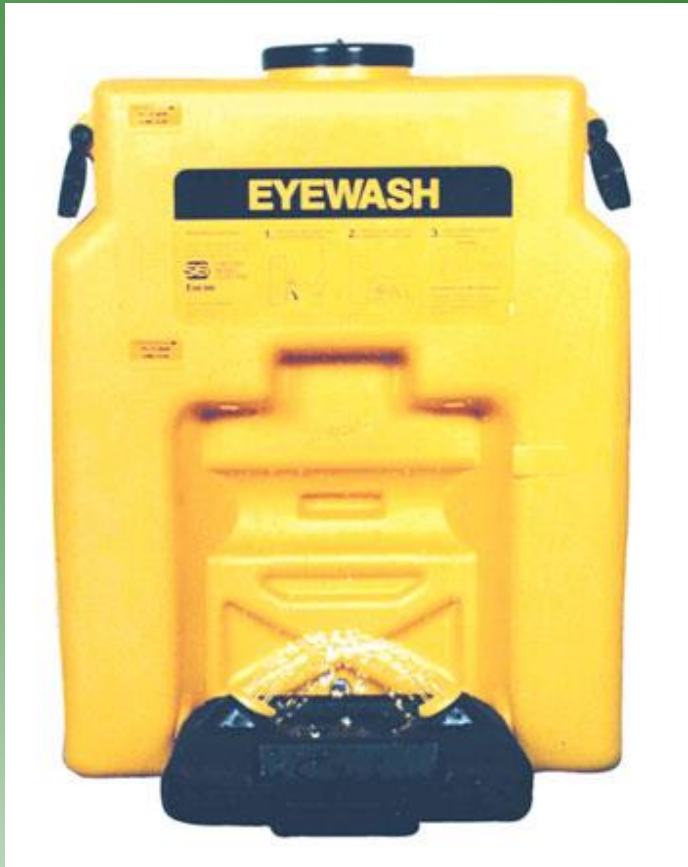
Introduction



- Chemical Hazards and reactions:
  - Chemicals are the most common significant health hazards
  - Chemicals can be hazardous for numerous reasons and can combine with other chemicals to make new hazards
  - All hazards must be taken into account when using and storing chemicals.

Learning Objectives

- At the end of this module, you will be able to :
  - Recognize chemical hazards commonly encountered in the field
  - Provide examples of physical and chemical characteristics of contaminants
  - Explain warning properties of various chemical hazards
  - Describe how to evaluate and control these hazards.

Chemical Hazard Recognition

- The degree of hazard associated with a particular chemical will depend on:
  - Its physical properties
  - Its toxicity
  - The way it is used
  - The environment in which it is encountered.

Physical Classification

- Chemicals may be found in solid, liquid, aerosol, or gas and vapor form. The degree of danger varies according to the form of the chemical and the factors previously discussed.

Test your knowledge

- The degree of a chemical hazard depends upon certain properties. Click on the physical classifications which are are potential skin hazards.

  - Solid
  - Aerosol
  - Liquid
  - Gas and Vapor

Physical and Chemical Characteristics

- Knowing the physical and chemical you anticipate finding during a field activity can help you recognize potential hazards and appropriately protect yourself.

- You can find the details on the physical and chemical characteristics by referring to the chemical's Material Safety Data Sheet (MSDS). MSDS s must be readily available in work areas where the hazardous materials are being used. More information about Material Safety Data Sheets is found in the Hazard Communication module.

Test your knowledge

- Vapor pressure is “the pressure exerted by a vapor against the sides of a closed container.” If vapor pressure is temperature dependent, what does a container of liquid with the sides pushed out mean?
  - The container was exposed to cold temperatures.
  - The container was exposed to heat.
  - The container is leaking.
  - The container is old.

Warning Properties

- Warning properties, such as those shown below, are examples of characteristics that could alert you to the presence of a chemical in the air.
  - Odor threshold
  - Color of product
  - Other senses.

Odor Threshold

- The odor threshold is the airborne concentration of gas or vapor is expressed as parts per million parts (ppm) of air. This odor threshold is considered to be one of the warning properties of gases and vapors but always be used with caution because of variations between individuals and their senses of smell. Allergies, head cold, and olfactory fatigue also can reduce one's ability to smell.

Odor Threshold

- Ammonia is a good example of a chemical with a “useful” odor threshold. Some individuals can detect ammonia at 5 ppm which is below the average of 17 ppm. It is also 10 times lower than the Threshold Limit Value (TLV) and PEL are reached, ammonia is said to have adequate warning properties.
- Another reference indicates that Methyl Formate has an odor threshold of 2,000 ppm, which is 20 times higher than its PEL of 100 ppm. Thus, it is dangerous to rely on methyl formate’s odor as a warning property.

Odor Threshold

- Some chemicals can be detected easily by smell initially but can then cause olfactory fatigue or the loss of ability to smell the substance. H2S causes olfactory fatigue and causes paralysis of the olfactory nerves.
- Relying on sense of smell can provide a false and potentially fatal sense of security with an extremely toxic gas. Never use your nose as a quantifier of chemical concentration or as a device to determine whether or not the air is safe.

Color of Product

- Color can present a visual indication of the presence of a potentially hazardous chemical. Two examples are fuming nitric acid, which creates a red cloud, and chlorine gas, which has a greenish color. Both of these materials are highly toxic.

Other Senses

- Mild irritation of the eyes, nose, or throat can be a useful warning property if it occurs at a concentration that does not produce other harmful or toxic effects.
- Some chemicals will produce a taste before, or instead of, odor or irritation.

Test your knowledge

- Odor threshold is the concentration at which a hazardous chemical can be detected by smell. However, _____ impair(s) the body's ability to smell.

  - Allergies
  - A head cold
  - Olfactory fatigue
  - All of the above

Chemical use

- The way a chemical is used will have a significant influence on the degree of hazard associated with its use. Careful review of the process and a walk-through inspection of the work area will provide useful information to help anticipate potential exposure points.

Other Environmental Factors

- Four environmental factors that can have an impact on potential hazards are:
  - Wind
  - Humidity
  - Precipitation
  - Temperature

Test your knowledge

- Match the effect with the appropriate environmental factor.

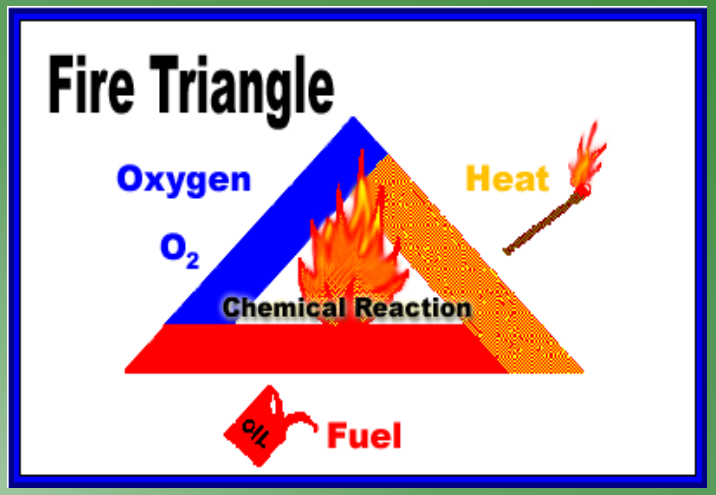
- Effect:
  - Increases or decreases the generation of static electricity
  - Can cause incompatible reactions
  - Changes the air quality by spreading air contaminants
  - Can increase evaporation rates

- Environmental Factor
  - Precipitation
  - Temperature
  - Humidity
  - Wind

Fire and Explosion Hazards

- During field work for EPA you may be exposed to on-site materials that are flammable, burn rapidly or are explosive.
- Such materials may also be present as a part of your own work: either in the emissions or discharges being monitored, in the chemicals used for field test procedures, or in the solvents used for cleaning sampling apparatus.

Combustion and Fire



- Combustion is any chemical process accompanied by the emission of light and heat. When a flame is produced, as well as light and heat, the combustion process is known as fire. Some fires can be deceiving. An alcohol fire can go undetected during daylight because the flame is invisible.

- A fire require three components:
  - Combustible material (fuel source)
  - Oxidizing substance (usually the oxygen in the atmosphere)
  - Ignition energy (heat or spark).

Combustible Materials and Contributing Factors

- The following factors contribute to the occurrence of a fire of explosion of combustible materials:
  - Vapor pressure
  - Area of material from which evaporation can occur
  - Amount of material needed to produce flammable concentrations
  - Temperature of the material
  - Ambient temperature
  - Specific gravity
  - Vapor density
  - Oxygen concentration
  - Source of energy for ignition
  - Ventilation.

Flammable Materials

- These are four types of flammable materials.
  - Flammable liquids
  - Flammable gases
  - Flammable solids
  - Pyrophoric liquids

Explosives and Ordnance

- Explosives:
  - explosives are substances that undergo a very rapid chemical transformation producing large amounts of gases and heat.
- Ordnance:
  - ordnance refers to explosive military weapons and ammunition.

Explosives

- Explosives produce gases like nitrogen, oxygen, carbon monoxide, carbon dioxide, and steam. Due to the heat produced, these gases rapidly expand at velocities exceeding the speed of sound creating both a shock wave and noise.

Ordnance

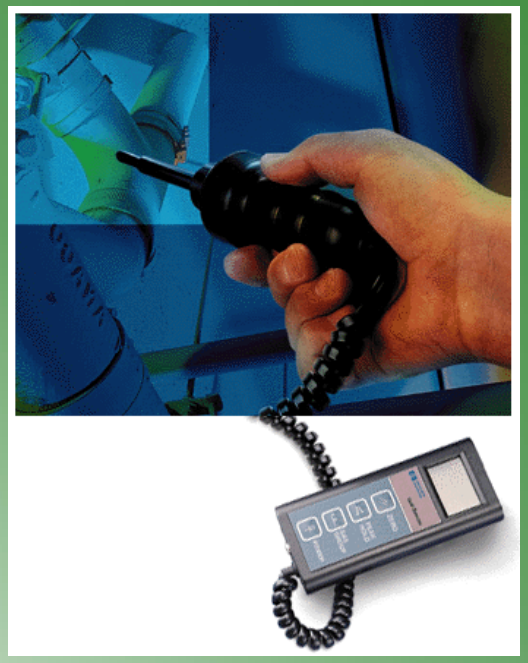
- Whenever the presence of unexploded ordnance (UXO) such as grenades, shells, mines, and other explosive devices is a possibility, personnel and support shall be provided with equipment necessary to locate, identify, recover/remove/dispose, and consolidate all ordnance or energetic items from work areas. These efforts shall be conducted in a safe and environmentally personnel (e.g., Army, bomb squad).

- Prior to starting work, it is recommended that all field personnel attend general orientation sessions that include lectures and visual training aids covering the various types of ordnance.

Preventing Fires and Explosions

- Fires and explosions can be prevented by evaluating possible hazards and taking measures to eliminate and control hazard sources.

Hazard Evaluation

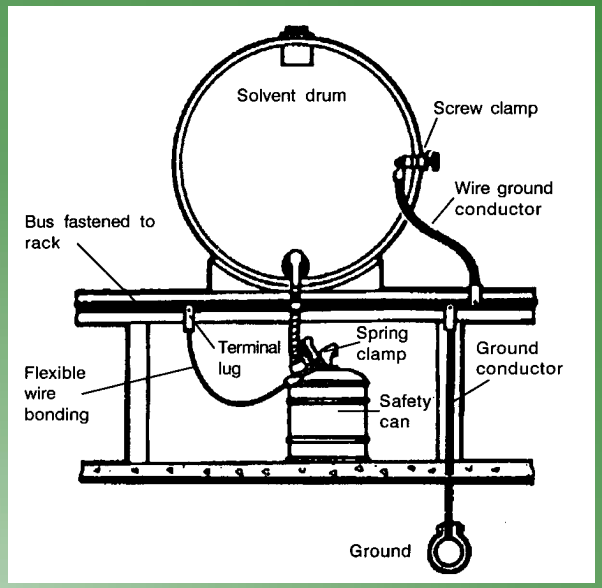


- Identify which materials may be present and get information from reliable and knowledgeable sources on their hazards.
- Use instruments (combustible gas indicators) to see if there is a flammable concentration of vapors or gases in the working area. (Note: Certain field equipment and instrumentation that is battery or line-powered is not safe for use in flammable atmospheres because the electrical elements are not protected from exposure to flammable vapors or gases, or combustible dusts.)
- Take precautions as if the hazards do exist even if you are not sure.

Hazard Control

- To prevent the combustion process, measures must be taken to reduce or eliminate one or more of the four components (fuel, oxygen, heat, chemical chain reaction) needed for combustion.
- Safe work practices and controls should especially be used when sampling, handling or working with flammable materials.

Static Electricity



- Static electricity is generated by contact and separation of materials, such as particulates moving through a stack, gas flowing from a nozzle at high velocity, or pouring or spraying of non-conducting liquids or solids.
- Static electricity is also generated when:
  - Material flow through pipes, hoses, ducts
  - A belt runs over a pulley
  - A person walks across a floor.
- Static electricity accumulates to higher voltages in atmospheres with low humidity and during day weather.

Static Electricity Prevention

- It is important to recognize activities that generate static electricity since it can provide sufficient energy to ignite flammable concentrations of gases and vapors. Practical measures to prevent accumulation or allow discharge of static electricity in field activities include the following:
  - Grounding all probes used for stack sampling
  - Providing a bonding connection between metal containers when flammable gases or liquids are transferred or poured
  - Wearing footwear with adequate conductivity for the conditions.

Test your knowledge

- What is a difference between detonating and deflagrating explosives?
  - Deflagrating is generally combustion followed by a shock wave
  - Detonating explosives have a detonation rate of 1000 fee per second, and deflagrating have a rate of 4 feet per second
  - Detonation can only be caused by shock, heat, or friction and deflagration can only occur if there is a booster
  - None of the above

Corrosive Hazards

- Corrosive material, solid or liquid, may destroy body tissue, metal, and plastic upon contact.
- Common corrosives include halogens, acids, and bases.

- EPA RCRA regulations classify a waste material as corrosive if the pH is less than or equal to 2.0 acid or above 12.5 basic.

Acids

- Acids
- Corrosives which form the greatest number of hydrogen ions are the strongest acids.
- Bases
- Corrosives which form the greatest number of hydroxide ions are the strongest bases. Bases are also called alkaline materials or by the generic term “caustic.”
- Halogens
- Corrosives which are most often found in the gaseous state. They are considered corrosive because contact can lead to burns, irritations, and destruction of organic tissues such as skin and lungs.

Practical Considerations

- When dealing with corrosive materials in the field, it is imperative to determine:
  - How toxic is the corrosive material? Is it an irritant or does it cause severe burns?
  - What kind of structural damage does it do, and what other hazards can it lead to?
  - What protective equipment is needed to minimize exposure?
  - Are emergency flushing facilities or equipment nearby (e.g., safety showers, eyewashes)?
  - What specific handling procedures can be used to minimize exposure?

Reactive

- Below are four representative types of reactive materials.
  - **Oxidizers**
  - **Organic peroxides**
  - **Water reactives**
  - **Pyrophoric Materials**

Compressed Gases

- A compressed gas refers to a chemical which is typically stored under pressure in cylinders.
- Compressed gases are often shipped and stored as liquids (under pressure at low temperature) or gases (under high pressure).
- Compressed gases can be flammable, corrosive, toxic, reactive or they may exhibit various combinations of these traits.

BLEVE

- A highly dangerous condition which can occur when a container of liquefied gas in exposed to a fire is known as BLEVE (Boiling Liquid Expanding Vapor Explosion). BLEVEs occur due to container metal fatigue combined with a tremendous increase in pressure. The container breakup can be explosive, releasing contents in an instant and rocketing the container shell hundreds of feet.

Chemical reactions/compatibility

- Understanding chemical reactions is important in protecting yourself from the hazards they may present.

Testing/Determination

- The identity of unknown reactions must b determined by chemical analysis to establish compatibility. Sometimes it is impossible to ascertain the identity of a waste due to time and money constraints. In this event, simple tests must be performed to determine the nature of the material or mixture. Chemical test strips (SpilFyter), pH paper, and hazard categorization (HazCat) kits can be used to assist in classifying and possibly identifying unknowns. Two varieties of HazCat kits exist; a wet chemistry type and colorimetric detector tube-based.

Test your knowledge

- Which of the following corrosives forms the greatest number of hydrogen ions?
  - Bases
  - Halogens
  - Acids

Radiation Hazards

- **Radiation** hazards are typically considered to be physical rather than chemical. However, radioactive materials may exist in combination with hazardous chemicals as “missed or special waste: in a laboratory, at a facility or at a hazardous waste site, so both hazardous characteristics must be considered. For more information on radiation hazards, refer to your Radiation Protection Program.

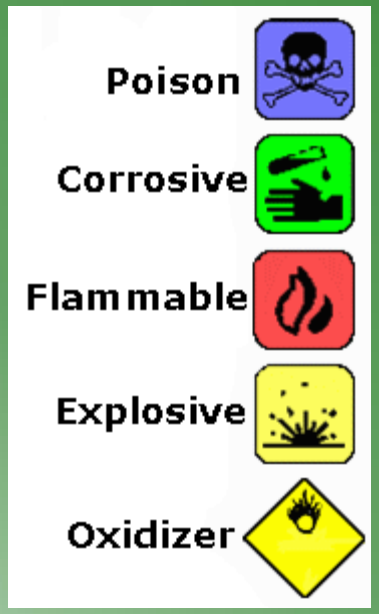
Radiation Hazards

- There are many aspects to Radiation Training
  - Types of Radiation
  - Radiation Units
  - Detection and Measurement
  - Biological Effects
  - Exposure Control
  - External Radiation

Test your knowledge

- When you are exposed to radiation, you will know because:
  - Your eyes will begin to water.
  - You will feel respiratory discomfort.
  - You will not know.
  - You will smell the fumes.

Multiple Hazard Class Rule



- Remember: Multiple hazards are the rule rather than the exception. Assume that a hazardous substance will present more than one hazard. Chemicals are typically classified (e.g., DOT) by their principal adverse property (e.g., flammability, corrosively).
- This does not mean that chemicals can not exhibit adverse properties other than those associated with their hazard class (e.g., flammable and poisonous). Multiple hazards can also result from the reaction of different chemicals with each other and/or with other materials.

Practical Considerations for Hazardous Chemical Awareness

- Know the chemicals and their properties.
- Always consult MSDSs or other reference sources.
- Be aware of incompatibilities.
- Plan your work procedure.
- Be aware of the types of reactions you can expect, especially when other chemicals are introduced to the process.
- Know how to respond to an unexpected reaction:
  - Stop work in progress
  - Attempt to determine the cause, if it is safe to do so
  - Consult an industrial hygienist or chemist.

Test your knowledge

- Which of the following in NOT a consideration when using hazardous chemicals?
  - Always consult an MSDS
  - Be aware of incompatibilities
  - Keep a glass of water in your work area in the event that you get thirsty.
  - Be aware of the types of reactions you can expect
  - Plan your work procedure

Hazard Control Practices

- The following safe work practices should always be used in hazard control:
  - Handle materials carefully to prevent direct contact
  - Limit exposure levels and time as much as possible
  - Enforce good hygiene practices
  - Take appropriate fire prevention and control measures
  - Use appropriate personal protective equipment
  - Utilize equipment and tools not affected by the chemical being handled
  - Ensure that a chemical in not mixed with other chemicals or substances which may result in adverse reactions
  - Use engineering controls
  - Use good common sense.

Test your knowledge

- Chemical hazard control practices include the following:
  - Limit exposure time
  - Use good hygiene
  - Prevent contamination
  - All of the above

Summary

- Measure you can take to minimize the risks associated with chemical hazard reactions include:
  - Recognize chemical hazards, which are dependent on physical properties, toxicity, use, and the environmental conditions present
  - Familiarize yourself with the chemical and physical characteristics as well as the warning properties of chemical hazards you may encounter during the course of your work
  - Be aware of the effect environmental factors may have on potential hazards
  - Know hazard control and evaluation methods for the potential hazards
  - Know hazard control and evaluation methods for the potential hazards
  - Always consult MSDSs or other reference sources for more information about chemical substances
  - Understand the multiple hazard rule
  - Familiarize yourself with the various hazard classes.

- You have completed the module:
- Chemical hazards and Reactions.