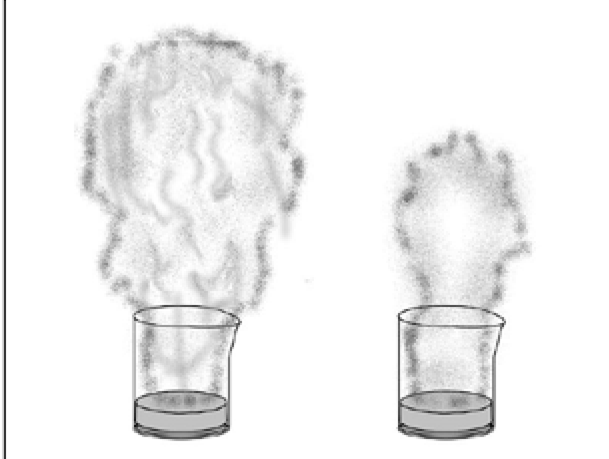
On the next several pages are some properties of chemicals that may be important at a release response.

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



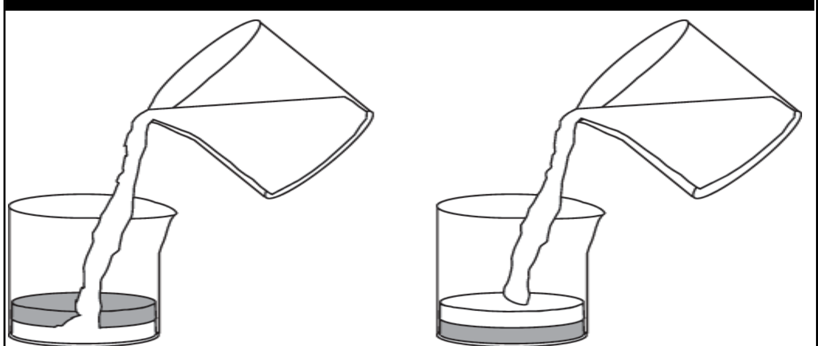
**VP** (Vapor Pressure, in millimeters of mercury (mm Hg) usually at 68ºF; atmospheric pressure reference is 760 mm Hg): In a closed system, the pressure exerted by a vapor in equilibrium with the solid or liquid form. The vapor pressure increases with increasing temperature. The higher the VP, the faster the chemical evaporates into space. See an illustration of vapor pressure below for two chemicals at the same temperature.

Vapor Pressure



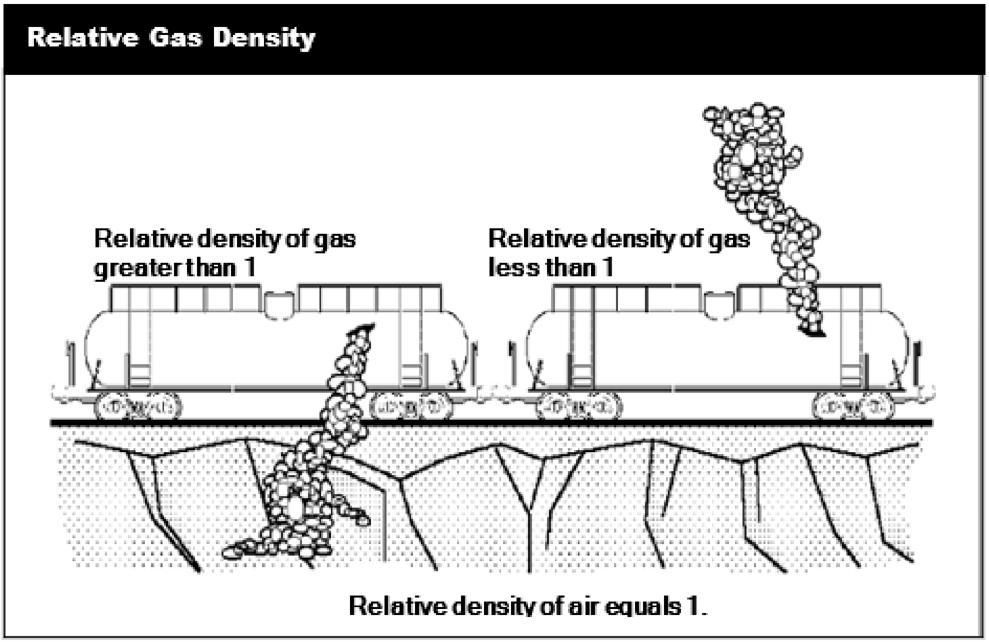

**Sp.Gr.** (unitless). Ratio of density of equal volumes of one substance compared with density of another at a specified temperature: usually water is the comparison at 68ºF. If a chemical is more dense than the comparison compound, it will sink (specific gravity greater than 1) If a chemical is less dense than the comparison, the specific gravity is less than 1 and it will rise to the top when mixed with the comparison compound. See an illustration of the importance of specific gravity below.

Specific Gravity




Specific gravity of water equals 1.

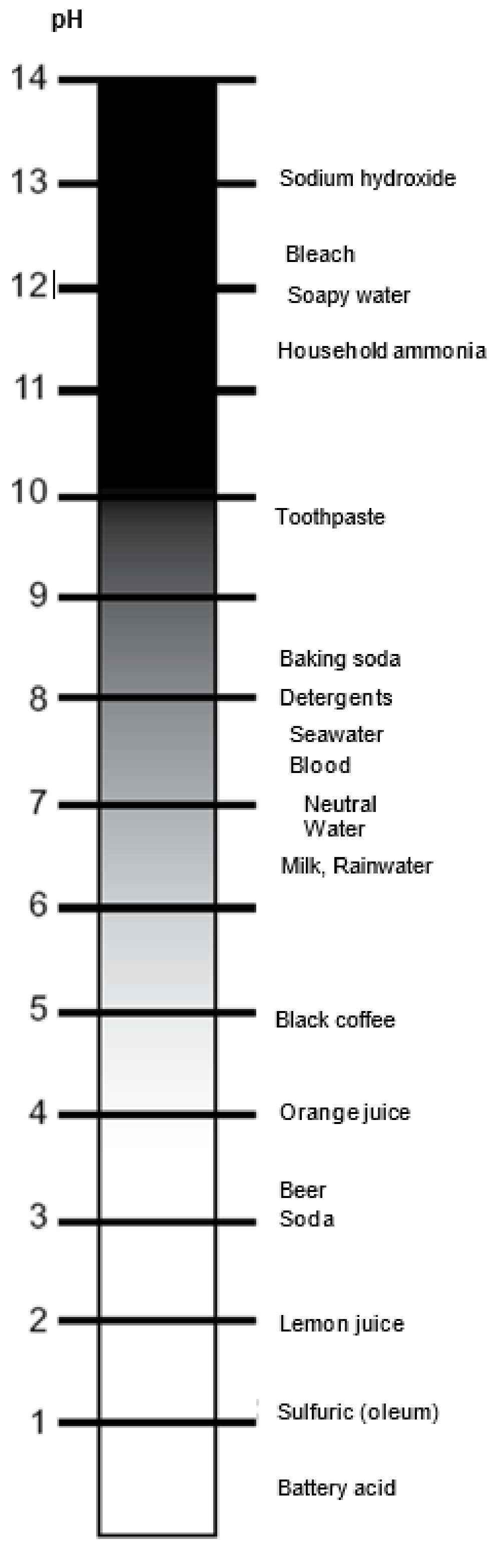
**RGasD** (Relative gas density of vapor compared to air=1). RGasD greater than 1 indicates the chemical is heavier than air; RGasD less than 1 indicates the chemical is lighter than air. If you know the molecular weight of the chemical, calculate the RGasD as MW/29. See an illustration of relative gas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




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

**pH - Acids and Bases**

Hydrogen ion concentration (measured as pH) is used to determine if a substance is an acid or a base (bases are also referred to as alkali, alkaline or caustic). Acids have low pH, and bases have high pH. Strong acids and strong bases are corrosive, meaning that they are very damaging to container materials, surfaces, skin, eyes, and lungs.
A strong acid and a strong base are incompatible and must never be mixed. A dangerous reaction will occur with a lot of heat produced and possible splashing. If they are mixed in a closed container, an explosion could result.
A scale of pH is given on the next page.




| | |
|---|---|
| **Definition** | Hydrogen ion concentration (pH) is used to determine if a substance is an acid or a base. A pH of 1 is very acidic; a pH of 14 is very basic (or alkaline).<br><br>Because of the very large range in the values of pH, a special scale has been created.<br><br>A one unit change in pH (for example, from 3 to 4) represents a 10-fold change in acidity or alkalinity. |
| **Example** | See scale. |
| **Importance** | Compounds with high and low pH cause burns, and irritate eyes, nose and lungs.<br><br>Substances with a pH less than or equal to 2 or greater than or equal to 12.5 are legally defined as hazardous waste.<br><br>Materials with a pH less than 2.0 or greater than 12 will burn skin, eyes and lungs. |

## Incompatible Chemicals

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

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

Many chemicals react with strong oxidizers. Oxidizers are chemicals that readily give off large amounts of oxygen or other oxidizing substances (such as bromine, chlorine, or fluorine) when they react, and they react readily with other chemicals. The potential to react is increased at higher temperatures.

## Reactive Materials

Reactive materials may become unstable and will decompose without reacting with any other compound if they are shaken, heated, or compressed. Some reactive materials react with water or air. Heat or flammable gases may be generated, resulting in fire or explosion. Toxic gases may also result. Reactive materials pose additional problems for the emergency responder. Examples include:

**Peroxides:** Ethers stored for a long time react with the oxygen in the air to form peroxides. These peroxides are chemically unstable and shock-sensitive, and an explosion may result from moving a container. Tetrahydrofuran and ethyl ethers are examples of ethers which form peroxides. They must be handled with extreme care.
**Monomers:** During polymerization, monomers (short chemicals) combine into long-chain compounds called polymers. To decrease the potential for explosion and fire during transit, monomers are usually mixed with a chemical inhibitor prior to shipping to prevent polymerization. If the inhibitor becomes ineffective, runaway polymerization may cause an increase in pressure, rupturing containers. Vinyl chloride and 1,3-butadiene are examples of monomers.

**Flammable, Combustible, Ignitable**

The terms “flammable, combustible and ignitable” are commonly used to describe chemicals. In general, all three terms refer to chemicals that can catch fire easily. The lower the Flash Point (Fl.P., the temperature at or above which there is enough vapor of a liquid chemical to ignite if an ignition source is applied; see earlier defined/illustrated section), the more flammable, combustible or ignitable a chemical is.

**Explosive Limits**

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

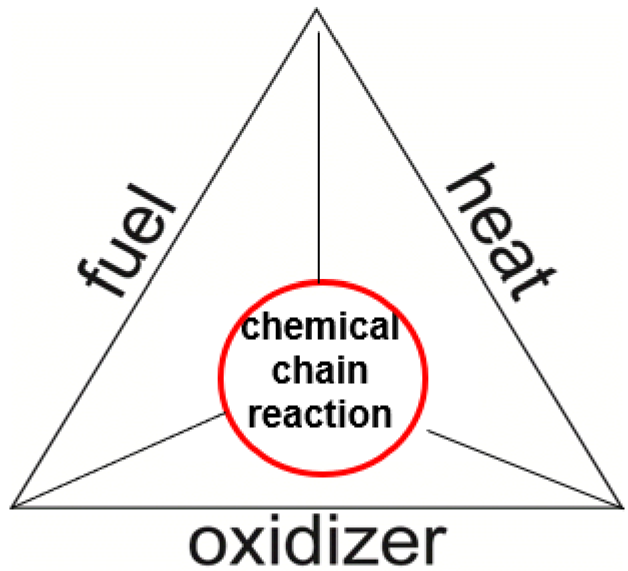
When there is just enough gas or vapor in the air to ignite, the concentration is at the Lower Explosive Limit (**LEL**, % in air). As the concentration of chemical in the air increases, it will reach a point where there is too much to support combustion. This concentration is called the Upper Explosive Limit (**UEL**, % in air). These limits may also be called the Lower Flammable Limit (**LFL**) and Upper Flammable Limit (**UFL**).

The Explosive Range (**ER**) or Flammability Range (**FR**) is the concentration of a substance in air between the LEL and the UEL. In this range, the substance will readily ignite.

When concentrations in an area are higher than a certain percentage of the LEL (guidelines may vary from employer to employer), the area must be evacuated. During an emergency or operation involving flammable/explosive gases or vapors, constant air monitoring is essential because the concentration can change rapidly. The air must be monitored not just in the immediate areas of the release but in any area that may potentially be contaminated.

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

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




The addition of the chemical chain reaction allows for the conversion of the triangle to a four-sided pyramid-shaped figure known as a tetrahedron. The base of the pyramid is the chemical chain reaction that causes combustion. The sides of the pyramid - fuel, oxidizer, and heat - are the elements of the older figure known as the fire triangle.

**Spontaneous Combustion**

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

## Video

*Videos illustrating important properties will be shown.*

**Toxic Products of Combustion**

When a fire destroys a building, it presents a very hostile environment. Heat from a fire can exceed 1,000ºF; thermal drafts can create gale-force winds; buildings weakened by fire can collapse on firefighters; and lack of oxygen can cause suffocation.

Fires can also create hidden dangers in the form of chemicals that are given off when products burn. Products such as furniture, pipes, wall coverings, and insulation materials may contain chemicals that can give off deadly gases and fumes when burned.

For example, polyvinyl chloride (PVC), one of the major ingredients in many plastics, decomposes in a fire to form hydrogen chloride, phosgene, and many other products. In addition to being poisonous, some of these gases also may cause cancer.

Here are a few types of common materials that might be in a meth lab or surrounding rooms and the chemicals created when they are burned. Each of the toxic chemicals can interfere with a responder's ability to breathe.

| Product | Created When Burned |
|---|---|
| Wool, silk, nylon, polyurethane, upholstery | Hydrogen cyanide |
| Wool, silk, nylon, melamine tableware | Ammonia |
| PVC, acrylics, retardant-treated materials | Hydrogen chloride, phosgene |
| Fluorinated resins (Teflon ™) | Hydrogen fluoride |
| Sulfur sources (such as sulfuric acid) | Sulfur dioxide |
| Hair, wool, meats, hides | Hydrogen sulfide |
| Plastics, chlorinated solvents (chloroform, tri-chloroethane, methylene chloride) | Phosgene |
| Fabrics, celluloid | Nitrogen oxides |

**Unstable Compounds**

Unstable materials will decompose without reacting with any other compound. Heat or flammable gases may be generated, resulting in fire or explosion. Toxic gases may also result.

Ethers stored for a long time react with oxygen in the air to form peroxides. These peroxides are chemically unstable and shock-sensitive, and an explosion may result from moving a container. Tetrahydrofuran and ethyl ethers are examples of ethers that form peroxides.

### Water-Reactive Materials

Some materials react violently if contacted by water. These materials must be identified and appropriately labeled to prevent use of water for firefighting, diversion of a spill into a sewer line, or use of water during clean-up procedures. Examples include concentrated sulfuric acid (release of heat), sodium metal (release of hydrogen gas) and carbides (release of acetylene gas).

### Air-Reactive Materials

Some materials ignite if exposed to air. These materials are generally stored under water or in another non-reactive material. Examples of these pyrophoric materials include potassium (stored under water-free xylene) and white phosphorous (stored under water).

## Exercise – Using the NIOSH Pocket Guide to find Chemical Properties

The NIOSH Pocket Guide to Chemical Hazards (NPG) is an important resource. (See http://www.cdc.gov/niosh/npg/npgd0070.html). In this exercise, you will use the NIOSH Pocket Guide to look up the properties of some chemicals identified as important to you during the introduction. (See Exercise Manual)

Not all the properties described above are included in the NPG (e.g., pH), but most are. When using the NPG, it is important to refer to the Definitions sections. See the "Incompatibilities and Reactivities" section for each chemical to determine which other chemicals are incompatible. Another useful resource includes Cameo Chemicals (https://cameochemicals.noaa.gov/).

### Explosions

Explosions are violent chemical reactions that produce a large amount of heat and usually gas. When the reaction between the ingredients of blasting powder is started with a spark or shock, a vigorous generation of heat and gas occurs that can shatter rocks or shell casings. In such a reaction, one compound that can burn reacts with an oxidizer, which takes the place of the oxygen in the air. Nitrates, perchlorates, and peroxides are examples of oxidizers found in explosives. Some single compounds, such as trinitrotoluene (TNT), contain all the ingredients necessary to create an explosion.

### Boiling Liquid Expanding Vapor Explosion (BLEVE)

A BLEVE is commonly defined as a container rupture caused by heat. When a container holding a liquid is heated, the heat is absorbed into the liquid, causing the vapor pressure to rise. If the container, such as a tank car, is equipped with a safety valve system, the buildup of pressure will result in product vapor being released through the valve; however, the pressure relief is usually not designed to relieve the amount of gas generated.

As vapors are released, the contents of the tank are cooled, and the wetted surface area of the tank is reduced. If the source of heat continues to impinge on the container, it will eventually begin heating the metal surface, which is not in contact with the liquid. The vapor behind the metal surface cannot remove the heat as fast as the liquid, and the tank shell heats up, losing its strength. When the strength of the metal is reduced enough, the tank shell will tear open as the hot vapors ignite. The tank will break up (sometimes violently) depending on how much product is left.  Rail cars/pieces have been found a mile from a BLEVE site.

A BLEVE can be prevented in several ways. First, and most importantly, any source of ignition should be removed to prevent the heating of the tank or container. Second, water can be applied at a minimum of 500 gallons per minute at each point of flame impingement with an unmanned nozzle to keep the container cooled.

In situations where massive amounts of water cannot be applied, such as in incidents on isolated transportation routes, the area may have to be evacuated as the container and contents are allowed to burn. Although property may be destroyed, lives will be saved.

## Combustible Dust Explosions

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

## Summary – Chemical Properties

Hazardous substance releases and reactions can cause harm to people and the environment.
Knowing the properties of chemicals helps to predict their behavior in the environment. These include:

- Organic or inorganic
- Boiling point (BP)
- Vapor Pressure (VP)
- Specific gravity (Sp. Gr.)
- Relative gas density (RGasD)
- Fl. P.
- pH
- Incompatibilities
- Reactive materials
- Flammable, Combustible, Ignitable
- Lower and Upper Explosive Limits (LEL, UEL)
- Spontaneous Combustion
- Toxic products of combustion
- Unstable Compounds
- Water- and Air-Reactive Materials
- Explosions
- Boiling Liquid Expanding Vapor Explosion (BLEVE)
- Combustible Dust

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

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

It is very important to be able to identify the properties of chemicals.

The NIOSH Pocket Guide to Chemical Hazards (https://www.cdc.gov/niosh/npg/) and Cameo Chemicals (https://cameochemicals.noaa.gov/) are useful resources. NPG and Cameo Chemicals are all available as apps.

# Toxicology and Health Effects

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

## Chapter Objectives

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

- Identify several principles of toxicology
- Identify human responses to some chemical exposures
- List reasons why medical surveillance is important to emergency responders
- Demonstrate an ability to find health effects of chemical exposure using resources

## Introduction

**How does the body react to exposure?**

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

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

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

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

## Some Basic Principles of Toxicology

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

**Acute Effects or Acute Toxicity**
An acute health effect means that the body’s response occurs at the time of exposure or within a few hours or days. Acute effects may result from a single exposure to a high concentration of a substance for a short period of time as in an accidental chemical release. Examples of acute health effects include:

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

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

You may move away from an acute exposure if you experience a warning property. Warning properties may be reactions such as:

- Irritation to the skin, eyes, or respiratory tract (upper airways or lungs)
- Bad/unpleasant smell (but don't depend on your nose to alert you)
- Dizziness or sleepiness such as a narcotic effect
- Tingling skin (e.g., caustic dusts)

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

**Pictograms in the Hazard Communication standard**

(29 CFR 1910.1200) indicate the potential for an acute effect. For example, the following Hazards:

- Irritant (skin and eyes)
- Skin sensitizer
- Acute toxicity (harmful)
- Narcotic effects
- Respiratory tract irritant

are linked to the "Exclamation Mark" Pictogram on labels.

Also, a material that has been determined to require a label with the Skull and Crossbones pictogram at the right is associated with:

Acute toxicity (fatal or toxic).

**Chronic Effects or Chronic Toxicity**

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

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

The following hazards are linked to the Health Hazard Pictogram, sometimes called the Bursting Chest:

- Carcinogen
- Mutagen
- Reproductive toxicity
- Respiratory sensitizer
- Target organ toxicity
- Aspiration toxicity

Note that most of these hazard words are often linked with chronic effects; however, responses like aspiration toxicity can be acute, resulting from a single exposure or event.

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

## Routes of Entry

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

- Lungs (inhalation)
- Skin (absorption) (Skin and eye contact are also considered)
- Mouth (ingestion)
- Injection (skin puncture)

**Inhalation**

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

**Skin Absorption/Contact; eye contact**

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

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

**Ingestion**

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

**Injection**

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

**Multiple Routes of Entry**

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

- Solvents: skin absorption, skin/eye contact, inhalation, ingestion, injection
- Metal fumes: inhalation, skin contact
- Carbon monoxide: inhalation, skin/eye contact (cryogenic liquid),
- Metal particles: skin/eye contact, inhalation, ingestion, injection

**Be alert for secondary sources of exposure**

Hand contamination can contribute to ingestion and inhalation!

Example: Lead on your fingers/hand:

Transfer to a snack → ingestion

Transfer to a cigarette → inhaled when it burns

Example: Lead on your shirtsleeve or arm:

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

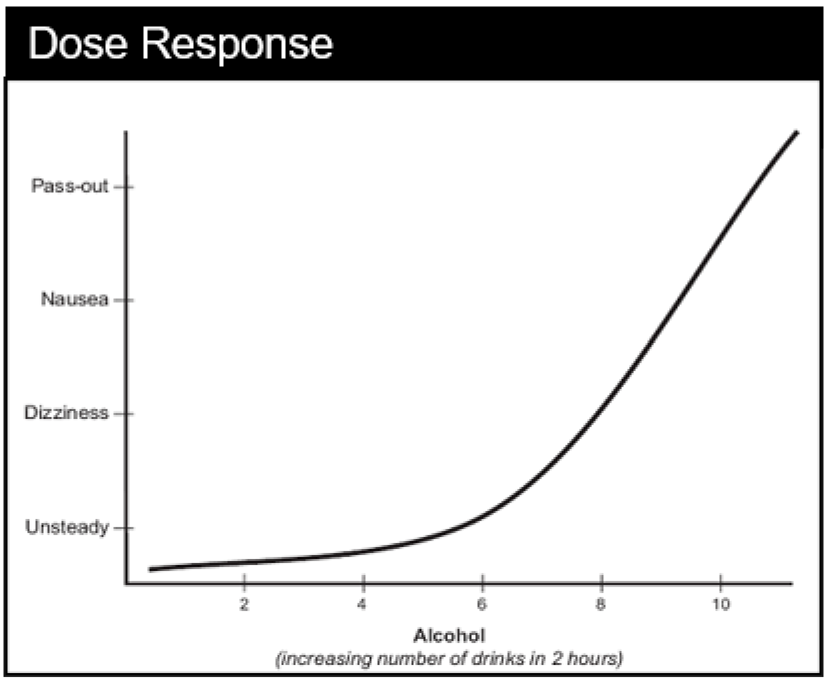
Example: Wash your hands and go to lunchroom; put hands on back of chair where someone with dusty shirt has been sitting

Transfer to your hands→ ingestion

## Factors That Influence the Body's Response to Exposure

Different chemicals can also cause varying responses at different concentrations.

This is known as a dose-response relationship. (See the illustration that follows).
A chemical is considered relatively nontoxic if a large amount of a chemical (dose) is needed to cause an adverse health effect. The chemical is considered highly toxic if a small amount causes an adverse health effect.




**Importance:** As the intake increases, there is more in the body (the dose increases) and the effect also increases.

Different individuals have different responses to a chemical exposure. There are several factors which seem to influence response. These include current health status, age, race, sex, allergy history, genetics (heredity) and previous chemical exposure.

**Exposure or Dose?**

The concentration of a chemical in the air is Exposure. The concentration of the chemical or a metabolite in the body is Dose.

**Exposure Interactions**

When chemicals interact after they have entered the body, the effect can be different than if only one of the chemicals was present. For example, asbestos exposure plus cigarette smoking increases the risk for lung cancer. These interactions are shown below:

**Additive** (2 + 2 = 4) The combination of the parts equals the sum. For example, the insecticides Malathion™ and Sevin™ have the same effect on the body. If you were exposed to both Malathion™ and Sevin™, the effect would be additive.

**Antagonistic** (2 + 1 = 1) Antagonistic effects result when exposure to a combination of toxic chemicals results in an effect that is less than the effect of each. Such effects form the basis of many antidotes for poisonings. For instance, even though ethyl alcohol (ethanol) can have toxic effects on its own, it can antagonize (diminish) the effects of ingesting methyl alcohol (methanol) by displacing it from the enzyme that oxidizes the methanol.

**Synergistic** (2 + 8 = 16) The effects combine to be greater than the sum. Exposure to a combination of asbestos and cigarette smoke increases the risk of lung cancer far more than the risk of each added together.

**Potentiation** (2 + 0 = 4) This effect occurs when the toxic effect of one substance is increased with exposure to the second substance, even though the second substance does not cause that effect on its own. For example, even though exposure to methyl ethyl ketone does not damage the nerves in the arms and legs, it increases the ability of n-hexane to cause this damage.

## Effects of Chemicals on the Body - Local and Systemic Effects and Target Organs

Chemicals can have health effects at the point where they contact the body, or they may travel through the bloodstream and have effects on other areas of the body.

**Local effects** occur at the point of contact with the skin, eyes, nose, throat, and airways. Chemical and physical agents that produce local damage include the corrosive action of acids and alkalis on the skin and eyes; irritation of the nose, throat, and lungs by chlorine, ammonia, and sulfur dioxide; and skin irritation from chemicals such as formaldehyde. The effect occurs in the tissue where the contact occurred.

**Systemic effects** occur when away from where the exposure entered the body. For example, the route of entry of solvents such as benzene may be at the skin or through the lungs, but the exposure affects the bone marrow or brain. A toxic gas such as hydrogen cyanide is inhaled, but the exposure affects the ability of cells to get energy; in these exposures, the heart (muscle) or brain (organ) is starved of energy, and death is rapid.

**Target organ** is the part of the body which is specifically affected by the exposure.

| Exposure | Target Organ(s) |
|---|---|
| Methylene chloride (solvent) | Skin (local), liver (systemic) |
| Lead | Central nervous system (systemic) |
| Trichloroethylene | Skin (local), central nervous system (systemic) |

Several examples of target organ toxicity (effect) are given below.

A **carcinogen** is a chemical or physical agent that can cause cancer when a worker is exposed, generally over a long period of time. There may be no safe level of exposure to carcinogens. The NIOSH Pocket Guide shows a listing of chemicals that the agency has categorized as carcinogenic. See https://www.cdc.gov/niosh/npg/default.html

Carcinogenic effects may be local or systemic.

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

**Solvents** irritate the skin, eyes, and airways of the nose, throat, and lungs. When solvents get into the blood, the nervous system is affected. Long-term exposure can cause damage to the liver and kidneys. Exposures to solvents may cause narcotic effects, making you feel sleepy and impairing judgment. The effects may be local or systemic.

**Acids and bases** (alkalis) damage the skin, eyes, and airways. Strong acids and bases are corrosive and can cause burns and ulcerations at the site of contact (local). Certain chemicals can cause reproductive toxicity in men and women. Infertility, changes in hormone level and menstrual problems are associated with exposure to such chemicals as lead, mercury, and styrene. Birth defects and developmental problems in children may also occur when the woman is exposed during pregnancy. A **teratogen** is a chemical or physical agent that causes birth defects. Some examples of teratogens are organic mercury compounds, arsenic and radiation. These effects are systemic.

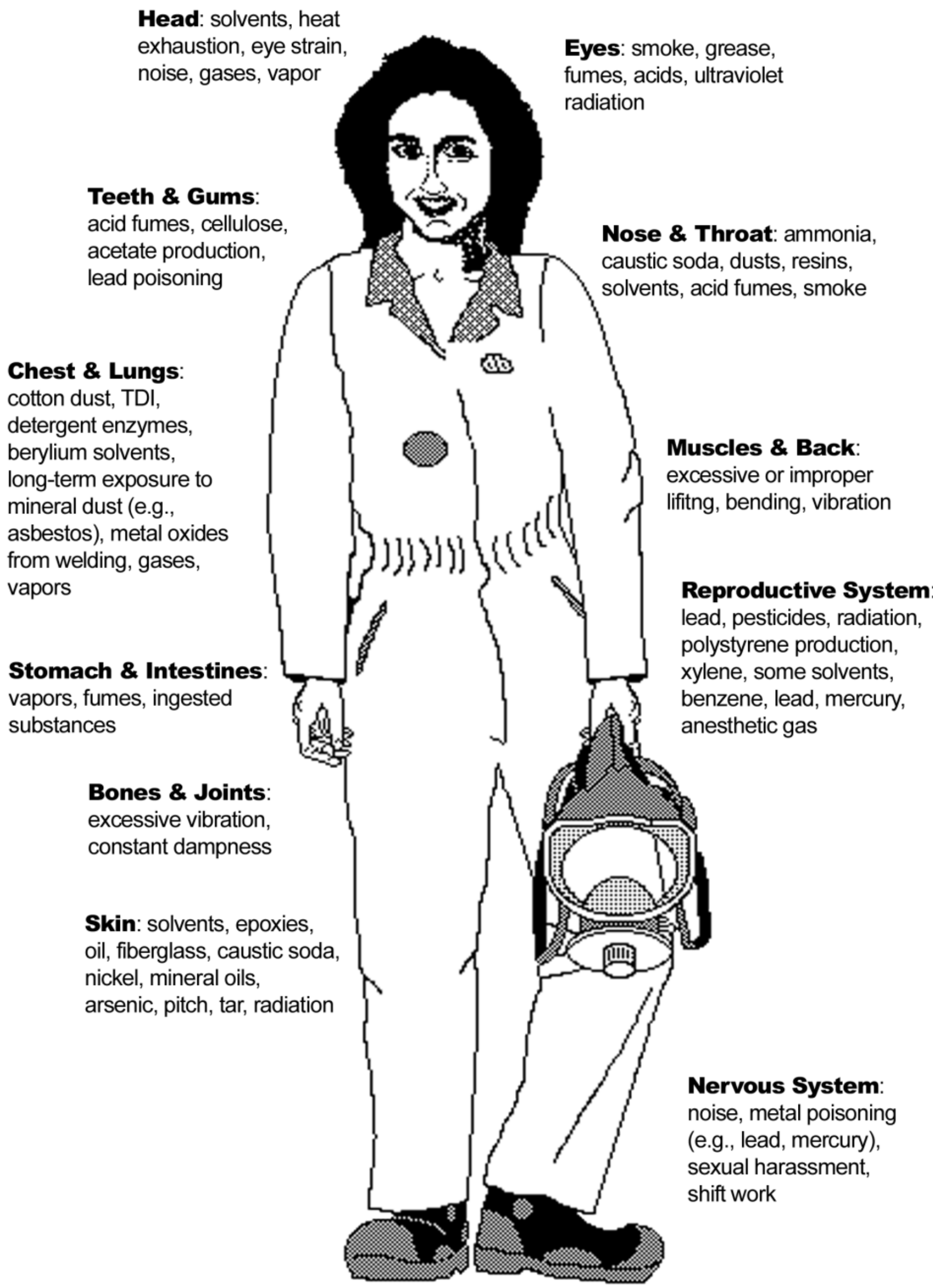
A **sensitizer** causes little or no reaction on first exposure, but after repeated exposures a marked response may result at the site of contact (local) or in another part of the body (systemic). Isocyanates are respiratory sensitizers. A skin sensitizer causes an allergic response following skin contact; epoxy resin is one example.

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

> Any time you suspect that signs or symptoms of illness are due to occupational exposure, consult an occupational healthcare provider.
>
> Find an occupational healthcare provider: http://www.aoec.org/ , a nationwide Association of Occupational and Environmental Clinics.

The illustrations on the next two pages show harmful effects of chemicals and how different target organs may react to them.

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




Adapted from the International Metal Worker's Union

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

**Head:** dizziness, headache

**Teeth & Gums:** corrosion of tooth enamel, blue gums

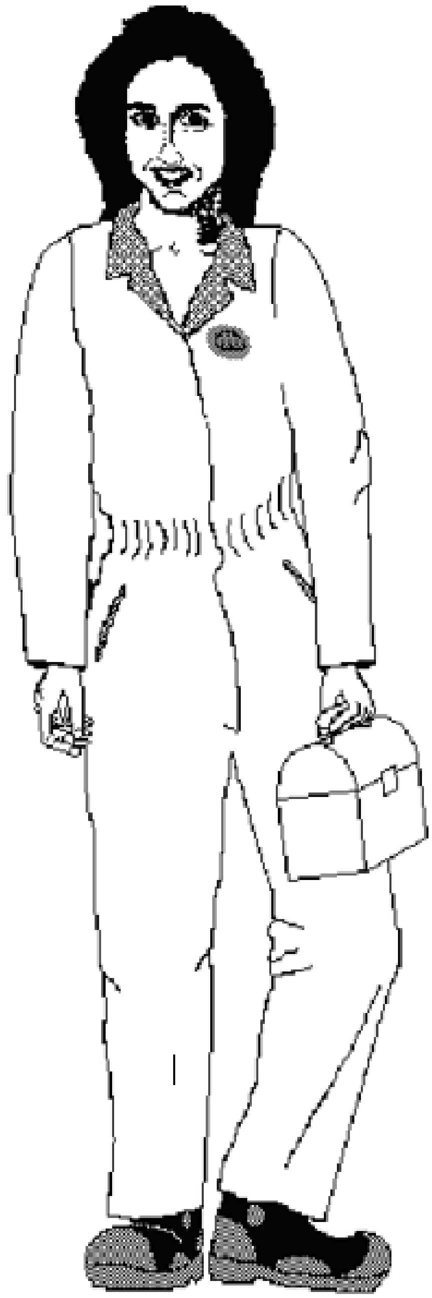
**Chest & Lungs:** wheezing, congestion, shortness of breath on mild exercise, flu-like symptoms (e.g., "metal fume fever")

**Stomach & Intestines:**

Vomiting, diarrhea

**Bones & Joints:** arthritis.

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



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

**Ears:** ringing, temporary deafness, hearing loss

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

**Muscles & Back:**

soreness, strain

**Reproductive System:**

miscarriage, irregularities in menstruation, damage to fetus or chromosomes, sterilization

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

Adapted from the International Metalworker's Union

## Exercise – Using the NIOSH Pocket Guide to Find Health Effect information

In this exercise you will use the NIOSH Pocket Guide to find health effect information for a chemical selected by the facilitator.  Complete the worksheet, in small groups. (See Exercise Manual)

## Heat and Cold

Wearing protective gear adds to the risk of heat stress. Temperature puts extra physical stress on the body. Long periods of exposure to heat may cause illness, particularly if a responder is not accustomed to working with a high heat load. Heat builds up inside protective clothing, so there is a risk of heat stress even if outside temperatures are moderate.

Regular monitoring, observation, and other protective measures such as rest breaks and adequate fluids are vital to prevent heat stress. Individuals react to heat in different ways. Some factors that add to the risk of heat stress include lack of physical fitness, age, low fluid intake, alcohol or drug use, sunburn, diarrhea, and infection.

**Signs and Symptoms of Heat Stress**

**Heat Rash or Prickly Heat**

Symptoms: Little bumps that look like blisters on the skin surrounded by reddened skin
Cause: Increased sweating causes pores to be blocked causing irritation
Treatment: Remove or loosen clothing; topical creams may help relieve itching.

**Heat Cramps**

Symptoms: Painful muscle spasms
Cause: Profuse sweating and drinking large amounts of water
Treatment: Provide liquids with electrolytes (sodium, potassium) like diluted Gatorade™

**Heat Exhaustion**

Symptoms: Weakness; fatigue; dizziness; pale, cool, moist skin; heavy sweating; headache; nausea; and fainting
Cause: Reduced blood volume resulting from dehydration from profuse sweating and insufficient replacement of water and salts
Treatment: If worker is conscious, rest in a cool place is recommended. Replace water and electrolytes lost in sweat. If worker is unconscious, get medical help immediately. Do not give liquids if the person is unconscious.

**Heat Stroke**

Symptoms: Very dry, hot skin with red, mottled, or bluish appearance; confusion. convulsions; unconsciousness; rapidly rising temperature
Cause: Body becomes overheated because the worker does not sweat. Can be fatal.
Treatment: Call for medical help immediately. Move person to a cool place. Remove PPE. Use wet towels or water and fan to cool while waiting for help.

Heat stroke is a life-threatening emergency. Medical attention is required.

Cold stress is less common but may occur outdoors in winter months or in responses that involve cryogenic materials or cold storage areas.

**Signs and Symptoms of Cold Exposure**

**Frostbite**

Symptoms: Numbness of hands, feet, or face.
Cause: Prolonged exposure to cold environments.
Treatment: Frostbitten tissue should be gently warmed and not exposed to further cold.

**Hypothermia**

Symptoms: Lowered body temperature, shivering, or drowsiness. If body temperature is reduced to 80ºF (or below), unconsciousness is often followed by death.
Cause: Wet, cold, exhaustion; body's response to minimize heat loss becomes ineffective when body temperature goes below 86ºF
Treatment: Warm the body. Get medical assistance.

## Medical Surveillance Program

Medical surveillance is a required consideration for emergency response (OSHA 29 CFR 1910.120[f]). It is essential to assess and monitor responders' health and fitness both prior to and during the course of employment, provide emergency and other treatment as needed, and retain accurate records for future reference. A medical surveillance program must be instituted by the employer for the following employees:

- All employees who are or may be exposed to hazardous substances or health hazards at or above the PEL or above another published exposure level (if no PEL) for 30 days or more a year
- All employees who wear a respirator for 30 days or more a year
- All employees who are injured due to overexposure from an emergency incident involving hazardous substances or health hazards
- Members of official hazardous materials response teams

In accordance with the standard, medical examinations and consultations are made available by the employer to each employee who falls into one or more of the above categories.

Medical exams should be conducted:

- Prior to a new job assignment (pre-placement or reassessment exam)
- At least once every year but not less often than every two years
- At termination
- If an employee exhibits signs or symptoms which may have resulted from exposure to hazardous substances during the course of an emergency incident, or if the employee has been injured or exposed above the PEL or published exposure levels in an emergency situation
- More than once each year, if the physician determines that an increased frequency of examination is medically necessary

All medical examinations and procedures must be performed by or under the supervision of a licensed physician, preferably one knowledgeable in occupational medicine. The exam is provided without cost to the employee, without loss of pay, and at a reasonable time and place.

The content of the examination or consultations made will be determined by the physician. The physician may not understand the details of the employee's work. Therefore before the examination, it is important to explain to the physician the type of work, potential health risks, and the type of protective equipment which may be worn for the response. Materials provided may include but may not be limited to:

- Copy of 29 CFR 1910.120 (HAZWOPER)
- Information required by 29 CFR 1910.134 (Respiratory protection)

The employer should then obtain the following items from the attending physician and furnish the information to the employee:

- The physician's opinion relative to the individual's employment or job assignment. (Findings not relevant to the response duties are not to be included)
- The physician's recommended limitations upon the employee's assigned response role
- The results of the medical examination and tests if requested by the employee
- A statement that the employee has been informed by the physician of the examination results and any conditions which require further examination or treatment

The employee has a right to request and be given a copy of the physician's full report. The employer receives only work-related information. The report should be kept in a safe place or forwarded to your family physician.

The employer should keep records of medical exams and other exposure records for the duration of an individual's employment plus 30 years thereafter. The record should include at least the following items:

- Name and social security number and employee physician's report
- Employee reports of health effects related to exposure
- Copy of information provided to the physician by the employer, except for 29 CFR 1910.120

**Exposure Records**

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

See the OSHA Standard "Access to Employee Exposure and Medical Records" (29 CFR 1910.1020). Records that workers can request include either environmental information (including monitoring results, SDSs, lists of chemical or physical agents related to the job, studies/analyses of data) or personal medical records. When requested, the employer must provide access within fifteen working days. The employer can comply by making a copy of the requested record at no cost to the employee or allowing the employee to use the employer copy machine to copy the requested record.

**Things the Responder Should Do**

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

## Summary – Toxicology and Health Effects

- An acute exposure involves a high concentration of a toxic chemical once or for a short period of time
- A chronic exposure is characterized by repeated exposure over a long period of time (generally years)
- Pictograms on chemical labels provide a visual information about hazards, including an indication of potential acute or chronic effect.
- Routes of entry for toxic substances are absorption through the skin, inhalation, injection, and ingestion
- Dose-response refers to the relationship between uptake of a chemical and a toxic response. As the dose increases, the health hazard to the worker increases. Exposure is measured outside the body; exposure-response is the relation between exposure and response.
- Local effects of a toxic chemical occur at the point of contact with the body (skin, eyes, and lungs)
- Systemic effects occur when a toxic chemical enters the body and through one or more of the routes of entry and then affects other tissues and organs in the body
- The organ(s) of the body affected by a certain toxic chemical is called the target organ
- Exposures may be to chemical, radiological, physical, or biological agents. An exposure or exposure situation may result in psychological effects.
- Temperature, heat or cold, puts extra physical stress on the body, and wearing protective gear adds to the risk of heat stress.
- Medical surveillance that must be conducted for emergency responders is shown in HAZWOPER. The employer must pay for required exams; all medical records (including relevant exposure records) must be retained by the employer for the duration of employment plus 30 years after each employee leaves employment.
- You have the right to obtain a copy of your work medical record at no cost to retain with your personal medical records

# Personal Protective Equipment (PPE)

## Introduction

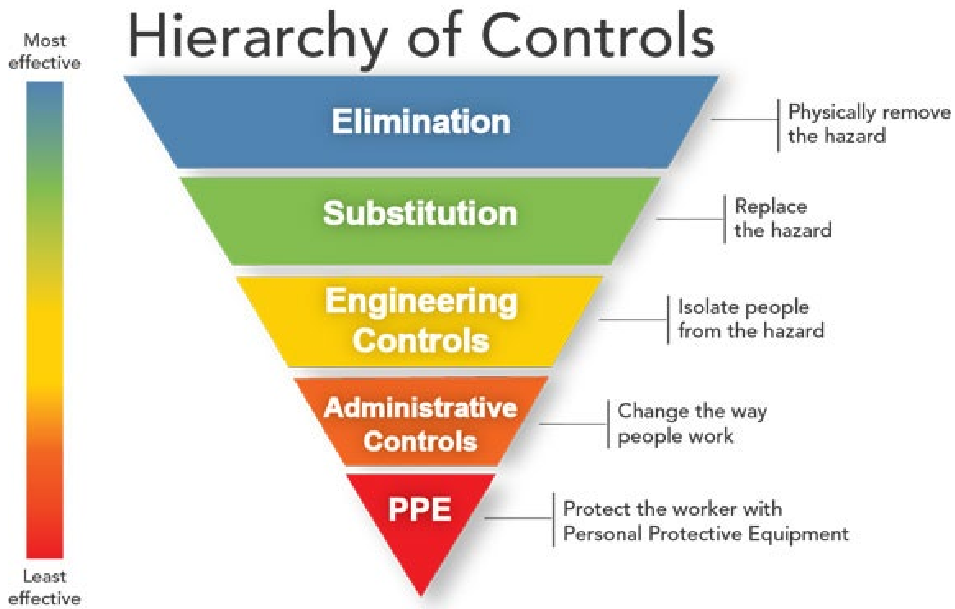
The purpose of PPE is to shield or isolate responders from the chemical, physical, and biological hazards that may be encountered at a response.

Careful selection and use of adequate PPE should protect the respiratory system, skin, eyes, ears, face, hands, feet, and head. OSHA requires that the selected personal protective equipment must fit the responder who is utilizing it; this can be accomplished by having several sizes.  For example, not everyone can wear the same size of gloves; different sizes of coveralls are needed for a person who is 6 feet tall and a person who is 5 feet tall, even if the waist sizes are the same.

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

In this chapter, respiratory protection, chemical protective clothing and other PPE are covered.

Personal protective equipment is the last choice in the Hierarchy of Controls to prevent exposure.




Source: [https://www.cdc.gov/niosh/topics/hierarchy/default.html](https://www.cdc.gov/niosh/topics/hierarchy/default.html)

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

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

Work practice controls are often described in written procedures (called administrative controls and include Standard Operating Procedures) that detail how work is to be done or the duration that someone can work in a particular area. For example, an administrative control for emergency response is an Emergency Response Plan that details the various procedures needed from initial assessment to response to termination; confined space entry permitting is a specific administrative control that might be used during a response.

What part of the Hierarchy of Controls is illustrated by the following?

Keep adsorbents from losing the contaminant through evaporation

Confined Space work

Fire suppression

# PPE - Respiratory Protective Equipment

Respiratory protection is required during emergency response activities because adequate protection is rarely provided using engineering or administrative controls. This section outlines different types of respiratory protection equipment, its use, and its limitations.

Respirators provide protection against chemical and dust exposure. Employers must provide responders with appropriate respirators and training if respirators are needed for usual or emergency work tasks. OSHA Standard 29 CFR 1910.134 requires that a written respiratory protection program be developed by the employer if responders may be required to wear respirators during an emergency.

## Section Objectives

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

- Describe appropriate applications of respiratory protection
- Evaluate situations to determine if respiratory protection is required
- Identify the requirements of a respiratory protection program
- Demonstrate ability to don, use and doff respirators
- Identify the elements of respirator training that should be provided by the employer

**Respirator Selection**

Different hazards require different types of respirators. Several factors should be considered when selecting a respirator. Selecting the appropriate respirator is the responsibility of qualified personnel, such as an industrial hygienist.

Some considerations used to select a respirator include:

- What is the oxygen content of the atmosphere?
- What are the hazardous substances to which the responder may be exposed?
- Is the atmosphere immediately dangerous to life and health (IDLH)?
- What is the concentration of the substance in the air?
- What is the Permissible Exposure Limit (PEL) or Short-term Exposure Limit (STEL) for the substance?
- Is the respirator approved for the application?

Other selection considerations include:

- Communication needs
- Use in confined space
- Use in extreme temperatures
- Skin and eye absorption hazards
- Maximum concentrations for use
- Face protection
- Manufacturer limitations and cautions

## Types of Respirators

Two basic types of respiratory protection are:

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

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

## Air-Purifying Respirators

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

- all toxic substances must be identified
- the concentration must be known throughout the response by monitoring
- the respirator and cartridge must be selected to protect against those specific chemicals
- the oxygen concentration must be greater than or equal to 19.5%
- APRs are not used in atmospheres Immediately Dangerous to Life and Health (IDLH)

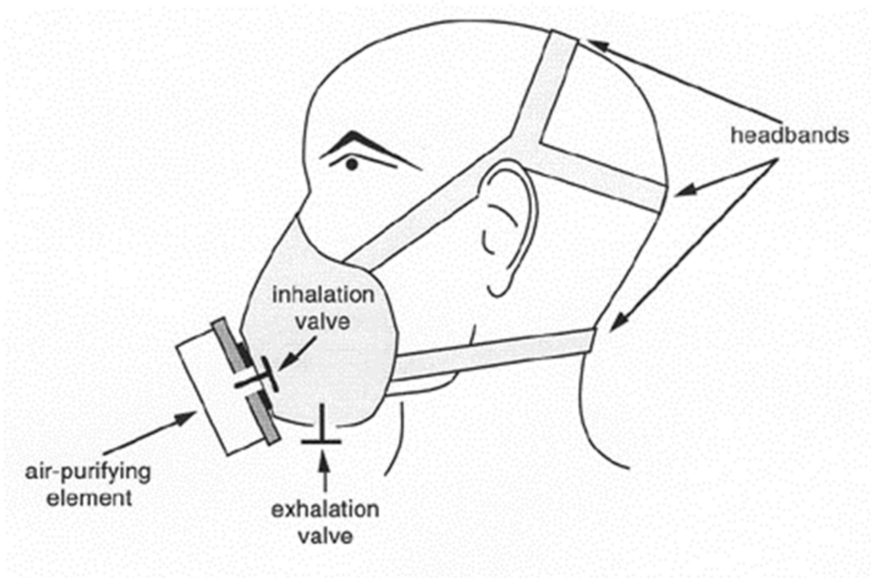
APRs can be reusable or single use. Reusable APRs consist of a facepiece with an exhalation valve and one or two filtering cartridges through which the air enters. The most widely used facepieces are full-face or half-mask. Full-face and half-mask respirators are illustrated below. Single-use types are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

APRs cannot be used in an IDLH atmosphere.

Full-face Air Purifying Respirator

Half-face Air Purifying Respirator

**Operation of a Reusable Air-Purifying Respirator**




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

**Cartridges and filters for protection from chemical and particle exposure**

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

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

Cartridges are selected for specific exposures which are expected. Factors that affect APR use include the size of the particles, concentration of the substance, and type of filter used. There is no appropriate protective cartridge filter for some environments; examples include oxygen displacement, or the concentration exceeds APR guidance. APRs are not recommended by NIOSH for known or suspected carcinogens.

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

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

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

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

**Chemical Cartridges**

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

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

**Particulate Cartridges/Filters**

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

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

The filters should be changed when the breathing resistance increases, or the filter is dirty, wet, or damaged. Employer guidelines may be more specific.

### Other Reusable APRs

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

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

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

Limitations for are shown in the written respiratory protection program.

| |
|---|
| PAPRs cannot be used in an IDLH atmosphere. |

### Atmosphere-Supplying Respirators (ASR)

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

### Supplied-Air Respirators (SAR)

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

There are three classifications of supplied air respirators:

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

Types A and B do not meet the requirements for emergency response and cannot be used; therefore these units are not covered in this training.

Airline respirators must operate in either **continuous-flow** or **pressure-demand** mode. In continuous-flow mode, air is always flowing, even when the wearer is not inhaling. In pressure-demand mode, a constant positive pressure is maintained inside the facepiece; air flows when the positive pressure in the facepiece is reduced as the wearer inhales. A third mode of operation is **demand mode**, in which air only flows when the pressure inside the facepiece becomes negative due to the wearer inhaling. Demand mode provides the least protection, because contaminants can leak into a poorly sealed facepiece when the pressure becomes negative. NOTE: Not allowed when the concentration is unknown or IDLH conditions.
Compressors used to supply air must meet special requirements. Compressor exhaust and lubricants must not contaminate the air supplied. Compressor air intakes must be located in a contaminant-free area.

**Self-Contained Breathing Apparatus (SCBA)**

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

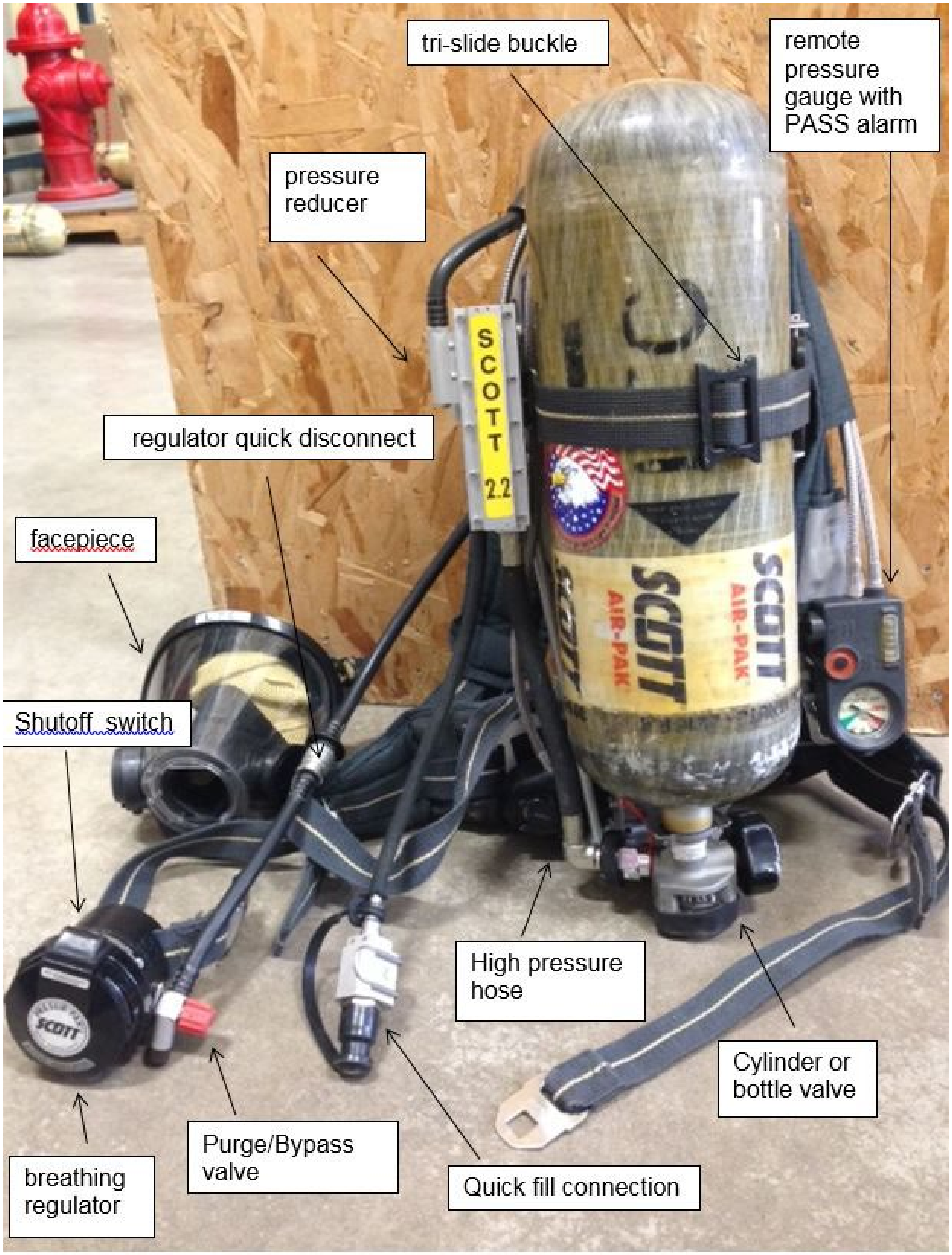
- **Bottle (tank or cylinder)** contains compressed breathing air (2216 psi-5500 psi)
- **Harness** secures cylinder and connects user to apparatus
- **Gauge** displays current cylinder pressure
- **Safety/by-pass valve** by-passes the regulator in case of malfunction of the regulator. The by-pass valve should be open only when needed
- **Pressure regulator(s)** provide reduced pressure air during inhalation
- **Full facepiece** isolates user's face from exterior environment

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

SCBAs and cylinders differ by manufacturer and type. You must be trained in the manufacturer's instructions and checkout procedures before using any SCBA. These units should be NIOSH certified for IDLH, full facepiece and with a minimum duration of 30 minutes or combined with SAR with auxiliary SCBA escape bottle. An SCBA can operate in either demand mode (less protective) or pressure-demand mode. SCBA cylinders may be constructed of steel, aluminum, or composite materials. These have varying service lives and hydrostatic testing requirements. Users should familiarize themselves with their specific cylinders. A positive-pressure SCBA or positive-pressure airline respirator equipped with an escape air supply must be used when exposure levels are likely to present an IDLH situation or impair the ability to escape.

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

When the contaminant is unknown, wear a pressure-demand SCBA with a full facepiece, or a pressure-demand SAR with a full facepiece in combination with an auxiliary pressure-demand SCBA or 5-minute escape bottle. Auxiliary SCBA must provide air for sufficient time to permit escape to safety if needed.


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

**Rebreather**

A rebreather apparatus may be used in specialized applications by responders. These units are useful because in each breath, only about 4 percent of the oxygen in inhaled air is used.

## Occupational Exposure Limits and Guidelines

OSHA sets and enforces airborne exposure limits. Generally, the enforced level is the Permissible Exposure Limit (PEL); however, OSHA inspectors can build a case to cite based on an exposure guideline if the PEL is considered ‘old and outdated’ or there is no PEL.
NIOSH and non-governmental agencies (such as ACGIH®) have also established exposure levels to protect health. These guidelines and recommendations are not legally enforceable. Some exposure levels have a “skin” designation to indicate that the material is readily absorbed through the skin.
All these organizations provide background on how the number was determined; however, it is notable that the numbers are often quite different. The process to set a standard through OSHA takes many years, and therefore most OSHA standards have not been changed since the agency was established in 1970. ACGIH® and NIOSH update values more often. All groups consider the need to limit exposure to preserve health when a new number is developed.

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

**Measures of Concentration**

Exposure levels are expressed as a concentration, or the amount of a substance contained in a known volume of air.

Concentrations of gases or vapors in workplace air are usually measured in parts per million (ppm), or milligrams per cubic meter ($mg/m^3$).

- 1 ppm is a drop in 13.2 gallons of water or about 4 drops in a 55-gallon drum

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

Percent by volume of air (%) is used for higher concentrations such as explosive limits; a concentration of 1% is 10,000 ppm

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

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

## Exposure Guidelines and Standards

Exposure guidelines are recommendations made by various groups based on the information available; this includes companies who adopt internal exposure levels for use by the organization. Exposure standards as used in this training are enforceable by a government agency. You may see other sources of standards; for example, the American National Standards Institute (ANSI) develops consensus documents referred to as standards, but that are not enforced by ANSI.

Below are listed several terms used to describe exposure guidelines and standards.

**Immediately Dangerous to Life and Health (IDLH)**

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

**Permissible Exposure Limits (PELs)**

Permissible exposure limits (PELs) are legal exposure levels set by OSHA. Employers are required by law to not exceed the PELs using the hierarchy of controls to achieve compliance. In most cases, the PELs have not been updated for many years.

**Threshold Limit Values (TLVs)**

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

### Recommended Exposure Limits (RELs)

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

### Short-Term Exposure Limits (STELs)

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

### Ceiling Limits (C)

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

### Time-Weighted Averages (TWAs)

Most PELs, TLVs, and RELs are 8-hour time-weighted average concentrations. The purpose of this type of average exposure is to characterize exposure during an 8-hour work shift. In setting a TWA it is assumed that there is time away from exposure during which the chemical is metabolized or cleared from the body.
An example of how the TWA is calculated follows:

**Time-Weighted Averages Calculated**

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

$$\text{TWA} = \frac{(\text{Exposure}_1 \times \text{Time}_1) + (\text{Exposure}_2 \times \text{Time}_2) + \ldots}{(\text{Time}_1 + \text{Time}_2 + \ldots)}$$

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

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

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

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

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

**Biological Exposure Indices (BEIs) and Standards**

Instead of measuring a concentration in the air, a person's exposure to some substances can be evaluated by measuring the concentration of the substance or a related compound such as a metabolite in their blood, urine, or exhaled breath.
While the exposures measured in air reflect the work environment, the BEIs or biological-based standards, reflect what has been taken into the body and are closer to a measure of dose than external exposure.
Examples include:

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

A few OSHA standards include biological monitoring; the lead exposure standard is one example.
For more information on biological exposure standards see individual OSHA standards; guidelines are shown in the section on Biological Exposure Indices in the ACGIH® annual publication, Threshold Limit Value (TLVs®) and Biological Exposure Indices (BEIs®).

## Exercise – Using the NIOSH Pocket Guide to find Occupational Exposure Limits and Protective Measures

Use the NIOSH Pocket Guide to identify the occupational exposure standards, guidelines and protective measures for the chemicals reviewed earlier. (See Exercise Manual)

### Exposure Records

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

See the OSHA Standard "Access to Employee Exposure and Medical Records" (29 CFR 1910.1020). Records that workers can request include relevant worker exposure data, written studies of exposure and/or health outcomes and personal medical records. When requested, the employer must provide access within fifteen working days after the request is made. The employer can comply by either making a copy of the requested record at no cost to the employee, allowing the employee to use the employer copy machine to copy the requested record.

## Respirator Fit

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

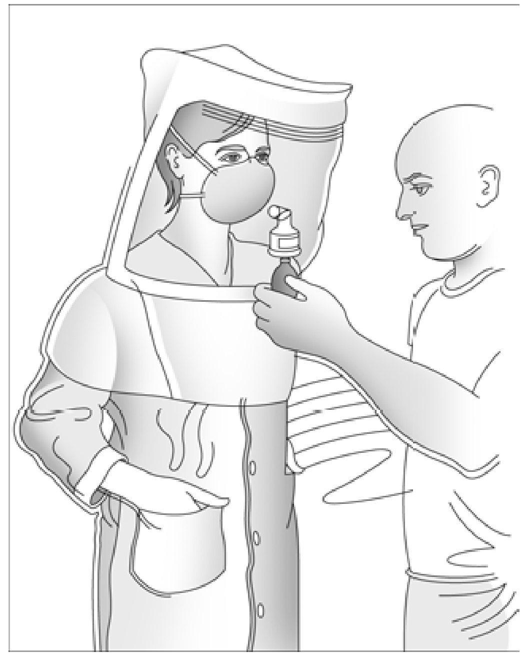
Because human faces come in many different shapes and sizes, each manufacturer has several facepiece sizes. The purpose of fit testing is to find the manufacturer/size combination which offers adequate protection. Factors such as weight loss or gain, dentures, dental work, or facial injury can change the shape of the face, thus potentially changing the fit and efficiency of the respirator. If any of these factors exist, retesting is required.

### Annual Fit Tests

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

**Qualitative Testing**

**Purpose**: Checks effectiveness of preventing substances from entering the facepiece.
**Method**: While the individual is wearing a respirator, a test substance is released, as shown on the right. The test substance could be smelly (banana oil), sweet (saccharin), bitter (Bitrex) or an irritant (special smoke tube). The wearer should not be able to detect the substance while performing a series of prescribed tasks.
**Requirements**: This test or its equivalent is required by OSHA at least once a year.
There are several important cautions to qualitative fit testing:



- Some of the test substances may irritate the eyes or cause coughing
- A sensitivity test is first performed to determine the individual is capable of sensing the test solution
- Fit testing is often done in "ideal" environments. The fit may change after wearing the respirator several hours or during strenuous activity.
  Must be used only when the ratio of the concentration outside to the concentration inside the facepiece is less than or equal to 100; this is called the Fit Factor

**Quantitative (Numerical) Testing**

This test measures the fit factor (FF), a comparison of the concentration of a substance outside of the mask to the concentration of a substance inside of the mask, or a loss of vacuum between the outside and inside of the mask. The FF is useful in determining whether the respirator will effectively protect the wearer from exposure. A disadvantage to this test is that special equipment and specially trained personnel are needed to administer it.

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

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

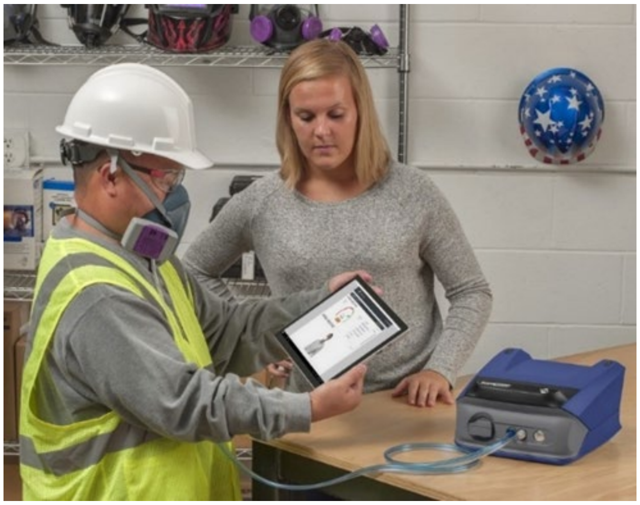


Photo courtesy of TSI Inc. to MWC

1. While an individual wears a respirator modified with a probe, the concentrations of particulates in the air inside and outside of the respirator are measured, as shown above. The test is repeated while the person performs specific tasks (speaking, running in place, etc.) that may affect fit.
2. While an individual wears a respirator connected to a fit testing device, a vacuum is drawn in the mask to assess the seal for leaks. Then the user removes and re-dons the mask and the test is repeated twice.

**Requirement**: This test is mandated when a fit factor of 500 is required.

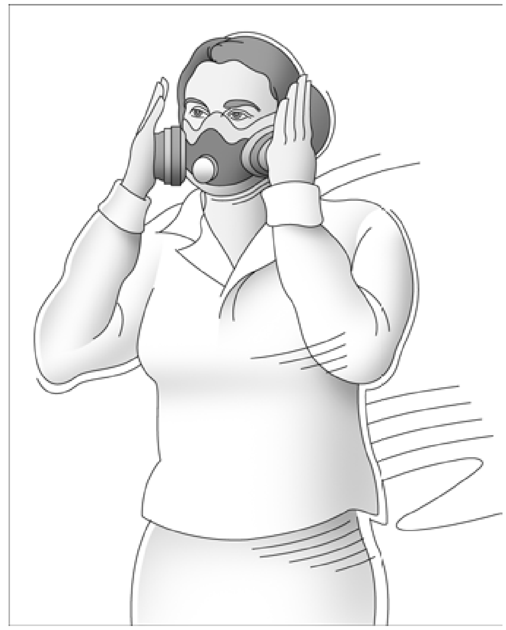
**Routine User Checks**

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

**Positive-Pressure Check**

**Purpose**: Checks the facepiece components for leaks at valves or other points. NOTE: Not all respirators allow easy access to the exhalation valve for this test.
**Method**: Close off the exhalation valve (if possible) and exhale gently into the facepiece. The face fit is considered satisfactory if a slight positive pressure can be built up inside the facepiece without any evidence of outward leakage of air at the seal. For most respirators, this method of leak testing requires the wearer to first remove the exhalation valve cover before closing off the exhalation valve and then carefully replacing it after the test. This is only performed if the cover can be manually removed.
**Requirement**: Shall be done before each use.

### Negative-Pressure Check



**Purpose**: Checks the facepiece-to-face seal.
**Method**: SCBA wearer disconnects the regulator and places hands over the hole for the regulator connection and inhales. APR wearer places hands over cartridges and inhales, as shown on the right. No outside air should be felt leaking into the facepiece.
**Requirement**: Shall be done each time the respirator is donned (first use, break, lunch).
Positive- and negative-pressure checks can be done quickly and easily in the field. If the wearer is unable block the holes or cartridges with their hands, additional measures may need to be performed to accomplish the blocking requirement to detect the leaks.

### Assigned Protection Factors

Respirators are selected by using Assigned Protection Factors (APFs). The higher the APF, the more protective the respirator is. A protection factor has been determined in the laboratory at NIOSH for each type of respirator (APR, PAPR, SCBA, etc.) and mask (half- or full-face). Protection factors also exist for combinations of the above respirators. For example, an SAR with a full-face mask and an auxiliary SCBA equals 10,000.

The following table shows Assigned Protection Factors (APFs):

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

*Quarter masks are rarely used and are not presented here.

See https://www.osha.gov/pls/oshaweb/owalink.query_links?src_doc_type=STANDARDS&src_unique_file=1910_0134&src_anchor_name=1910.134%28d%29%283%29%28i%29%28A%29 for additional information about this table.

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

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

**Fit Factor Calculation**

Selection of respirators includes calculation of the fit factor by dividing the known chemical concentration by the APF. The resulting value is compared with the occupational exposure guideline used by your employer.

$$\frac{measured\ chemical\ concentration\ (ppm)}{APF} = parts\ per\ million\ (ppm)$$

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

**Sample Fit Factor Calculation:**

Cyclohexene released from a faulty valve has resulted in a loss of about 480 gallons in the transfer building. The first entry team wore SCBAs and stopped the release. The safety and health officer monitored the concentration and found 400 ppm at the entrance. This is not a TWA, but a single measurement on a direct-reading instrument. The OSHA PEL is 300 ppm for an 8-hour work shift; it is expected that the cleanup by the responders will take four hours. Because engineering controls cannot be implemented, respiratory protection must continue to be used. What type of respiratory protection would provide adequate protection against this contaminant?

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

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

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

The resulting answer is 40 ppm, which means that 40 ppm of cyclohexene could be present inside the facepiece of a properly fitted respirator. A concentration of 40 ppm is less than the OSHA 300 ppm PEL, so this type of respiratory protection would be adequate, especially since the duration of work is less than eight hours. However, the safety and health supervisor questions the fit for all responders as it is very hot in the transfer building. Does a full-face APR provide better protection?

$$\frac{400\ ppm}{50} = 8\ ppm$$

The resulting answer is 8 ppm. A properly fitted full-face APR would protect better than the half-face APR.

NOTE: This solvent is an eye irritant. How does this affect respirator selection? What protection is needed to prevent eye irritation? How does the temperature affect selection?

If the concentration of the contaminant in the workplace changes, another calculation of fit factor would need to be done to see if the respirator is still protective at the new concentration (if higher) or the cartridge change-out schedule is altered (lower).

**Maximum Use Concentration**

The Maximum Use Concentration (MUC) is calculated to know the highest concentration for which the particular respirator is protective. To calculate the MUC, multiply the PEL (or other exposure guideline) by the APF:

$$MUC = PEL * APF$$

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

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

Therefore, the half-face APR could be used up to a cyclohexene concentration of 3000 ppm if that concentration is not above the IDLH. Checking the NIOSH Pocket Guide, the IDLH for cyclohexene is 2000 ppm; therefore the MUC for an APR is set at 2000 ppm. Always check the IDLH when considering the MUC.

Calculating the MUC for the full-face APR, you get:

$$MUC = 300 * 50 = 15{,}000\ ppm$$

You cannot use an APR above the IDLH, therefore, the MUC for cyclohexene for the full-face APR would also be 2000 ppm.

The duration of use of an APR cartridge is calculated using breakthrough time information from the manufacturer and is shown in the change-out schedule. Discuss this with your Safety and Health manager, if needed.

## Exercise - Respiratory Protection Factor Exercise

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

## Cleaning, Storage, Inspection and Maintenance of Respirators

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

**Cleaning respirators**

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

A. Remove filters, cartridges, or canisters. Disassemble facepieces by removing speaking diaphragms, demand and pressure- demand valve assemblies, hoses, or any components recommended by the manufacturer. Discard or repair any defective parts.
B. Wash components in warm (43 deg. C [110 deg. F] maximum) water with a mild detergent or with a cleaner recommended by the manufacturer. A stiff bristle (not wire) brush may be used to facilitate the removal of dirt.
C. Rinse components thoroughly in clean, warm (43 deg. C [110 deg. F] maximum), preferably running water. Drain.
D. When the cleaner used does not contain a disinfecting agent, respirator components should be immersed for two minutes in one of the following:

1. Hypochlorite solution (50 ppm of chlorine) made by adding approximately one milliliter (approximately 20 drops) of laundry bleach to one liter of water (about a 1000:1 dilution) at 43 deg. C (110 deg. F); or,
2. Aqueous solution of iodine (50 ppm iodine) made by adding approximately 0.8 milliliters (about 16 drops) of tincture of iodine (6-8 grams ammonium and/or potassium iodide/100 cc of 45% alcohol) to one liter of water (about a 1250:1 dilution) at 43 deg. C (110 deg. F); or,
3. Other commercially available cleansers of equivalent disinfectant quality when used as directed, if use is recommended or approved by the respirator

manufacturer.

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

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

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

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

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

**Respirator Storage**

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

**Inspection**

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

- A check of respirator function
- Tightness of connections
- The condition of the various parts including, but not limited to, the facepiece, head straps, valves, connecting tube, and cartridges, and canisters or filters
- A check of elastomeric parts for pliability and signs of deterioration.
- In addition to the above, self-contained breathing apparatus must be inspected monthly

Air cylinders must be maintained in a fully charged state and be recharged when the pressure falls to 90% of the manufacturer's recommended pressure level. The employer must determine that the regulator and warning devices function properly.

NOTE: Cold temperatures may result in pressure below 90%, even if the cylinder is full.

**Maintenance**

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

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

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

## Minimum Requirements for a Respiratory Protection Program

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

- Medical evaluations of employees required to use respirators
- Fit testing procedures for tight-fitting respirators
- Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators
- Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators
- Training of responders in the respiratory hazards to which they may be potentially exposed during routine and emergency situations

- Training of responders in the proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance
- Procedures for regularly evaluating the effectiveness of the program

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

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

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

Effective training must be provided at least annually by the employer for all employees who are required to use respirators (see 29 CFR 1910.134(k)). This training must be understandable to the participant.

Based on the training, the employer shall ensure that each employee can demonstrate knowledge of at least the following:

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

## Medical Fitness to Wear a Respirator

Before a responder receives clearance to wear a respirator, a medical evaluation must be performed by a physician or other licensed health care professional (PLHCP). The evaluation helps ensure that the employee is physically capable of working with the added stress of a respirator. Any follow-up evaluations and testing will be determined by the PLHCP.
Some medical conditions which may prevent respirator usage include:

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

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

- Contact lenses
- Eyeglasses
- Moustache that may interfere with fit
- Perforated tympanic membrane (ruptured eardrum)

Changes in weight or dental work may alter the fit of a respirator and require a new fit test.

Special eyeglass kits are available for use with full facepiece respirators.

## Exercise – Respiratory Protection Scenarios

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

## Exercise – Respiratory Protection Demo and Workshop

In this exercise, you will become familiar with SCBAs, APRs, egress units and equipment cleaning and inspection procedures. See Exercise Manual.

## Summary – Respiratory Protective Equipment

Respiratory protection is required to prevent inhalation of toxic gases, vapors, particles (dusts, mists) and fibers. Situations which may require the use of respiratory protection include:

- Oxygen deficiency
- Hazardous substances in the air during spill control
- An atmosphere immediately dangerous to life and health (IDLH)
- Confined-space entry
- Fire suppression

The two basic types of respirators are air-purifying respirators (APRs) and atmosphere-supplying respirators (ASRs). Routine training and practice are necessary for use.
APRs may be reusable or single use. Reusable APRs consist of a facepiece with an exhalation valve and one or two filtering units through which the air enters. Filters may be for dust, vapors, or both. APRs may not be used where the identity of the contaminant is unknown or in an IDLH atmosphere.
ASRs may be supplied-air respirators (SARs) or self-contained breathing apparatus (SCBAs). SCBAs consist of a facepiece, supply of air, gauge, and safety valve. If SARs are used, an escape unit must also be worn.

**Important Points to Remember About Occupational Exposure Limits**

- Exposure levels are expressed as a concentration, or the amount of a substance contained in a known volume of air
- Most PELs, RELs, and TLVs are 8-hour average concentrations
- STELs are set for very few compounds
- IDLH, STELs, and C values are generally measured over short periods of time
- Results of exposure monitoring can be requested by the employee under the OSHA Standard on Access to Employee Exposure and Medical Records (29 CFR 1910.1020)

A respirator is assigned for use after either qualitative (the desired protection factor is $\leq$100) or quantitative fit testing. Before each use, the wearer conducts positive- and negative-pressure user checks.
Care of respirators includes diligent cleaning, disinfecting, storing and maintenance. Units should be inspected before and after each use or monthly if not used routinely.
A respiratory protection program must include the following points:

- Medical evaluations of employees required to use respirators
- Fit testing procedures for tight-fitting respirators

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

The employer must:

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

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

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

# PPE – Chemical Protective Clothing

Chemical-protective clothing (CPC) includes suits, aprons, gloves, safety goggles, and face shields. This provides an important barrier between chemicals or other hazards in the environment and your body. Although CPC and respirators cannot provide protection from all exposures, when properly selected and worn, it can limit harmful exposures. This section includes the use, selection and application of levels of protection as designated by EPA and OSHA.

You will don and doff PPE.

## Section Objectives

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

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

**Chemical-Protective Clothing**
Chemical-Protective Clothing (CPC) consists of special clothing worn to prevent chemicals from contacting the body. CPC generally includes eye/face protection, aprons, boots, gloves, and suits/coveralls. CPC is used to protect responders from both chemical and physical hazards. The proper use of CPC can prevent or reduce exposure to a hazard. CPC is an important part of an emergency responder's personal protective equipment (PPE).

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

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

**PPE must be properly selected and used to be effective.**

Examples of improper selection
- Goggles, when whole body splash is likely
- Gloves known to swell when wetted with solvent that must be cleaned up

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

What examples of improper selection or use have you seen?

The PPE program must address:
- Selection, based upon anticipated hazards (See 29 CFR 1910.132 Appendix B for guidance)
- Use and limitations
- Work task duration
- Maintenance and storage

- Decontamination and disposal
- Training and proper fitting
- Donning and doffing procedures prior to, during, and after use
- Inspection procedures
- Evaluation of program effectiveness
- Special limitations during temperature extremes, heat stress, and other appropriate medical considerations

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

Appropriate PPE must be purchased as part of preplanning, and it must be selected and properly used during initial size-up and response activities. The size-up should provide sufficient information to select PPE to protect personnel from overexposures to chemicals. During size up and other initial actions, responders may a high level of protection. With the information gathered, including air monitoring, a decreased level of respiratory protection may be ordered by the person in charge and following the ERP for the response activities. All PPE selected and used must meet OSHA requirements where applicable (1910, Subpart I and 1910.120).

## Types of Chemical-Protective Suits

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

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

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

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

## Selection of CPC and other PPE

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

A hazard assessment with a survey of the facility is part of pre-emergency planning at fixed sites and will include a list of potential emergency releases or events. This list is used in planning for required PPE. Hazards to take into consideration include:

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

The type of chemical-protective suits selected will depend on the type and nature of potential exposure. For example, totally encapsulating suits may be required for persons approaching a perc release at a faulty valve; less protection is required for those involved in maintaining site security during the response. Generally, the level of protection provided will be re-evaluated as additional information is gained. Guidelines for selection of PPE, including CPC suits, are presented in the following table.

## CPC Selection Guidelines

**Always follow manufacturer's recommendations**

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

**Physical integrity**: Construction of the suit is important for the proper functioning of the CPC. Seams and zippers should provide solid barriers to chemicals and should be constructed to prevent seam tears and rips during use

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

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

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

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

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

**Design**: CPC should be designed so that all required respiratory PPE can be used at the same time.  Some styles/designs require assistance to don/doff.

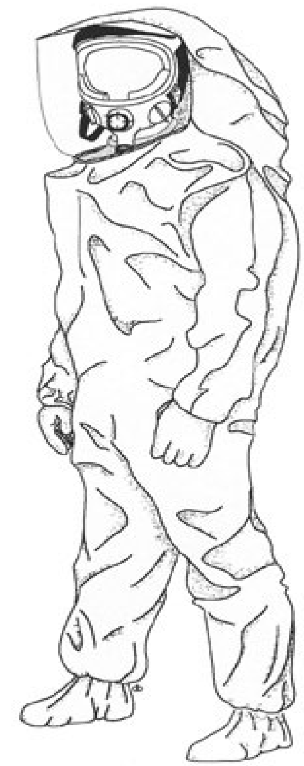
## Levels of PPE (see 29 CFR 1910.120, Appendix B)

**Level A**

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

**What Is Level A Protection?**
The following list constitutes Level A equipment; it may be used as appropriate:

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



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

**When Is Level A Protection Needed?**

Level A protection is required when:

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

**Level B**

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

**What Is Level B Protection?**

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

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

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

*Optional as applicable

**When Is Level B Protection Needed?**

Level B protection is required when:

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

**Level C**

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

**What Is Level C Protection?**

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

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

*Optional as applicable

**When Is Level C Protection Needed?**

Level C provides protection when:

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

## Level D

This level offers no respiratory protection and low skin protection.

### What Is Level D Protection?

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

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

*Optional as applicable

### When Is Level D Protection Needed?

Level D is required when:

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

### Typical Uses of Level D Equipment

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

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

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

| Remembering Levels of Protection |
| --- |
| A helpful way to remember the levels of protection is:<br>Level A - "A"ll Covered, gas/mist tight<br>Level B - "B"reathing Air, splash protection<br>Level C - "C"artridge Respirator or air purifying respirator<br>Level D – "D"on't Expect Protection", regular work clothes |

Note: Levels A and B suits must be tested. See:

- 29 CFR 1910.120, Appendix A—PPE Test Methods
- ASTM F23.50.01, Practice for Pressure Testing of TECP
- NFPA 1991, Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies (EPA Level A)
- NFPA 1992, Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies (EPA Level B)
- ANSI/ISEA-101-1996, Limited-Use and Disposable Coveralls—Size and Labeling Requirements
- Chemical-Resistant Clothing: ASTM F739, Permeation; ASTM F903, Penetration

## Exercise – Levels of Protection

The facilitator will describe several emergency response scenarios. Work in small groups to identify the level of protection required. (See Exercise Manual)

## Characteristics and Properties of CPC

PPE is effective only if it is properly selected, worn, and maintained. Standard Operating Procedures (SOPs) for PPE are included in the ERP. SOPs are employer-specific versions of the more general Standard Operating Guides (SOGs) often used in training. SOGs are written instructions and are a form of administrative control.

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

Penetration, Degradation, Permeation

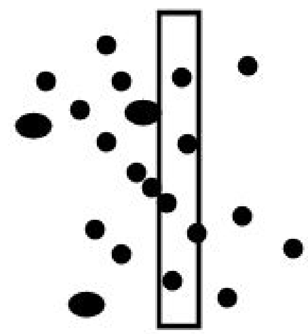
Chemicals can reduce the effectiveness of CPC garments through penetration, degradation, or permeation.

NOTE: Mixtures of chemicals may behave differently from the components.

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

**Degradation** is a reduction in one or more physical properties of a protective material due to contact with a chemical, use or ambient conditions such as sunlight or cold. This may be seen by swelling or 'gumminess' of the material, discoloration or loss of strength.

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



- Contact time
- Material thickness
- Concentration
- Temperature
- Physical state of chemicals
- Size of the contaminant molecules and pore space

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

## Chemical-Resistant Materials

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

**Butyl Rubber**

**Use** Mainly in encapsulating suit, but some gloves, boots, and splash gear.
**Advantages** Good for bases and many organics. Very resistant to gas/vapor permeation. Readily releases contamination. Good heat and ozone resistance.
**Disadvantages** Poor for aliphatic and aromatic hydrocarbons, gasoline, halogenated hydrocarbons, and abrasion resistance. More expensive than PVC or neoprene.

**Chlorinated Polyethylene (CPE)**

**Use** Only in fully encapsulating suits
**Advantages** Good for aliphatic hydrocarbons, acids and bases, alcohols, and phenols. Resists abrasion and ozone.
**Disadvantages** Poor for amines, esters, ketones, and halogenated hydrocarbons. Becomes very rigid when cold.

**Natural Rubber**

**Use** For boot covers because of durability and for disposable inner and outer gloves.
**Advantages** Good for bases, alcohols, and dilute acids. Inexpensive. Flexible.
**Disadvantages** Poor for organic chemicals. Ages (affected by ozone).

**Neoprene**

**Use** In all types of protective clothing.

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

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

**Nitrile Rubber**

**Use** In gloves and boots and one encapsulating suit.
**Advantages** Made specifically for petroleum products. Abrasion- and cut-resistant. Flexible. Good for bases, peroxides, PCBs, phenols, and alcohol.
**Disadvantages** Poor for aromatic and halogenated hydrocarbons, amines, ketones, and esters. Loses flexibility in cold weather.

**Polyurethane**

**Use** In boots and splash gear.
**Advantages** Good for bases and organic acids, oils, and alcohols. Abrasion-resistant. Flexible (especially in cold weather).
**Disadvantages** Poor for inorganic acids and other organic solvents.

**Polyvinyl Alcohol (PVA)**

**Use** For gloves only.
**Advantages** Excellent (the best) for oils, aromatic solvents, and chlorinated hydrocarbons. Ozone-resistant.
**Disadvantages** Degraded by water. Not flexible. Expensive.

**Polyvinyl Chloride (PVC)**

**Use** All types of protective clothing.
**Advantages** Excellent for acids and bases. Very durable. Relatively inexpensive.

**Disadvantages** Poor for chlorinated and aromatic solvents. Difficult to decontaminate.

**Viton**

**Use** In fully encapsulating suits and gloves.
**Advantages** Good for most organics including chlorinated hydrocarbons. Fair durability. Good for acids. Good for decontamination. Good for physical properties.
**Disadvantages** Poor for oxygenated solvents—aldehydes, ketones, esters, and ethers. Expensive.

**Teflon**

**Use** In fully encapsulating suits.
**Advantages** Excellent chemical resistance against most chemicals.
**Disadvantages** Limited permeation test data. Expensive.

**Nomex**

**Use** For flame retardant PPE and a base fabric for some suits.
**Advantages** Fire-resistant. Durable.
**Disadvantages** Readily penetrated.

**Tyvek®**

**Use** Predominantly for coveralls.
**Advantages** Dry particulate and dust protection. Disposable, lightweight, and inexpensive.
**Disadvantages** Penetrable if not chemically treated. Poor durability.

**Polyethylene (coated Tyvek®)**

**Use** Predominantly for coveralls, but also gloves and booties. It can be worn over CPC to prevent gross contamination of non-disposables.
**Advantages** Good for acids and bases, alcohols, phenols, and aldehydes. Good for decontamination (disposable) and lightweight.
**Disadvantages** Poor for halogenated hydrocarbons, aliphatic and aromatic hydrocarbons. Not very durable. Easily penetrated (stitched seams).

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

**Use** Gloves, aprons, sleeves, and booties
**Advantages** Good for alcohols, aliphatics, aromatics, chlorines, ketones, and esters, economical
**Disadvantages** Poor fit of gloves impacts dexterity, easily punctured.

**Trellchem®**

**Use** Fully encapsulating and partially encapsulating suits
**Advantages** Resistant to a wide range of chemicals, some models also including chemical warfare agents, abrasion resistance and flame resistance.

**Disadvantages** Stiff and bulky, expensive

**Tychem®**

**Use** Fully encapsulating and partially encapsulating suits, coveralls, and hoods
**Advantages** Resistant to a wide range of chemicals. Some models also resist chemical warfare agents, puncture and abrasion, heat, arc flash and flame.
**Disadvantages** Expensive, stiff, and bulky
See resources from manufacturers when selecting CPC. The rating for a material does not necessarily predict performance of a garment; thickness, formulation, substrate, and manufacturing process can all affect the product performance.

## Precautions When Wearing CPC

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

- Hearing and speaking to be heard may be difficult in CPC with respiratory protection. It is important to establish other ways to communicate with each other. Hand signals or audio signals such as horns, sirens, and whistles can be used to communicate. Communication can also be improved by using two-way radios, such as a portable radio with microphone or radio with a microphone and speaker combination attached to the full-face respirator. Remember, any radio must be intrinsically safe to prevent an ignition hazard. Be aware of potential traffic areas.
- Due to the size, weight and design of some suits, motion is restricted, especially when climbing, working in tight areas, or using hand tools.
- Look for signs of heat stress (dizziness, headache, nausea, perspiration ceases), especially at temperatures over 70ºF.


- Always wear the correct size of footwear to prevent accidents. You should also make certain that the soles provide a proper grip for the surfaces that you will be encountering. Steel shanks, toes, and shin guards help to prevent puncture wounds and/or crushing injuries.
- Disposable booties may be slippery. Use caution when walking to prevent slips and falls.
- Care should be taken when donning and doffing inner and outer gloves. When donning gloves, make sure that no cracks or tears are present. When doffing gloves, take care not to spread contamination.
- All joints such as suit-to-boots and suit-to-gloves in Levels B and C protection should be secured with tape that is compatible with the CPC; see manufacturer recommendations. Fold the end of the tape back under to make a tab for easy removal. Use special care when removing tape.
- Goggles and eye/face protection may become clouded due to moisture condensation during use. Follow manufacturer recommendation regarding use of products such as anti-fog film or spray on protective eye/face gear. Similarly, follow manufacturer instructions regarding clearing away any fog that may form on the inside of the face shield of a fully encapsulating suit.

- Be sure you are adequately hydrated prior to and after use of CPC.
- Avoid placing your hands or knees on the ground when in the Hot Zone to prevent contamination by chemicals and abrasion to the suit material. Avoid sitting on anything sharp in suits.
- When removing a suit, open and fold down onto itself as it is removed to prevent contamination of internal clothing.
- Suits have weak seams, especially if they are disposable. Be careful not to strain and split them. If splitting occurs, report it, and follow the appropriate SOP (standard operating procedure).
- Use caution when suits are used in potential fire areas. If fire occurs, get out of the area.
- When dressing out with a team be careful to coordinate your dressout at the same speed and level as your team/buddy. The longer you are dressed out, the more stress is being put on your body.
- Completion of dressout should be delayed until ready to conduct your assigned duty/response activity.

## Inspection, Maintenance, and Storage of CPC

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

- Received from the distributor
- Issued to responders
- Put into storage
- Taken out of storage
- Used for training
- Used for an emergency response
- Sent for maintenance
- Returned from repair or service

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

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

> Note: CPC may be contaminated or degraded even though there are no visible signs.

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

Proper storage is important to prevent CPC failures. The written SOP should describe storage before the CPC is issued to the responder, as well as storage after use, Check the manufacturer data for specific temperature and humidity storage requirements, shelf life and any expiration date.

## Donning and Doffing PPE

Proper donning and doffing of PPE will preserve the integrity of the PPE, protect the wearer from chemical exposure and may facilitate efficient decon.

## Exercise – Level C Dressout and Level C PPE Checkout

This exercise will give you the opportunity to practice donning and doffing and inspecting Level C protection. (See Exercise Manual, agenda)

## Exercise – Level B Dressout

This exercise will give you the opportunity to practice donning and doffing and inspecting Level B protection. (See Exercise Manual, agenda)

## Exercise – Level A Dressout

This exercise will give you the opportunity to practice donning and doffing and inspecting Level A protection. (See Exercise Manual, agenda)

## Summary – Chemical Protective Clothing

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

**Level A provides the most protection and includes:**

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

Level A protection is required when:

- The hazardous substance has been identified and requires the highest level of protection for skin, eyes, and respiratory system

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

**Level B includes:**

- A positive-pressure, full facepiece SCBA or supplied-air respirator with escape unit
- Hooded, chemical-resistant clothing
- Inner and outer chemical-resistant gloves
- Chemical-resistant boots with steel toe and shank

Level B protection is required when:

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

**Level C includes:**

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

Level C provides protection when:

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

**Level D includes:**

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

Level D is required when:

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

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

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

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

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

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

# PPE - Other Protective Gear

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

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

## Section Objectives

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

- Identify OSHA requirements and other guidelines for hearing, eye/face, head and foot, hand/arm protection
- Describe special protective clothing

In addition to RPE and CPC, other types of PPE may be required in an emergency response. OSHA standards for additional PPE include:

- 1910.95 Hearing Protection (fire truck siren can exceed 100 dB)
- 1910.132 General Requirements: Personal Protective Equipment
- 1910.133 Eye and Face Protection
- 1910.135 Head Protection
- 1910.136 Foot Protection
- 1910.137 Electrical Protective (gloves and sleeves)
- 1910.138 Hand Protection

With the exceptions of hearing protection and electrical protection, these protective devices are required in one or more of the Levels of Protection (A, B, C, D).

## Exposure-Specific Protective Clothing and Testing

Some protective clothing is developed for specific exposures. Those exposures include high temperature, low temperature, arc flash, welding, diving, flash fire, hazardous equipment, and hazardous animals. Protective clothing designed for a specific exposure may not protect against other types of exposures, such as a chemical exposure; some protective clothing can prevent exposure to multiple hazards. Never assume protective clothing will prevent any exposure not specifically shown in manufacturer information or attached labels.

**High-Temperature Clothing:** High-temperature clothing may be referred to as flash-over protection suits. At one time, separate flash-over protection suits were worn over other protective clothing, such as CPC, firefighter turnout gear, or flame-retardant coveralls. Currently, many Level A suits also offer flash fire protection. Although high-temperature clothing protects against brief exposure to heat, it is not intended for long-term exposure to fire.

**Arc Flash Protection:** The recent increased awareness of the dangers of arc flash has resulted in an increase in arc flash personal protective equipment (PPE). The materials are tested for their arc rating. The arc rating is the maximum incident energy resistance demonstrated by a material prior to break open (a hole in the material) or necessary to pass through and cause with 50% probability a second- or third-degree burn. Arc rating is normally expressed in $Cal/cm^2$ (or small calories of heat energy per square centimeter). The tests for determining arc rating are defined in ASTM F1506 Standard Performance Specification for Flame Resistant Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal

Hazards.  Among the best fabrics for protection against electric arc flash are the Modacrylic-cotton blends.

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

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

Testing guidelines for head, shoe and eye/face protection is shown in the table below.

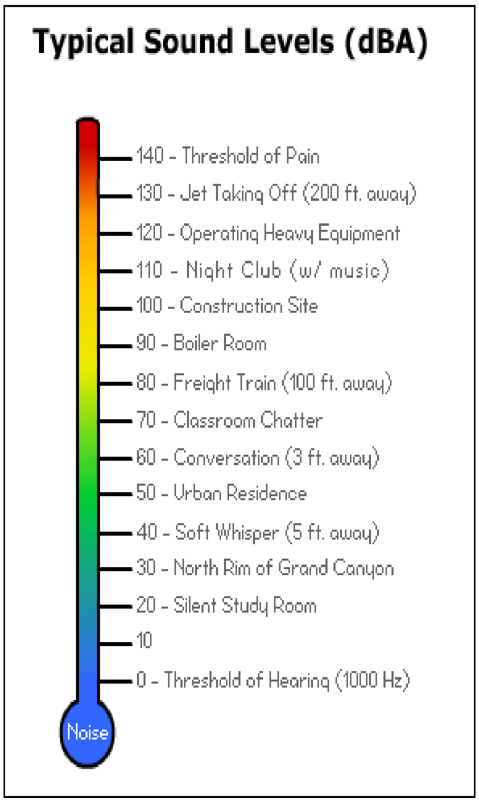
| Protective Equipment | Use/Testing Guideline |
|---|---|
| Hard Hats | ANSI Z89.1-2009 Industrial Heal Protection<br>ANSI Z89.1-2003 Industrial Heal Protection<br>ANSI Z89.1-1997, Protective Headwear for Industrial Workers |
| Shoes | ASTM F-2413-2018, Standard Specification for Performance Requirements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

**Noise**

During a response, noise levels from alerting signals and other sources may be very high. Short exposures to high noise levels can cause a temporary change in hearing or the sound of ringing in your ears. Repeated exposures over longer periods of time to noise can lead to permanent effects, including hearing loss. Exposure to high noise levels is also linked to high blood pressure, insomnia, headaches, and psychological stress.

Loud noise during a response can interfere with communication and concentration resulting in slower or inappropriate actions, accidents, and injuries.

See noise exposure levels in the figure, below.




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

Occupational exposure to noise is measured on this scale. dB and dBA cannot be compared easily.

Other useful noise levels are:

| | |
|---|---|
| Forklift | 90 dBA |
| Ambulance siren | 120 dBA |
| Air horn alert system | 130 dBA |

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

NIOSH and ACGIH recommend lower exposures.

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

source:[https://www.osha.gov/SLTC/noisehearingconservation/loud.html](https://www.osha.gov/SLTC/noisehearingconservation/loud.html).

## Exercise – Using the OSHA standards and Other Guidelines

Your facilitator will provide standards or guidelines for you to identify requirements. Work in small groups and complete the worksheet in the Exercise Manual. One member of the group should prepare a brief report back to the entire group.

## Summary – Other Protective Gear

OSHA standards cover

- Hearing Protection
- General Requirements: Personal Protective Equipment
- Eye and Face Protection
- Head Protection
- Foot Protection
- Electrical Protective (gloves and sleeves)
- Hand Protection

Other specialized clothing includes high-temperature and arc flash protection.

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

During a response, noise levels from alerting signals and other sources may be very high. Short exposures to high noise levels can cause a temporary change in hearing or the sound of ringing in your ears. Repeated exposures over longer periods of time to noise can lead to permanent effects, including hearing loss.

Loud noise during a response can interfere with communication and concentration resulting in slower or inappropriate actions, accidents, and injuries.

# Material Identification

Recognizing a potential hazard is an important step toward avoiding it during a hazardous materials response.
This chapter includes resources that will help you identify a material, based on the container shape or labels or written papers describing the contents.

## Chapter Objectives

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

- Identify possible contents of containers based on shapes and sizes
- Identify label information in the Hazard Communication standard or other systems including NFPA 704 and HMIS
- Identify hazards indicated by placards in the DOT system
- Identify other resources for hazmat information available with shipments or when containers are transferred
- Demonstrate an ability to identify health and safety hazards using resources

**Container Shapes and Sizes**

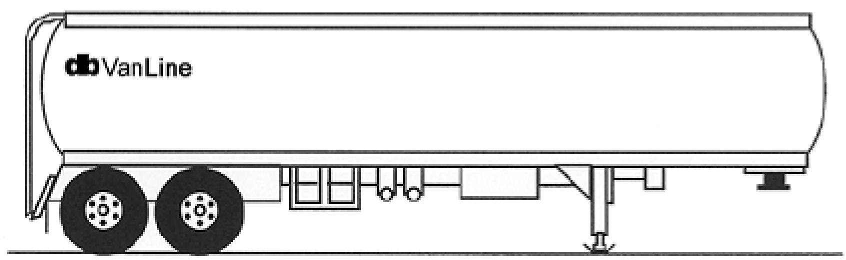
Containers are used to store and ship materials. In an emergency at a fixed site or in transit the labels or placards may be damaged or blocked from view. Therefore, it may be important to recognize specific types of containers.

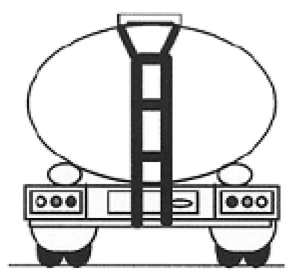
Some container types and their contents are identified in this section. Other specialized types of containers may be used and require review as part of preplanning.

**Atmospheric Pressure Tank Truck**

Oval cylinder trailers generally contain flammable and combustible liquids, usually liquids lighter than water (especially petroleum products).  DOT406, TC407, SCT-306; MC306, TC306.

Side View



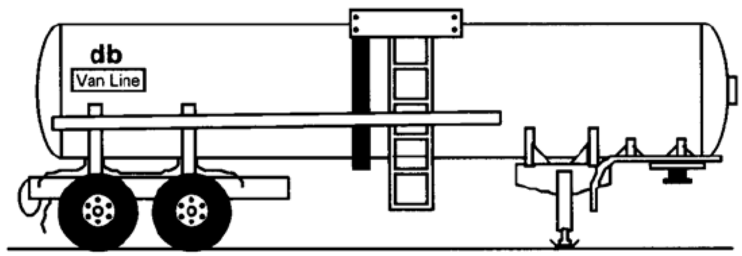



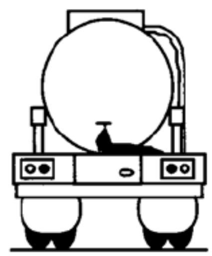
Back View

## Low-Pressure Chemical Carrier

The trailer shown here—a round cylinder often insulated with a double shell—probably contains poisons, mild corrosives, or mild oxidizing solutions. This type of trailer may or may not have reinforcing rings. (Compare with the Corrosive Liquid Carrier below.) DOT407, TC407, SCT307; MC307, TC307.

Side View



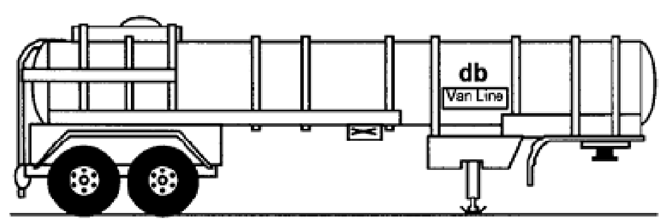



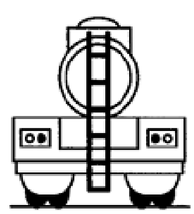
Back View

## Corrosive Liquid Carrier

These tanks can be identified by their small circular diameter with reinforcing exterior stiffening rings.  DOT412, TC412, SCT312; MC312, TC312.

Side View



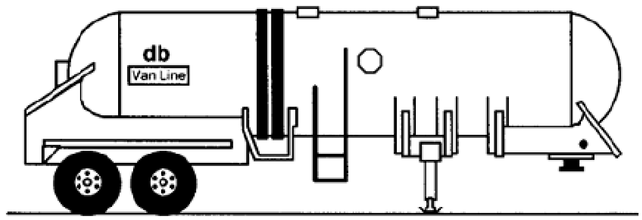



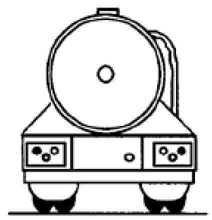
Back View

### High-Pressure Liquefied Gas Tanker

These tanks are circular with rounded ends. They may contain propane, butane, or anhydrous ammonia under pressure. MC331, TC331, SCT-331.

Side View



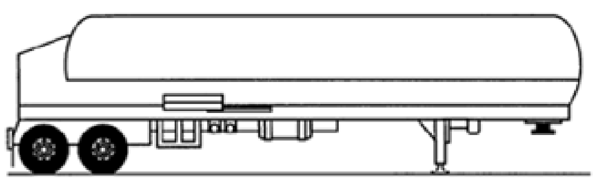



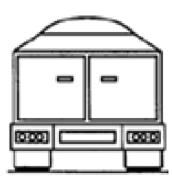
Back View

### Cryogenic Cargo Tanks

Cryogenic cargo tanks transport cryogenic liquids, which must be kept below -200°F. The cryogenic tank is actually a tank within a tank. The space between the inner and outer tanks is filled with insulation and normally maintained under vacuum. MC338, TC338, SCT-38; TC341, CGA341.

Side View



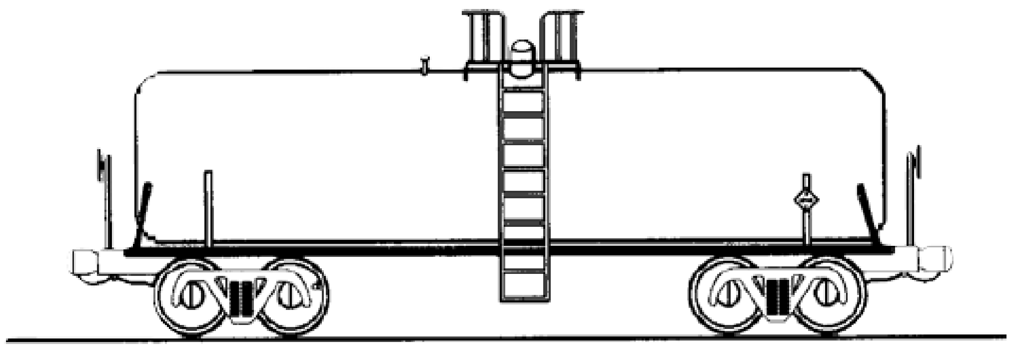


Back View

Other road trailer shapes are shown in the Emergency Response Guidebook (ERG).

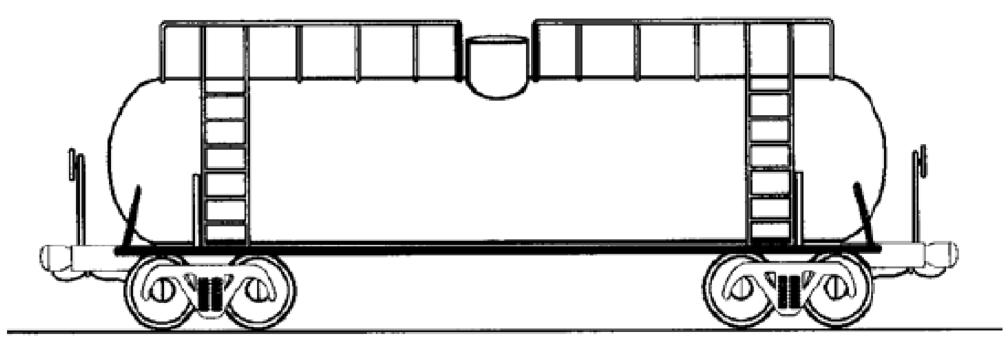
**Non-Pressurized Rail Tank Cars**

These rail tank cars are identified by the horizontal tank with flat ends and a manway at the top with valves and fittings. These tank cars contain flammable and combustible liquids, flammable solids, oxidizers, organic peroxides, poisons, and corrosives.



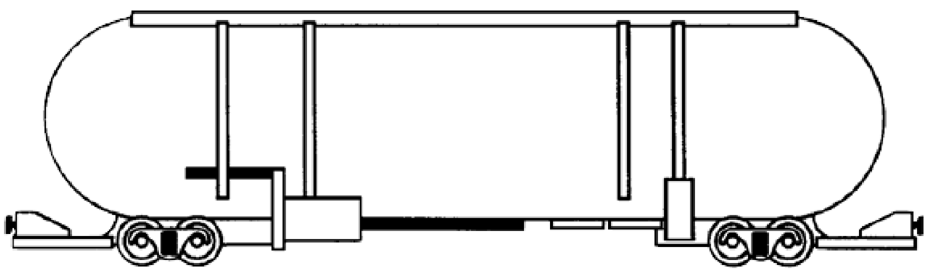
**Pressurized Rail Tank Cars**

These rail cars have horizontal tanks with rounded ends unless they are double shelled and have a bonnet (dome cover). These tank cars usually contain flammable and nonflammable gases and poisons.



**Specialized Tank Cars—Cryogenic**

The cryogenic tank car is a tank within a tank. It is distinguished by the absence of top fittings, which are enclosed in cabinets at ground level on both sides or at one end of the car. Cryogenic tank cars may contain liquid argon, hydrogen, and nitrogen.



**Rail Car Markings**

The side of the car will include:

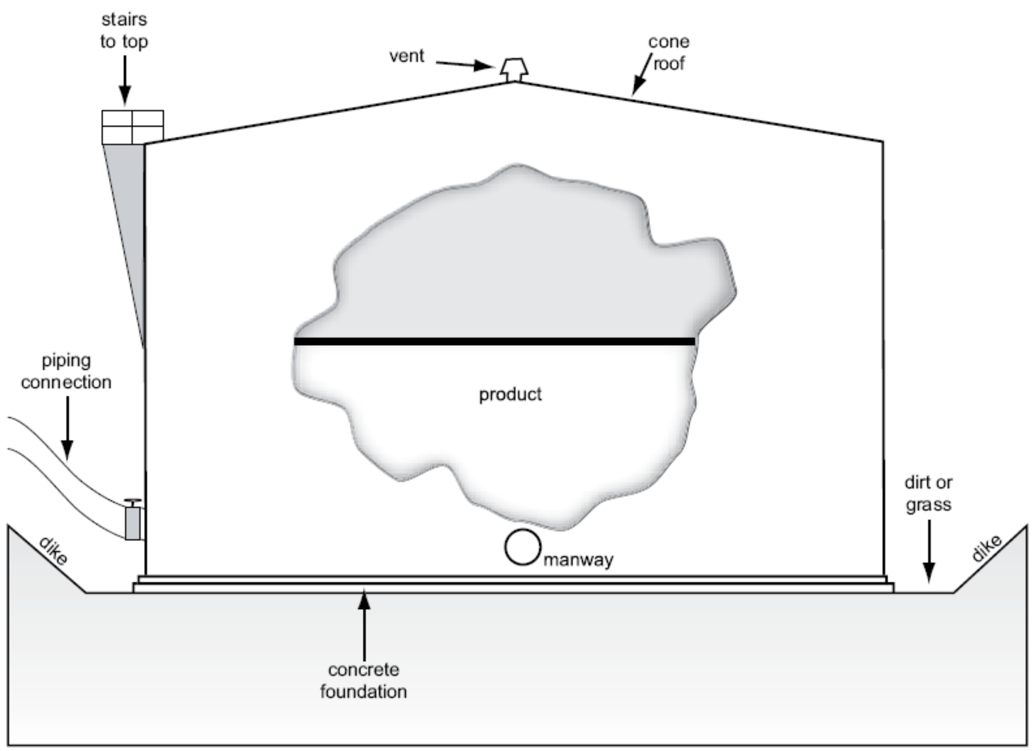
- Reporting marks and car number
- Load limit (pounds or kilograms)
- Empty weight of car
- Placard in holder
- Tank test and safety valve testing information
- Car specification
- Commodity name
- TC permit number

The rear of the car will show

- Reporting marks and car number
- Capacity in gallons or liters
- Placard in holder

**Fixed Roof Tanks**

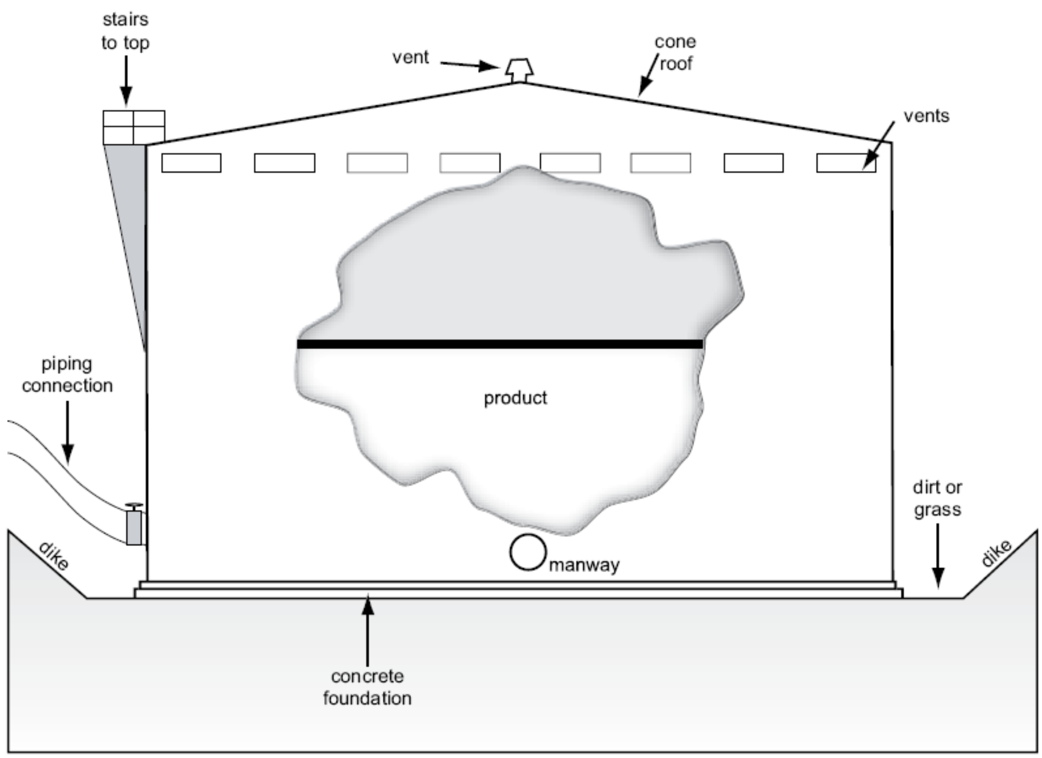
Fixed roof tanks are often identified by a cone roof. These tanks frequently contain hydrocarbons.




- May store anything that will not damage the tank, including flammables/combustibles (with vapor pressure close to atmospheric), corrosives, and poisons
- Pressure vacuum valves and purging with compatible gas eliminates air intake in the space above the product
- Filling and emptying are normally done by valves on the sides of the tanks near the bottom
- Quick opening gauge hatch at top of tank

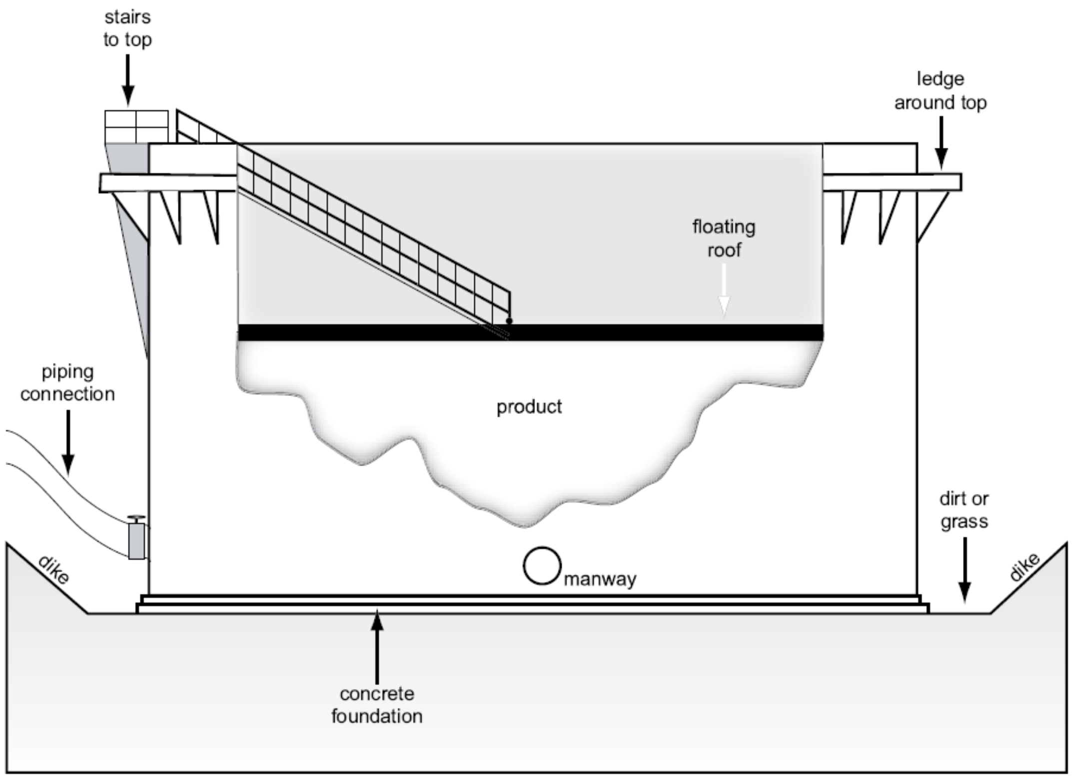
**Internal Floating Roof Tank**

These tanks are identified by the conical roof and vents around the edge of the tank. They commonly store materials that will easily burn or explode.




- The floating roof is protected from weather, including lightning strikes
- Vents prevent accumulation of vapors above the floating roof
- Used for products with VP > 0.5 psia and < 11.2 psia (examples: gasoline, jet fuel, aldehyde, alcohols, ketones, aromatic hydrocarbons
- Designed and manufactured based on temperature, pressure, and chemical properties of material

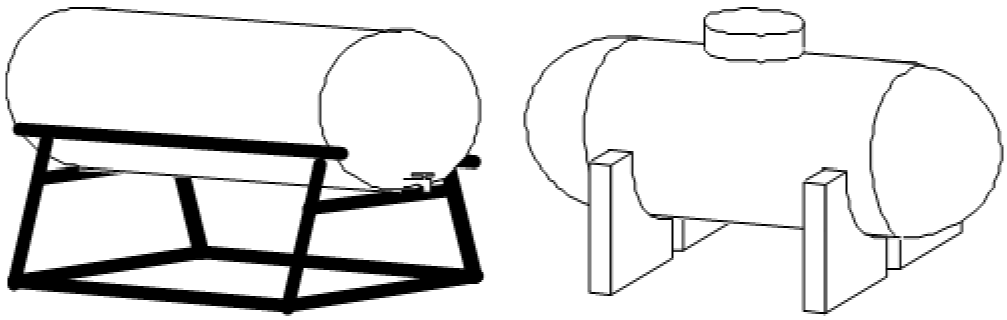
## External Floating Roof Tank




- The flat roof floats up and down on the liquid in the tank
- Normally store petroleum products such as crude oil or condensate
- Roof floating on the liquid reduces release of vapors and prevents vapor build-up and rim-space fire hazard
- Snow and rain can accumulate on the roof. Weather can speed corrosion of the roof

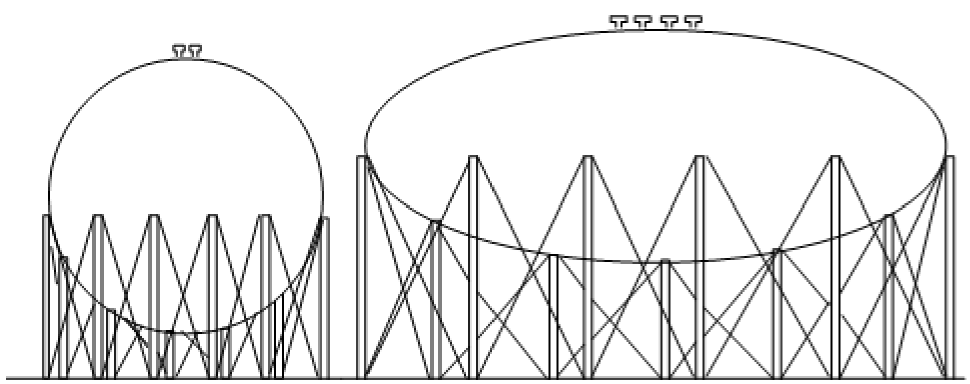
**Horizontal Storage Tanks**

Horizontal tanks are horizontal cylinders which sit on the ground or on legs. These tanks usually store flammable liquids, corrosives, and poisons but may contain most anything. Pay close attention to the ends of cylinders. Rounded ends may be a clue that the container holds a pressurized liquid or gas.



**Sphere Storage Tanks**

These may be round or elliptical and have large relief devices at the very top of the tank. Sphere tanks store pressurized materials such as methane, propane, LPG, heptane, ethane, and other light gases.



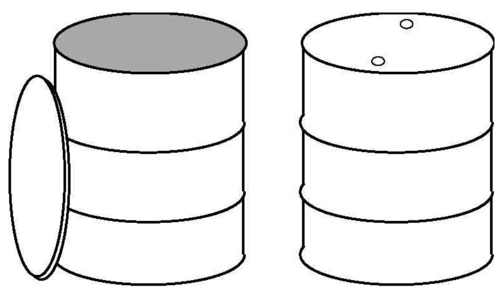
**Underground Storage Tanks**
Petroleum products and raw materials used in manufacturing processes are frequently stored in underground storage tanks (USTs). Leaking underground storage tanks (LUST), deteriorating piping and product loss during overfilling or poor filling work practices have resulted in potential ground and water contamination.

## Drums

The “clues” to the contents of drums come from the material from which the drums are made as well as whether the drum is closed-top or open-top. Closed-top drums are sealed and have small openings in the top through which liquids can be poured. Open-top drums have removable lids and may or may not have the small openings characteristic of the closed-top drum.

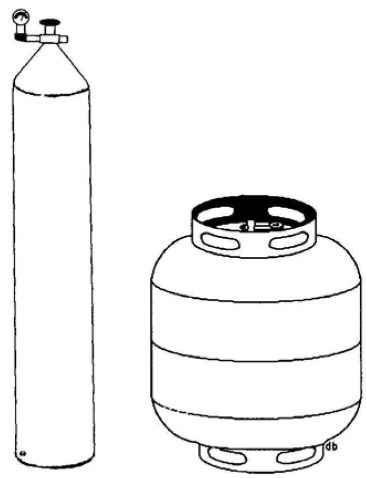
Some types of drums and their potential contents are listed below.

- Closed-top metal drums normally contain non-corrosive products in liquid form.
- Closed-top plastic or composite (plastic inside metal or cardboard) drums usually contain corrosive liquids.
- Open-top metal drums usually contain non-corrosive solids or sludges.
- Open-top plastic drums usually contain corrosive solids or sludges.
- Other types of drums such as stainless steel, nickel, and Monel® are used for chemicals that require special container because of their specific properties. These containers usually can be recognized by their metallic color.



**Open-Top (Left) and Closed-Top (Right) Drums**

**Cylinders**



The emergency responder needs to be aware of the potential danger posed by the presence of cylinders in an emergency.

Cylinders usually contain **pressurized flammable** or **non-flammable gases**. Cylinders may be involved in transportation or storage facility incidents.

Explosion potential of pressurized cylinders should be considered, particularly in fire situations. Ruptures of the cylinders may result in dangerous airborne projectiles.

**Bulk Containers or Totes**

Bulk containers are designed to hold up to several hundred gallons of liquid or solid raw material, intermediate or product that may be hazardous or non-hazardous. Intermediate bulk containers (IBCs) are mounted on a pallet and may be designed to be stacked with a forklift or other assistive device depending on construction. Contents (liquid or solid) are removed through a built-in tap. The large size (a 275-gallon IBC is equivalent to 5 55-gallon drums) is an advantage in material handling. Common construction materials are polyethylene housed in a metal cage or heavy gauge (e.g., 1/2-inch-thick) polyethylene that requires no housing and may have a built-in pallet at the base. Additional advantages of these construction materials are low weight, durability, and corrosion resistance. IBCs may also be constructed from fiberboard, aluminum, wood, and galvanized iron.

Two examples of Intermediate Bulk Storage containers in front of a bulk storage container

Flexible Intermediate Bulk Containers (FIBCs), giant sacks sometimes referred to as ‘super sacks’, are generally made from woven polypropylene and hold solids. FIBCs are constructed to be moved mechanically, usually by inserting forks into the large loops that are attached into the seams. FIBCs come in a variety of shapes (circular, baffled, u-panel) and sizes; openings and coatings and lift locations can be customized.


Flexible Intermediate Bulk container being off-loaded for shipment.

Responders to facilities using totes should be familiar with the shutoff valves on the specific containers as some have the on/off position opposite of normal due to the location of the valve.

Other types of containers may contain hazardous materials. Liquid hazardous materials may be stored in glass containers. Dry materials may be stored in boxes, bags, or wooden barrels. Hazardous materials stored in these types of containers may be transported by any means or stored at any location. Just because a material is in this type of container does not mean that it is safe.

**It is important that you report unlabeled containers discovered during a response**

## Systems and Symbols

It is important to know the systems which are used to identify hazardous materials. Identification information is included on labels applied to small containers (drums, packages, boxes) and placards applied to large containers (trailers, rail cars, tanks). There are several different systems; one or more may be used at the plant by contract personnel or companies which supply raw materials. Some of these systems are described below.

**Globally Harmonized System for Labeling - Hazard Communication Standard**

The purpose of the OSHA Hazard Communication Standard is to ensure that everyone at a worksite has access to information about the chemicals that are used and has been trained to use them safely. This information is important for responders who must manage an unexpected release.
The 2012 revision of the Hazard Communication Standard (HCS2012) included major changes in labels for containers and Safety Data Sheets (SDS, no longer MSDS—but the same idea). This update of the OSHA standard has the same number (29 CFR 1910.1200) in the Federal Register. See https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10099.

HCS2012 requires all manufacturer labels to have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification. HCS2012 covers most hazardous chemicals (excluding wastes) in an overall system that looks at physical hazards (such as flammability and corrosivity), health hazards (including both immediate and long-term health effects) and environmental hazards.

Employers may continue to use rating systems such as National Fire Protection Association (NFPA) diamonds or HMIS requirements (both discussed later in this chapter) for workplace labels, as long as they are consistent with the requirements of the Hazard Communication Standard and the employees have immediate access to the specific hazard information for the chemicals (for example, in an up-to-date SDS). An employer using NFPA or HMIS labeling must, through training, ensure that its employees are fully aware of the hazards of the chemicals used.

If a chemical is transferred from a labeled container to a portable container that is only intended for immediate use by the employee who performs the transfer, no label is required for the portable container. For more information, see OSHA Brief, Hazard

Communication Standard: Labels and Pictograms,
http://www.osha.gov/Publications/OSHA3636.pdf

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

## Exercise – Pictograms

In this exercise, you will use an OSHA Quick Card to find information on pictograms. (See Exercise Manual.)

## Labels

Appendix C to 29 CFR 1910.1200 describes required elements of container labels. A few key points:

- The label must include the name, address, and telephone number of the manufacturer/importer/responsible party. The product identifier on label must match the SDS.
- There is a hierarchy of signal words:
  - Danger or Warning must be used
  - If Danger is used, Warning is not
- There is a hierarchy of pictograms:
  - If the skull and crossbones are used, then the exclamation mark is not used for acute toxicity
  - If a corrosive pictogram is used, the exclamation mark is not used for skin and eye irritation
  - If the health hazard pictogram for respiratory sensitization is used, the exclamation mark is not used for skin sensitization or skin and eye irritation
- Hazard statements can be combined
- There are four types of Precautionary Statements:
  - Prevention
  - Response
  - Storage
  - Disposal

- Each Hazard Class is detailed in Appendix C.4 of 29 CFR 1910.1200. Shown for each are:
  - Hazard Category
  - Signal Words
  - Hazard Statements
  - Pictograms
  - Precautionary Statements

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

**National Fire Protection Association (NFPA)–704 System**

The NFPA system is used for storage vessels and stationary containers at an industrial facility.
The hazard communication training program must include this system, if used.

Below is an example of the NFPA 704 System.


Notice the … Shape: diamond

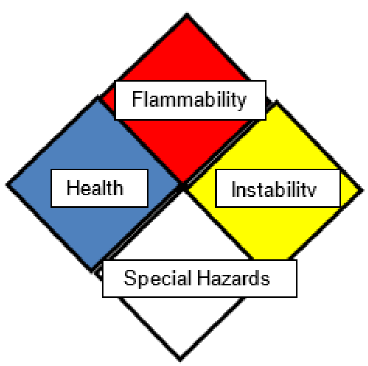
Colors: Red, Blue, Yellow, White

Numbers: 4, 2, 3

Symbol: ₩

All NFPA placards and labels are the same shape and have the same colors. What differs are the numbers and symbol.

The color of each of the four small diamonds indicates the type of hazard as shown below.




| Color | Hazard |
|---|---|
| Red | Flammability |
| Blue | Health |
| Yellow | Instability |
| White | Special hazards |

The number in the red, blue, and yellow diamonds is a relative rank of the potential flammability, health, and instability hazard, respectively, ranging from 0 or blank (low) to 4 (high hazard).

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

NFPA Standard Symbols:

| ~~W~~ | OX | SA |
|---|---|---|
| Reacts with water | Oxidizer | Simple Asphyxiant |

Non-Standard Symbols:

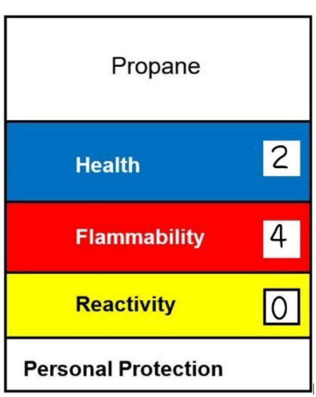
- **COR:** Corrosives
- **ACID** and **ALK** (Alkali) to be more specific
- **BIO:** Biological Hazard
- **POI:** Poisonous Material (e.g. strychnine)
- **CYL or CRYO:** Cryogenic Material (e.g. liquid nitrogen)
- **Radioactive trefoil:** Radioactive materials. (e.g. plutonium, uranium)

This field may also be left blank if no special hazards are present.

When multiple special hazards exist, add white panels below the placard to list the additional special hazards that apply.

**The HMIS (Hazardous Material Information System) Label**

The HMIS is used for storage vessels and containers




Below is an example of an HMIS label

Notice the ….

Shape: Rectangular

Chemical Name: Propane

Colors: Blue, Red, Orange, White

Boxes: Contain numbers or letters

All HMIS labels have the same shape and colors. For hazard recognition, it is important to note numbers in the blue, red and orange boxes, and any letter in the white section.

The numbers rank the potential health, flammability, and physical hazard and range from 0 (low) to 4 (high).

The Personal Protection section may contain a letter which tells you what personal protective equipment you should use to protect yourself when working with the material. Capital letters range from A (safety glasses) to K (full protective suit with gloves, boots, a hood or mask, and an airline or Self-Contained Breathing Apparatus). If the personal protection is coded X, specialized handling procedures are needed. Lower-case letters n through u, w, y, and z are codes for specific protective equipment. For example, q represents boots and u represents an organic vapor respirator. A chart outlining each letter code will be accessible.

Two boxes may appear next to Health. The first box contains an asterisk (*) if the material poses a risk of a chronic health effect; otherwise, a slash (/) should be in the box. The box on the right contains the numerical hazard rating (0–4). Alternatively, the two symbols may be combined in the box on the right. For example, 3* in the box on the right would mean a serious chronic health effect.

Note of caution: While HMIS and NFPA 704 are US systems that have been in place for many years, the transition to a globally harmonized approach as in HCS2012 may cause confusion. It is very important to recognize that the numbering system in the two approaches is not consistent—and is in fact opposite as shown below.

| HCS2012 Hazard categories | | HMIS/NFPA 704 numerical ratings | |
|---|---|---|---|
| 1 | Severe Hazard | 0 | Minimal Hazard |
| 2 | Serious Hazard | 1 | Slight Hazard |
| 3 | Moderate Hazard | 2 | Moderate Hazard |
| 4 | Slight Hazard | 3 | Serious Hazard |
| 5 | Minimal Hazard | 4 | Severe Hazard |

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

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

Below is an example of a DOT signage or label that might be seen on a truck, train, or cardboard shipping box.


Notice the… Shape: diamond

Color: red

Symbol: a flame

4-digit number: 1075

1-digit number: 2

All DOT placards are the same shape but differ in the other 'clues' that are shown.

The red color of this placard indicates that the contents are flammable. A full listing of the hazard for each color is shown below:

| Color | Hazard |
|---|---|
| Orange | Explosive |
| Red | Flammable or combustible gas or liquid |
| Green | Non-flammable gas |
| Yellow | Reactive |
| White with skull and crossbones | Toxic |
| White and red vertical stripes | Flammable solid |
| White top with black bottom | Corrosive |
| White top with red bottom | Spontaneously combustible |
| Yellow top with white bottom | Radioactive |
| Blue | Water-reactive |
| Black and white stripes on top, white bottom | Low to moderate hazard |

The flame symbol of this placard also indicates that the chemical is flammable. Other symbols are shown in the table below:

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

A **four-digit** number in the **center** identifies a specific compound. These numbers are identified in the *Emergency Response Guidebook*. For example, 1223 is kerosene. This number may be in the center of the placard (number placards) or on an orange-colored panel below the placard, along with a “word placard” such as the “Flammable” diamond.

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

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

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

You can find more information on what these numbers and symbols mean in a DOT Chart and the *Emergency Response Guidebook*. See Divisions under classes 1-7. For example, Class 1 is further divided into:

Division 1.1 Explosives with a mass explosion hazard
Division 1.2 Explosives with a projectile hazard
Division 1.3 Explosives with predominantly a fire hazard
Division 1.4 Explosives with no significant blast hazard
Division 1.5 Very insensitive explosives with a mass explosion hazard
Division 1.6 Extremely insensitive articles

The 2020 ERG can be downloaded onto your device for free at https://www.phmsa.dot.gov/hazmat/erg/erg2020-mobileapp

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

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

Use Table 1 for initial isolation and downwind protective distances for spills (large and small) occurring during the day or at night. Use Table 3 to identify the same parameters for several important industrial chemicals (ammonia, chlorine, ethylene oxide, hydrogen chloride, hydrogen fluoride and sulfur dioxide) by spill size, wind speed, day, or night and shipping container (rail tank car, highway tanker, multiple ton cylinders, multiple small or single ton cylinder).

**Pesticide Labels**

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

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

The EPA requires the following label elements:

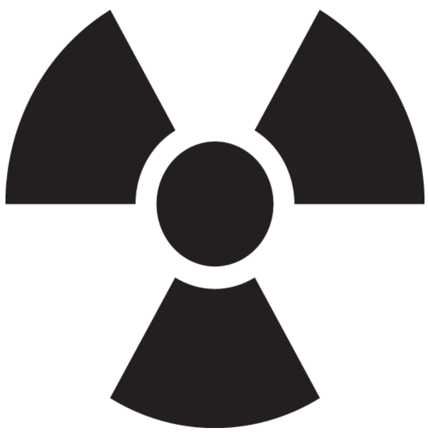
- Name and address of the producer, registrant, or person for whom produced
- Restricted Use Statement (if required)
- Product Name, Brand or Trademark
- Ingredient Statement
- Signal Word, including skull & crossbones, if either are required
- First Aid statement, if necessary
- “Keep Out of Reach of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

As needed, consult other regulations for labeling requirements that may not be the same as OSHA or EPA.

**Infectious Materials Symbol**

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

**Radioactive Materials Symbol**



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

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

Note:  there are special NFPA/DOT packaging requirements for radioactive materials. Not all required package labels include the radiation symbol.  For example, if the package contains material with surface contamination (SCO) or low surface activity (LSA) the marking will read: Radiation - SCO or Radiation-LSA. Packaging for higher-activity radiation materials are shipped in Type A or B packaging that can withstand higher impacts. Types A or B packages will show the radiation symbol.

## Exercise – Labels and Placards

In this exercise you will compare different types of labels. (See Exercise Manual)

# Documentation

Written documents are available describing the hazardous chemicals and materials. Four important sources are shipping papers, manifest forms, waste profile sheets and Safety Data Sheets (SDSs). As part of the Emergency Response Plan, it is important to know where these resources are found and the types of information each contains.

**Shipping Papers**

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

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

A copy of the shipping papers is given to plant personnel upon arrival at the delivery site. A copy is retained showing the date of acceptance by the initial carrier. Papers are retained by the shipper for 2 years and the carrier for 1 year. Hazardous waste manifests are kept for 3 years by both the carrier and shipper. These must be accessible at the principal place of business and available upon request.

**Information Included in Shipping Papers**

Shipping papers are required by the Department of Transportation (DOT). The shipper of the material provides this information. One of the most frequent violations of the Hazardous Materials Regulations (HMR) 49 CFR Parts 100-185 is a failure to properly describe hazardous material on the shipping papers.
The proper shipping description of hazardous cargo includes the following 4 categories:

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

The basic description should include:

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

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

The shipper must provide a certification statement, certifying that the shipment complies with the HMR. The shipping papers must also contain an emergency response telephone number, unless exempted. This number must be monitored by a knowledgeable person at all times while the shipment is underway.

**Example: Bill of Lading**

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

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

An example of a bill of lading form (format may differ as long as the content is complete):

# CONTAINS HAZARDOUS MATERIALS

For help in chemical emergencies involving spill, leak, fire or exposure,

CALL TOLL FREE **1-800-424-9300** DAY OR NIGHT

**Straight Bill of Lading**
Original—Not Negotiable

Shipper's No.:
Carrier's No.

(Name of Carrier) SCAC Date

| TO: | | FROM: | |
|---|---|---|---|
| Consignee | | Shipper | |
| Street | | Street | |
| Destination | Zip | Origin | Zip |
| Route | | Vehicle # | |

| No. Shipping Units | HM | Kind of Packages, Description of Articles **(If Hazardous Materials, Proper Shipping Name)** | Hazard Class | ID No. | Weight | Rate | Labels Required (or exemption) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

| | | |
|---|---|---|
| Remit COD To:<br>Address<br>City State Zip | COD Amount<br>$ | COD Fee:<br>Prepaid<br>Collect |

| | | |
|---|---|---|
| Note—Where the rate is dependent on value, shippers are required to state specifically in writing the agreed or declared value of the property. The agreed or declared value of the property is hereby specifically stated by the shipper to be not exceeding $__________ per ________. | Subject to Section 7 of the conditions, if this shipment is to be delivered to the consignee without recourse on the consignor, the consignor shall sign the following statement: The carrier shall not make delivery of this shipment without payment of freight and all other lawful charges.<br>______________________<br>Signature of consignor | Freight Charges:<br>Prepaid<br>Collect |

Received, subject to the classifications and lawfully filed tariffs in effect on the date of issue of this Bill of Lading, the property described above in apparent good order, except as noted (contents and condition of contents of packages unknown), marked, consigned, and destined as indicated above wh ich said carrier (the word "carrier" being understood throughout this contract as meaning any person or corporation in possession of the property under the contract) agrees to carry to its usual place of delivery at said destination, if on its route, otherwise to deliver to another carrier on the route to said destination. It is mutually agreed as to each carrier of all or any of said property over all or any portion of said route to destination and as to each party at any time interested in all or any said property over all or any portion of said route to destination and as to each party at any time interested in all or any said property, that every service to be performed hereunder shall be subject to all the bill of lading terms and conditions in the governing classification on the date of shipment. Shipper hereby certifies that he is familiar with all the bill of lading terms and conditions in the governing classification and the said terms and conditions are hereby agreed to by the shipper and accepted for himself and his assigns.

| | | | |
|---|---|---|---|
| This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation. | **Placards Required**<br>**Placards Supplied** | **Yes** ____<br>**Yes** ____ | **No** ____<br>**No** ____ |

| | |
|---|---|
| SHIPPER<br>PER<br>DATE | CARRIER<br>PER<br>DATE |

**Emergency Response Telephone Number:**
(_____) ______________________________

Manned 24 hrs/day by a person with knowledge of the hazards of the material and emergency response information or who has access to a person with that knowledge.

.

**Example: Manifest Form**

The uniform hazardous waste manifest provides cradle-to-grave tracking of hazardous wastes. As required by EPA and DOT, all hazardous waste shipments must be accompanied by this form. The manifest consists of a number of copies which are given to the generator, transporter, and responders to conduct hazard assessment. Manifest information may be identified as part of the ERP.

The information on the waste manifest form includes:

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

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

An example of a hazardous waste manifest form shown below and also found here: https://www.epa.gov/sites/production/files/2018-05/documents/uniform_hazardous_waste_manifest.pdf

## Uniform Hazardous Waste Manifest Form

Please print or type.

Form Approved. OMB No. 2050-0039

GENERATOR

| UNIFORM HAZARDOUS WASTE MANIFEST | 1. Generator ID Number | 2. Page 1 of | 3. Emergency Response Phone | **4. Manifest Tracking Number** |
|---|---|---|---|---|

5. Generator's Name and Mailing Address

Generator's Site Address (if different than mailing address)

Generator's Phone:

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

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

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

Facility's Phone:

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

14. Special Handling Instructions and Additional Information

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

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

INT'L

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter signature (for exports only): Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials

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

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

DESIGNATED FACILITY

18. Discrepancy

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

Manifest Reference Number:

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

Facility's Phone:

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

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

| 1. | 2. | 3. | 4. |
|---|---|---|---|

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

Printed/Typed Name — Signature — Month Day Year

EPA Form 8700-22 (Rev. 12-17) Previous editions are obsolete.

DESIGNATED FACILITY TO EPA's e-MANIFEST SYSTEM

VOID

## Example: Waste Profile Sheet

The waste profile sheet is a document provided by the laboratory that conducted the analysis of the hazardous waste prior to removal of waste to a treatment, storage, and disposal facility. The profile sheet describes the physical and chemical properties of the waste. Information from waste profile sheets is important during a response involving hazardous wastes. An example is shown below and found here: https://www.epa.gov/sites/production/files/2015-04/documents/tsdf-wap-guide-final.pdf

Waste Profile #:____________________ EPA Facility ID #:____________________

**I. GENERATOR INFORMATION**

1. Generator Name:____________________
2. EPA ID #:____________________
3. Mailing Address:____________________
4. Plant Address:____________________
5. Business Contact:____________________Phone #:____________
6. Technical Contact:____________________Phone #:____________

*The following information is requested pursuant to 40 CFR 264/265.13 General Waste Analysis (RCRA).*

**II. GENERAL WASTE INFORMATION**

7. Waste Material Name:____________________
8. Generator Code (Optional):____________________
9. Describe process that generates waste:____________________
10. NAICS Code:____________________
11. Is your company the original generator of the waste? No ____ Yes ____ If not, provide the name of the original generator: ____________________
12. If this waste is a still bottom, are you the original generator of the feed stock? No ____ Yes ____
13. Rate of Generation:__________Current Accumulation: Drums:__________Bulk (gal.):__________
14. Check all types of containerization for which you request quotation:
    - ____ 55-gallon steel drum
    - ____ 30-gallon steel drum
    - ____ 85-gallon steel drum (w/o inside container)
    - ____ 85-gallon salvage drum (w/drums inside)
    - ____ 55-gallon fiber drums
    - ____ 5-gallon pail
    - ____ bulk (waste viscosity must be < 5000 cps)
    - ____ other:
    - _____ Palletized small containers

    Overall dimensions of material on pallet: ______X______X______ (l X w X h)
    Dimensions of pallet only: ______X______X______ (l X w X h)
    What are the small containers on the pallet?____________(1 qt. bottles, 8 oz. aerosol cans, etc.)

**III. WASTESTREAM CHEMICAL COMPOSITION****

15.

| Components Including 40 CFR 261 Appendix VII Hazardous Constituents | Concentration Range (units) | Average % (must total 100%) | TLV (if published) | |
|---|---|---|---|---|
| | | | ACGIH | OSHA |
| | to | | | |
| | to | | | |
| | to | | | |
| | to | | | |
| | to | | | |

* If applicable, this Waste Profile Sheet is a new revision of a previously submitted Waste Profile Sheet dated: _________. Attach to the Form any additional information which must be known to treat, store, or dispose of the waste in accordance with RCRA §§264/265.13, including but not limited to data developed under RCRA Part 261, Laboratory Analysis Technical Publications or Materials Safety Data Sheets.

**40 CFR 261 Appendix VIII constituents should be identified for combustion facilities, even if not present in high enough concentrations to significantly contribute to the 100% composition.

## IV. SPECIFIC ANALYSIS OF WASTE

16. Method used to obtain a **representative sample** of the analyzed waste (i.e., grab, composite, etc.). Sampling methods are described in RCRA 40 CFR 261 Appendix I: ________________________________

**Generator's Knowledge & SDS** – in completing the next two items, do not leave blanks. If the specific element is not present, indicate "None."

| Organic Bound | Concentration Range | Average |
|---|---|---|
| Sulfur | to | |
| Chlorine | to | |
| Fluorine | to | |
| Bromine | to | |
| Iodine | to | |
| Nitrogen | to | |
| Phosphorus | to | |

17.

| Metals (Actual Content) - Base % WT on | |
|---|---|
| Arsenic (ppm) | Mercury (ppm) |
| Barium (ppm) | Nickel (ppm) |
| Cadmium (ppm) | Selenium (ppm) |
| Chromium (ppm) | Silver (ppm) |
| Lead (ppm) | Thallium (ppm) |
| Aluminum (%) | Silicon (%) |
| Magnesium (%) | Sodium (%) |

18. Does this waste contain PCBs ≥ 50 ppm? No ____ Yes ____
If yes, give the concentration regardless of amount and attach supporting documentation:________________
19. Does this waste contain insecticides, pesticides, herbicides, or rodenticides? No ____ Yes ____
If yes, identify each and the concentrations (ppm):________________________________
(Include the SDS for each)
20. Does this waste contain dioxin? No ____ Yes ____
21. Does this waste contain free cyanide > 250 ppm? No ____ Yes ____
22. Does this waste contain free sulfide > 250 ppm? No ____ Yes ____

## V. TOXICITY

23.

| Check Applicable Data | Explain |
|---|---|
| Eye | |
| Inhalation | |
| Dermal | |
| Ingestion | |
| Other | |
| Carcinogen (suspected or known) | |

## VI. PHYSICAL PROPERTIES

24. Physical state/viscosity at 70° F: liquid___ semisolid___ solid___ slurry___ sludge___ gas___
Viscosity (cps): ________________________________
25. Is material pumpable? No ____ Yes ____ If varies, explain________________________
26. Is waste multilayered? No ____ Yes ____ If yes, please describe and quantify each layer below:
Top (%):________________________________
Next (%):________________________________
Next (%):________________________________

| | | | |
|---|---|---|---|
| 27. Dissolved Solids (%WT) | | 32. Vapor Pressure at 70ºF | |
| 28. Suspended Solids (%WT) | | 33. Specific Gravity | |
| 29. Btu Value/lbs | | 34. pH | |
| 30. Ash Content (% WT) | | 35. Corrosivity | |
| 31. Flashpoint (ºF) | | 36. Color | |

37. What is the Reactivity Group Number(s) for this waste?________________________________
(in accordance with *Design and Development of Hazardous Waste Reactivity Testing Protocol*, EPA-600/2-84-057,1984)

38. Is this material stable? No ____ Yes ____ If no, explain:____________________________________

39. Is this material shock sensitive? No ____ Yes ____ If yes, explain:____________________________________

## VII. EPA INFORMATION

40. Is this waste hazardous as defined by RCRA 40 CFR Part 261? No ____ Yes ____ If yes, list the applicable EPA Hazardous Waste Number(s) and explain why you have assigned the number(s). For example, if you assign D001, the reason for selection is that the flash point is less than 140° F. If you assign F002, the reason for selection may be that the waste is the still bottom from the recovery of methylene chloride.

| EPA Hazardous Waste Numbers | Reason for Selection |
|---|---|
| | |
| | |
| | |
| | |

41. If the answer to #40 is yes, list CERCLA reportable quantities found in 40 CFR Part 302.4: ________________________
________________________________________________________________________________

42. If the waste is not hazardous as defined by federal regulations but is hazardous as defined by state regulations in which the waste was generated, please provide the state hazardous waste number(s). Also, provide any state hazardous number(s) that are not included in the federal regulations:

| State Hazardous Waste Numbers | Reason for Selection |
|---|---|
| | |
| | |
| | |

## VIII. SAMPLING INFORMATION

43. Sample source (e.g., drum, lagoon, pond, tank, vat, etc.):__________________________________________
Date Sampled:_______________ Sampler's Name/Company:___________________________________________

44. Generator's Agent Supervising Sampling: __________________________________________________________
If no sample required, provide rationale:____________________________________________________________

## IX. LAND DISPOSAL RESTRICTIONS INFORMATION

45. Identify all characteristic and listed EPA hazardous waste numbers that apply (as defined by 40 CFR Part 261). For each waste number, identify the subcategory (as applicable, check none, or write in the description from 40 CFR 268.40).

| EPA Hazardous Waste Code(s) | Subcategory (enter subcategory or none if not applicable) | | Applicable Treatment Standards | | | Management Restrictions (Designate A-D per below) |
|---|---|---|---|---|---|---|
| | | | Performance Based (check as applicable) | | Specified Technology (enter 268.42 Table 1 codes) | |
| | Description | None | 268.41(a) | 268.43(a) | 268.42 | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

To list additional EPA waste numbers and categories, use additional page and check here: ____

If this waste includes any RCRA Codes D001 through D043, can this waste reasonably be expected to exceed the 40 CFR 268.48 Universal Treatment Standards (UTS) for any Underlying Hazardous Constituent(s)? No ____ Yes ____. If yes, include an attachment that identifies each constituent expected to exceed the UTS.

**Management under the land disposal restrictions:**

A. Restricted waste requires treatment? No ____ Yes ____

B1. Restricted waste treated to performance standards? No ____Yes____ Method:______________________

B2. Restricted wastes for which the treatment standard is expressed as a specified technology (and the waste has been treated by that technology)? No ____ Yes ____ Method:________________________________

B3. Good faith analytical certification for incinerated organics No ____ Yes ____
Method:______________________

C. Restricted waste subject to a variance? No ____ Yes ____
Date/Type:______________________________

D. Restricted waste can be and disposed without further treatment? No ____ Yes ____

## X. DOT INFORMATION

In accordance with the Department of Transportation 49 CFR Parts 171 through 177, complete the following:

46. DOT Proper Shipping Name:______________________________________________________________
47. DOT Hazard Class:____________________________________________________________________
48. DOT UN or NA Number:_________________________________________________________________
49. Container Label(s) - for containers of 110 gallons or less:___________________________________________
50. Placards:____________________________________________________________________________
(Generator's hazardous waste shipments must also comply with the labeling requirements of RCRA 40 CFR Part 262)
51. Is this waste a soil and/or debris? No____ Yes, Soil:____ Yes, Debris:____ Yes, Both:_____

| 52. Complete Only for Wastes Intended for Fuels or Incineration (Total) | 53. Reclamation, Fuels or Incineration Parameters (provide if information is available) |
|---|---|
| Antimony as Sb (ppm) | A. Heat value range (Btu/lb.): to |
| Beryllium as Be (ppm) | B. Water: |
| Potassium as K (ppm) | C. Viscosity (cps): @ °F 100° F 150° F |
| Sodium as Na (ppm) | D. Ash (%): |
| Bromine as Br (ppm) | E. Settleable Solids (%): |
| Chlorine as Cl (*ppm or %) | F. Vapor Pressure @ STP (mm/Hg): |
| Fluorine as F (*ppm or %) | G. Is this waste a pumpable liquid? ☐ No ☐ Yes |
| Sulfur as S (*ppm or %) | H. Can this waste be heated to improve flow? ☐ No ☐ Yes |
| *indicate ppm or % | I. Is this waste soluble in water? ☐ No ☐ Yes |
| | J. Particle Size: Will the solid portion of this waste pass through a 1/8-inch screen? ☐ No ☐ Yes |

54. Special Handling Information: ________________________________________________________
_____________________________________________________________________________________

## XI. ACCOUNTABILITY STATEMENT

55. I hereby certify that all information in this and all attached documents contains true and accurate descriptions of this waste. Any sample submitted is representative as defined in 40 CFR 262 Appendix I or by using an equivalent method. All relevant information regarding known or suspected hazards in the possession of the generator has been disclosed. I authorize (______________________________) to obtain a sample from any waste shipment for purposes of recertification.

______________________________________________ ______________________________
Authorized Signature Date

______________________________________________
Printed (or typed) Name and Title

**Safety Data Sheets (SDSs)**

SDSs are required by the OSHA Hazard Communication Standard (29 CFR 1910.1200). The SDS consists of 16 required sections as shown on the OSHA Quick Card: Hazard Communication Safety Data Sheets on the next page. Regardless of manufacturer, the order of the information must be as listed.

Workers must be trained in using SDSs to find information and to work safely with materials that are used on site or off site.

OSHA QUICK CARD™

## Hazard Communication Safety Data Sheets

The Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, or importers to provide Safety Data Sheets (SDSs) (formerly known as Material Safety Data Sheets or MSDSs) to communicate the hazards of hazardous chemical products. As of June 1, 2015, the HCS will require new SDSs to be in a uniform format, and include the section numbers, the headings, and associated information under the headings below:

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

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

**Limitations of Documents**

Although the shipping papers (bills of lading, manifest forms, waste profile sheets) and SDSs contain important information, they have limitations. Some of these are listed below.

- Limited information:
  - Information may be incomplete or inaccurate
  - Space on the form may be inadequate
  - Information may not be relevant for the site or specific use
  - Information may be too general for use
  - SDS may not be current
  - Insufficient time to read and understand the information, particularly in an emergency
  - Insufficient time to call manufacturer/supplier contact, particularly in an emergency
- May not be readily available:
  - Not accessible due to damage to vehicle
  - Not accessible if electronic systems are damaged or access to location blocked by the emergency
  - In some rural areas, cell or internet access may be limited

## Exercise – Finding Safety and Health Information, SDS

Or

## Exercise – Electronic Resources

You will use a resource to find information about a chemical selected by the Facilitator using either an SDS or Electronic resources. (See Exercise Manual)

## Summary – Material Identification

As an emergency responder, you may encounter a variety of hazards; using container shapes, labels and markings and written documents to identify hazards will help you avoid exposure to hazardous materials and protect your health and safety.

The Emergency Response Guidebook contains information on placards and road trailer and rail car containers and stationary storage containers.

Printed materials, including a uniform hazardous waste manifest, waste profile sheets and SDSs, provide valuable information for responders about chemical properties, health effects and hazard controls. Electronic resources are also important for responders.

# Monitoring

Detecting and measuring hazardous substances at a response is very important to protect safety and health and the environment. Potentially toxic compounds can be detected and measured using a variety of different monitoring instruments. Exposure levels have been set by government agencies as well as non-governmental organizations. These levels and limits are used to guide response objectives and select proper protective equipment to ensure a safe response.

## Chapter Objectives

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

- Identify hazards that can be detected or measured
- Identify resources to monitor air, water, soil, and surfaces, as appropriate
- Describe procedures required when conducting monitoring
- Demonstrate the ability to use one or more monitoring devices

## The Importance of Monitoring

Monitoring provides important information about the presence of hazardous substances at an emergency. Readings or samples of the atmosphere are taken regularly and in different locations. Although no single instrument can detect all hazards, proper use of air-sampling equipment can provide information needed to protect life and property. Using the wrong type of instrument may provide information that results in responders being exposed to an unsafe environment.

## Uses for Monitoring Data

Detect potential hazards to:

- Determine possible immediate effects of hazards, especially conditions which are Immediately Dangerous to Life and Health (IDLH) before and during response actions
- Identify changes in or sudden release of toxic materials that would require new emergency action during the response
- Determine that no hazardous exposures remain when the response has ended

Measure concentrations to:

- Determine the extent of hazardous conditions
- Assist in planning response actions
- Provide records of exposure for medical purposes
- Provide a historical record to submit to regulatory agencies

Responders with more advanced training will be involved in other monitoring activities, such as identifying specific compounds, if the substance(s) is unknown. This information will:

- Document chemical(s) present
- Assist in the selection of respiratory protection and ensure that it remains effective during the period in which work is performed
- Assist in the selection of chemical-protective clothing
- Help determine whether there is a need for medical monitoring

## Monitoring at an Emergency

**General considerations**
It is important to carefully monitor the atmosphere during a response to an unexpected release. Failure to recognize toxic, explosive, oxygen-deficient, or oxygen-enriched atmospheres could result in serious damage to life and property. The ERP provides a plan for monitoring as part of the emergency response.

Monitoring will be performed when there is a question as to whether responders may be exposed to hazardous substances; the results are used as one factor in selecting PPE. Air monitoring will usually be conducted as part of initial actions and throughout the response to ensure that the proper level of PPE is used by the responders. In addition, it is often necessary to document concentrations at the perimeter or in other locations near or adjacent to the response such as downwind, where contaminants may be transported. Specific SOPs developed in advance and included in the ERP are followed. Where monitoring will not be conducted, the reasons must be listed in response documentation.

Monitoring data will be used for specific purposes before and throughout the response and may include:

**Pre-Emergency**

Establishing background or usual levels may available from routine monitoring or might be determined in advance as a training exercise

**Emergency**
- Determining whether entry can be made
- Providing information for the response strategy
- Determining level of PPE protection
- Monitoring conditions, in case of change

**Post-Emergency**
- Establishing levels after containment/confinement
- Documenting perimeter levels
- Identify post-emergency response needs during termination
- Completing termination documents

Some general considerations during various phases of the response follow:

**Preplanning**

- Monitoring equipment appropriate for anticipated hazards should be available
- Members of the emergency response team who are expected to use the equipment must be trained in its use
- Emergency response team members should practice using the equipment during emergency response drills
- Equipment must be properly maintained and stored so it is ready for use during an emergency
- Spare parts should be available to trained personnel to repair the equipment in case it is damaged during response activities. Alternatively, back-up equipment should be available, and a repair service identified for contact as needed

**Before using an instrument to detect or measure**

- Review Exposure Assessment SOP and manufacturer recommendations
- Allow adequate warm-up time as appropriate
- Calibrate equipment as appropriate
- Cover with plastic to prevent contamination as appropriate

**During size-up (risk assessment)**

- Approach from upwind of the spill or release
- Begin monitoring at a distance where no contamination is expected
- Monitor for oxygen first, then flammable/explosive limits and toxic substances
- Continue to take readings as the spill or release is approached
- Take readings at ground level, a few feet from the ground, and higher in the air
- For confined space, take readings at the entry and throughout a confined space. Do not allow entry if there is inadequate oxygen or an explosive or toxic atmosphere
- Leave the area immediately if readings indicate that PPE is inadequate

**During response actions**

- Continuously monitor all areas near the source of the spill where response activities are occurring; conditions can change rapidly
- Retreat immediately if readings indicate that PPE is inadequate
- Decontaminate the equipment properly

**Post-emergency**

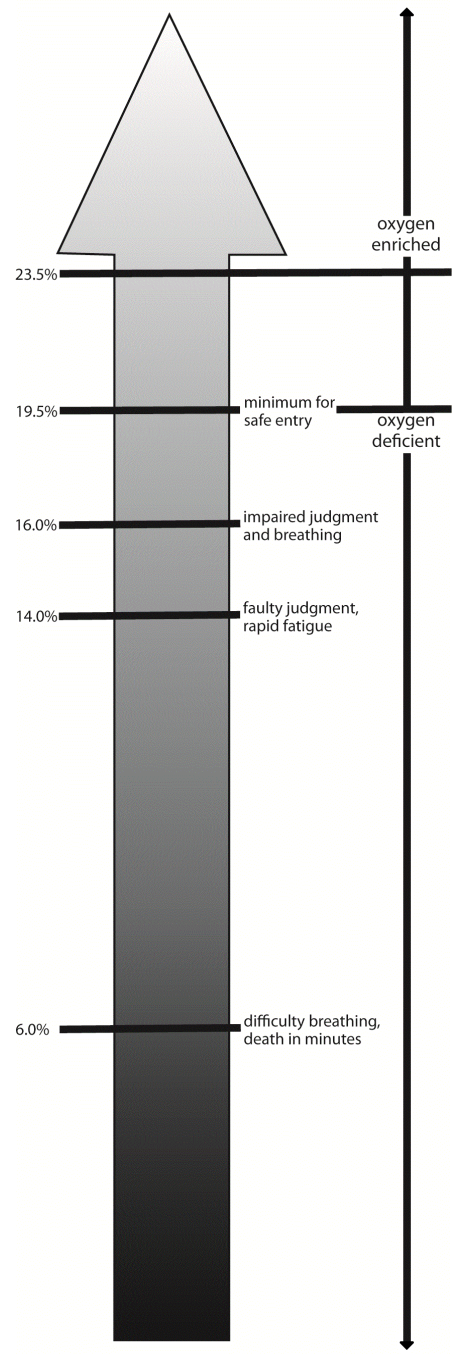
- Recharge power sources
- Replace any damaged or expended parts or send for repair
- Store monitors properly to be ready for any use
- Order any needed disposable sampling supplies or replacement parts

**Note:** Detailed information on air monitoring must be included in the ERP to ensure adequate training, appropriate use, and proper storage and maintenance of equipment.

## What Can Be Monitored in the Air?

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

1. Oxygen Deficiency/Enrichment
2. Fire and Explosion Hazards
3. Toxic Chemicals
4. Corrosivity
5. Radioactivity
6. Biological Hazards




**Oxygen-Deficient/-Enriched**

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

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

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

## Fire and Explosion Hazards

Determining whether there is a possibility of fire or explosion is critical. Flammable and explosive atmospheres develop when reactions occur with oxygen in the air, evaporation of flammables, gas leaks, and dust accumulation. Potentially flammable atmospheres must be monitored frequently in accordance with the Emergency Response Plan (ERP). Protective clothing and respirators which protect the worker from toxic hazards provide little, if any, protection against fire or explosions.

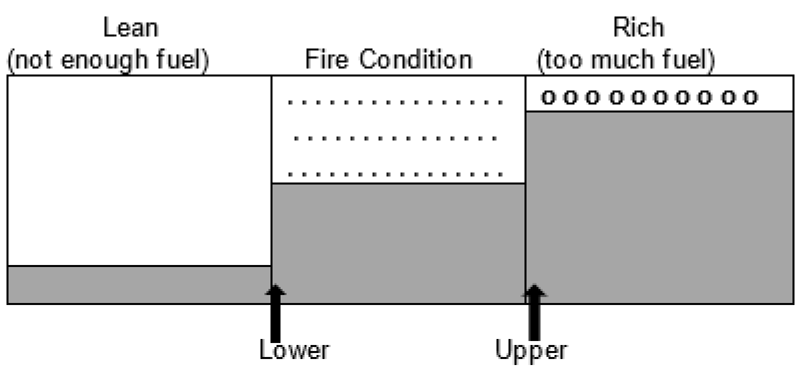
## Explosive Limits

Monitoring results reported as percent can provide information about substances in the air which may potentially cause an explosion. For flammable vapors and dusts, explosive limits have been determined. Two limits are defined below:

**Lower Explosive Limit (LEL)** is the minimum concentration of a flammable gas in the air that can result in ignition. Concentrations below the LEL will not ignite. Below the LEL, the mixture is called “lean.”

**Upper Explosive Limit (UEL)** is the maximum concentration of a flammable gas in the air which can result in ignition. Concentrations above the UEL will not ignite. Above the UEL, the mixture is called “rich.”

NOTE: UEL and LEL are determined in a controlled lab situation. Changes in oxygen concentration will potentially affect the values.




Explosive Limits

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

### Toxic Chemicals

Determining the specific hazard by monitoring the air is limited by the capabilities of the monitoring instrument(s) available.

For immediate results, direct reading instruments are used. These provide information about the presence (detect) and sometimes the concentration (measure) of the gas, vapor, or dust hazard. They are generally used near active work or near the breathing zone of workers; this is referred to as area monitoring. Conducting personal monitoring of gas, vapor, or dust exposure requires a worker to wear a sampling device; generally the sample is sent to a laboratory to determine the concentration of specific materials in the air.

### Corrosivity

Corrosives (acids or bases, having significantly low or high pH) can have adverse health effects, including damage to skin, eyes, and the respiratory system. In addition, they can damage monitoring equipment and PPE. Corrosive compounds in the air can be detected using pH paper. If strong acids or bases are present, the pH paper will change color.

There are chemical-specific monitors for some acids such as hydrochloric acid.

### Radiation from radioactive substances

If the presence of radioactive material is detected, adequate precautions must be implemented to prevent exposure. The presence of radiation usually requires special technicians (Radiation Safety Officers) to conduct monitoring. No single instrument can measure all forms of radiation accurately.

### Biological Hazards

Responders may also be exposed to biological hazards such as bacteria, viruses, certain parasites, mold, and animal/bird droppings. Specialized training and equipment are needed to detect and measure biological hazards and is not usually available at a response. The visual presence of these agents should be considered in the selection of PPE, as well as decontamination and disposal procedures.

As needed, it may be necessary to isolate an area where suspected biological hazards are present and call for specialists to investigate after the emergency to implement a safe, final cleanup.

## What Can Be Monitored in Soil, Water or on Surfaces?

Evaluation of contaminants in media other than air may be performed by assessing water, soil, and surface contamination. See manufacturer literature for a range of environmental sampling equipment. For specific protocols, search the EPA website, including https://www.epa.gov/quality/sampling-and-analysis-plan-guidance-and-template-v4-general-projects-042014.

Except for pH in water, soil, water, and surface contamination samples generally are analyzed in a laboratory.

**Soil Sampling**

Soil samples may be collected at a response site, or on neighboring property to determine if or how far the hazardous material has migrated or has been released into or onto the soil. Laboratory analysis of soil samples will indicate if there is contamination and the depth and area of the contamination. Contamination by solids, liquids and vapor may be evaluated.

**Water Sampling**

Sampling and laboratory analysis of effluent, groundwater, and water from wells, ponds, and streams may be performed to determine whether hazardous materials (examples: metals, biologic, organic compounds) are present or have migrated off-site.

**Wipe (Swipe) Testing for Surface Contamination**

Surface contamination is evaluated from a sample(s) collected by passing a filter or wipe across a surface according to a specified procedure and then submitting the sample to a laboratory for analysis. Swipes are often used to evaluate metals and radiation hazards. Contamination of PPE or human skin can also be evaluated by wipe testing. Wipe sampling is often used to determine the need for decon and to evaluate the effectiveness of decon procedures.

| **What to Monitor?** | | | |
|---|---|---|---|
| Air | Soil | Water | Surfaces |

## Conducting Monitoring Activities

### Overall Guidance

Worksite or municipal management is responsible for selecting equipment appropriate for routine sampling and anticipated emergencies. Manufacturers provide information about equipment uses and limitations. NIOSH (National Institute of Occupational Safety and Health) and the EPA (Environmental Protection Agency) also provide information about monitoring equipment.

Real-time monitoring with direct-reading instruments provides an immediate result and can be performed with a range of devices depending on the information required; the result provides information about the area where the reading was made. If the exposure of a worker is to be evaluated, personal monitoring is conducted; the sample may be sent to a laboratory and therefore may not be available immediately.

Some general considerations when selecting/using monitoring equipment follow:

- The unit should be intrinsically safe. (It will not produce sparks that could trigger an explosion.) Check the label and the manufacturer guide
- Most direct-reading instruments are designed to detect or measure only one contaminant or group of contaminants
- There are no instruments which can sample all toxic substances
- Equipment should be easy to transport and operate in the field under changing conditions and be decontaminated after use as needed
- Instruments should operate properly at temperatures which are anticipated during response activities
- Instrument should be easy to observe/operate while wearing PPE
- Instrument training should be provided through routine “hands-on” practice
- Many sampling instruments have rechargeable batteries that typically last longer than 8 hours when new and fully charged. Operation may reduce the battery life. Cold temperatures also reduce battery duration of use; never store fully charged equipment in a cold location prior to use.
- Some equipment can be operated with non-rechargeable batteries that can be an option when working in remote locations
- For rechargeable batteries, periodically discharge the battery fully and recharge to prevent ‘battery memory’
- Many instruments do not reach the highest readout instantaneously. For chemical sensors, the time to reach 90% of the actual concentration is referred to as T90 and is typically in the range of 15 seconds to 2 minutes. (See

manufacturer information)
- Catalytic bead LEL sensors require a minimum oxygen concentration of 10-12% to operate properly

**Sampling Plan or Protocol**

A sampling plan is designed to provide representative and accurate information on exposure.

A sampling plan includes:

- Areas where sampling is required:
    - By regulation
    - By Emergency Response Plan
- Equipment needed
- Frequency, duration, and procedures
- Sampling methods
- Analytical method (if needed)
- Benchmarks for comparison of result with accepted values
- Name (and signature)/date of plan developer and any amendments

Documentation for sampling generally includes:

- Pre- and post-calibration (if specified in protocol; initials of person doing it)
- Name/number of sampling/analytical method (if used)
- Person conducting the monitoring
- Person monitored (if personal monitoring)
- Equipment ID number
- Drawings showing location of sample collection
- Notes regarding activities conducted during sampling
- Notes regarding work practices and other exposure controls
- Use of any PPE
- Any observed problems with the equipment
- Any deviation from the sampling protocol
- Chain of Custody, as appropriate
- Result (recorded by sampling personnel or laboratory report)
- Record of transmitting result to person sampled (if personal monitoring)

A Calibration and Maintenance Logbook will include the following for each device:

- Description of required calibration and maintenance
- Date of each calibration/maintenance
- Results (often as a letter from an external source)
- Location of Manufacturer Literature for review, as needed

Note: electronic calibrators must be calibrated according to manufacturer recommendations.

Sampling personnel must be trained in the collection method(s) and use of all needed equipment and how to recognize problems during sample collection.

## Before you sample…

For any sample collection, first make sure you have been trained in the methods and the use of the equipment. It is also important to be trained to recognize problems during sample collection and who to alert if you need assistance.

Below are several considerations for use of instruments during exposure monitoring:

**Direct-reading instruments**

1. Calibrate
Check with the safety officer to be sure that it has been properly calibrated. Calibration involves exposing the instrument to a known concentration of a compound and documenting or adjusting for the proper response value. It is important that all instruments be calibrated on a regular basis. Some direct-reading instruments are compatible with a docking station interface (consult manufacturer's data for more information).

2. Be conservative
If the instrument gives an unexpectedly high response, assume that it is correct. If the reading is suspiciously low, assume that there may be an instrument problem.

3. A zero reading does not mean clean air
Always remember that a reading of zero does not mean that the air is free of hazards. Some highly toxic materials are not detected by common direct-reading instruments. A

reading of “zero” may mean contaminants are present but at levels below the detection capability of the instrument.

4. Read even a small response as positive
Any response, even a small one, on a direct-reading instrument should be interpreted as indicating a potentially dangerous situation. It is far safer to assume that if the instrument can detect a chemical, the concentration may be high enough to pose a health threat.

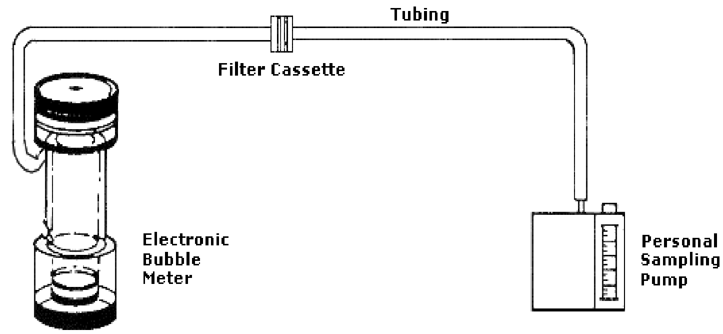
5. Use multiple instrument types
Whenever possible, use more than one type of direct-reading instrument. Remember that each type of instrument has different capabilities, so a reading of zero on one instrument could turn out to be a high reading on another instrument.

6. Follow maintenance guidelines
All equipment is supplied with a recommended maintenance schedule. Follow it. Should any indication of malfunction be noted during routine checks or usage, report it to the safety officer or other designated person.

**Personal Monitoring**

Personal monitoring is not usually done during the response but may be conducted during cleanup or remediation. An overview is provided below; if this is assigned to you or coworkers, additional training is required. Follow the sampling and analysis protocol included in and Exposure Assessment SOP. As needed discuss collection with the lab personnel before initiating monitoring.

1. Calibrate (pumps and alarms)
Check with the safety officer to be sure that it has been properly calibrated. If a personal pump is to be used, this will ensure that the initial rate of air flow through the sampling media matches the method being used. Calibration will also be conducted after sample collection to determine the total volume (duration x flow rate). If the flow rate has changed by more than 5%, resampling may be required. Consult the method cited in the sampling plan. If a personal alarm is to be used, this will ensure that the monitor responds according to manufacturer specifications.




Calibration set up for personal sampling pump, with filter cassette in-line

2. Sampling lines
If you will use tubing to connect a pump and a collection filter/tube, ensure that you have different lengths of tubing (for different heights of workers) and methods to keep the tubing close to the wearer's clothing (tape or pins). Sampling lines can separate from the pump and may result in loss of a sample. Loose or floppy tubing can be a safety hazard to the wearer.

3. Know the demands of work, and the schedule
Wearing a sampling device is an imposition. If you know the work demands, you can better ensure that it will not interfere with usual activities. For example, forklift operators will not want a pump positioned in the small of the back. Women often need a belt to hold a pump—so be ready to provide a belt, as needed. Folks who want to leave the workplace at lunch will not wait for you to come when it is time to leave. You may jeopardize sample collection if it is removed and placed on a contaminated surface.

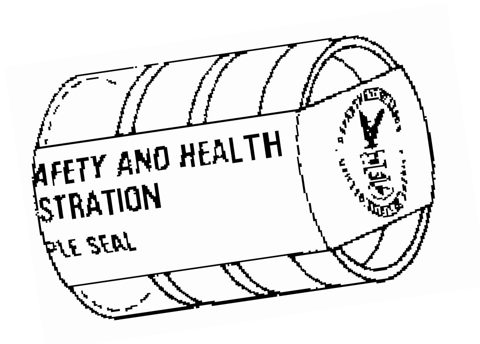
4. Tell each person what to expect
Go over the reason for sampling, how the equipment works and what will happen after the collection. Ask if the equipment is comfortable (or as much as possible) and if there are any questions.

5. Let persons being sampled know where you will be
Let each person know how to reach you if there is a question or a problem. Most pump protocols require at least hourly observation, so sampling personnel must stay near the response, being careful to not interfere with activities.

6. Follow maintenance guidelines
All equipment is supplied with a recommended maintenance schedule. Follow it. Should any indication of malfunction be noted during routine checks or usage report it to the safety officer or other designated personnel.

7. Chain of Custody supplies

A Chain of Custody form showing each person who has had control of the sample is required for any sample to be shipped, to detect any tampering when outside your control. Wrap seals around entry/exit plugs or caps to secure the sample.




Air sampling cassette for particles ready for shipment

## After You Sample...

After sampling actions are also part of the plan. These activities are specific to the type of sampling conducted and may include:

1. Is there reason to decontaminate the equipment before leaving the field?
   Follow protocol, as appropriate
   Dispose of contaminated materials appropriately

2. Post calibrate, if included in the protocol
   Record results and determine if the sample is valid as described in the protocol

3. Complete paperwork
   Record results, chain of custody etc.
   Log any problems with the instrument and notify appropriate personnel
   Report results as required

4. Prepare samples for shipment, as needed
   Follow instructions from the receiving laboratory

5. Ensure proper disposal of waste
   For example, the glass shards from colorimetric tubes and the tubes must be disposed of in a manner to ensure no one is cut when handling waste

6. Follow post-use, back-to-service protocol
   Store equipment, recharge, restock depleted supplies, etc.

## Sampling Instruments and Tools

Uses of some types of instruments and tools for taking samples of air, soil, water, and surface contamination are described in this section, specifically:
Frequently used

- pH paper
- Oxygen/Combustible Gas/Combination Instruments
- Colorimetric tubes
- Personal Alarms
- Hydrocarbon Detectors
- Flame Ionization Detectors

**More specialized Instruments**

- Infrared Spectroscopy
- Ion Mobility Spectrometry
- Surface Acoustic Wave
- Raman Spectroscopy
- Gas Chromatography
- Metal Oxide Sensors

**Specific hazard monitoring**

- Radiation Exposure Monitoring
- Noise Monitoring
- Personal Monitoring for Organic Vapors and Particles
- Area Monitoring for Particles/Fibers/Dust

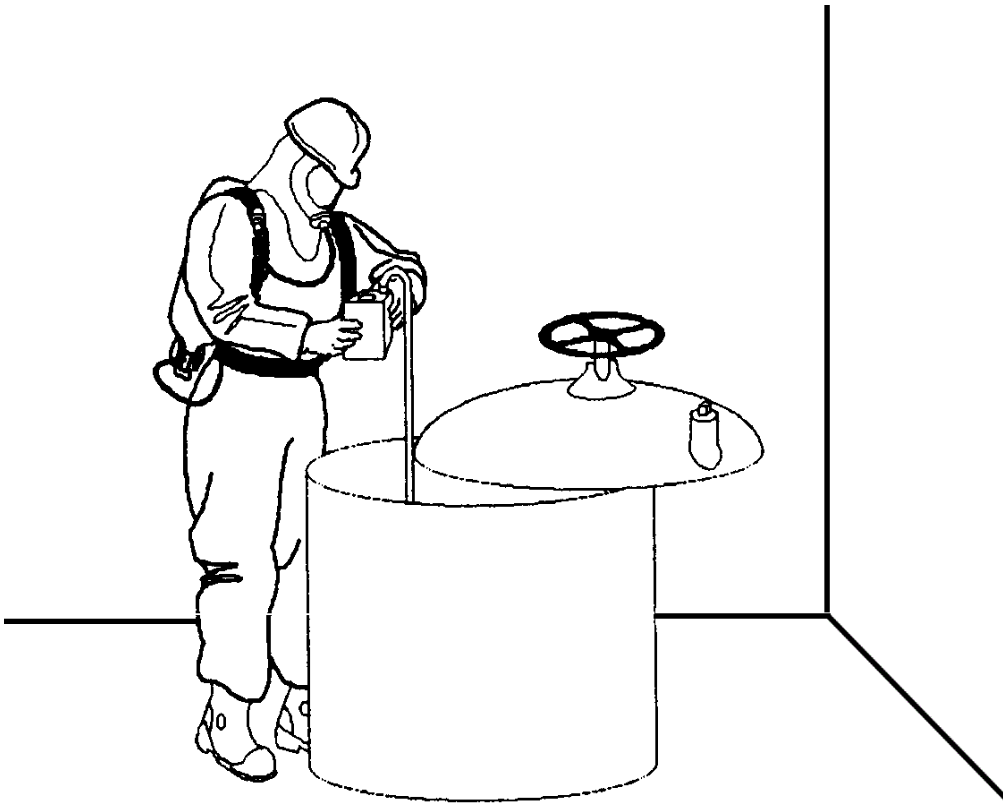
**Water, soil, or surface sampling**

- Water Sampling
- Soil Sampling
- Surface Contamination Sampling

Use, readout, and notes are shown. These overviews do not replace manufacturer instructions.

| ALWAYS: read and follow the manufacturer instructions carefully |
|---|

It is not expected that you will use all of these instruments or tools. The facilitator will tailor the discussion to include those that are appropriate for the expected releases, based on the list you contributed to on Day 1 of the program. The remaining information may be a useful resource in the future.



## Exercise - Monitoring

The facilitator will review several of the instruments described below that may be used during an emergency response. You will demonstrate use of one or more instruments in an Exercise (see Exercise Manual) and complete one Performance Checklist.

**pH paper**

When exposed to a chemical, pH paper changes color.
**Use**: Measure presence of corrosive substance
**Read-out:** Observed color matched to chart
**Notes:**

- When pH paper changes color in the presence of corrosive vapors, the color change is easy to interpret. The color change may be harder to interpret when testing liquids.
- Hydrocarbons, which are neutral, may appear to change the color of the paper. In this case, the border between the wet and dry sides of the paper will be straight. If the border is jagged, multicolored, and the liquid seems to be wicking through the pH paper, the liquid is actually corrosive.
- The result may be difficult to interpret depending on the chemicals that are present; for example, in the presence of hydrocarbons, use of pH paper may provide an inaccurate result.
- When using the wetted pH paper for corrosive vapor detection, a neutral reading should not give you a sense of security. Other hazards may be present.
- pH paper can be attached to a stick or an extension tool when approaching an unknown environment, such as during hazard assessment.
- Utilize two pieces of pH paper (one wetted and one dry). The wetted paper reacts more quickly than the dry paper especially for low levels of a chemical in the air. The wetted pH paper is used for detecting corrosive vapor and dry is used to dip into liquids.

Tip: pH meters are subject to interferences, so pH paper is preferred

NOTE: The presence of strong oxidizers may change the colors and give false results.

**Oxygen and Combustible Gas Meters, and Combination Meters**

**Oxygen Meter**


**Use:** To sample oxygen concentration, particularly near and in confined spaces

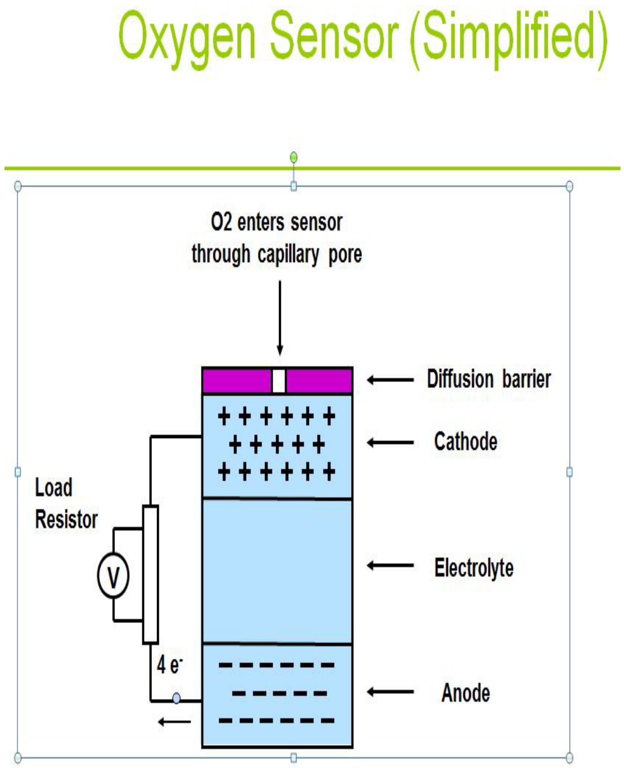
**Read-out:**

- Usually 0% - 25% oxygen concentration.
- At greater than 23.5% oxygen, the explosion hazard increases.
- The normal oxygen concentration is 20.9% - any deviation from this is abnormal and should be investigated as to why there is a change. (Theoretically, a 0.1% decrease in oxygen due to displacement of the air by another chemical is indicative of a concentration of approximately 5,000 ppm of other chemicals – replacing 1/5 of $O_2$ and 4/5 of $N_2$).
- At less than 19.5%, do not enter without an SCBA or SAR.

Notes:

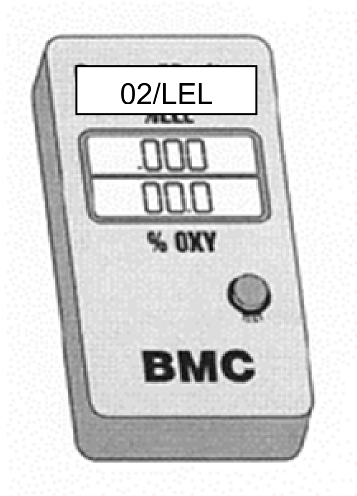
O2 sensors

- Need about 2-3 minutes to warm up
- Continuously react with the air
- Contain electrolyte solution
- Typical operating range: -5° to 120°F
- High carbon dioxide levels may affect reading.
- Typically the meter calibrates for oxygen during each startup.
- Requires maintenance. (Life of sensor is approximately 2 years under normal use.)
- Acid vapors shorten the life of the electrochemical sensor
- Condensation and/or absorption may occur in long probes
- User must be trained
- Affected by temperature and pressure




| |
|---|
| At -5°F to 32°F sensor reaction time slows and eventually will freeze at extreme temperatures |

**Combustible-Gas Indicator (CGI)/ LEL Meter/Explosion Meter**




**Use:**

- To measure flammable vapor concentration in percent, particularly near and in confined spaces
- General purpose for most combustible hydrocarbons
- Responds to all combustibles present

**Read-out:**

- % LEL (sometimes referred to as Lower Flammability Limit, or LFL).
- A reading above 10% should be considered a potentially explosive atmosphere. (Know what to do when a potentially dangerous reading is noted - for example: leave the area, notify safety officer or incident commander). For added safety, many teams use lower values such as any positive reading, or 5%. The primary reason for this is for a flammable chemical that is also toxic. A low meter reading, or no reading at all, could still be a dangerous environment.
- Accurate over most of its range

**Notes:**

- Requires periodic calibrations. Normal practice is at least every 30 days.
- Relatively unaffected by temperature and humidity
- Does not respond the same to all vapors

- Oxygen must be measured first. Many combustible-gas instruments require sufficient oxygen (consult manufacturer's manual) to determine LEL.
- User must be trained.
- Calibration should be checked or done before each use, as per the manufacturer's requirements. Recommendations vary by manufacturer, but before each use is best practice. It is a good idea to check calibration after using an instrument to verify good data and confirm the sensor was not compromised or injured.
- Should be bump tested to ensure that all sensors are operating before each use
- Nonspecific. Reflects total combustibles present. The specific flammable(s) is not identified. The %LEL is read as if the flammables were the calibration gas. (If a single flammable is present, the manufacturer may provide correction factors.)
- Not recommended for chlorinated hydrocarbons or tetraethyl lead-containing compounds
- Avoid exposing sensors to the following: lead compounds, compounds with sulfur, silicones, phosphates and phosphorous and inhibitors such as hydrogen sulfide and halogenated hydrocarbons.

**Example:**

LEL of methane is 5% by volume
100% LEL = 5% VOL = 50,000 PPM (ignite)
10% LEL = 5,000 PPM Alarm
1% LEL = 500 ppm (LEL 1)
449 PPM ⇒ meter displays 0

**Example:**

Calibrated with methane, used in an atmosphere known to only contain pentane
reading of 5%
Pentane correction factor is 2.0
→Actual value is 10% of the pentane LEL

| | |
|---|---|
| Tip: | The common LEL meter is calibrated to read 100% at the LEL of the calibration gas. A small % reading on the meter, while indicating a low risk of fire/explosion at the meter may indicate a potentially toxic concentration. For methane a reading of 5% on the meter indicates a methane concentration of 0.25% or 2,500 ppm. |
| Important background: | LEL sensor technology is typically either catalytic bead on a wire or infrared (IR). The flammable is burned at the bead, increasing the resistance in the wire; the resistance is adjusted for air temperature using a Wheatstone bridge and converted to a reading of LEL. Therefore, oxygen is needed for the meter to function; typically 10-12% is the minimum required (see manufacturer specs). The IR sensor does not require oxygen for operation. |

**Problem:**

At a paint factory, several drums have been punctured by a forklift. Evaluation of the air 30 feet from a leaking drum of toluene of toluene results in an LEL reading of 8%. The calibration gas was methane. Using the toluene correction factor of 1.3, answer the following:

What is the LEL % for toluene?

What is the ppm?

What type of respiratory protection should be used?

## Combination Instruments

The meter shown above for combustible gases is also used to measure oxygen. This is a common combination. Combination real-time monitors for oxygen and flammability (LEL, explosivity, combustibility) are approved for use in flammable environments where the oxygen does not exceed 20.9%, unless tested and approved for use in high-oxygen environments. An alternative is to have sample tubing (probe) to draw the air into the meter that is positioned at a location with acceptable oxygen concentration. The length of the sample tubing will vary for each meter, but typically ranges from 30 to 100 feet. Common problems with drawing samples through tubing include condensation of vapors, and absorption onto or adsorption into the tubing.

Three or more hazards can be measured with other combination meters. These multi-gas instruments, which may be called 3-gas or 4-gas meters or something similar, are used to measure oxygen and combustibles and other gases such as carbon monoxide and/or hydrogen sulfide. They are often used to test the atmosphere before entry into a confined space.

**Notes:**

- The chemical sensors respond to a specific chemical or class of chemicals. Interferences are usually limited (refer to manufacturer literature).
- In addition to temperature, a limitation of these electrochemical sensors is that use in high concentration atmospheres may use up all the reactivity of a cell in a single measurement, rendering the cell useless until there has been time (hours) for the cell to re-stabilize.

Example:

> While sizing up a fire scene for CO exposure, putting the CO monitor near the exhaust of a support vehicle may ‘blow it away’ and require replacement or recalibration of the sensor.

**Colorimetric Detector Tubes (also known as length-of-stain tubes)**

A colorimetric detector tube is a glass tube filled with a solid material or gel that has been impregnated with a chemical. When the tube is used, the ends are broken off and the tube is inserted into a bellows or piston pump. An arrow on the tube indicates which end of the tube to insert into the pump orifice. A predetermined volume of air is pulled through the tube, measured by pump strokes. The contaminant of interest reacts with the chemical in the tube. This reaction produces a stain in the tube with a length proportional to the concentration of the contaminant.  The concentration scale is read based on manufacturer guidance, including the, length of change and color intensity.

**Use:**

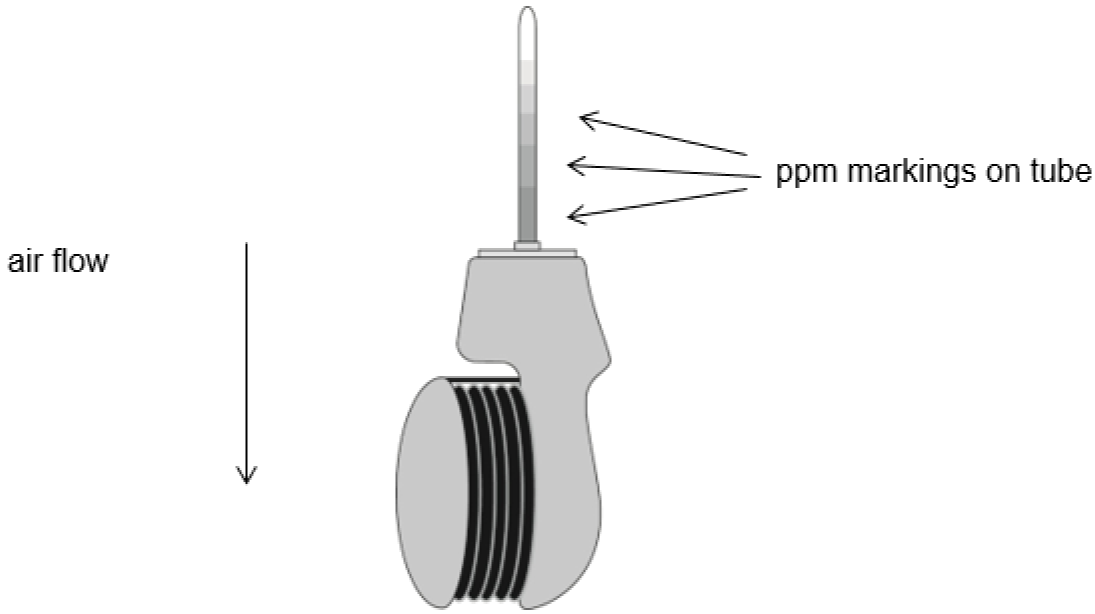
- Measure gas or vapor concentration
- Identify chemical family of contaminant using manufacturer decision charts and tables.

**Read-out:**

- Concentration in ppm, mg/m3 or percent is indicated by color change or length of color stain.

**Notes:**

- Not very accurate—within 25% of the real value at best
- Pump must be checked for leaks and volume calibrated.
- Tubes have a limited lifetime, so the expiration date on the container should be checked before use.
- User must be trained in reading the scales on the tubes.
- User must follow specific pump-stroke requirements and all other directions.
- Interferences are possible; not very specific.
- May be misread if the sample-taker is color blind
- Specific temperature and humidity ranges shown in directions
- Tube heaters are available from some manufacturers
- Tubes may be marked with number of required pump strokes




Tip: The Dräger Chip Measurement System (CMS)® includes a chip for the chemical of interest. The measurement is complete and digital result read on the screen is 30 seconds to 5 minutes, depending on concentration and chip type. Note that there are not as many chemicals available in the CMS as there are when using single colorimetric tubes.

## Personal Alarms

Monitors worn on the belt or in a pocket are used to detect a specific level of a contaminant and sound an alarm to exit the area.  Worker in areas where there may be an oxygen deficiency or exposure to carbon monoxide or hydrogen sulfide are among those who may use personal alarms.


Oxygen meter with two alarms, audible and
visible, shown here

A vibration alarm is available on some meters

**Use:**

- To detect gas or vapor compared with a pre-set concentration in any workspace
- Alert workers to levels of contaminants to which they should not be exposed

**Read-out:**

Audible alarm and sometimes visible alarm and/or display of concentration (examples: ppm or %)

**Notes:**

- Inaccurate readings may be given if there are interferences
- Battery-operated
- Wearers must be trained in actions to take if the alarm sounds

## Hydrocarbon Detectors

The total amount of all detectable flammable organic compounds can be measured using a device with either a Flame Ionization Detector (FID) or a Photoionization Detector (PID). These devices are used to measure exposure to solvents, fuels, and volatile organic compounds (VOCs) in the work area; results are compared with exposure guidelines.

## Photoionization Detectors (PID)

In PID instruments, ultraviolet radiation is used to ionize (break apart) gas and vapor molecules. The current produced is proportional to the number of ions and is a measure of concentration.

The energy needed to ionize a compound is its characteristic "ionization potential" (IP), expressed in electron volts (eV). Ionization potentials for selected materials are shown below.

| Chemical | IP(eV) | Chemical | IP(eV) |
|---|---|---|---|
| Hydrogen cyanide | 13.9 | Hydrogen sulfide | 10.5 |
| Methane | 13.0 | Hexane | 10.2 |
| Chlorine | 11.5 | Acetone | 9.7 |
| Benzene | 9.2 | Phenol | 8.5 |

**Use:**

- To sample toxic and some flammable vapor concentrations, particularly near and in confined spaces
- Detects organic and some inorganic gases such as Ammonia, Arsine, Phosphine, Hydrogen Sulfide, Bromine, and Iodine (0.1 – 10,000ppm) (most 1-2000 ppm.)
- Alerts user to areas of exposure or contamination
- Identify sources of emission

**Readout:**

- Concentration in ppm

**Notes:**

- Ability to detect wide variety of chemicals in small amounts

- Quick response
- Can operate in low-oxygen environment
- Detects only those compounds with ionization potentials less than the energy of the lamp.
- Response affected by composition of mixed gases.
- Only quantifiable if measuring a known substance
- Lamps affected by high humidity, high levels of methane and dust
- Does not detect methane, CO, $CO_2$, or $SO_2$
- Cannot separate mixtures
- Other voltage sources may interfere.
- Requires calibration (usually with isobutylene).
- User must be trained.
- Must know lamp voltage and correction factor (CF).
- Requires regular maintenance

## Correction Factors (10.6 eV Lamp)

| | RAE | BW | Ion | | IP (eV) |
|---|---|---|---|---|---|
| *Acetaldehyde* | 5.5 | 4.6 | 4.9 | | 10.21 |
| *Acetone* | 1.1 | 0.9 | 0.7 | | 9.69 |
| *Ammonia* | 9.7 | 10.6 | 8.5 | | 10.2 |
| *Benzene* | 0.5 | 0.55 | 0.5 | | 9.25 |
| *Butadiene* | 1 | 0.9 | 0.85 | | 9.07 |
| *Diesel fuel* | 0.8 | 0.93 | 0.75 | | n/a |
| *Ethanol* | 12 | 13.2 | 8.7 | | 10.48 |
| *Ethylene* | 10 | 11 | 8 | | 10.52 |
| *Gasoline* | 0.9 | 0.73 | 1.1 | | n/a |
| *n-Hexane* | 4.3 | 4 | 3.3 | | 10.18 |
| *Jet fuel (J.P.8)* | 0.6 | 0.51 | 0.7 | | n/a |
| *Kerosine* | n/a | 1.11 | 0.8 | | n/a |
| *Methylethylketone* | 0.9 | 0.78 | 0.77 | | 9.53 |
| *Naptha (iso-octane)* | 1.2 | 1.2 | 1.1 | | 9.82 |
| *Styrene* | 0.4 | 0.45 | 0.45 | | 8.47 |
| *Toluene* | 0.5 | 0.53 | 0.51 | | 8.82 |
| *Turpentine* | 0.4 | 0.45 | 0.45 | | n/a |
| *Vinyl chloride* | 2 | 2.19 | 2.2 | | 10.0 |
| *Xylene* | 0.4 | 0.5 | 0.43 | | 8.5 |

PIDs are often calibrated with isobutylene, which has a correction factor of 1.0. If you know that a single gas is present in the atmosphere, you multiply the correction factor for that gas by the instrument reading to obtain the true concentration of the chemical.

Example:

An RAE instrument is being used to measure toluene, with a CF of 0.5.
The instrument calibrated with isobutylene reads 100 ppm.
The actual concentration is:

$$C = 0.5_{CF} \times 100\ \text{ppm}_{(iso\text{-}calib)} = 50\ \text{ppm of toluene}$$

**Flame Ionization Detectors (FID)**

In FID instruments, the gases and vapors are ionized (molecules broken apart) in a flame. The current produced is proportional to the number of carbon atoms. The current is converted to a measure of concentration.

**Use:**

- To detect many organic gases and vapors
- Can see chemicals with higher IP than PID (more accurate) (1.0-100,000ppm)
- Only organics

**Readout:**

- ppm

**Notes:**

- Requires gas chromatography option to identify and measure specific compounds
- Does not detect inorganics
- Affected by low temperatures, high contaminant concentrations, and oxygen-deficient atmospheres
- Must be calibrated
- User must be trained
- Requires maintenance and leak checks
- Must be intrinsically safe if used where explosive atmospheres may exist. Some models are not intrinsically safe.
- Flame may extinguish in high wind
- Only carries limited amount of hydrogen
- Needs $O_2$ to operate


PID/FID combination

**More-specialized monitoring instruments**
In addition to the widely used instruments described above, more sophisticated instruments increasingly are being employed in emergency response. The following instruments have specialized capabilities or lower measurement ranges, generally a higher cost.

**Infrared Spectroscopy**

Infrared (IR) Spectroscopy may be used to detect and measure chemicals in air, liquids, and solids. It functions by comparing the infrared absorption spectra of contaminants to the known spectra of pure chemicals. It can be used for contaminants such as volatile and semi-volatile organics, ammonia, carbon disulfide, carbon monoxide, hydrogen sulfide, acids, nitrogen oxides, and many others. It does not respond to noble gases, vapor-phase metals, and chemicals that are made up of two atoms of the same element, such as oxygen ($O_2$), nitrogen ($N_2$) and chlorine ($Cl_2$). Water vapor and carbon dioxide are frequent interferences. During a response, IR spectroscopy may be deployed in several different configurations.

**Active Open-path Fourier transform IR**

Active open-path Fourier transform IR (Active open-path FTIR or active OP-FTIR) may be deployed for fence line or perimeter monitoring or worker exposure monitoring. The technique relies on instruments placed in two different fixed locations in sight of one another. In this configuration, it can measure an average concentration of contaminants across the straight-line path between the two instruments. Measurements down to the low parts-per-billion can be achieved.

**Passive Open-path Fourier transform IR**

Passive open-path Fourier transform IR (Passive open-path FTIR or passive OP-FTIR) is operated as a portable "point and shoot" instrument that can be used to detect, but not measure, chemical releases. It also cannot tell the difference between different chemicals. The technique relies on an infrared source in the environment, such as the sun, instead of generating its own infrared source, as active OP-FTIR instruments do. Its detection limits are higher than for active OP-FTIR, in the range of hundreds of ppm, but its range is longer, up to a mile or more.

**Handheld Fourier transform IR for solid and liquid identification**

Handheld Fourier transform IR (FTIR) units are available for identification of unknown solids and liquids. They can work from a library of over 10,000 chemicals to identify substances including chemical warfare agents, explosives, toxic industrial chemicals, narcotics, suspicious powders, and other dangerous chemicals.  Analysis is performed by placing a small amount of unknown substance onto the interface.

**Ion Mobility Spectrometry Instruments**


Portable ion mobility spectrometry (IMS) instruments can be used to identify airborne chemicals. The instruments utilize built-in pumps to draw air through the instrument. Substances that can be identified include chemical warfare agents, toxic industrial chemicals, narcotics, and explosives. These instruments utilize an ionization source, which may or may not be radioactive, to put a positive or negative charge on a chemical. The ion mobility spectrum of the chemical is compared to the spectra of known chemicals to identify the unknown. Substances that will interfere with the reading include menthol, oil of wintergreen, perfumes, food flavorings and engine exhaust. It is sensitive down to parts per billion of a chemical but may not detect at levels below the IDLH for chemical warfare agents.

**Surface Acoustic Wave**

The NRL SAW sensor.

Surface acoustic wave (SAW) instruments utilize vibrating piezoelectric crystals to detect and identify airborne chemicals. Chemicals adsorbed onto the crystal surface change the frequency of the vibration. The change is compared to the change for known substances to identify the unknown chemical. These instruments may be calibrated to detect chemical warfare agents. Like IMS instruments, SAW instruments cannot usually detect chemical warfare agents below IDLH levels, but they are less susceptible to interference from other chemicals.

**Raman Spectroscopy**

Raman spectroscopy utilizes laser light scattering to detect and measure chemicals. It can be used in an open-path mode, similar to open-path FTIR, but unlike IR methods, water and carbon dioxide do not interfere with the readings. Portable systems generally have a range of less than 50 yards, but large, fixed systems can cover up to 6 miles at night. A wide range of airborne, solid, or liquid chemicals can be measured, with detection limits from the low ppm to percent levels, although better detection limits can be achieved.

**Gas Chromatography**

Gas chromatography (GC) uses a stationary phase and a mobile phase to separate contaminants based on how strongly they are attracted to the stationary phase. It can be employed for hazard characterization, source testing and monitoring, employee exposure monitoring, fence line or perimeter monitoring and emergency response. A large number of different detectors can be used with this technique. Depending on the detector, different volatile and semi-volatile organic chemicals can be detected and measured, sometimes at levels as low as parts per billion. When a mass spectrometer is used as the detector, the technique is called GC-mass spec, or GC-MS.

**Metal Oxide Sensors**

While not new, these semiconductor sensors are used in special applications (generally when the contaminant is known). The sensor will react to a variety of chemicals and is therefore non-specific. Calibration is done for a specific chemical, but it will detect other contaminants if present.

### Specific Hazard Monitoring

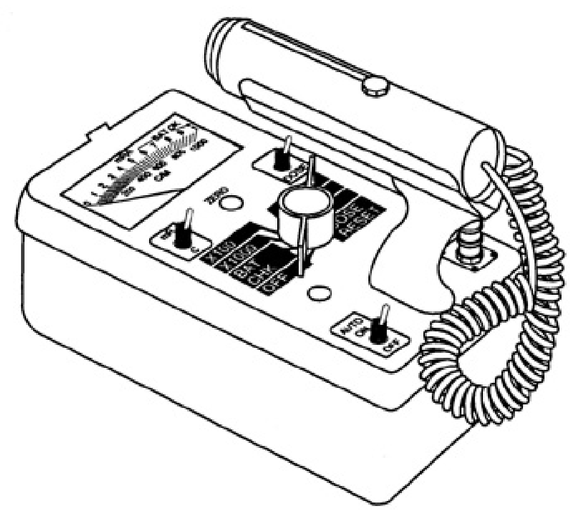
### Radiation Exposure Monitoring

No single instrument can measure all forms of radiation. Where radiation sources are present, a specific monitoring program will be included in the ERP detailing the type of hazard, how monitoring devices were selected, and exposure control methods. Area monitors (for example, the Geiger counter and the Cutie Pie survey meter) are available. Personal monitors include the film badge and thermoluminescence detectors. Pancake monitors such as Geiger counters which use a thin-window pancake-shaped detector are best for monitoring particle emissions.

- used for measuring alpha and beta
- sensitive for gamma rays, but not generally preferred for determining exposure rates because of the irregularity of the thickness and density of the walls and the energy response curve.

The Geiger-Mueller is sometimes equipped with the external probe for alpha and beta radiation and an internal probe for gamma radiation.

When the amount of radiation is higher, the surveyor switches to the internal probe that will pick up background radiation which should be minimal.



Pancake detectors are used when surveying for contamination. The detector is housed in an aluminum casing; the thin mica window of the detector is protected by a stainless-steel screen.

Another type of instrument often referred to as a “hot dog” detector is useful for measuring background levels of gamma radiation.  The detector is used for surveying direct radiation. The detector has a rotary shield which is used to differentiate between beta and gamma radiation. When the shield is closed, only gamma can be detected.

Victoreen CD V-700 overview

A description and illustration of a Geiger-Mueller detector follows.

**Geiger-Mueller Tube**
**Use:**

- The tube is filled with gas. When radiation enters the tube, it reacts with the gas, causing the release of energy.
- Used to scan surfaces rapidly
- Detects beta, gamma, and X-rays; can detect alpha only with the cap removed

**Readout:**
- Clicks per minute. The amount of energy released is related to the number of counts per minute.

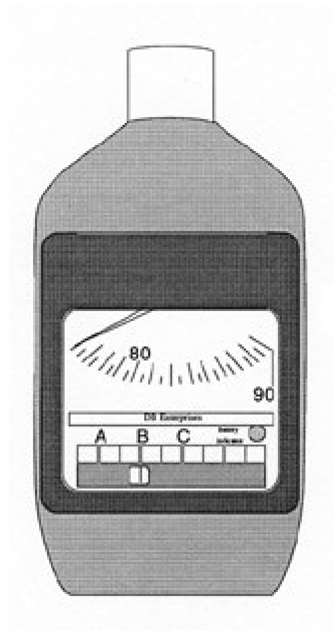
**Notes:**

- Audible “clicks” alert user to changes in amount of radiation detected
- Wide range and sensitive
- Area monitor only
- Not a measure of dose
- Not accurate at high exposure rates
- Rugged instrument

## Noise Monitoring

A Sound Level Meter (SLM) is a direct-reading instrument. Some models have additional features such as:

- measure sound in small bands across the entire spectrum of sound, called octave bands
- data-logging for future analysis




**Use:** To monitor noise exposure in the area
**Read-out:**

- Decibels (dB) usually on the A scale

**Notes:**

- A-Scale used for occupational exposure
- A-Scale developed to mimic the way the human ear responds to noise
- Requires calibration before and after each use
- Some instruments require manually changing the range of noise that can be measured
- Battery must be checked before use
- General-purpose meters are designed to measure continuous noise only (sounds which last at least 1 second)
- Personnel must be trained to use the instrument

| | |
|---|---|
| Tip: | Personal noise dosimeters are also available for routine operations. These instruments are worn by the employee during the entire shift and give a time-weighted average exposure. |
| Tip: | iPhone and Android apps are available for noise monitoring with your phone. |

## Personal Monitoring for Organic Vapors and Particles

Individual worker exposure may be measured during cleanup or remediation and provides the most accurate measurement of a worker's actual exposure, because it goes where the worker goes and can be placed in the breathing zone (near the nose).

- Results can be compared with a TWA or STEL set by OSHA, ACGIH®, NIOSH or the company.
- Documents an individual's exposure without regard to protective equipment.

In some instances, personal monitoring may be done during an emergency.

In planning to conduct personal air monitoring for exposure assessment, identify a published method and laboratory that is experienced in the analytical procedure you want used. Methods are shown at NIOSH (https://www.cdc.gov/niosh/docs/2003-154/) and OSHA (https://www.osha.gov/dts/sltc/methods/) websites.

Specific storage requirements may be needed for some samples. Whenever collecting a sample to characterize exposure to a contaminant for the first time, always discuss the method you will use with the laboratory in advance. The laboratory personnel will alert you to the number of blanks required and discuss other issues such as the collection media and turn-around time. When the media is rarely used, it may be obtained from the laboratory, rather than purchasing a larger quantity from a vendor.

**Organic vapor monitoring**

**Use:** Measure gas or vapor exposure
**Readout:**

- None immediately
- Laboratory reports result

**Notes:**
Sampling media selected for specific hazard. Generally, a solid sorbent in a glass tube is used. An example use of several types are:

- Coconut shell charcoal – acetone
- Silica gel—sulfuric acid
- XAD-2 (2-hydroxymethyl piperidine)—acetaldehyde
- Soda lime—hydrogen sulfide

Each glass tube has two sections of solid sorbent. The larger part is generally twice the volume of the smaller (back up) section. The ends of the tube are broken off, the tube is placed in a 'tube holder' and connected to the pump, with the air flowing in the direction shown on the tube. Caps are supplied to cover the ends of the tube when sampling is complete.

See examples with the sampling train (pump, tubing, and holder) pictured below.

- Battery operated pump must be calibrated before and after use
- One or more tubes is taken into the field, opened, and capped and submitted to the lab as a field blank
- Sampling personnel must be trained
- Use care in breaking the glass tubes (use a tube cutter and wear safety glasses)
- Dispose of any glass ends or broken tubes to minimize cuts to personnel handling trash
- Position the sample holder near the breathing zone; ensure pump does not hinder work
- Monitor pump operation during use to prevent loss of sample due to malfunction
- Have back up pumps and media
- Match media to the contaminant by following an available air sampling/analysis method
- Match duration of sampling to exposure guideline (TWA, STEL, C)
    - Use multiple tubes for TWA, as needed
    - If collected over several hours, result cannot be compared with STEL or C
- Media are dated for service life; some are temperature-sensitive
- Calculate sample volume/flow rate based on expected concentration
- Resample if needed due to questionable/invalid result

Holder with media to collect contaminant from the air

Tubing must be secured to shirt with clips

Tubes containing media; ends are broken for sample collection then sealed with the red caps before shipping to a laboratory.

Personal monitoring sampling train for gas or vapor

Tip: Personal air samples for some contaminants can be collected by using a passive monitor. This device is a badge clipped to the worker's collar which collects one or more contaminant in the air without using a pump. The monitor is sent to a laboratory for analysis.
VOCs and mercury are often measured with a passive badge.

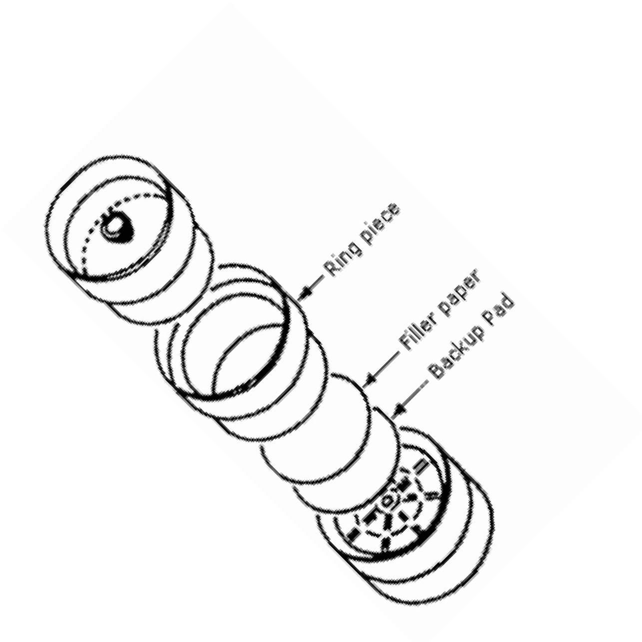
**Personal Monitoring for Particles/Particulates/Fibers/Dusts**

Dust, fibers, flakes, and mists are particles or particulates; the shapes are not all the same, and mists are liquids, not solids. For air sampling, they can be grouped, as the collection method is generally a filter.
**Use:** Measure exposure to solids in the air
**Readout:**

- None immediately
- Laboratory reports result

**Notes:**

- The filter is selected for the contaminant and the analysis method. Several examples of filters and use are:
    MCE (mixed cellulose ester)—Lead, Asbestos (analysis by polarized light microscopy)
    PVC (poly vinyl chloride)—Lead Chromate
    Quartz filter—diesel particulate
    Polycarbonate—Asbestos (analysis by transmission electron microscopy)
- The filter is held in a two- or three-piece cassette and supported by a back-up pad that rests on the part of the cassette that has ridges; air flows across the filter, through the back up pad and to the pump. Plugs removed just prior to sampling are replaced when sampling is complete.




Expanded view of three-piece cassette for sampling particles in the air.

- One or more cassettes are taken into the field, plugs removed and immediately reinserted and submitted to the lab as a field blank.
- Sampling personnel must be trained
- Battery operated pump must be calibrated before and after use
- Monitor pump operation during use to prevent loss of sample due to malfunction
- Have back up pumps and media
- Match media to the contaminant by following an available air sampling/analysis method
- Match duration of sampling to exposure guideline
- Use multiple cassettes if overloading is possible
- Media are dated for service life
- Calculate sample volume/flow rate based on expected concentration
- Resample if needed due to questionable/invalid result

> Tip: There are exceptions to filters being used to only sample solids. Example: ozone is captured on two nitrite-impregnated glass filters.

## Area Monitoring for Particles/Fibers/Dust

Potential movement of contaminants from the response site to the perimeter boundry or beyond may require sampling.  To do this a pump with large capacity is needed.

**Use:** Measure exposure to solids in the air at the perimeter fence
**Readout:**

- None immediately
- Laboratory reports result

**Notes:**

- Requires electric power source
- Noisy, may have to be housed in noise-absorbing box if residents nearby
- Flow rates of 1 cfm or more
- Sampling personnel must be trained
- Requires calibration or use of a flow regulator that is calibrated
- Monitor pump periodically for proper function
- Match filter media to contaminant by following available air sampling/analysis methods


High volume area sampling pump

## Water, soil, or surface sampling

### Water Sampling

Contaminants may be in surface water, run off or in wells following an unexpected release. An overview of equipment for water sampling is provided. There a several types of water samples, as described below.

**Readout:**

- None immediately
- Laboratory reports result

**Type 1**: Grab sample from the surface

**Use:** Collect water samples at or just below the surface to test for contaminants or environmental parameters (such as pH, conductivity, oxygen)

**Notes:** (Grab sample from the surface)

- On-site or laboratory testing
- Ensure that sample container is correct for contaminant/test (stainless steel, glass, plastic)
- Do not contaminate sample with your hand—wash before collecting; wear gloves
- Follow requirements for sample preservations (chemical, temperature)
- Decontaminate between samples

**Type 2**: Below the surface using Bomb Discrete Sampler, Van Dorn-style Bottle, Kemmerer-style, Peristaltic and Vacuum pumps

**Uses:** Evaluate for specific contaminant(s)

**Notes:**

- On-site or laboratory testing
- Ensure that sample container is correct for contaminant/test (stainless steel, glass, plastic)
- Do not contaminate sample with your hand—wash before collecting; wear gloves
- Follow requirements for sample preservations (chemical, temperature)
- Decontaminate between samples
- Follow water safety SOP as necessary

**Type 3**: monitoring well sampling using

- Bailers (hand or pump)
- Samplers (hand, vacuum, pneumatic, peristaltic, battery or 120V electric powered, submersible)
- Liquid level indicators (meters available to indicate the level of an organic such as gasoline floating on the water and the level of the organic/water interface

**Uses:** Monitor water levels in wells and collect samples for analysis


Submersible Pump—can be operated by battery or electricity source

Sampling apparatus: Bury to sample through tubing, as needed

**Notes:**

- On-site or laboratory testing
- Well depth and size may dictate/limit types of equipment to be used
- Ensure that sample container is correct for contaminant/test (stainless steel, glass, plastic)
- Do not contaminate sample with your hand—wash before collecting; wear gloves
- Follow requirements for sample preservations (chemical, temperature)
- Decontaminate between samples or use dedicated equipment to prevent cross contamination
- Follow water and electrical safety SOP(s) as necessary


An interface meter:
Used to determine the light (floating on water) phase and the dense (sinking) phase

> Tip: Permanent soil water samplers may be installed in the vadose zone (above the water table). Two tubes from the buried sampler allow water samples to be taken with pressure/vacuum.
> Tip: Initial soil water investigations may be done with a piezometer, a device driven directly into the ground or down a small bore hole; a ground water sample is retrieved through tubing.

## Soil Sampling

Contaminants in soil at the surface or below the surface may be evaluated. Sampling at each location is described here.

Readout:
- None immediately
- Laboratory reports result

Non-mechanized soil sampling

**Type:** Surface sampling using Trowel, Spoon, Spade

**Use:** Collect soil from the surface for testing in the lab

**Notes:**
- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis

**Type:** Below surface sampling—handheld, manual collection using Soil Recovery Probe, Auger or push type

**Use:** Collect Grab or Undisturbed soil sample below the surface, typically up to 24 inches

**Notes:**
- Select auger head for soil type
- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis
- Soil type may dictate/limit sampler type
- Must use plastic liner to take an undisturbed soil sample/profile; may not be compatible with some organic chemicals

**Below surface sampling—mechanized**

**Type A:** Below surface sampling, mechanized using Augers--electric powered, gas powered, hand-held and mechanized
**Use:** Collect at greater depths than manual tools allow
**Notes:**

- Auger may be used to access the sample depth, then a different soil sampler is used to collect the sample
- Soil type and depth guide decision on sampler used
- Soil type and condition may increase possibility of contamination with soils closer to the surface. Training is required to recognize and prevent/reduce this contamination and may require consideration in selecting the collection tools.
- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis
- Must use plastic liner to take an undisturbed soil sample/profile; may not be compatible with some organic chemicals
- Mechanized equipment hazards

**Type B:** Below surface sampling using Split Spoon

**Use:** Collect soil sample cores at extended depths or in 'hard, compacted' ground. A hole is augured with a mechanical device and then the spoon is attached to replace the auger and driven into the soil to collect a profiled soil sample. Alternatively, drive the spoon down without auguring, collecting samples in series. The spoon is extricated and split open to remove the core, typically 12-24 inches.
**Notes:**

- Soil type and depth guide decision on sampler used
- Soil type and condition may increase possibility of contamination with soils closer to the surface. Training is required to recognize and prevent/reduce this contamination and may require consideration in selecting the collection tools.
- Decontaminate the tool between samples to prevent cross contamination
- Use wide-mouth, non-reactive containers for ease in transfer
- Send to a laboratory for chemical analysis
- Must use plastic liner to take an undisturbed soil sample/profile; may not be compatible with some organic chemicals
- Mechanized equipment hazards; heavy equipment hazards may result from need for drilling and pounding of the split spoons. Activity-specific OJT may be required.

Soil sampling tools (from the top)

Metal sampling tool, for collecting in shallow areas, up to two feet

Plastic attachments (liner) to contain sample; metal extender

Split spoon sampler

Plastic liner sample container and metal probe that fits over liner

**Surface Contamination Sampling**

Possible contamination of surfaces is of interest for several reasons, including:

- Evaluating decontamination of PPE and tools
- Identification of possible spread of contaminants
- Document possible need for cleanup or additional cleanup

There are some published guidelines regarding allowable contamination (e.g., lead, radiation), but many determinations are made on present (above the limit of detection) and not present (below the limit of detection). Commercial kits are available for some contaminants of interest.

**Use:** Determine surface contamination

**Readout:**

- None for chemicals; laboratory report needed
- Radiation evaluated with direct-reading instrument

**Notes:**

- Consult with laboratory personnel
    - Collection media (filter, swipe)
    - Need for bulk material
    - Packing and shipping requirements
- Consult with laboratory personnel if bulk material is required for analysis
    - Packing and shipping requirements
- Follow a protocol carefully
    - Collection media
    - Area swiped
    - Direction and pressure of swiping
- Document location
    - Written notes
    - Photos, if possible

## Summary - Monitoring

When there is potential for responder or off-site resident exposure to substances, monitoring is done to detect potential hazards and measure concentrations.

**Detect** a hazard means that it is present; detect a hazardous substance means that it is present in an amount greater than the limit of detection.

**Measure** a substance to determine a concentration.

Monitoring may be conducted pre-emergency, during emergency and post-emergency. In the air, toxic chemicals, fire and explosion hazards, oxygen-enriched and oxygen-deficient atmospheres, corrosivity, radioactivity, and biological hazards can be monitored.

Sampling water, soil and surfaces provides additional information regarding the extent of contamination and groups that may be at risk of exposure.
There are several ways to describe evaluation of exposures using a variety of sampling instruments and tools:

> **Direct-reading** or **real-time instruments** provide a reading of air contamination at the moment you are using the equipment. Direct-reading instruments may be used to detect IDLH conditions, flammable vapors, oxygen, and toxic materials.

**Laboratory Analysis.** If laboratory analysis is needed, the results will not be available for some time. Consult with the lab regarding sampling procedures, shipping and time needed for analysis.

> **Personal sampling** is used to measure the amount of a toxic chemical in the air to which a worker is exposed, and it requires laboratory support. Personal sampling (when the worker wears a small pump all day and the sample is taken in the breathing zone) gives the best information on a worker's exposure.

**Area monitoring** gives you a measurement of the air concentration of a substance at a particular place**.**

Personnel taking samples for exposure assessment must be trained and use calibrated and maintained equipment. A written sampling plan is developed as part of planning for emergencies; this plan includes procedures to ensure that any equipment that would be needed in an unexpected situation is available and always ready for use.

# Work Practices

Good work practices are vitally important to protect the safety and health and the environment. Some work practices conducted by technician-level emergency responders are outlined in this chapter.

Standard operating procedures (SOPs) are written instructions for work practices that will reduce the risk of exposure to chemical or physical hazards and are a form of administrative control. To be effective, SOPs must be prepared in advance, practiced regularly, and reviewed at least annually. Implementation of work practices that have been thought out in advance, practice and reviewed/revised routinely will minimize the risk to responders, the environment and nearby community residents.

## Chapter Objectives

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

- Define the terms standard operating procedure (SOP) and standard operating guide (SOG)
- Describe work practices to reduce risk of injury and further release/contamination during response operations
- Demonstrate use of a written work practice SOG or SOP to control hazards

## Types of Hazards

Physical and safety hazards include a wide range of potential exposures.
Emergency responders face hazards that are unpredictable and may change even during the response. Some of the hazards are listed below:

- Ponds and lagoons
- Slips, trips, and falls
- Steam
- Spills/releases
- Confined spaces
- Electricity
- Radiation
- Ergonomics
- Vehicle operation

Safety is enhanced when responders work in teams, using the ‘buddy system’. The “buddy system” is an administrative (written) control to ensure that work is performed by a pair of responders in close proximity of one another to safeguard one another’s safety and health. A buddy provides assistance, observes his/her partner for signs of injury or chemical or heat exposure, periodically checks the integrity of the partner’s protective clothing, and notifies the incident commander or others if emergency help is needed. Buddies should work in line-of-sight contact or communication with each other and the incident command post. When wearing protective clothing, workers must make sure that hand signals are recognized, or other communication procedures are in place. (Covered later in this program.) Any IDLH situation requires communication (method selected to be safe for the conditions) and back up for rescue or help. The buddy system is required for any activity in the IDLH area.

## Standard Operating Procedures (SOPs)/Standard Operating Guides (SOGs)

Standard Operating Procedures (SOPs) are carefully planned and detailed work instructions intended to provide emergency responders with necessary guidelines to carry out work tasks safely. Some SOPs for emergencies are adapted from routine plant operations; others provide guidelines for actions that should or should not be taken during an emergency. An SOP includes required training that must be completed prior to conducting the activity.

The Emergency Response Plan includes information about the employer-specific work tasks and activities that you are trained to undertake during or after a release. The tasks and the methods of conducting the work are described in the SOP.

In this program, we use the term Standard Operating Guide (SOG) as a generic term to describe elements of a safe work practice. An employer-specific or operation-specific work practice is an SOP that includes and expands considerations shown in an SOG. These SOPs are an administrative control. On the next pages are SOG elements that should be considered in developing an SOP for the selected work operations or exposures shown above.

**Ponds and Lagoons**

Ponds and lagoons found at many industrial sites and municipal facilities are used to store large volumes of materials including cooling water. When responding, these ponds may be visible, or the surface may be obscured by ice formation or other unstable surfaces that increase risk of injury.

The hazards around ponds and lagoons include:

- Drowning
- A partially solidified surface
- Corrosive or toxic materials
- Gases or vapors

Work practices you should be trained to implement around ponds and lagoons include:

- Observing conditions of railings and work surfaces before entering
- Observing surface conditions
- Using protective equipment such as life jackets, safety belts, or lifelines when working close to unrailed areas
- Wearing protective clothing if contents or contaminants could cause injury if contacted or inhaled
- Limiting access by marking or establishing barriers
- Selecting appropriate float support if entry to the water surface is needed
- Controlling contamination

These and other local aspects will be included in a Ponds and Lagoons SOP in the ERP. For example, if you are part of a team that responds to rescues at ponds/lakes in the winter, the SOP will include cold stress/frost bite recognition and where to find treatment.

### Slips, Trips, and Falls

Slips, trips, and falls are common causes of injuries. Examples of situations causing slips, trips, and falls during a hazmat emergency include:

- Slick surfaces
- Steps or debris
- Ice and snow
- Poor-fitting PPE
- Reduced visibility

Prevention is the key to avoiding injuries. Always work in sight of buddy or in communication according to the task-specific SOP. In addition, work practices that reduce the potential for injury include:

- Where surfaces are wet or slippery- avoid wet areas, move slowly, use available handrails, use footwear with skid-limiting soles
- On uneven surfaces/debris - step high, use walking stick
- Low visibility – probe ahead with walking stick

### Steam

Steam can cause severe burns. Maintain a safe distance. The steam, or the heat from it, may also react with other materials to complicate the response. It is possible that what appears to be steam may not actually be steam. Some chemicals may give off toxic clouds that appear steam-like. Also, gases escaping from a pressurized container may look like steam.

### Vehicle Operation

Training in the operation of powered equipment and vehicles used during a response is required before a responder is assigned. Experienced operators need to become familiar with the differences in driving and operating their equipment when wearing Level A, B, or C personal protective equipment due to motion and visibility restrictions. Also, special rules of operation may be in effect during an emergency. The following items should be part of an SOP describing use of equipment in an emergency:

- Whenever the equipment is parked, the parking brake must be set
- Do not leave any unattended unit running
- Prevent potential carbon monoxide hazards by minimizing exhaust in closed areas
- Equipment parked on inclines must have the wheels chocked and parking brake set
- Equipment used only during emergencies must be routinely inspected

- Breathing air cylinders must be positioned to prevent valve and regulator damage during operation
- Cylinders must be securely attached to equipment
- All equipment taken into the Hot Zone (contaminated area) must remain in that zone until decontaminated

Equipment operators working in Level B must be able to access and connect the equipment air system without the use of the 5-minute escape system. This requirement may be met by:

- Using a longer-duration, NIOSH-approved SCBA unit for entry and egress, modified to fit the vehicle.
- Having the operator park the equipment at the edge of the Hot Zone and use egress to decontaminate and enter the support area. Long de-contamination procedures may require an airline hook-up in the de-contamination area.
- Using an airline from the support area to access and egress a piece of heavy equipment in the work area, then switching the airline to a supply on the equipment.

An assistant will be required to take out and return the airline.

All vehicles should be checked periodically to ensure that the following parts, equipment, and accessories are in safe operating condition and free of apparent damage that could cause failure while in use:

- Service brakes (including trailer brake connection, fluid level, etc.)
- Parking system (hand brake)
- Emergency stopping system (brakes)
- Tires
- Horn
- Steering mechanism
- Coupling device
- Seat belts
- Operating controls
- Safety devices (back-up alarms, fire extinguisher, mirrors, etc.)
- Lights, reflectors
- Windshield wipers
- Defrosters
- Hydraulics

All defects must be corrected before the vehicle is placed in service.

When operating vehicles equipped with the Roll-Over Protection System (ROPS), personnel must wear seat belts for the system to be effective. When leaving a machine, operators should step to the ground instead of jumping from the equipment, because PPE may pose additional hazards. Blades, buckets, or other similar devices should be lowered to the ground and the engine shut down before leaving the equipment. Because the contaminant level may rise suddenly, operators must be prepared to shut down and immediately leave the area when signaled to do so. Equipment should be operated upwind from the emergency whenever possible.

Moving equipment can pose a struck-by hazard. To avoid being hit:
- Secure area and prohibit traffic
- Stay alert to your surroundings
- Listen for vehicle back-up alarms/horns or other alarms
- Assign a spotter to communicate with the responders and equipment operator

An effective communication system for the response will reduce hazards due to vehicle operation.

**Spills/Releases**

A spill containment plan is required wherever drum and container rupture may result in a major spill. (OSHA does not define major spill.) Containment may be part of an overall spill control plan, which describes actions which should/must be taken if either a minor or major spill occurs.

If you respond at a fixed-site, training in this plan is required; if you are a contract or municipal responder, you must be trained in the skills you will use at facilities where you are assigned for technician-level response activities.

Spill control activities are generally broken down into three types:
- Basic
- Confinement
- Containment

Specific methods of basic control, containment, and confinement during a response are described in an SOP in the ERP.

**Basic Control:** Basic control prevents further release. Methods may include shutting off a valve or positioning a drum so that the hole is at the top. The actions are done by the operator and generally do not result in an emergency response.

**Confinement:** Confinement includes those procedures taken to keep a material in a defined area. These activities include confining a spill or release by: (a) diking, (b) blocking, (c) absorption, and/or (d) collection. Confinement is typically done by trained Operations-level personnel. Confinement is done from a distance. You should maintain enough distance to prevent contact with the leaking material.

- **Diking** - Dikes may be built of sand, earth, straw, sorbent, or similar materials around the perimeter of the leak. The type of diking material used must be compatible with the spill material. Plastic sheeting can be used as an additional barrier to slow leakage, if appropriate.
- **Blocking** - Drains, ditches, or storm sewers should be covered and blocked to prevent run-off of spill materials. This blocking can be done with a sorbent pad, 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 sometimes be absorbed with dirt, sand, sawdust, wood chips, peat moss, vermiculite, or other material. The sorbent materials should be positioned so that spill material runs into it. Care must be taken to be certain that the absorbent is compatible with the spilled material. The rate of absorption and the ratio of the pounds of absorbent to the pounds of contaminant absorbed are important factors in selection; consult supplier information for this technical data.
- **Collection** - Run-off can also be collected in containers such as drums or buckets.

**Containment:** Containment includes those procedures undertaken to keep a material in its container. Containment activities are described below. Containment procedures are typically done by Technician-level personnel. During containment, you approach the point of release. Your potential for exposure is generally greatest during containment.

- **Plugging** - A plug is placed in the leaking drum to prevent or limit further release. Common plugging materials include wood and rubber. All plug materials must be compatible with the chemical which 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 which is leaking.
- **Over packing** - Placing a leaking drum into a larger one will contain the spread of the contents.
- **Dome Clamps** - These specially designed clamps fit over the manway and are used to apply pressure to it to slow or stop a leak. Using clamps is preferable to simply tightening the manway bolts, as overtightening the bolts could cause them to break and dump the contents.

- **Valving** - A common source of container leaks is the valves. Some points to consider include:
    - Is the valve closed tight?
    - Can it be plugged or capped?
    - Can the packing gland be tightened?
    - Is there another valve to close (an internal valve on tank trucks, a valve up the line on piping)?

When working with valves, remember the following:

- Lock out the system
- If it breaks, the entire contents may be released
- Some valves and fittings are left-hand threads. When you think you are tightening, you are actually loosening; and you may not know until it is too late.
- If are unsure of the valving, use other containment methods until you are certain about the situation

**Common Materials for Spill Control**

| Control | Materials/Equipment |
|---|---|
| **Blocking** | $H_2O$-filled plastic bag<br>Plastic<br>Special-made drain covers<br>Sewer plugs<br>Sorbents<br>Dikes<br>Sewer valves—closing or diverting |
| **Absorption** | Oil sorbent (expanded clay)<br>Sand<br>Vermiculite<br>Polypropylene<br>Cellulose<br>Expanded amorphous silicate, enclosed by cloth, fashioned into absorbent pillows, rolls, or booms. |
| **Collection** | Buckets<br>Drums<br>Pans |
| **Transfer** | Pump<br>Hose<br>Container |
| **Plugging** | Round or square tapered wood pieces<br>Golf tees<br>Screws<br>Tennis balls<br>Lead, Teflon, or other packing materials<br>Any other material that will fit and is chemically compatible except steel if the chemical is flammable. (Steel is rarely used because of spark potential.) |
| **Patching** | Toggle bolts with rubber plugs<br>Putty, paste, caulking<br>Rubber sheeting with wood frame, chain, etc. to hold in place<br>Air bags<br>Steel plate with gasket and valve to relieve pressure until in place |

**Special control equipment:** For some hazardous materials, special equipment/supplies are required when responding to spills or leaks. An example is chlorine, for which “kits” of supplies are available to assist responders in controlling a release.

The following kits are available:

- Chlorine Kit A—used for small, 100- or 150-pound cylinders
- Chlorine Kit B—used for one-ton containers
- Chlorine Kit C—used for railcars
- Chlorine Kit D—used for barges. These kits should be used to contain chlorine only. A work practice SOP for chlorine control might include the following steps:
    - Report release
    - Don appropriate protective equipment
    - Responders position themselves upwind, in Level A
    - Confirm release, using ammonia in the kit
    - Contact back-up personnel, if needed
    - Identify location of leak
    - Use appropriate chlorine kit, if necessary
    - Review SOP and revise, if necessary
    - Restock supplies/protective equipment

Work in or around a chlorine release requires additional, specialized training and participation in routine drills to ensure an effective response.

Other specialized supplies may be appropriate for your expected responses (e.g., Vetter Bags). Control of spills on waterways frequently involves the use of booms to confine the materials and prevent spread downstream. Booms are effective if the materials float on the water (specific gravity < 1) and are insoluble. Personnel who may be involved in laying booms must receive specific training in working in or near water, the impact of weather on the use of single or multiple booms, and the rate at which spilled material may spread on the water surface.

Dams can be constructed to collect heavy, insoluble materials or to separate uncontaminated water from lighter, contaminated material floating on the surface. Preparation for damming requires an assessment of whether:

- The dam materials are compatible with the spill
- There is an adequate volume of dam material
- The material can be moved quickly, without increasing the hazard

Pre-planning and specialized training and PPE are required for these control methods.

**Confined Spaces**

As an emergency responder, you may be called upon to work in confined spaces to control releases or rescue victims.

NOTE: Entry into a permit-required confined space requires training that is outside the scope of this program. This section is designed to alert you to considerations only.

A confined space generally has three distinct properties which set it apart from other areas and dramatically increase the risk of exposure to physical or chemical hazards.

Properties of confined spaces:

- Limited ways to get in and out of the space
- Not intended for continuous human occupancy
- Bodily entry is possible, and work can be performed

Some common confined spaces include, but are not limited to:

- Ditches, culverts, and ravines
- Excavations and trenches
- Tank cars
- Vaults
- Sewer systems with manhole entrances
- Vats
- Tanks

Entry into confined spaces poses many potential dangers. Chemical vapors can accumulate quickly in confined spaces. A confined space might also contain a material that could trap a worker or a moving part that could trap or injure. Entry into confined spaces may block your view of what else is happening around you. Other common confined-space hazards involve explosions or fires. Lack of ventilation in a confined space can result in accumulation of toxic or flammable vapors. Something as common as rusting metal or the operation of fuel-powered engines may deplete oxygen. Decaying organic materials such as plants or animals can create hydrogen sulfide gas.

It is important to identify hazards prior to entry; emergency responders must have information from testing of the air throughout the space to be adequately protected. The most common confined-space injuries are asphyxiation from lack of oxygen, being overcome by very high concentrations of toxic vapors, or rapid skin absorption of organic solvents.

The OSHA Permit-Required Confined-Space Entry Standard (29 CFR 1910.146) requires that each employer survey all confined spaces at a workplace and designate those for which a permit is required.

NOTE: In an emergency, the hazards of a space may change. For example, a ditch not usually containing any hazard could be a catch basin for spilled material. Although not designated a permit-required confined space by the employer, it must be treated as one until air monitoring shows there is no hazard.

A permit-required confined space (permit space) means a confined space that has one or more of the following characteristics:

- Contains or may contain a hazardous atmosphere
- Contains a material that has the potential for engulfing an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section
- Contains any other recognized serious safety or health hazard

Responders performing rescue must be informed of the hazards before entry.

Several steps must be taken to make work safer in confined spaces. Careful advance planning for confined-space entry can help minimize the risk of injury. This advance planning must include the following points:

- Identifying confined spaces (determine which require a permit to enter)
- Developing written standard operating procedures (SOPs) and the permitting process
- Arranging for and strategically locating adequate air-supplied respirators and protective and life-saving equipment
- Training for personnel who must enter permit-required confined spaces to identify and report emergency conditions
- Training personnel how to monitor and properly safeguard the space before and during entry
- Monitoring confined spaces before entry and during work for oxygen deficiency and flammable or toxic atmospheres. Monitoring must be conducted throughout the space, not just at the entry point.
- Complying with the permit and logging system. Under this system, confined-space entry is permitted only after all hazards and risks associated with entry have been controlled and/or adequate PPE provided. The permit must be signed by a responsible manager. No personnel can enter the confined space

without a signed entry permit. Permits are valid only for a specific date, time, and place.
- Providing appropriate ventilation before and during the work.
- Posting a qualified and trained safety attendant who is ready to provide assistance, if required, outside the confined-space entrance *at all times*.
- Training personnel to recognize when the hazards of a confined space may have changed.

Implementing a confined-space entry SOP minimizes danger through good work practices. Examples of a confined-space entry log and a confined-space entry permit are on the next pages. Other samples can be found in 29 CFR 1910.146, Appendix D.

**Confined-Space Entry Log Personnel and Check-in/Check-out**

Location of confined space:
Building:
Process or Area:
Person in Charge ___________ Title _____________________
Date of Entry:

| Personnel Authorized to Enter Confined Space | Job Title | Work Location in Confined Space | Stand-by Employee(s): |
|---|---|---|---|
| | | | |

| Calibration of Instrumentation | | Instrument Readings | | | | |
|---|---|---|---|---|---|---|
| Oxygen Unit | Combust. Gas Unit | Sampling Point Location | Time of Readings | Oxygen Percent | Combust. Gas%LEL | Other Chemicals |
| | | | | | | |

| Authorized Personnel in Confined Space | | | Ventilation of Confined Space | | | |
|---|---|---|---|---|---|---|
| Signature of the | Time | | Provided | | Time Period | Discharge |
| | Into Space | Out of Space | Yes | No | | |
| | | | | | | |

# Confined-Space Entry Permit

Date and time issued: ___________________Date and time expires:______________________

Job site/space ID:_______________________Job supervisor:____________________________

Equipment to be worked on:_________________ Work to be performed:____________________

Stand-by personnel:______________________________________________________________

1. Atmospheric checks:

   Time ___________

   Oxygen ___________%

   Explosive ___________% LFL

   Toxic ___________PPM

2. Tester's signature:______________________________________________________________

3. Source isolation (no entry):

   Pumps or lines blinded, disconnected, or blocked ………………………..☐ N/A ☐ Yes ☐ No

4. Ventilation modification:

   Mechanical………………………………………………………………… ☐ N/A ☐ Yes ☐ No

   Natural ventilation only……………………………………………………….. ☐ N/A ☐ Yes ☐ No

5. Atmospheric check after isolation and ventilation:
   Oxygen ___________% $\geq$ 19.5 %

   Explosive ___________% LFL < 10 %

   Toxic ___________PPM < 10 PPM $H_2S$

   Time ___________

Tester's signature:__________________________________________________________________

6. Communication procedures:______________________________________________________

7. Rescue procedures:_____________________________________________________________

# Confined-Space Entry Permit, cont.

8. Entry, standby, and back up persons:

Successfully completed required training?.................................................. ☐ Yes ☐ No

Is it current?.......................................................................................... ☐ Yes ☐ No

9. Equipment:

Direct reading gas monitor tested……………………………………… ☐ N/A ☐ Yes ☐ No

Safety harnesses and lifelines for entry and standby persons………… ☐ N/A ☐ Yes ☐ No

Hoisting equipment …………………………………………………….☐ N/A ☐ Yes ☐ No

Powered communications…………………………………………….. ☐ N/A ☐ Yes ☐ No

SCBAs for entry and standby persons………………………………... ☐ N/A ☐ Yes ☐ No

Protective clothing……………………………………………………….. ☐ N/A ☐ Yes ☐ No

All electric equipment listed Class I, Division I,
Group D, and non-sparking tools………………………………………. ☐ N/A ☐ Yes ☐ No

10. Periodic atmospheric tests:

| | | | |
|---|---|---|---|
| Oxygen _______% | Time _______ | Oxygen _______% | Time _______ |
| Oxygen _______% | Time _______ | Oxygen _______% | Time _______ |
| Explosive _______% | Time _______ | Explosive _______% | Time _______ |
| Explosive _______% | Time _______ | Explosive _______% | Time _______ |
| Toxic _______% | Time _______ | Toxic _______% | Time _______ |
| Toxic _______% | Time _______ | Toxic _______% | Time _______ |

We have reviewed the work authorized by this permit and the information contained herein. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any squares are marked in the "No" column. This permit is not valid unless all appropriate items are completed.

Permit prepared by: (Supervisor)_______________________________________________
Approved by: (Unit Supervisor)_______________________________________________
Reviewed by: (CS Operations Personnel)_________________________________________

This permit to be kept at job site. Return job site copy to Safety Officer following job completion.
Copies: White Original (Safety Office), Yellow (Unit Supervisor), Hard (Job site)

The employer confined-space permit program must be in writing and include a description of procedures to:

- Implement measures necessary to prevent unauthorized entry
- Identify/evaluate hazards of permit spaces before employees enter
- Develop and implement the means, procedures, and practices necessary for safe operation including but not limited to:
    - Specify acceptable entry conditions
    - Provide each authorized entrant or that employee's authorized representative with opportunity to observe the monitoring or testing of permit space
    - Isolate the permit space
    - Purge/inert/flush/ventilate the permit space as necessary to eliminate or control atmospheric hazards
    - Provide pedestrian, vehicle, or other barriers to protect entrants from external hazards
    - Verify that conditions in the permit space are acceptable for entry throughout the duration of an authorized entry
    - Provide equipment for testing and monitoring, ventilating, communication, PPE, lighting, barriers and shielding, equipment for safe access/egress, rescue and emergency and any other needs for safe entry or rescue
    - Evaluate conditions when entry operations are conducted
    - Test conditions before entry is authorized (except in limited, specified situations)
    - Test for oxygen, combustible gases/vapors, toxic gases/vapors in that order
    - Test to determine if acceptable entry conditions are being maintained during the operation
    - Provide each authorized entrant or representative opportunity to observe all testing
    - Reevaluate when there is a request due to belief that prior testing was inadequate
    - Provide the requester with results immediately
    - Provide at least one attendant outside the space throughout the operation (special requirements if multiple entries are monitored, including adequate emergency procedures)
    - Designate roles, duties and provide training for all
- Develop and implement procedures to summon rescue/emergency personnel, including:
    - Emergency services to rescued employees
    - Methods to prevent unauthorized employees from attempting rescue
- Develop and implement methods to coordinate operations if multiple employers are represented
- Develop and implement termination procedures at conclusion of entry
- Review operations when there is reason to believe that the program has deficiencies
- Review the program (at least annually)

**Confined space training and information**

If you provide emergency response at a workplace where you are employed (industrial facility, municipal utility), training is provided by your employer for entry and any specialized task (such as containment) to be conducted in a permit-required space

If you provide emergency response at worksites of multiple employers (municipal or county response team), your employer will provide training in confined space entry procedures and safety

As part of host-company pre-planning or upon arrival at a response that requires entry into a permit-required space, the host employer will inform you:

- That all work must be conducted with an acceptable permit space program
- Of the hazards of the space that result in making it a permit space
- Of precautions and procedures implemented for protection of employees in or near the permit space
- Procedures to coordinate entry operations if both employer and contract workers are involved
- Of requirement to debrief the contractor at conclusion of the operation

Your employer must:

- Obtain any available information about hazards and entry operations
- Coordinate with the host employer if host employees will be in or near the entry
- Inform the host employer of any hazards confronted or created in the entry, during or at the final debriefing

**Electricity**

Among the electrical hazards that responders may encounter are downed wires, equipment that could be energized during the emergency response, and risk of sparking due to inadequate or improper grounding and bonding.

Downed wires and other sources: Be observant. Do not approach or try to handle downed electrical wires. Report any wires to the Safety Officer or the Incident Commander. Assume the wire is energized unless trained utility specialists have certified that the line is not energized.

Other safe work practices include:

- Lock-out/tag-out
- Using double-insulated tools
- Using pneumatic equipment

- Using ground fault circuit interrupters (GFCI) on all circuits on outdoor jobs and other potentially wet areas
- Using cords and equipment in good repair and with ground prong in good condition
- Using the OSHA-required electrical PPE for the voltage rating of the circuit

**Energized Systems:** Process or other mechanical equipment may need to be shut down to respond to an emergency or control a release. Lockout/tagout (LOTO) procedures are used to ensure that equipment and processes are de-energized and cannot be restarted by someone who is unaware of the activity of another responder.

| |
|---|
| Implement lockout/tagout before attempting response actions.<br><br>Never assume a machine, circuit, or pipe is locked out just because it should be.<br><br>**When in doubt, lock it out!** |

Common examples of equipment requiring lockout include the following:

- Electrical junction boxes
- Pipes that hold liquid, steam, etc.
- Mechanical equipment with moving parts (grinders, crushers, pulverizers, hydraulics)
- Spring-loaded or -activated devices

The risk of ignition of flammable materials and electrocution is lessened by locking out an electrical circuit. Locking out a steam or hot water pipe may cut off a transmission path for vapors or fumes and prevent burns or accidental contact with the contents of the piping system.

Lock-out requirements are described in 29 CFR 1910.147, The Control of Hazardous Energy (Lock-Out/Tag-Out--LOTO).

Examples of uses of lock-out during an emergency include:

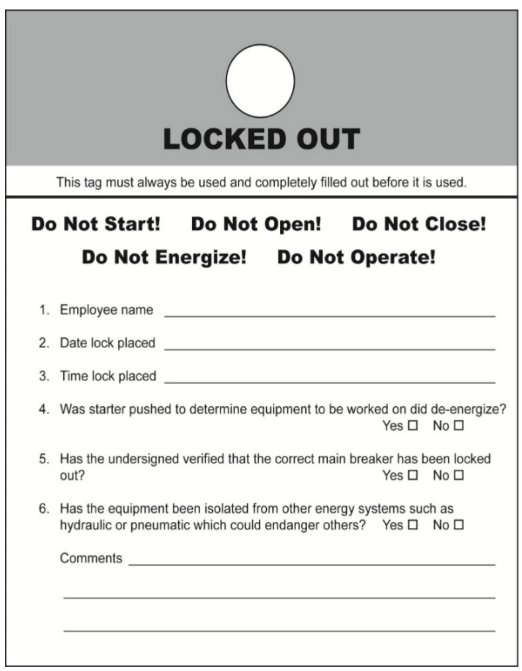
- To reduce power to the area
- To reduce material flow
- As part of confined-space entry
- Ventilation systems on or off
- Doors open or closed

The following list is minimum procedures for LOTO:

- Prepare for shut down: Authorized or affected employee has knowledge of the energy and hazards and means to control the energy.
- Shut down machine or equipment using established procedure
- Isolate the machine or equipment by locating and operating all energy isolating devices
- Affix lockout or tagout devices to each energy isolating device
- Verify isolation prior to initiating any response activity
- Prepare for release from lockout/tagout by inspecting the work area to ensure
    - All nonessential items have been removed
    - Machine or equipment components are operationally intact
    - All employees have been safely positioned or removed from the area
- Remove devices—each by the person who applied it or as specified in SOP
- Inform all affected employees that the lockout or tagout devices have been removed

The employer must review the SOP at least annually to remediate any inadequacies and ensure that the standard is being met. Initial training is required, depending upon the responsibilities of each worker; retraining is required when there is a change in machines, procedures, or job assignments or if deficiencies have been identified.

### Example of a Lockout Tag



LOCKED OUT

This tag must always be used and completely filled out before it is used.

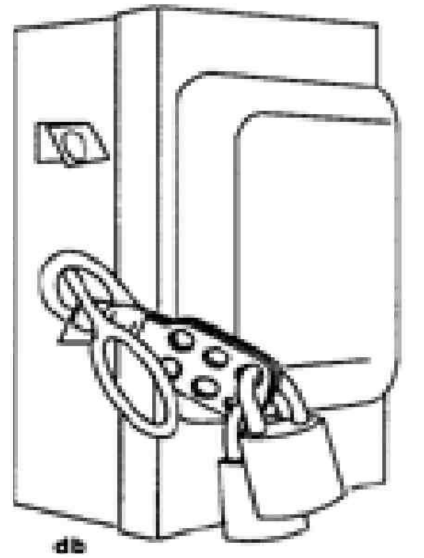
Do Not Start! Do Not Open! Do Not Close!
Do Not Energize! Do Not Operate!

1. Employee name ______
2. Date lock placed ______
3. Time lock placed ______
4. Was starter pushed to determine equipment to be worked on did de-energize? Yes ☐ No ☐
5. Has the undersigned verified that the correct main breaker has been locked out? Yes ☐ No ☐
6. Has the equipment been isolated from other energy systems such as hydraulic or pneumatic which could endanger others? Yes ☐ No ☐

Comments ______

If a contract or outside employer is involved in lockout/ tagout, the outside and on-site employer must inform each other of their respective procedures and the on-site employer must ensure that his/her employees understand and comply with the restrictions of the outside employer energy control program.

Failure to follow LOTO procedures may increase the dangers during the response resulting in electrocution, chemical or other burns, or being caught in or crushed by mechanical, pneumatic, or other moving parts.



**Locked out, showing multiple locks**

**Bonding and grounding:** Static electricity may be created during the transfer of flammable liquids from one metal container to another. Two procedures must be followed to prevent a spark. First, the two containers must be bonded, or connected by an electrically conducting wire. Conducting wires are frequently made of copper and have end clamps called alligator clips. In addition, one of the containers must be connected to a known ground such as a water pipe or grounded metal building support. It is essential that all clamps make good metal-to-metal contact and are not blocked by any non-conductive material such as paint or rust.

Containers made from other materials such as conductive plastics also require bonding and grounding. If a non-conductive plastic container (such as polyethylene) is being used for the transfer of a flammable liquid, turbulence during the transfer can cause a build-up of charge. It is recommended that a grounded dip rod or wire be in the liquid of both containers and any metal parts of the container should be grounded.

**Radiation**

There are many forms of radiation, separated into categories: ionizing, nonionizing. Measurement of exposure and protective measures are proscribed by a Radiation Safety Officer (RSO). Report markings or signs indicating radiation sources you encounter during a response immediately to the safety officer or incident commander.

Ionizing radiation: Radiation sources that emit particles or high-energy waves known as ionizing radiation may be found at industrial sites or along transportation routes during a response. The three common kinds of ionizing radiation are Alpha, Beta, and Gamma.

The degree of damage from exposure depends on the type of radioactivity, as well as the dose. All beta and gamma sources can result in serious health hazards, causing reproductive and developmental injury or cancer.

Alpha radiation**:** Alpha particles are large and travel only a short distance in air (about three inches). Alpha particles are stopped by thin layers of material (paper, tightly-woven clothing, intact skin). Alpha radiation:

- Can damage the body if ingested or inhaled
- Calls for the use of respiratory protection
- Is emitted from radon, uranium, and polonium

Beta Radiation**:** Beta radiation particles are small and travel far. They can penetrate more deeply. Beta particles will travel through clothes but are somewhat reflected by plastic. Beta radiation:

- Can damage the body if ingested or allowed to penetrate
- Can result in skin burns or even skin cancer
- Is emitted from radioactive phosphorus and radioactive carbon

Gamma Radiation**:** Gamma radiation energy can pass through the body. It takes a thick lead or concrete shield to stop penetration of gamma rays. Gamma radiation:

- Can deeply penetrate the body
- Can result in cancer, or burns
- Includes X-rays and emission forms radioactive cobalt

For protection from ionizing radiation:

- Minimize exposure. Keep the amount of <u>time</u> exposed as short as possible.
- Maximize <u>distance</u>. Keep as far away as possible.
- Use protective barriers (or <u>shielding</u>), a respirator, and clothing specifically designed for the kinds of radioactive materials present. Respirators are the only effective protection against airborne radioactive particles.

| | |
|---|---|
| Minimize: | Time |
| Maximize: | Distance |
| Use: | Shielding |

Non-ionizing Radiation: Radio frequency (RF), microwaves, infrared (IR) and ultraviolet (UV) radiation are all examples of radiation that is of lower energy compared with ionizing radiation; the energy of these forms is too low to remove electrons (ionize) elements or compounds and is referred to as non-ionizing. There are still possible health effects from these sources. For example, UV from the sun causes skin burns and skin cancer. IR lasers can damage skin or eyes.

Sources should be identified to responders if you are at a work site where there is a risk of exposure.

**Ergonomics**

The goal of an ergonomics program is to increase the well-being of the worker and make the workplace safer by fitting the job to the worker.

During a hazmat emergency response, unusual postures, lifting, confined space entry and tasks on ladders, unstable or slippery work surfaces, especially while wearing PPE put additional stresses on the body.

Work practice controls include working in teams to reduce carry loads, maintaining erect posture, and using handholds reduce the potential for a strain injury.

A reminder: Hurrying may result in delays and injury. OSHA currently has voluntary guidelines to control ergonomics exposures in some workplaces but not for emergency response. NIOSH has no specific guidance for responders; however publications for the construction industry include several examples of good work practices for material handling that might be adapted (http://www.cdc.gov/niosh/docs/2013-111/, http://www.cdc.gov/niosh/docs/2007-122/).

## Exercise – Work Practices

You will work in small groups to conduct one or more work practice exercises. (See Exercise Manual)

## Summary – Work Practices

Physical and safety hazards include a wide range of potential exposures.

Hazards can be minimized with the development, practice, use and critique of work practices, often referred to as Standard Operating Procedures (SOPs).

**Basic control** actions are generally conducted by the operator to prevent further release: Orient a container so that there is no longer release through a hole, Shut off a valve.

**Confinement** includes those procedures taken to keep a material in a defined area and includes: Diking, Blocking, Absorption, and Collection. Confinement is conducted at a distance from the point of release. (Operations-level response action.)

**Containment** includes those procedures undertaken to keep a material in its container and includes: Plugging, Patching, Over packing, Dome Clamps, Valving. Containment is conducted at the point of release. (Technician-level response action.)

# Decontamination

Decontamination is the process of removing or neutralizing contaminants to clean PPE, tools and other equipment, surfaces and supplies used during a hazmat response. The decontamination standard operating procedure describes the methods and procedures.

## Chapter Objectives

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

- Identify steps in pre-planning decontamination
- Identify methods to limit contamination of personnel, PPE, and equipment
- Identify the purpose of each work zone
- Identify basic decontamination methods
- Identify safe procedures for decontamination line operators
- Demonstrate ability to set up a decontamination line

## Introduction

Decontamination (decon) is the process of removing and/or neutralizing contaminants from PPE, personnel, and equipment to prevent exposure that may cause a health effect to the responder or others. If decon cannot be accomplished, then proper disposal is required. The need for and methods and procedures to accomplish decon is detailed in the decon SOP in the ERP.

Adequate decon may be as simple as thorough hand washing or it may require scrubbing of PPE prior to removal in a specific sequence followed by a shower for the responder. For most chemicals, soap and water washing is sufficient to decontaminate PPE.

## Pre-Planning for Decontamination

Decontamination is the process of removing and/or neutralizing contaminants that may have accumulated on PPE and equipment. Proper decontamination or replacement of protective clothing or equipment is critical in controlling hazards and ensuring the health and safety of responders. The need for decontamination is documented in the employer's emergency response plan (ERP) as required in 29 CFR 1910.120(q) (2)(vii). The detailed plan is developed, communicated to responders and other workers, and implemented before responders or equipment enter the hazmat area.

The plan must be monitored by the incident commander or his/her designee.

Decontamination plans include the following:

- A description of the location and layout of potential decontamination stations for the response
- A list of the decontamination equipment needed for the possible hazards (for example, water for removal and brushes for scrubbing)
- The appropriate PPE for persons assisting with decontamination
- Specific procedures for decontamination of substances that may be encountered during the response
- Methods and procedures for preventing contamination of clean areas
- Methods and procedures for minimizing contact with contaminants during removal of PPE
- Safe disposal methods for clothing and equipment that are not completely decontaminated

- Revisions whenever the type of personal protective clothing or equipment changes, the conditions change, or the hazards are reassessed based on new information

If commercial laundries or cleaning establishments receive contaminated clothing or equipment, they must be informed of potential harmful effects of exposure to the contaminant(s).

Where the decontamination procedure specifies regular showers and change rooms outside of a contaminated area, they must be provided according to the requirements of 29 CFR 1910.141. If water cannot be used due to temperature conditions, then other effective cleansing means must be provided and used.

Following the plan results in these outcomes:

- Protects responders from exposure to hazardous substances and contaminated equipment
- Prevents continued permeation of the hazardous substance into PPE
- Contamination of other PPE, equipment, or tools
- Limits transfer of harmful substances to employees in clean areas
- Prevents the mixing of incompatible substances during decon
- Prevents the transfer of contaminants outside the response area
- Ensures routine critique and revised as necessary

The following examples illustrate situations when decontamination should be utilized:

- When PPE becomes contaminated
- Before responders go from a “dirty” to “clean” work area
- Before responders, eat or drink, smoke, or use restroom facilities
- Before contaminated response emergency vehicles or equipment leave the response site
- Before process equipment in the area of the response is put back into service

## Limiting Contamination

The primary goal is to avoid employee contamination by minimizing contact with hazardous materials.

Specific procedures are used to prevent personal contamination. For example, procedures during donning PPE will minimize the potential for contact with a hazardous material, such as:

- Inspecting PPE before each use to ensure it is in proper condition
- Closing zippers, buttons, and snaps fully
- Tucking gloves over or under the sleeves will be specified in the SOP for any task where gloves and sleeves are overlaid to prevent contaminants entering between the two
- Wearing a third pair of tough outer gloves
- Putting legs of outer clothing over boot tops
- Place any head covering that is not attached to a suit, outside the collar
- Taping all junctures with tape adhesive compatible with suit materials to help prevent contaminants from entering inside gloves, boots, and zippers

Other precautionary measures can help reduce the amount of contamination during response activities, such as:

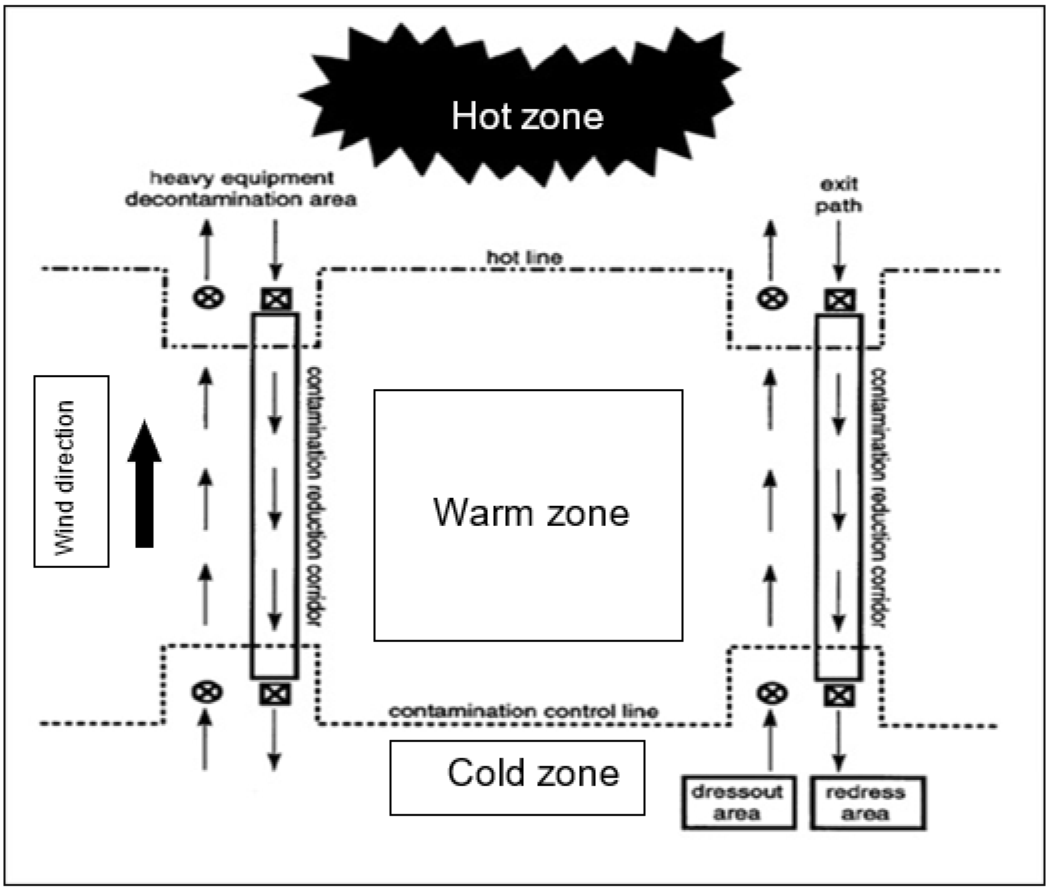
- Using work practices that minimize contact with hazardous substances
- Avoiding puddles, plumes, or areas of obvious contamination
- Minimizing contact with surfaces potentially contaminated with hazardous substances
- Using remote devices such as robots and cameras
- Covering monitoring and sampling instruments (plastic bags with openings for sensors or intake ports), following manufacturer recommendations for preventing contamination to instruments and decontaminating those instruments after use
- Covering equipment and tools with a coating which can be stripped away as one step in decontamination
- Wearing disposable outer garments
- Using disposable equipment where appropriate
- The spread of contamination after the response is limited by actions including:
- Using methods to verify effectiveness of decon
- Decon containers and supplies that will be re-stowed
- Proper disposal of all wastes—tools, disposables, solutions

## Work Zones

Zones are established to limit movement of contamination and contaminated materials. Three work zones are:

- The **Hot Zone**, or **Exclusion Zone**, which is the area of highest contamination.
- The **Warm Zone, or Contamination Reduction Zone (CRZ)**, which is the area surrounding the hot zone, where decontamination occurs.
- The **Cold Zone, or Support Zone**, which is the area free of contamination, where support activities occur.

These zones are shown in the figure below:



## Primary Activities in Each Work Zone

Different activities are performed by authorized employees in each zone. Movement of personnel and equipment between zones occurs at specific access control points.

**Hot Zone/Exclusion Zone/Danger Zone:** This zone refers to the area where the hazard is being assessed or controlled. Primary activities in this zone include emergency response hazard assessment (mapping, photographing, and sampling) and spill containment and control.

The size of the zone is determined by the characteristics of the area where the hazmat emergency has occurred and access points. The “Hot line” is the outer boundary and should be clearly marked with hazard tape, lines, signs, or ropes. Further subdivision of the area may be necessary depending on the hazard and activities being conducted. The level of PPE necessary will be determined by the hazard, monitoring results, and the ERP. It will usually be Level A or Level B; Level C may be used when the hazard is identified, and the situation meets the criteria shown in the ERP.

**Warm Zone/Contamination Reduction Zone/Decontamination Zone:**
Decontamination takes place in a designated area called the Contamination Reduction Zone (CRZ) and is the primary activity in the Warm Zone. The boundary of this zone is called the Contamination Control Line.

The degree of contamination decreases along the CRZ, from the Hot Zone to the Cold Zone. Tools are dropped and clothing and protective gear are removed step-by-step to prevent the transfer of hazardous substances to cleaner areas. PPE for responders in this zone is usually one level lower than that used in the Hot Zone. Depending on the hazard and the ERP, the same level of PPE may be required.

**Cold Zone/Support Zone/Clean Zone:** The Cold Zone is free of known contamination. Here, responders exiting the Hot Zone have removed all PPE. Final determinations should be made here about the effectiveness of the decontamination procedures by visual examination and other methods shown in the ERP.
This zone also contains the administrative and other support functions that keep the response running smoothly.

## Decontamination Line

Decontamination must occur before responders re-enter any clean areas. Decontamination procedures will vary depending on the nature and extent of contamination. Procedures must be specified in the ERP.

The decontamination line is an organized series of procedures performed in a specific sequence to reduce levels of contamination on personnel, PPE, and equipment until no contaminant is present. Each procedure is performed at a separate station. The stations are arranged in order of decreasing contamination, preferably in a straight line. All decontamination activities are located in the Contamination Reduction Zone (CRZ).

Outer, more heavily contaminated items such as boots, gloves, and suit should be decontaminated and removed first, followed by the decontamination and removal of inner, less-contaminated items (inner boots and gloves).

The graphics on the following pages show selected, generic decontamination layouts taken from https://www.osha.gov/SLTC/hazardouswaste/training/decon.html. Additional layouts are shown in this resource. Each of those shown below is labeled.

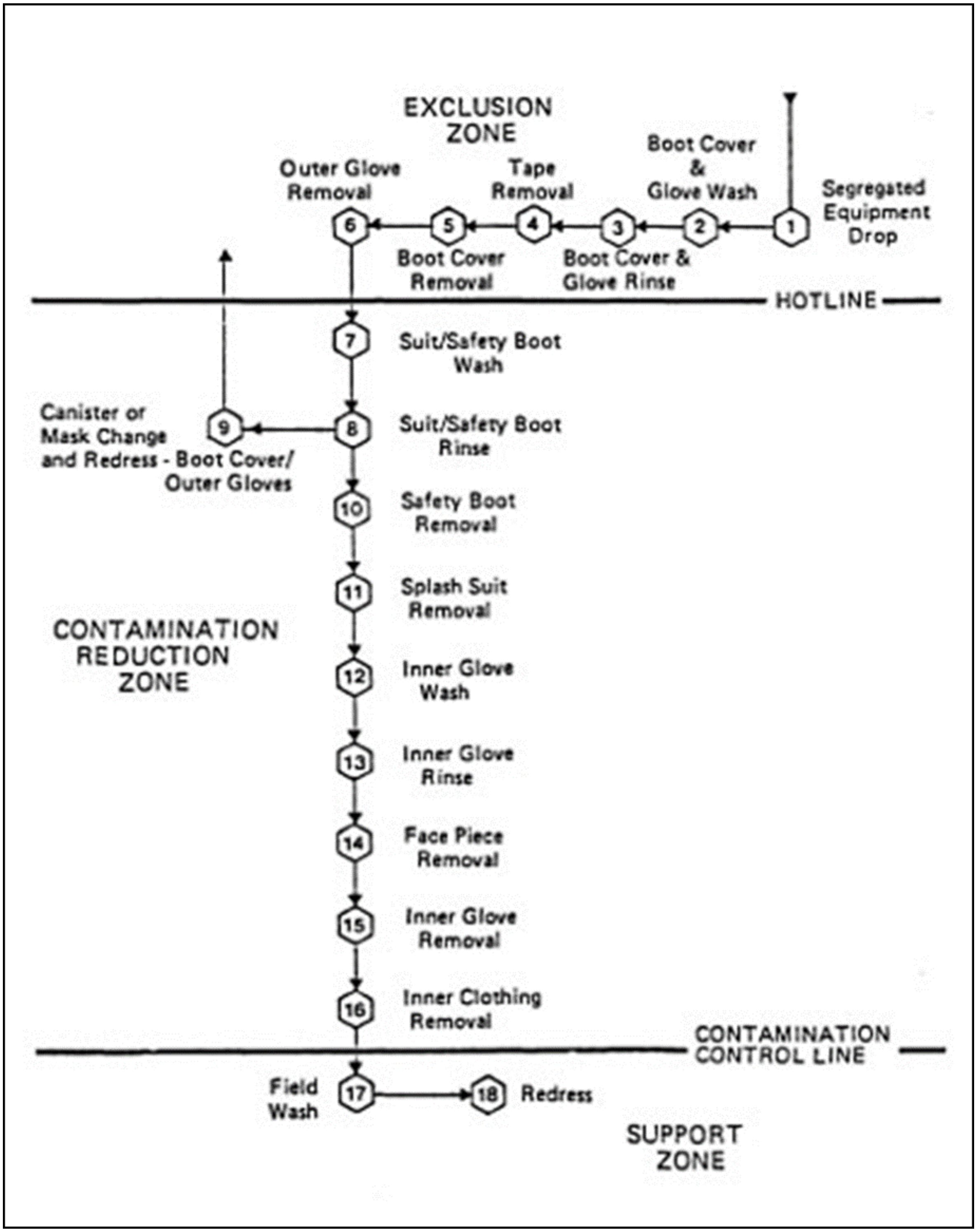
Some important observations:

- Each procedure is performed at a separate station. The stations are arranged in order of decreasing contamination, preferably in a straight line
- Tools and equipment are dropped at specified locations
- First, outer more heavily contaminated items such as boots, gloves, and suits are decontaminated and then removed
- Next, inner, less-contaminated clothing (inner boots and gloves) is decontaminated and removed
- Facepieces are removed near the end of the line
- Materials that cannot be decontaminated are discarded

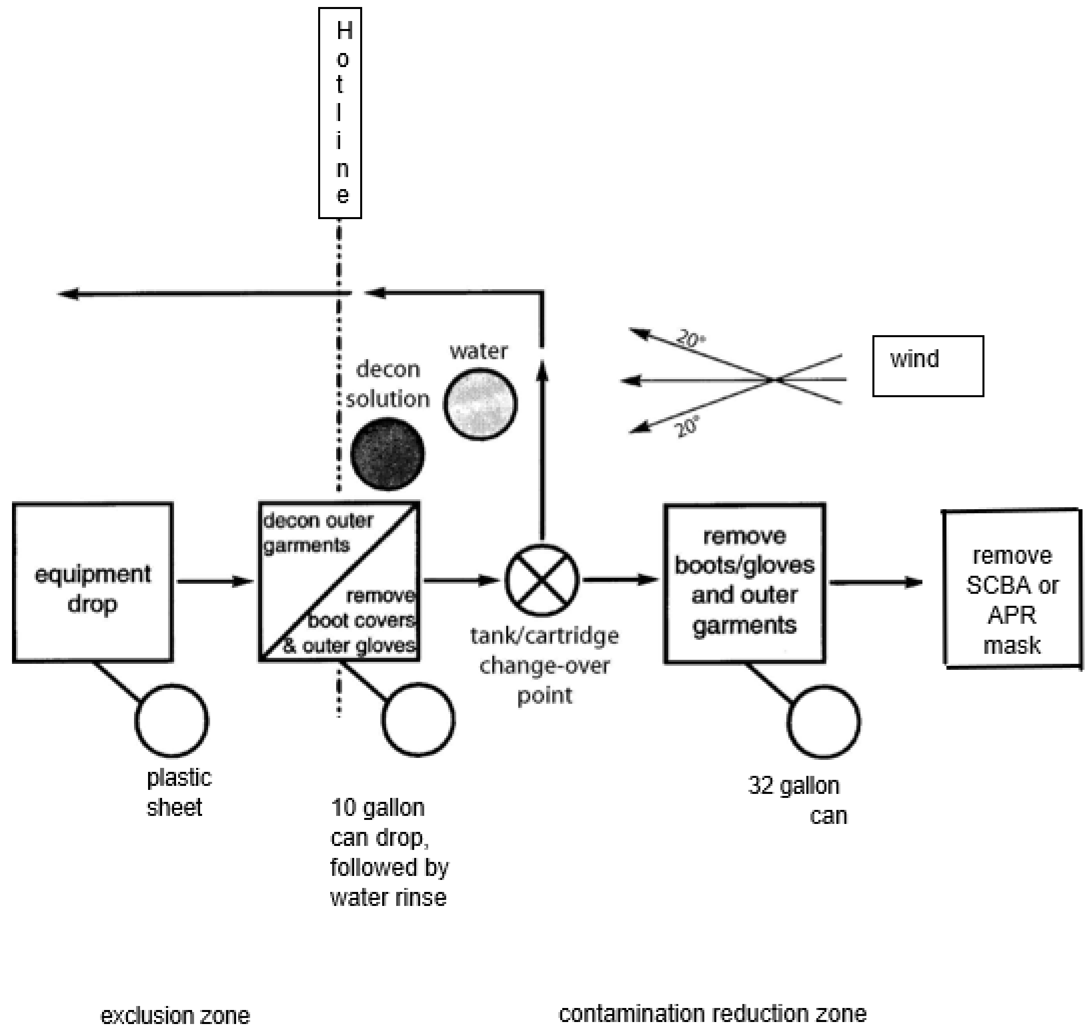
Complete decontamination of protective clothing may not be possible if the contaminant has permeated into the CPC. If permeation has occurred, the CPC should be discarded.

As a general guideline, if a team of responders comes to the decontamination area at the same time, the least contaminated individuals should be decontaminated first. Exceptions to this guideline are medical emergencies and responders who are low on air or who have damage to PPE that might result in direct contamination to inner clothing or skin.

**Level C Maximum Decontamination Line Layout**



**Minimum Decontamination Layout Level A, B and C**



## Decontamination Procedures and Follow up Steps

All responders and workers, clothing, equipment, and sample containers leaving contaminated areas must be decontaminated to remove any hazardous materials that may have adhered to them.

Decontamination can be accomplished by:

- Physically removing contaminants
- Chemically removing contaminants
- Rinsing off contaminants
- Disinfecting and sterilizing (infectious materials)
- Combining the above methods

The selection of method(s) is based on the contaminants, the materials to be deconned and other factors, and is described in the ERP. Manufacturer recommendations for decon methods and materials should be consulted during the process of developing the Decon SOP and the follow up actions needed to support decon.

### Physical Removal

Some contaminants stick to the surface of PPE and equipment and can be removed by scraping, brushing, or wiping, adsorbing, or absorbing, vacuuming, or use of pressurized air jets. These methods are referred to as dry decon, as solutions are not used. One reason to select dry decon is temperature—when appropriate for the contaminants, dry decon may be preferred to limit the risk of hypothermia.

Care is needed during removal by scraping, brushing, or wiping to not degrade the PPE and to minimize the spread of contamination into the air. Any adsorbent or absorbing material(s) used in dry decon must be compatible with the contaminant to be removed. When using pressurized air, the pressure should be regulated to prevent injury to the person being deconned and to protect the PPE; a pressure reducer is installed in the line, as needed.

### Chemical Removal

Removing contaminants with a chemical requires special planning and training. The solution must be chemically compatible with the PPE and equipment being cleaned.

Some specific methods of chemically removing contaminants include halogen stripping, neutralization, oxidation/reduction, and thermal degradation. If contaminated materials are transferred outside the CRZ for chemical decon, the SOP will include handling, packaging, transfer, and unpacking procedures.

Rinsing off Contaminants
A soap and water solution is most frequently used to help remove contaminants. The soap may be referred to as a surfactant.
Rinsing is an important method. Multiple rinses with clean solutions will remove more contaminants than a single rinse with the same volume of solution. The most common type of removal is a water rinse with or without soap, either pressurized or by gravity flow. Chemical leaching, extraction, evaporation, vaporization, and steam jets may be used for specialized applications.

**Disinfecting and Sterilizing**

Disinfectant methods are used to deactivate infectious agents. Examples of methods are dry heat, gas/vapor, irradiation, bleach solution and steam sterilization; specialized procedures and training are required. Disposable PPE is often selected for use with infectious agents to minimize need for decon. If contaminated materials are transferred outside the CRZ for these decon methods, the SOP will include handling, packaging, transfer, and unpacking procedures.

**Notes**
Volatile liquid contaminants can be removed from protective clothing or equipment by evaporation followed by a water rinse. Care must be taken to prevent inhalation of the evaporating chemicals.

Dust and vapors that cling to PPE and equipment may become trapped in small openings, such as the weave of the fabric, and can be removed with water or a liquid rinse.

Removal of tightly-adhering contaminants such as glues, cements or resins may be improved by solidifying, adsorption or absorption (powdered lime, kitty litter, clay, charcoal, poly fibers, or other materials); melting or freezing (dry ice or ice) may be used on PPE after removal, if compatible with the manufacturer instructions.

## Evaluating the Effectiveness of Decontamination

Decontamination methods vary in effectiveness to remove different substances. The effectiveness of any decontamination method should be assessed during development of the ERP and when new information is available. If contaminated materials are not being removed or are penetrating protective clothing, the decontamination program must be revised. The following methods may be useful in assessing the effectiveness of decontamination.

**Visual Observation**

There is no reliable test to immediately determine how effective decontamination is. In some cases, effectiveness can be estimated by visual observation.
In natural light, any discoloration, stain, corrosion, visible dirt, or alteration to fabric surfaces may indicate that contaminants have not been removed. However, not all contaminants leave visible traces or effects; many contaminants can permeate clothing and are not easily observed.

**Ultraviolet Light**

Certain contaminants, such as polycyclic aromatic hydrocarbons, which are common in many refined oils and solvent wastes, fluoresce and can be visually detected when exposed to ultraviolet light. Ultraviolet light can be used to observe contamination of skin, clothing, and equipment; however, certain areas of the skin may fluoresce naturally, thereby introducing uncertainty into the test. In addition, use of ultraviolet light can increase the risk of skin cancer and eye damage; therefore, a qualified health professional should assess the benefits and risks associated with ultraviolet light prior to its use.

**Wipe Sampling**

Wipe testing provides after-the-response information on the effectiveness of decontamination. In this procedure, a dry or wet cloth, glass fiber filter paper, or swab is wiped over the surface of the potentially contaminated object and then analyzed in a laboratory. Both the inner and outer surfaces of protective clothing should be sampled separately. Skin contamination may also be evaluated using wipe samples.

**Cleaning Solution Analysis**

Another way to test the effectiveness of decontamination procedures is to analyze for contaminants in the used cleaning solutions. Elevated levels of contaminants in the final rinse solution may suggest that additional cleaning and rinsing are needed.

### Testing for Permeation

Testing for the presence of permeated chemical contaminants requires that pieces of the protective garments be sent to a laboratory for analysis.

## Decontamination of Equipment and Breathing Apparatus

Decontamination of equipment is an important method of controlling the spread of hazardous substances and preventing deterioration of the equipment.

- **Monitors -** If monitoring equipment becomes contaminated, it will require special cleaning. The manufacturer or local/regional government agencies can provide information on proper decontamination methods.
- **Tools -** Metal tools should be cleaned, as appropriate by chemical or physical means. EPA regional laboratories may be consulted for specific methods to decontaminate tools. Wooden tools and tools with wooden handles are difficult to decontaminate because they absorb chemicals. Wooden tools should be discarded if contamination is suspected.

**Respirators and SCBAs -** Certain parts of contaminated respirators and SCBAs, such as the harness assembly and leather or fabric components are difficult to decontaminate. If grossly contaminated, they may be discarded rather than implement costly decon. Rubber components can be soaked in soap and water and scrubbed with a brush depending on the contaminant. All parts of the respirator should be decontaminated and maintained according to manufacturer recommendations. Persons responsible for decontaminating respirators should be thoroughly trained in respirator cleaning and inspection.

### Containing Contaminated Solutions

Contaminated wash and rinse solutions are contained by using step-in containers to hold spent solutions, or other methods of containment.

### Disposal of Contaminated Materials

All contaminated material, equipment and spent solutions must be segregated and placed in properly selected and labeled drums/containers for disposal according to local, state, and federal regulations.

## Other Considerations

**Protecting those on the Decontamination Line**

Personnel stationed in the warm zone to decontaminate those who have performed duties in the hot zone must be protected from exposure. Those at the beginning of the line (closest to the Hot Zone) may require more protection from contaminants than those assigned to the last station in the decontamination line. These workers on the decontamination line generally wear protection one level below that of personnel in the Hot Zone. For example, if Level B is worn in the Hot Zone, Level C may be appropriate for those in the CRZ. However, in some cases, decontamination personnel use the same level of PPE as is worn in the Hot Zone. The selection of the PPE for the decon line workers is detailed in the ERP. Decon line personnel go through appropriate decon after everyone from the hot zone has been deconned.

**Safety Precautions for Decontamination**

- Decontamination solutions must be compatible with the hazardous substances being removed to prevent a reaction which could produce an explosion, heat, or toxic products
- Include adequate personnel to help each person through the line
- If plastic sheeting is used or other slippery surfaces may be encountered, “gripper” decals or other material should be used to reduce the likelihood of slips
- Provide handholds while boots are being washed or boot covers removed
- Provide stools (not wooden unless they will be disposed of after the response) for personnel to sit on at stations where boots or suits are removed
- Shower and change rooms provided outside of a contaminated area must meet the requirements of OSHA 29 CFR 1910.141
- Unauthorized employees must not remove contaminated protective clothing or equipment from the decon line areas to avoid the spread of contamination

**Decontamination and Emergency Medical Issues**

People contaminated with hazardous materials may be injured. This combination poses a serious challenge to the emergency response personnel.

When there are injuries, a separate decon line may be put in place for victims.

**Which Comes First: Decon or Treatment?:** The approach taken requires preplanning and depends on the hazardous material, type of injury, and preparation to prevent spreading contamination.

Some basic areas that must be addressed in the ERP are listed below:

Hazard Assessment

- Overview of the scene
- Response plan
- Rescue plan
- Crime scene considerations

Patient Rescue Procedures

- HAZMAT team required
- PPE required

Patient Assessment

- Infectious agents precautions
- Airway/CPR
- Respiratory
- Bleeding/blood

Patient Decontamination

- Removal from Hot Zone
- Special equipment

The Incident Commander will make determinations based on the hazards and patient assessment.

## Demonstration - Victim Decon

Using a training mannequin, several Victim Decontamination Procedures will be demonstrated by the facilitator for discussion. (Optional)

## Exercise – Setting up a Decon Line

For a scenario provided by the facilitator, you will set up a decon line to control spread of contamination. (See Exercise Manual)

## Summary - Decontamination

Exposure to the responders during doffing of PPE and the spread of hazardous materials is prevented using decon methods. The HAZWOPER standard requires proper procedures to be developed for hazmat emergency response activities. Precautions should be taken to prevent contamination of personnel and expensive equipment, such as exposure monitors and powered equipment.

The need for decontamination is documented in the employer's emergency response plan (ERP) as required in 29 CFR 1910.120(q) (2)(vii). The detailed plan is developed, communicated to responders and other workers, and implemented before responders or equipment enter the hazmat area.

The primary goal is to avoid employee contamination by minimizing contact with hazardous materials.

During the implementation of the response, work zones are established to control the spread of contaminants. There are three zones:

- The **Hot Zone or Exclusion Zone** is the area immediately contaminated by the spill or release. Only personnel in adequate PPE should be in this zone.
- The **Warm Zone or Contamination Reduction Zone (CRZ)** is the area surrounding the hot zone where decontamination occurs.
- The **Cold Zone or Support Zone** is the area where there is no contamination and support activities occur.

The decontamination line is:

- An organized series of procedures, performed in a specific sequence
- Used to reduce levels of contamination on personnel, PPE, and equipment
- In operation until no contamination is present, pre criteria in the ERP

Methods to decontaminate personnel, PPE, and equipment will vary depending on the hazardous materials at the response site. Basic methods include:

- Physical removal
- Chemically removing contaminants
- Rinsing off contaminants
- Disinfecting and sterilizing (infectious materials)
- Combining the above methods

- Stations are arranged in order of decreasing contamination, preferably in a straight line. Decontamination activities are located in the Contamination Reduction Zone (CRZ).
- All personnel working the decon line must be decontaminated before leaving the CRZ. All decon supplies, solutions and equipment must be decontaminated or disposed of properly.
- When decontamination of materials is incomplete or not possible, the materials must be disposed of appropriately.
- Decontamination methods vary in effectiveness to remove different substances.
- The effectiveness of any decontamination method should be assessed during development of the ERP and when new information is available.

# Rights and Responsibilities

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

## Chapter Objectives

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

- Identify relevant government agencies and some emergency response safety and health regulations each enforces
- Identify worker rights and responsibilities under OSHA
- Identify employer rights and responsibilities under OSHA

## Federal Regulations

## Exercise – Worker and Employer Rights and Responsibilities

What do you already know about mandated employee and employer safety and health rights and responsibilities? (See Exercise Manual)

## OSHAct

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

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

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

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

Those not covered by the OSHAct include the self-employed, immediate family members of farm employers that do not employ outside employees, and employees at workplaces regulated by another Federal agency (for example, the Mine Safety and Health Administration, the Federal Aviation Administration, the Coast Guard).
In addition to setting standards such as HAZWOPER and HazCom, OSHA is charged with:

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

**Rights and Responsibilities Under OSHA**

Workers and employers have a number of rights and responsibilities regarding workplace safety and health.
Worker Rights

Detail of worker rights is shown at the OSHA website, www.osha.gov click on Worker and then Worker Rights. See also Workers' Rights booklet at: https://www.osha.gov/Publications/osha3021.pdf


A brief summary is provided below.

**Your Right to Have an Inspection of a Workplace**

A worker can notify OSHA of a potential hazard by completing the OSHA Notice of Alleged Safety or Health Hazards form, below. This is often called a ‘complaint form’. Once a complaint is received at the OSHA Office, it will be assigned to one of their compliance officers.
The inspection priority defined by OSHA is:

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

Note that complaints are high on the priority list.  The form is shown below. It can be anonymous and can be completed online.

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

**Notice of Alleged Safety or Health Hazards**

| **For the General Public:** |
|---|
| This form is provided for the assistance of any complainant and is not intended to constitute the exclusive means by which a complaint may be registered with the U.S. Department of Labor. |
| Sec 8 (f) (1) of the Williams-Steiger Occupational Safety and Health Act, 29 U.S.C. 651, provides as follows: Any employees or representative of employees who believe that a violation of a safety or health standard exists that threatens physical harm, or that an imminent danger exists, may request an inspection by giving notice to the Secretary or his authorized representative of such violation or danger. Any such notice shall be reduced to writing, shall set forth with reasonable particularity the grounds for the notice, and shall be signed by the employee or representative of employees, and a copy shall be provided the employer or his agent no later than at the time of inspection, except that, upon request of the person giving such notice, his name and the names of individual employees referred to therein shall not appear in such copy or on any record published, released, or made available pursuant to subsection (g) of this section. If upon receipt of such notification the Secretary determines there are reasonable grounds to believe that such violation or danger exists, he shall make a special inspection in accordance with the provisions of this section as soon as practicable to determine if such violation or danger exists. If the Secretary determines there are no reasonable grounds to believe that a violation or danger exists, he shall notify the employees or representative of the employees in writing of such determination.<br><br>NOTE: Section 11(c) of the Act provides explicit protection for employees exercising their rights, including making safety and health complaints |

| **For Federal Employees:** |
|---|
| This report format is provided to assist Federal employees or authorized representatives in registering a report of unsafe or unhealthful working conditions with the U.S. Department of Labor.<br><br>The Secretary of Labor may conduct unannounced inspection of agency workplaces when deemed necessary if an agency does not have occupational safety and health committees establish in accordance with Subpart F, 29 CFR 1960; or in response to the reports of unsafe or unhealthful working conditions upon request of such agency committees under Sec. 1-3, Executive Order 12196; or in the case of a report of imminent danger when such a committee has not responded to the report as required in Sec. 1-201 (h). |

| |
|---|
| Public reporting burden for this voluntary collection of information is estimated to vary from 15 to 25 minutes per response with an average of 17 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An Agency may not conduct or sponsor, and persons are not required to respond to the collection of information unless it displays a valid OMB Control Number. Send comment regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to the Directorate of Enforcement Programs, Department of Labor, Room N-3119,200 Constitution Ave., NW, Washington, DC; 20210.<br>*OMB Approval# 1218-0064; Expires 03-31-2011*<br>Do not send the completed form to this Office. |

| **Instructions:** |
|---|
| Open the form and complete the front page as accurately and completely as possible. Describe each hazard you think exists in as much detail as you can. If the hazards described in your complaint are not all in the same area, please identify where each hazard can be found at the worksite. If there is any particular evidence that supports your suspicion that a hazard exists (for instance, a recent accident or physical symptoms of employees at your site) include the information in your description. If you need more space than is provided on the form, continue on any other sheet of paper.<br><br>After you have completed the form, return it to your local OSHA office.<br><br>NOTE: It is unlawful to make any false statement, representation or certification in any document filed pursuant to the Occupational Safety and Health Act of 1970. Violations can be punished by a fine of not more than $10,000 or by imprisonment of not more than six months, or by both. (Section 17(g)). |

U.S. Department of Labor
Occupational Safety and Health Administration
Notice of Alleged Safety or Health Hazards

| | |
|---|---|
| **Complaint Number** | |

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

| | |
|---|---|
| Organization Name:<br>Your Title: | |

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

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

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

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

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

***Your Right to Appeal Abatement Dates (When a Violation Must Be Fixed)***
The findings of the OSHA officer may be appealed within 15 working days of the issuance of the citation to the employer. The right to contest the citation is limited only to the question of the reasonableness of the abatement period of the citation. Employees or their organization cannot contest the penalty amount or the citation itself.

***Your Right to Have a Closing Conference After an Inspection***
Employees have the right to meet privately with the OSHA officer and discuss the results of the inspection. OSHA procedures state that the OSHA inspector shall inform the employers and employees that a generally responsive discussion covering general issues will be held.

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

***Your Right to Have Access to OSHA Records***
Generally most OSHA records are available upon request. The employees, or their organization, should contact the OSHA Area Office where the plant is located.

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

***Your Right to Review a Citation Procedure When a Citation Is Not Issued***
Every employee has the right to request an informal review when a citation is not issued or for any other issue related to an inspection, citation, notice of proposed penalty, or notice of intention to contest a citation. A written statement as to why a citation was not issued in particular instances may be requested.

***Your Right to File a Discrimination Complaint***
If an employee has been discriminated against as a result of exercising his or her rights under OSHA, that employee has the right to file a complaint with the OSHA

Area Office within 30 days. This time limit is strictly enforced. Similar rights to file a complaint may exist with state and local anti-discrimination agencies, as well as the employee organization.

**Worker Responsibilities**

***Your Responsibility to Abide by Established Safety Rules***
Workers cannot be cited or fined by OSHA, but employers can take disciplinary action for violation of established safety rules.

***Your Responsibility to Wear and/or Use Required Safety Equipment***
Workers are responsible for wearing and/or using required safety equipment.

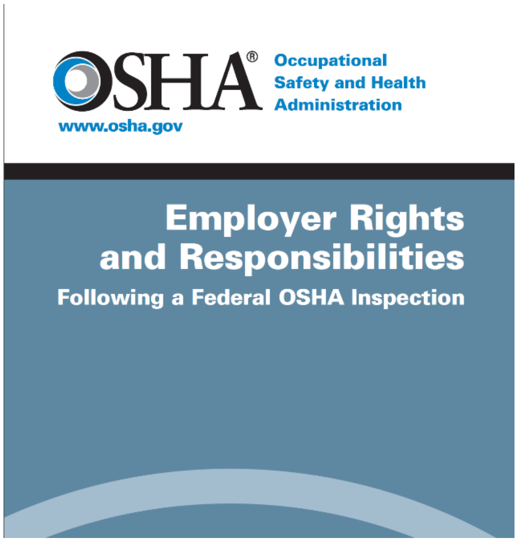
***Your Responsibility to Seek Prompt Medical Treatment When Required***
Workers should seek medical treatment promptly when required. Depending on applicable state law, workers have a right to be treated by a physician of their own choice for work-related injuries. The key here is not to delay medical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

***Your Responsibility to Bring Safety and Health Concerns to the Attention of Management***
Workers should bring safety and health hazards or concerns to the attention of their supervisors or forepersons as soon as possible. If the workers are organized, then they may want to ask the representative to bring the issue to the attention of management.

***Your Responsibility to Pay for Gear That Can Be Worn Off the Job***
Workers will have to pay for ordinary safety-toed footwear, ordinary prescription safety eyewear, logging boots, and ordinary clothing and weather-related gear that can be worn off the job.

## Employer Rights and Responsibilities

The OSHA publication shown below may be useful.




https://www.osha.gov/Publications/osha3000.pdf

See also the summaries below.

### Employer Rights

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

### Employer Responsibilities

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

***Employer Responsibility to Pay for Personal Safety Equipment***
The employer must pay the full cost for almost all required personal protective equipment (PPE) used to comply with OSHA standards, with the exception of safety

shoes and prescription safety eyewear, which are personal in nature and may be used off the jobsite.

***Employer Responsibility to Comply with OSHA Standards***

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

***Employer Responsibility to Report Fatalities and Injuries***

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

***Employer Responsibility to Maintain Records of Injuries***

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

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

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

## OSHA Form 300A - Summary of Work-Related Injuries and Illnesses

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

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

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

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

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

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

**Establishment information**

Your establishment name_______________________________________________

Street
_____________________________________________________________________

City _________________________________ State _______________ Zip ________

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

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

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

Annual average number of employees _______________

Total hours worked by all employees last year _______________

**Sign here**

**Knowingly falsifying this document may result in a fine.**

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

_____________________________________________________________________
Company executive Title

(_____)_______________________________________________________________
Phone Date

**SARA**

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

**Title I**

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

**Title II - Funding for clean-up**

**Title III - Community Right-to-Know**

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

## Other Agencies and Legislation

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

**Environmental Protection Agency (EPA)**

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

The federal EPA has delegated the enforcement of its regulations to state EPA agencies. Some states do not call their agency EPA. Some call them DNR (Department of Natural Resources), DLNR (Department of Land and Natural Resources), DPHE (Department of Public Health and Environment), DEQ (Department of Environmental Quality), DEM (Department of Environmental Management), etc. Some states have regulated other wastes in addition to EPA hazardous wastes, and they are called "special wastes." Examples of special wastes that come under state-by-state rules are waste oils, asbestos abatement waste, and petroleum-contaminated soil.
In states where federal personnel enforce OSHA, they cannot apply the regulations to state and local government employees; the EPA has a regulation identical to HAZWOPER to protect the safety and health of these hazmat responders.

**Department of Transportation (DOT)**

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

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

**United States Coast Guard (USCG)**

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

**Nuclear Regulatory Commission (NRC)**

The NRC is responsible for community and worker protection from radiation hazards. The agency focuses its attention on radiation protection, reactor safety, and the regulation of nuclear materials.

### National Oil and Hazardous Substances Pollution Contingency Plan, 40CFR300

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

Following the Clean Water Act of 1972, the NCP was revised to include hazardous substance spills. As part of Superfund legislation, the NCP was extended to cover releases at hazardous waste sites that require emergency removal actions. Responses to releases of hazardous substances depend on consideration of their threat to human or animal populations, drinking water supplies, sensitive ecosystems, high levels in soils, adverse weather conditions, threats of fire or explosions and other similar factors. Paragraph 150(a) of the NCP requires response actions to comply with worker health and safety protections specified under HAZWOPER. The OSHAct must also be followed. OSHA is responsible for ensuring worker safety and site compliance with HAZWOPER. Post-emergency response actions, such as cleanup, must also conform to the HAZWOPER standard (29 CFR 1910 (q)(11)).

### Hazardous Materials Transportation Uniform Safety Act (HMTUSA)

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

### Toxic Substance Control Act (TSCA)

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

**Resource Conservation and Recovery Act (RCRA)**

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

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

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

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

## Exercise – Rights and Responsibilities Revisited

Review the answers to the exercise completed earlier in this part of the program. (See Exercise Manual)

## Exercise – Using Rights and Responsibilities

In small groups, discuss the questions posed in this exercise (See Exercise Manual). Be prepared to share your answers during a report back.

## Summary – Rights and Responsibilities

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

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

Two important regulatory efforts bear directly on responder safety and health:

- SARA (EPA)
- Mandates training for responders to hazardous materials releases
  - Requires state and local emergency response plans and committees

- HAZWOPER (OSHA)

  Levels of emergency responder training to reduce hazards

The following additional governmental agencies may be involved in hazardous materials:

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

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

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

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

The following additional federal acts have an impact on hazardous materials workers:

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

**RCRA** (Resource Conservation and Recovery Act) of 1976

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

**HMTUSA** (Hazardous Materials Transportation Uniform Safety Act) of 1990

# Emergency Response

In this section, additional aspects of a response will be introduced. Then an emergency response plan relevant to your expected activities will be reviewed and implemented.

## Chapter Objectives

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

- Identify the functions of key positions in the Incident Command System
- Contrast the activities of technician-level and operations-level responders
- Implement an Emergency Response Plan through termination (tabletop)

## Review: What Is a Hazardous Material?

Legal definitions of hazardous materials are found in various environmental laws. OSHA defines 'hazardous substance' in 29 CFR 1910.120(a)(3) by reference to several lists:

Section 103(14) of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (42 U.S.C. 9601)

Any substance listed by the U.S. Department of Transportation as hazardous materials under 49 CFR 172.101 and appendices

Waste or combination of wastes as defined in 40CFR261.3, or substances defined as hazardous wastes in 49 CFR 171.8.

And this broad statement: Any biologic agent and other disease causing agent which after release into the environment and upon exposure, ingestion, inhalation, or assimilation into any person, either directly from the environment or indirectly by ingestion through food chains, will or may reasonably be anticipated to cause death, disease, behavioral abnormalities, cancer, genetic mutation, physiological malfunctions (including malfunctions in reproduction) or physical deformations in such persons or their offspring.

The following, less technical definition may be helpful, when in doubt:

A **hazardous material** is any substance that may cause damage to people, property, or the environment.

Sometimes non-hazardous materials will be considered hazardous when mixed with other materials. To protect people and the environment, emergencies involving hazardous materials need to be dealt with by trained personnel.

At a fixed site workplace, unintended releases could result from:
- Broken or rusted pipes
- Faulty valves or transfer hoses
- A leaking container
- Fire
- Inadequate training of workers
- Lack of appropriate Standard Operating Procedures
- Failure to follow the established procedures

Outside the industrial plant setting, unintended releases could result from:
- Railroad derailment

- Tractor-trailer overturned
- Pipeline rupture
- Multiple vehicle collision
- Meth lab explosion

## Review:  What is an Emergency?

A hazardous materials emergency is a spill or release that cannot be controlled without outside help.  OSHA defines “outside help” to mean anyone other than employees working in the immediate area or maintenance personnel (see HAZWOPER). This definition also includes the *threat* of a spill or release; determining the potential of incidents is done as part of the development of a plan.
Follow the SOP of your organization whenever a spill or release is detected.
With your reported information, it will be decided whether outside help is required. The following questions should be considered:

- Do you know the extent of the spill or release?
- Do you know the nature and type of material spilled or released?
- Have you participated in training specifically to respond to this type and quantity of spilled/ released material?

The determination will be based on factors and decision logic described in the HazCom program and/or the ERP.

## Emergency Response Plan (ERP)

Response to an emergency that involves a hazardous material requires a planned, structured approach to minimize exposure and preserve health and property. This is initiated through the Incident Command System, a structure of prescribed functions and responsibilities.

A plan, developed prior to an emergency, is activated when an emergency occurs. This Emergency Response Plan is a detailed, specific set of procedures or SOPs to be followed by trained responders, under the direction of an Incident Commander.

OSHA 29 CFR 1910.120(q)(2) is a list of elements that must be in included in the ERP:

- Pre-emergency planning and coordination with outside parties
- Personnel roles, lines of authority, training, and communication
- Emergency recognition and prevention
- Safe distances and places of refuge
- Site security and control
- Evacuation routes and procedures
- Decontamination
- Emergency medical treatment and first aid
- Emergency alerting and response procedures
- Critique of response and follow-up
- Personal protective equipment and emergency equipment

The format of the ERP is developed to meet the needs of the users but must include the above elements. A regional plan may be adapted; employers may use the format provided by the Integrated Contingency Plan Guidance from the National Response Team (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=13550. Existing SOPs can be incorporated, such as the Respiratory Protection Program. The ERP may include additional corporate requirements, or sections dictated by local and state governments.

The ERP is an administrative control: a road map to conduct safe work practices to limit injury and damage in an emergency. The ERP must be reviewed periodically. When conditions have changed or new information is available concerning hazards, the ERP must be updated. The ERP must be available for review and copying upon request by employees, their representatives, and personnel from OSHA and other relevant agencies.

Many of the topics in the ERP have been covered in previous parts of this training; however, information on additional sections of the ERP follows:

Potential emergencies are identified in the ERP; this is critical to plan for response activities and identify any needed coordination with outside groups. The ERP includes topography, layout, and usual weather conditions, as well as procedures for reporting incidents to local, state, and federal governmental agencies.

The Local Emergency Planning Committee (LEPC) can facilitate development of the ERP and contact with the local fire and emergency personnel. It is essential to communicate clearly with the local fire and emergency groups to ensure that the location of potentially hazardous chemicals known to all groups. There should be preplanning discussions of the responsibilities of each group in potential emergencies.

The plan includes contact information for any outside party that must be notified. For example, the (State Emergency Response Commission) SERC and LEPC must be contacted if the release is an “Extremely Hazardous Substance” above the reportable quantity.

As part of preplanning, the procedures used to conduct an initial evaluation of the hazards of the emergency are described. This initial size-up includes information about:

- Specific hazards
- Numbers of people at risk of exposure
- Need for protective equipment
- Need for back-up personnel
- Estimated exposure level(s)

This information is needed to determine appropriate response activities.

Response to an emergency incident requires a structured approach to ensure health and safety of all involved, efficient use of resources and appropriate follow up. The response operation can be small and managed by properly training in-plant personnel or may require outside assistance from the immediate area (e.g., fire service) or a larger area (e.g., State EPA) or federal involvement (e.g., US Coast Guard). The structures described by the Federal Emergency Management Administration (FEMA) in the National Incident Management System (NIMS, https://training.fema.gov/nims/) are flexible to address these contingencies.

In any response, Communication is the Key

NIMS was established to improve communication among public sector responders and those seeking assistance by using a uniform set of terms

- An ERP should include NIMS terms
- Training must include NIMS terms
- Training coordination with outside responders is detailed in the ERP

Private sector employers are not required to use NIMS, but use may facilitate communication with responders who likely include public sector employees.

NIMS-trained personnel, such as local fire department responders, may assist at work sites covered by an ERP.

- Plan for communication by meeting with responders BEFORE an incident
- Update responders when changes are made to the EAP
- Train with outside personnel included in the EAP

**It is critical** that outside personnel who may be called to the workplace be aware of your terminology, and you of theirs.

Communicate **in advance** with responders who may assist when the plan is activated; if possible do drills or tabletop exercises with responders.

**Personnel roles, lines of authority, training, and communication**

**Personnel roles and lines of authority**

The Incident Command System (ICS) is the overall structure for roles (referred to in NIMS as functions) and lines of authority. See https://training.fema.gov/nims/

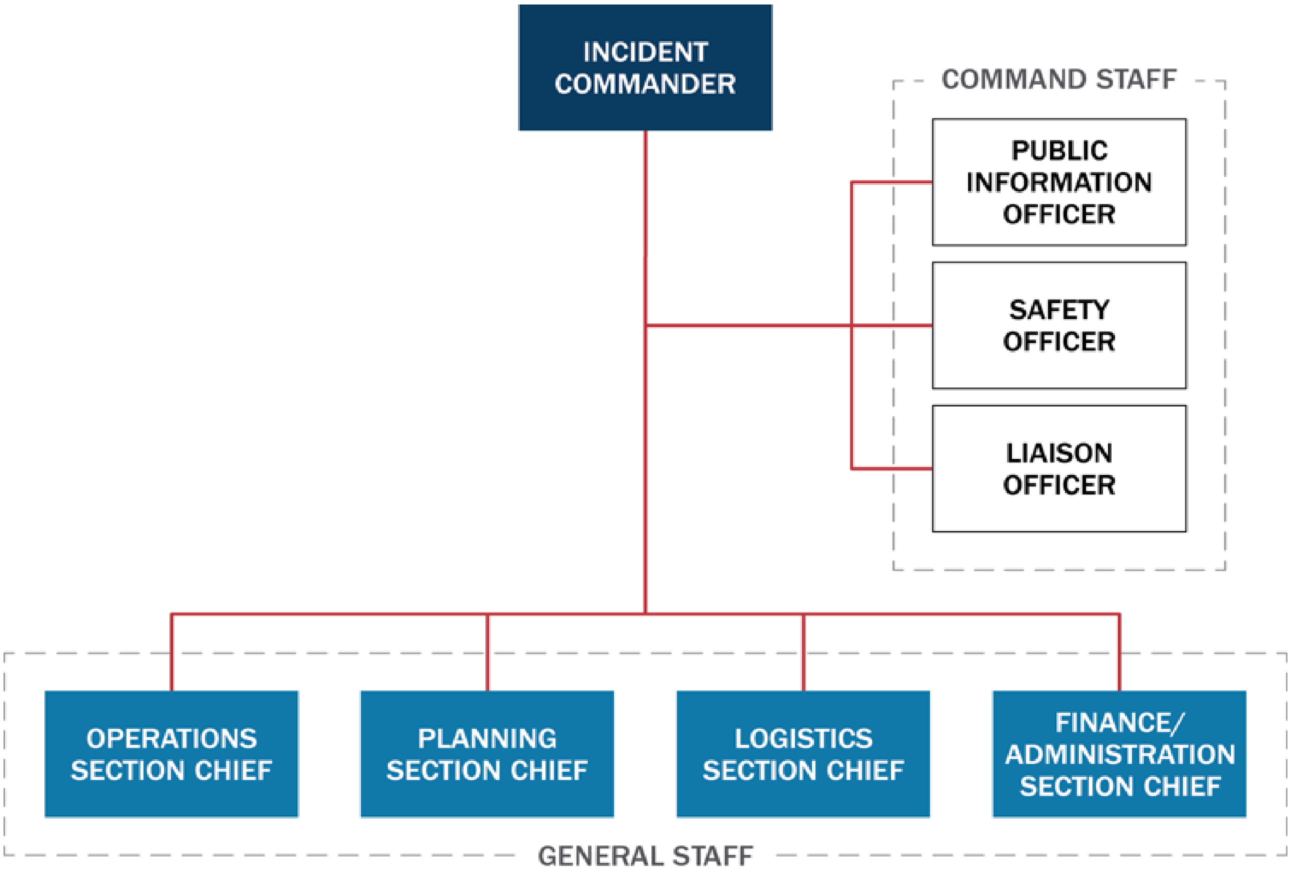
The ICS includes personnel fulfilling a number of different functions. The number of people involved and their functions depend on the types and nature of emergencies that could occur at a response.

Important response activities that are organized under the ICS include:

- Phone calls, to and from the response location
- Overseeing an assembly area
- Chemical Hazard and Risk Assessment
- PPE selection
- Monitoring needs
- Decon
- 2 in, 2 out
- Communication within the emergency response area
- Entry briefing
  - Written instructions
  - Pictures
- Medical needs and follow up
- Facility control
- Termination

Preplanning, training, and practice are required to ensure that each person is prepared for assigned responsibilities in the response. Specialized training may be required depending on expected assigned duties.

An example of an incident command organizational chart is shown below. An example of the structure of a response team follows, using the standard terms in the National Incident Management System (NIMS). This system was promoted after the 9/11 attack where the need for uniform terminology was identified as essential to ensure effective communication between parties.




Source: https://training.fema.gov/nims/

Key functions of the Incident Commander (person in charge of a response), and response team members in the Command Staff and General Staff are shown below: (reference under figure above).

**Incident Commander** – (The person in charge who oversees all aspects of the response)
Functions:

- Establishes a single Incident Command Post (ICP) for the incident
- Establishes consolidated incident objectives, priorities, and strategic guidance, and updating them every operational period
- Selects a single section chief for each position on the General Staff needed based on current incident priorities
- Establishes a single system for ordering resources
- Approves a consolidated Incident Action Plan (IAP) for each operational period
- Establishes procedures for joint decision making and documentation
- Captures lessons learned and best practices

**Command Staff** (see figure above)

**Public Information Officer (PIO)**

**Functions:**

- Interface with public, media and/or other agencies with information needs
- Gathers, verifies, coordinates, and disseminates information to both internal and external parties
- Monitors the media and other sources and provides information to relevant components of the responders
- Releases accurate information concerning the incident after it is cleared by the Incident Commander

**Safety Officer**

**Functions:**

- Reports directly to the Incident Commander
- Monitors incident operations
- Advises the IC on health and safety matters of incident personnel
- Establishes the systems and procedures to assess, communicate and mitigate hazardous environments
    - Developing and maintaining the Safety Plan
    - Coordinating safety efforts
    - Implementing measures to promote safety
- Stops or prevents unsafe acts

**Liaison Officer**

**Functions:**

- IC's point of contact for representatives from agencies such as fire and law enforcement or other jurisdictions
- Receives input from outside groups to Maintains communication between outside agencies and in-house response
- Point of contact to facilitate coordination of assisting or cooperating agencies or jurisdictions

**General Staff** (see figure above)

**Operations Section, led by Section Chief**

**Functions:**

- Section Chief appointed by the IC; assigned personnel may change as the incident evolves
- Directing management of tactical activities to achieve objectives established by the IC
- Developing and implementing strategies and tactics to achieve incident objectives
- Section Chief organizes the group to meet the needs, maintain manageable span of control and optimize use of resources
- Supporting Action Plan development for each part of the response

**Planning Section, led by Section Chief**

**Functions:**

- Collect, evaluate, and disseminate incident information to the IC or other personnel
- Prepare status reports, display information, maintain the status of resources
- Facilitate the incident action planning process and prepare the incident Plan sing input from other sections and command staff and IC guidance
- Facilitate incident planning meetings
- Record status of resources and anticipated needs
- Collecting, organizing, displaying, and disseminating status information and analyzing the situation as it changes
- Planning for the orderly, safe, and efficient demobilization of resources
- Collecting, recording, and safeguarding incident documents

**Logistic Section, led by Section Chief**

**Functions:**

- Ordering, receiving, storing/housing, and processing incident-related resources
- Providing ground transportation during an incident, maintaining, and supplying vehicles, keeping vehicles usage records, and developing incident traffic plans
- Setting up, maintaining, securing, and demobilizing incident facilities

- Determining food and water needs, including ordering food, providing cooking facilities, maintaining food service areas, and managing food security and safety (in cooperation with the Safety Officer)
- Maintaining an incident Communications Plan and acquiring, setting up, issuing, maintaining, and accounting for communications and IT equipment
- Providing medical services to incident personnel

**Finance/Administration Section, led by Section Chief**

**Functions:**

- Tracking costs, analyzing cost data, making estimates, and recommending cost savings measures
- Analyzing, reporting, and recording financial concerns resulting from property damage, responder injuries or fatalities at the incident
- Managing financial matters concerning leases and vendor contracts
- Managing administrative databases and spreadsheets for analysis and decision making
- Recording time for incident personnel and leased equipment

Additional functions may be integrated into the ICS. For example, in a response that could involve criminal activity, an Intelligence/Investigations Section might be activated by the IC. The basic ICS structure is flexible and can be scaled for more complex incidents, including events that involve multiple geographical or governmental jurisdictions or take place in more than one location.

Response functions are conducted by trained personnel. Training and practice are required to ensure that competency in assignments. Training differs for those who will contain materials, confine it to the source, have overall responsibility or provide specialized skills such as those required during response to a chlorine release.

**Training**

These are five distinct levels of training; they should not be confused or substituted (29 CFR 1910.120(q)(6)):

- Awareness
- Operations-Level, First Responder
- Hazardous Materials Technician
- Hazardous Materials Specialist
- On-Scene Incident Commander

Specific duties of responders and the training required are:

**Awareness Level** (report a release):

- Understand hazardous materials and associated risks
- Understand potential outcomes of emergencies
- Have the ability to recognize hazardous materials
- Identify hazardous materials if possible
- Understand the role of the emergency responder
- Have the ability to contact appropriate personnel

**Operations Level** (act defensively, away from release):

- Fulfill requirements of Awareness Level
- Know basic hazard and risk assessment techniques
- Select and use proper personal protective equipment that is provided
- Know basic hazardous materials terms
- Know basic control, containment, and/or confinement operations
- Know basic decontamination
- Understand relevant standard operating procedures
- Know termination procedures

**Technician Level** (offensive actions to stop a release):

- Have fulfilled requirements of Awareness and Operations levels
- Able to implement an emergency response plan
- Can identify, classify, and verify materials using air monitoring instruments and field survey techniques
- Know toxicological terms and behaviors
- Can perform advanced control, containment, and/or confinement operations
- Able to select and decontaminate personal protective equipment
- Understand risk assessment and incident command
- Understand and can implement termination procedures

**Specialist Level:**

- Have fulfilled requirements of Awareness, Operations, and Technician levels
- Able to implement the local emergency response plan
- Know the state emergency response plan
- Able to develop a site safety and control plan
- Have specialized skills in risk assessment, selection of PPE, control, and containment

**Incident Commander** (lead response):
- Have fulfilled requirements of Operations level
- Able to implement incident command system and emergency response plan
- Understand hazards for employees working in personal protective equipment
- Know the state emergency response plan and the federal regional response team plan
- Understand the importance of decontamination procedures

**Communication**

To alert all employees of an emergency situation, the employer must establish an alarm system (OSHA 29 CFR 1910.165). The alarm system must:

- Notify all employees of an emergency
- Result in work being stopped if necessary
- Lower the background noise to speed communication
- Signal the start of emergency procedures

The alarm system must produce a signal (noise, light, or other) that can be perceived by all employees in the affected area of the response. All alarms must be distinct and recognized as signaling a specific action.

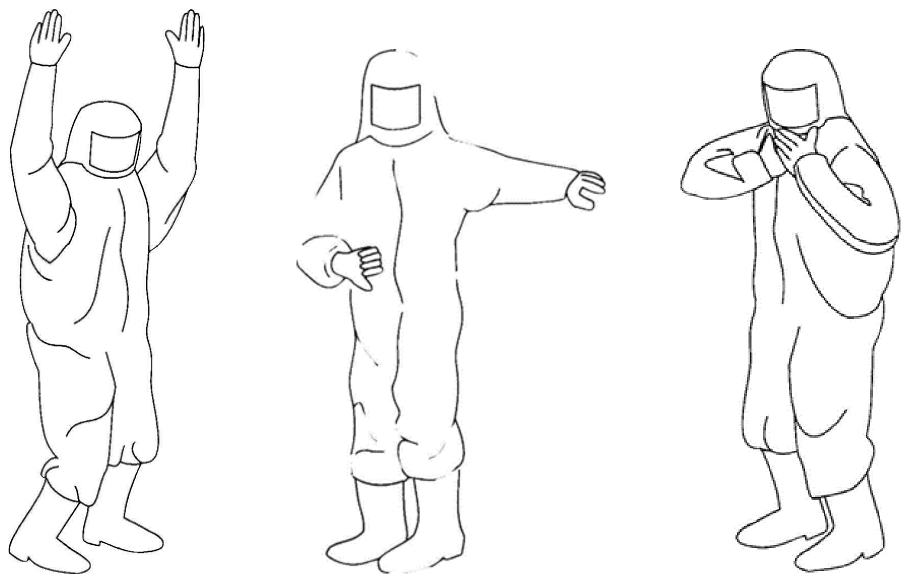
Emergency telephone numbers must be posted in conspicuous locations when telephones are used to report. If another communication system is used, the emergency message shall have priority over all other messages. All manually operated warning systems used to supplement the alarm must be unobstructed, conspicuous, and readily accessible for use. The employer shall ensure that all components of the alarm system are approved for the work site and operating properly. After use (for testing or alarm), the system must be returned to normal operation as soon as possible by the employer. Back-up parts or systems must be available, as appropriate.

The system must be tested at least every two months. If several methods are available to activate the system, a different method must be used for each successive test. The system must be operational at all times, unless undergoing repairs or maintenance. Maintenance work must be done by trained personnel. Systems installed after January 1, 1981 designed to be supervised must be operated as designed and tested annually.

**Communication during an emergency**

The “buddy system” is a protective procedure where workers perform in pairs or within close proximity of one another to safeguard other’s safety and health. A buddy provides assistance, observes his/her partner for signs of chemical or heat exposure, periodically checks the integrity of the partner's protective clothing, and notifies the command post supervisor or others if emergency help is needed. Buddies should work in line-of-sight contact or communication with each other and the command post supervisor. Workers must make sure that hand signals are understood. Some common hand signals are shown below.

**COMMON HAND SYMBOLS**



In trouble – need help getting out of suit | Task cannot be completed with remaining air | Out of air

Communication systems are established to alert workers to changing situations, transmit information, and initiate changes in response activities. Communication systems may be internal or external. Internal systems consist of visual cues such as hand signals, lights, flags, and audio cues such as bells, whistles, or compressed-air horns. External systems include telephones or radios; the use of these may be limited due to static electricity or constraints of protective clothing. Employees also must be trained to recognize and use these emergency systems.

**Emergency Recognition and Control** (see Communication above)
Responders may recognize an unexpected situation that is a new emergency or additional danger. This should be reported immediately.

**Safe Distances and Places of Refuge**
The Incident Commander will determine the safe distance. The pre-entry briefing will include locations of refuge.

**Site Security and Control**

Security and control are essential functions of the Incident Command System (ICS). Securing the area helps ensure that community members or other bystanders do not enter the facility and become unnecessarily exposed or injured. Also, it ensures only necessary responders are in hazardous areas. The need for multiple personnel to secure a site effectively must be considered during preplanning. You should also consider who will provide that service.

Site control involves ensuring that no one enters an area without reason and that proper equipment and training are provided. The response area must be cleared of employees not involved in the response and all entry points controlled. This task can be labor-intensive, depending upon the facility layout, location of the release, and potential release of the material on the ground or in air or water.

Within the ICS, there should be a strategy for working with subcontractors who may be on site. Subcontractors must be aware of what to do in an emergency (meaning of the alerts, safe refuge sites). Your company should define who trains these subcontractors.

**Evacuation Routes and Procedures**

All personnel will be briefed on evacuation routes and procedures, following the ERP.

**Decon (see section on Decon)**

**Emergency Medical Treatment and First Aid**

On-site personnel who will provide emergency medical treatment of First Aid are listed in the ERP. These personnel require specialized training for those certifications. OSHA requires a person trained as a first responder and patient transport be available at a hazmat emergency response.

**Emergency Alerting and Response Procedures**

All personnel will be briefed on the signal that will be sounded in the case of an emergency and/or evacuation and the actions to take.

**Termination (Critique of response and follow-up)**

Much can be learned by reviewing the response activity and conducting appropriate follow up.

These activities include:

- Gathering release data
- Documenting response activities
- Making needed reports to the parent company and/or governmental agencies
- Holding incident critique meetings and making reports
- Evaluating the procedures used and the ERP
- Modifying the ERP
- Checking equipment
- Performing final decontamination and storing equipment
- Restocking PPE and other response equipment
- Reviewing potential human exposures and following up medically when appropriate

The following steps are conducted in termination:

- Debrief
- Reconstruct the response
- Critique (review) the response
- Correct/Fix

Using a structured SOP with forms to document findings and actions will help ensure that all termination requirements are met and completed.

**Personal Protective Equipment and Emergency Equipment (see PPE and Work Practices)**

## Exercise – Tabletop Exercise

The facilitator will provide a scenario; use the information to describe response actions as a tabletop exercise. (See Exercise Manual)

## Summary – Emergency Response

A **hazardous material** is any substance that may cause damage to people, property, or the environment.

A hazardous materials emergency is a spill or release that cannot be controlled without outside help.

Potential unintentional or unexpected spills or releases may occur and require preparation through pre-planning and practice.

Emergency response actions follow predetermined plans that have specified content in the Emergency Response Plan (ERP).

In any response, communication is the key.

Use of the Incident Command System supports an organized response, termination, and after-action steps.

The training required for responders and other workers are detailed in the ERP.

An alerting system is used to inform everyone of an emergency condition.

# Level A or B Simulation with Full Decon Line

Technician-level emergency responders must have the following competencies, certified by the employer:

- Know how to implement an ERP
- Use field survey instruments
- Be able to function within an assigned role in the ICS
- Know how to select and use PPE
- Perform advanced control, containment and/or confinement
- Implement decontamination procedures

You have demonstrated ability to use of field survey instruments, use of levels A, B and C during dressout and performed advanced control, containment and/or confinement techniques and this has been documented with a performance checklist. You will continue to practice these skills and document the additional skills. In this simulation, you will function within an assigned role and implement decontamination.

Skill development requires practice!

## Objectives

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

- Demonstrate ability to don/doff a level of protection
- Demonstrate ability to set up a decon line, consistent with the level of protection of the simulation
- Conduct a technician-level task
- Properly dispose of contaminated materials

## Exercise – Level A or B Simulation with Full Decon

Working in the buddy system, you will dressout, conduct a task and participate in a full decon, appropriate for either a Level A or Level B response. Throughout the exercise, checklists will be provided to document skills in completing an assignment and implementing decon. (See Exercise Manual)

# Emergency Response Simulation

## Objectives

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

- Demonstrate ability to size up and plan a response
- Demonstrate ability to conduct the activities for an assigned role

## Exercise – Emergency Response Simulation

In this exercise, you will participate in a simulated emergency response, fulfilling your assignment as described in an Emergency Response Plan (mock for training-only, or from your employer). At the end of the response, you will complete one checklist to document your activity.

# Cleanup and Critique (Termination)

Following any response there is a need to clean up the area, evaluate resupply or repair needs and store equipment and supplies. As part of this overall termination procedure, much can be learned by discussing the response (what went well, what can be improved) and identifying actions that are needed. For example, revisions may be needed to an SOP or additional monitoring tools may be added to the protocol. Using the Simulation you just completed, a full Termination will be conducted.

## Objectives

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

- Inspect equipment used in the simulation and tag as appropriate
- Properly dispose of contaminated materials
- Critique a response

## Termination Activities

Much can be learned by reviewing the response activity and conducting appropriate follow up. These activities include:

- Gathering release data
- Documenting response activities
- Making needed reports to the parent company and/or governmental agencies
- Holding incident critique meetings and making reports
- Evaluating the procedures used and the ERP
- Modifying the ERP
- Checking equipment
- Performing final decontamination and storing equipment
- Restocking PPE and other response equipment
- Reviewing potential human exposures and following up medically when appropriate

A structured SOP with forms to document findings and actions will help ensure that all termination requirements are met and completed.

## Exercise – Clean up and Critique

This exercise is an opportunity to practice termination—a required skill of emergency responders trained at the Technician level. Use your responses on the Simulation Checklist during the critique. (See Exercise Manual)

## Summary – Cleanup and Critique

Termination activities bring together the information gained during the response, critique of the response and examination of evaluation tools and equipment so that appropriate follow-up can be done such as:

- Reduce potential for a similar release
- Document needs for additional training
- Resupply

Appropriate termination procedures and follow up enhance the capability to respond in the future, should it be necessary.

# Closing and Program Evaluation

Thank you for participating in this program.

This is an opportunity to ask any questions you may have, or to discuss how the knowledge and skills learned can be used at work.  Were all of your initial questions answered?

Please take the next 10 minutes to complete the program evaluation forms.  These are important for improving the program.  The Midwest Consortium does take your comments seriously and has made changes in content and the skill exercises based on feedback.  Your comments are anonymous.

We hope to see you at another Midwest Consortium program in the future.