1.0 Chemical Terms and Concepts

According to the CAS (Chemical Abstract Service – a division of the American Chemical Society), there are more than 130 million organic and inorganic compounds with individual registry number and this number grows by as much as 15,000 every day. About 84,000 of these chemicals are known to be hazardous, with more than a thousand more hazardous chemicals proposed for manufacture each year. Less than 10% of the chemicals known to be hazardous have been studied thoroughly enough to fully understand their health hazards. While EPA requires registration of some chemicals (e.g., pesticides, fungicides), there is no requirement that chemicals be thoroughly tested before they are sold. Therefore, most hazardous chemicals are not regulated. Of course, OSHA requires manufacturers, importers, and distributors to provide safety data sheets but an SDS is just a statement of known hazards and properties. There is no requirement that every potential hazard be identified.

1.0 Chemical Terms and Concepts

As regulatory agencies identify chemicals that are hazardous, they begin to regulate them, but no government agency is required to test all chemicals on the market. DOT regulates a few thousand chemicals and OSHA write regulations a few hundred. There are many more that possess hazards that have not yet been identified. For example, there are a few thousand pesticides on the market with information available to make a partial health assessment on only about 34% of them. There are about 2,000 drugs on the market with information available to make a partial health assessment on only about 36% of them. There are about 9,000 food additives on the market with information available to make a partial health assessment on only about 19% of them. There are about 50,000 other commonly used industrial chemicals on the market with information available to make a partial health assessment on only about 10% of them.

It is imperative that those responsible for workplace safety understand that simply because we are not told that a chemical causes cancer or lung disease or birth defects etc., it does not mean they really do NOT cause these problems. How many times have we learned for the first time that some common chemical is a carcinogen? It was being used without PPE until that fact was discovered. Gasoline is an example of this; it contains benzene. But many years ago, individuals would use it to remove oil and grease as it was considered an excellent solvent. Most hazards of chemicals are discovered long after many people have been exposed to the chemical. We cannot be too careful with chemicals.

Click Box

1.0 Chemical Terms and Concepts

Terminology

For the purpose of this course and for most general usage, the term hazardous materials or HAZMATs is sufficient to describe chemicals that may be hazardous to people or the environment. But many government regulations attach specific meaning to various terms often thought to synonymous. The term "hazardous materials" is used to describe DOT regulated materials that are a threat during transport. The term "hazardous substances" is used to describe EPA regulated materials which may threaten the environment and OSHA uses this term to describe every chemical regulated by DOT and EPA. The term "extremely hazardous substances (EHS)" is used to describe EPA regulated substances for materials requiring reporting of spills if the spill exceeds the published Reportable Quantity (RQ). The term "toxic chemicals" is used to describe EPA regulated substances whose emissions or releases must be reported annually by manufacturers. The term "hazardous wastes" is used to describe EPA regulated wastes under RCRA. The term "hazardous chemicals" is used by OSHA to denote any chemical that would be a risk to employees in the workplace.

1.1 Basic Chemical Properties

When teaching chemical and toxicological terms and concepts, NASP highly recommends teaching in “layperson” terms; that is, teach at a level of understanding that most employees can absorb. This can be difficult, as teaching scientific terms can be daunting; however, it is imperative that employees understand these principles to better protect themselves from the hazards associated with the chemicals to which they may be exposed. For example, while pH is defined as “the negative logarithm of the hydrogen ion activity across a semi-permeable membrane”, employees may not have the slightest idea of the inherent dangers of materials with high or low pHs. However, if it is explained that pH is a measure of acidity or alkalinity based on a scale of 0 to 14, with highly acidic materials having a low pH and basic (or alkaline) materials having a high pH and contact with either is destructive to skin tissue, then employees can grasp the concept of pH in a way that is relatable to them. Let’s look at some basic chemical properties, including pH, in more detail now.

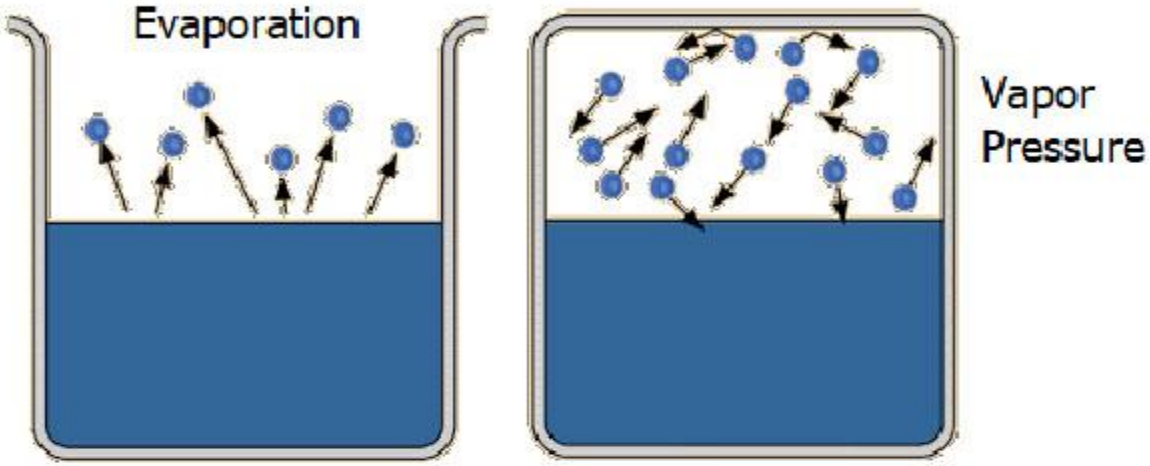
Click Box

1.1.1 Vapor Pressure

Vapor pressure is the force exerted by the vapors of a product against the atmosphere or the sides of a closed container at the level of the vapor space above the liquid. Think about a bottle of drinking water. On a molecular level, the surface water is putting a small amount of pressure on the column of air above it. The water molecules are changing their state to a gas. Water has a vapor pressure of 17.5 mm Hg at 68˚F (20˚C). When dealing with an unknown substance, a comparison may be made of its evaporation rate to that of water in order to have a relative sense of its vapor pressure.

Vapor pressure is normally measured in millimeters of mercury (mm Hg) at 68˚F (20˚C) at sea level. It can also be measured in psi, kPA and Tors. If the vapor pressure of a substance equals or exceeds 760 mmHg at sea level, the product is a gas in its normal state. When it comes to liquids, the closer the vapor pressure is to 760 mmHg, the more vapors the liquid produces, and the more protection is needed against the hazards associated with those vapors. Click play on the video tile to watch a brief overview on vapor pressure.

1.1.1 Vapor Pressure



Conversely, the lower the vapor pressure, the lower the risk. Take the example of sulfuric acid as one of the strongest acids known, with its vapors being strong irritants. However, its vapor pressure is so low that the vapors will not travel far. Another example is chlorine. Gaseous chlorine (stored under pressure as a liquid) has a high vapor pressure (approx. 5830 mm Hg) and a LOW boiling point (-29 deg. F). As a general rule, high vapor pressure typically correlates with a lower boiling point.

Vapor pressure is directly related to volatility. The higher the vapor pressure, the more volatile a material is and the more readily it will evaporate. A material is considered volatile if it evaporates quickly. Vapor pressure is temperature-dependent: the greater the temperature, the higher the vapor pressure.

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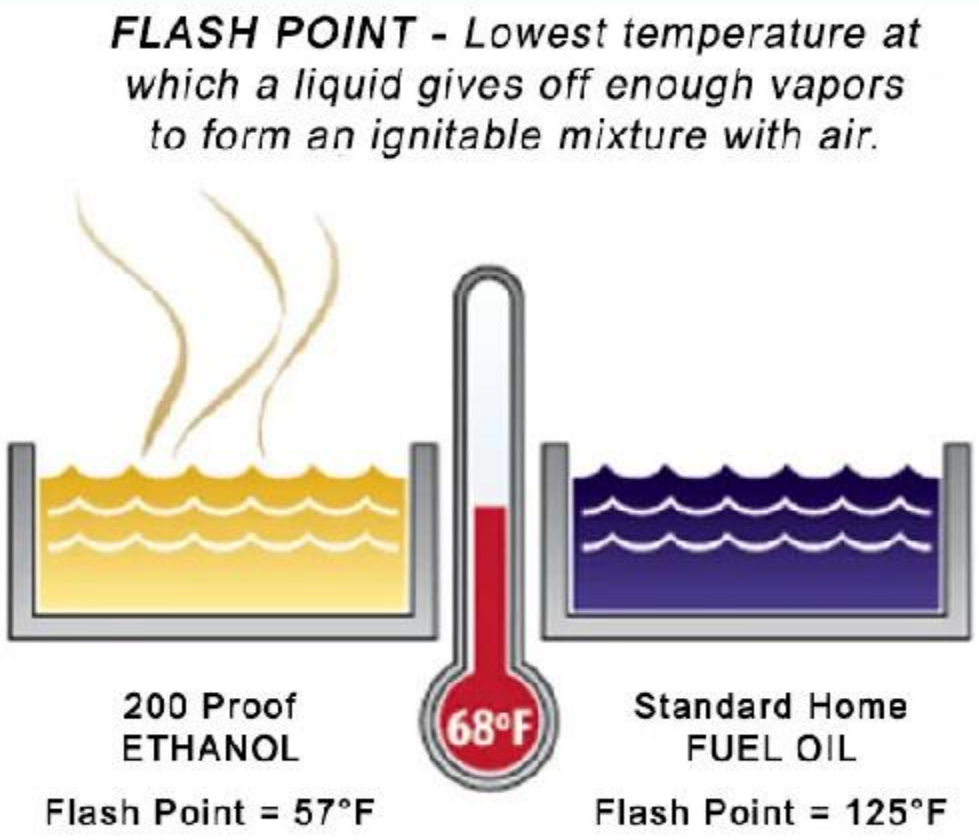
1.1.2 Flash Point



Flash point is the minimum temperature at which a liquid produces enough vapor to form an ignitable mixture in air. The vapors may ignite if an ignition source is present. However, the flame does not continue to burn when the source of ignition is removed; rather, the vapors flash and are consumed by the flame. *Fire (or ignition) point* is the temperature at which enough vapors are given off to support continuous burning even after the source of ignition has been removed. The fire point is generally just a few degrees above flash point.

Generally, the lower the flash point or fire point, the greater the hazard. When different reference sources list different temperatures, it is important to assume the worst and err on the side of safety. While other properties, such as flammable range and ignition temperature, play a significant role in flammability, flash point is usually considered to be the most important property in assessing the hazards of flammable and combustible liquids. As a general rule, materials with a lower flash point (e.g., gasoline, acetylene) are considered flammable, while materials with a higher flash point (e.g., oil, greases, paper) are not.

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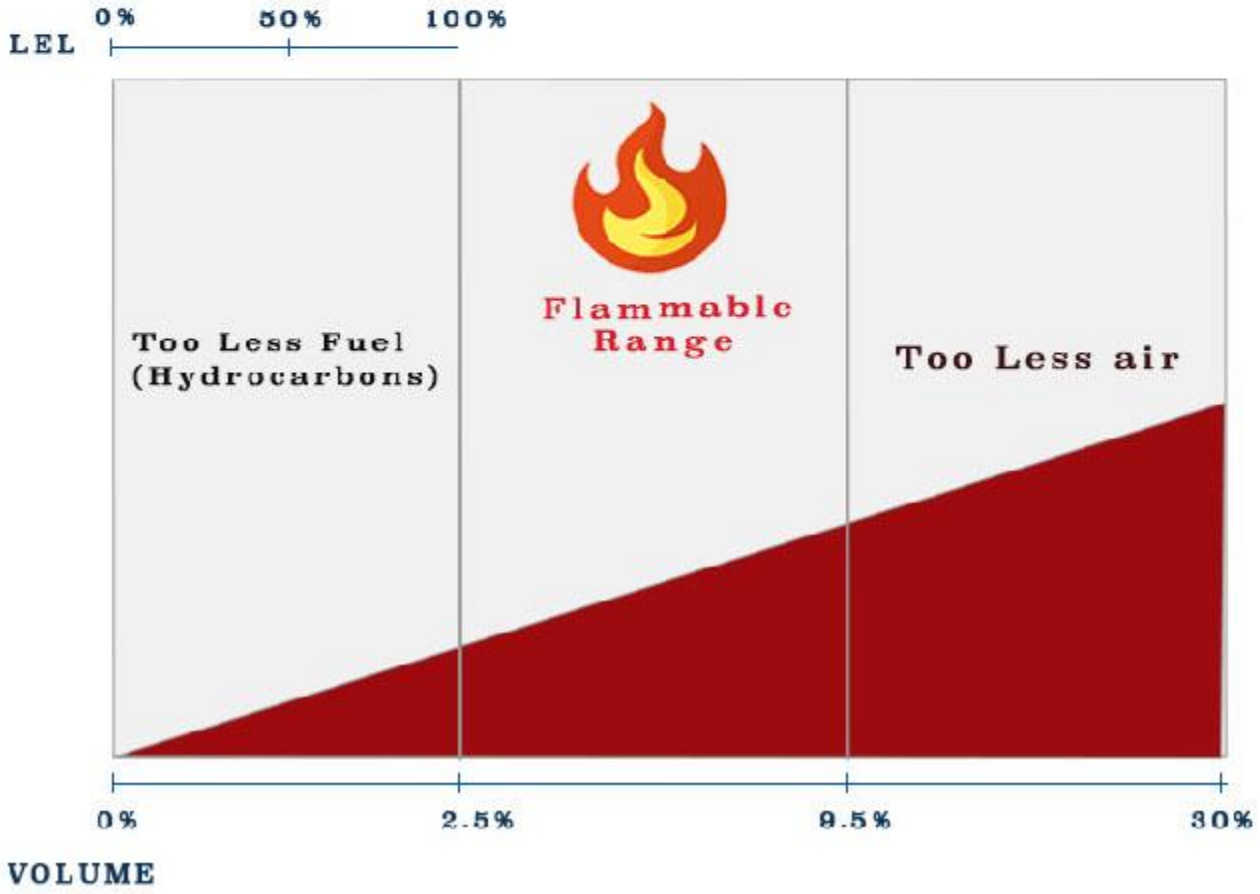
1.1.3 Ignition Temperature

Ignition (or autoignition) temperature of a substance is the minimum temperature required to cause self-sustained combustion of that substance, independent of an ignition source. It is the minimum temperature to which a material must be raised before it will ignite. It is also the temperature the ignition source must be. The lower the ignition temperature, the greater the risk of ignition. Ignition temperature is sometimes difficult to measure and should be considered an approximation. This may be applicable if there was a fire outside of a container (but not actually touching it) that heated up the room to a temperature which would cause the material inside the container to ignite.

A container that holds flammable liquid and ruptures (and typically causes an explosion) due to heat is referred to as a “BLEVE” (boiling liquid expanding vapor explosion). Click play to watch a brief BLEVE case study.

1.1.4 Explosive Limits

Before a fire or explosion can occur, three conditions must be met simultaneously. A fuel (i.e. combustible gas) and oxygen (air) must exist in certain proportions, along with an ignition source, such as a spark or flame. The ratio of fuel and oxygen that is required varies with each combustible gas or vapor. The minimum concentration of a particular combustible gas or vapor necessary to support its combustion in air is defined as the Lower Explosive Limit (LEL) for that gas. (This is sometimes also referred to as Lower Flammable Limit, or LFL). Below this level, the mixture is too "lean" to burn. The maximum concentration of a gas or vapor that will burn in air is defined as the Upper Explosive Limit (UEL or UFL). Above this level, the mixture is too "rich" to burn. The range between the LEL and UEL is known as the flammable range for that gas or vapor. The wider the range, the more flammable the material. For example, acetone has a LEL of 2.6% and an UEL of 13%, while acetylene has a LEL of 2.5% and an UEL of 100.0%.



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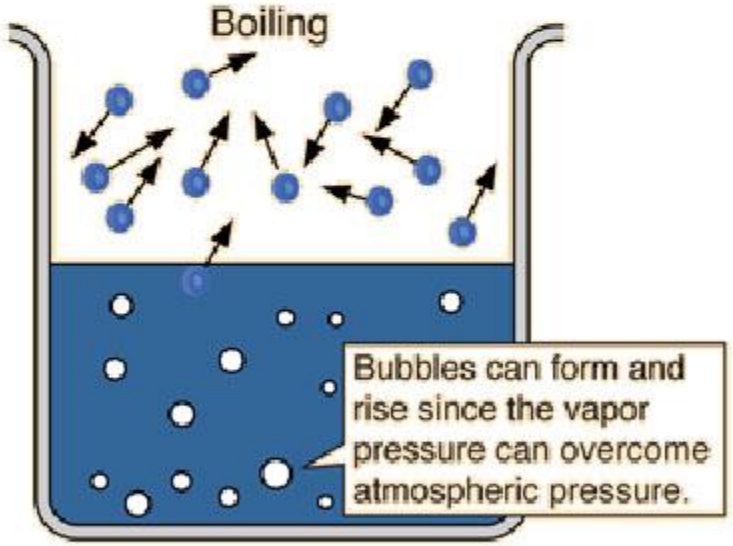
1.1.5 Boiling Point

Boiling point is the temperature at which the vapor pressure at the surface of the liquid is equal to or slightly greater than atmospheric pressure, meaning that individual molecules are able to easily break through the surface of the liquid in vapor form, escaping into the atmosphere. Boiling point is the point of maximum vapor production. The lower the boiling point, the greater the hazard potential since it takes less heat to get that liquid to the point of maximum vapor production.



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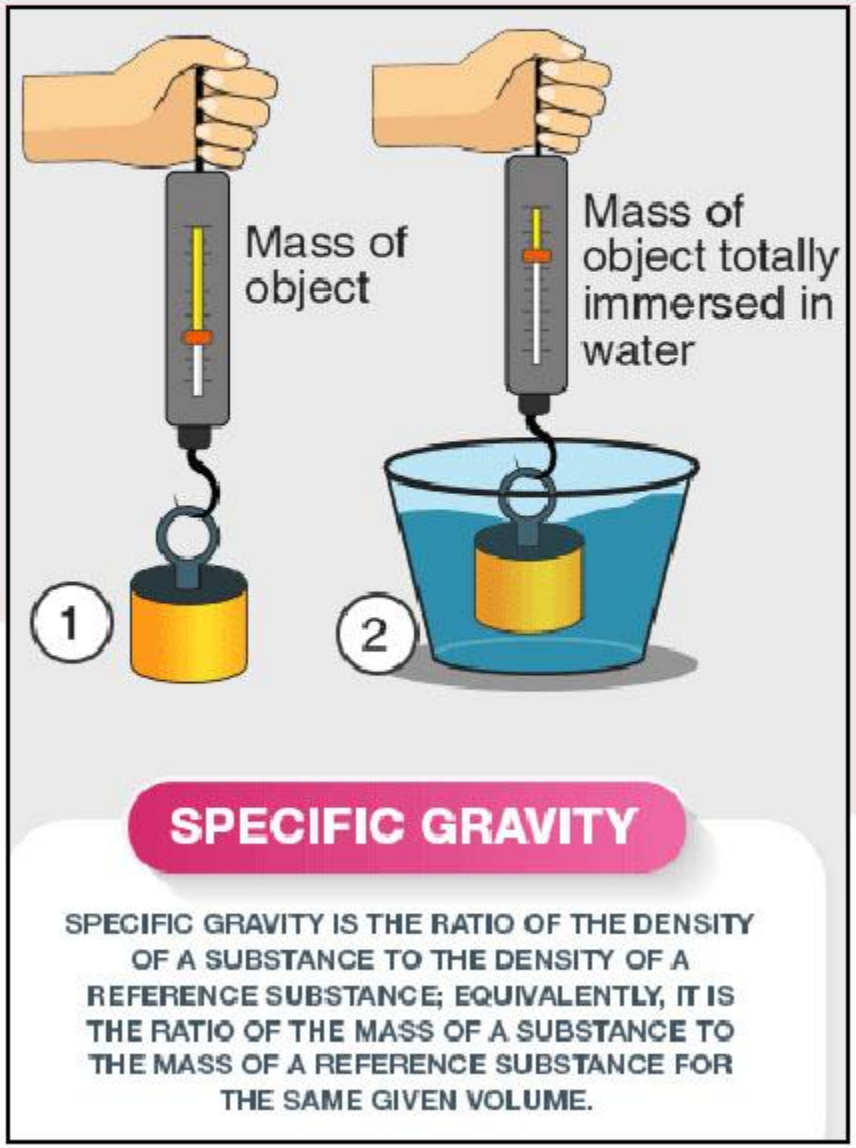
1.1.6 Specific Gravity



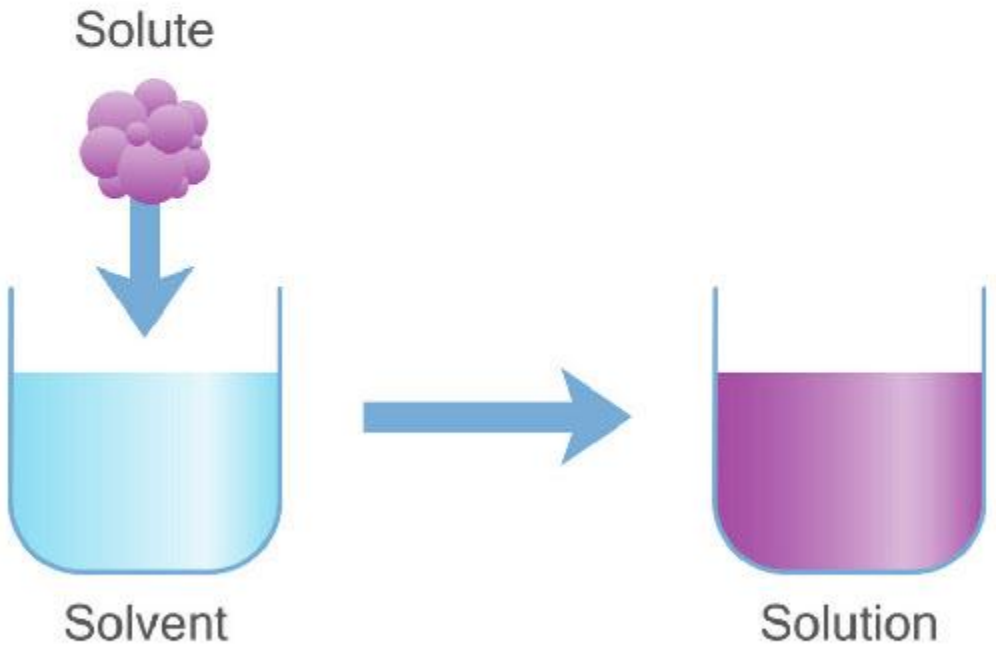
Specific gravity is the weight of a liquid as compared to an equal volume of water. Water weighs 8.33 pounds per gallon. However, since it is the standard against which all other liquids are measured, it is said to have a specific gravity of 1.

Generally speaking, a liquid that has a specific gravity greater than 1 will sink in water, whereas one with a specific gravity less than 1 will float on water. This term may help identify methods for proper cleanup of a material. Specific gravity, however, is not the sole factor in determining how a substance behaves with water. For example, some substances mix with water.

Click Box

1.1.7 Miscibility and Solubility

The terms miscibility and solubility are often used interchangeably. Miscibility refers to the ability of products to mix or form a uniform blend. Solubility refers to the ability of a product to dissolve. We usually refer to products mixing with or dissolving in water, but many chemicals can be dissolved in other solvents. Chemicals that mix in water (e.g., ethyl alcohol) are called miscible or soluble (water-soluble), while those that do not are called immiscible or insoluble. This is important to know, as the skin, eyes and mucosal linings of the nose and throat can be affected negatively by highly soluble materials.



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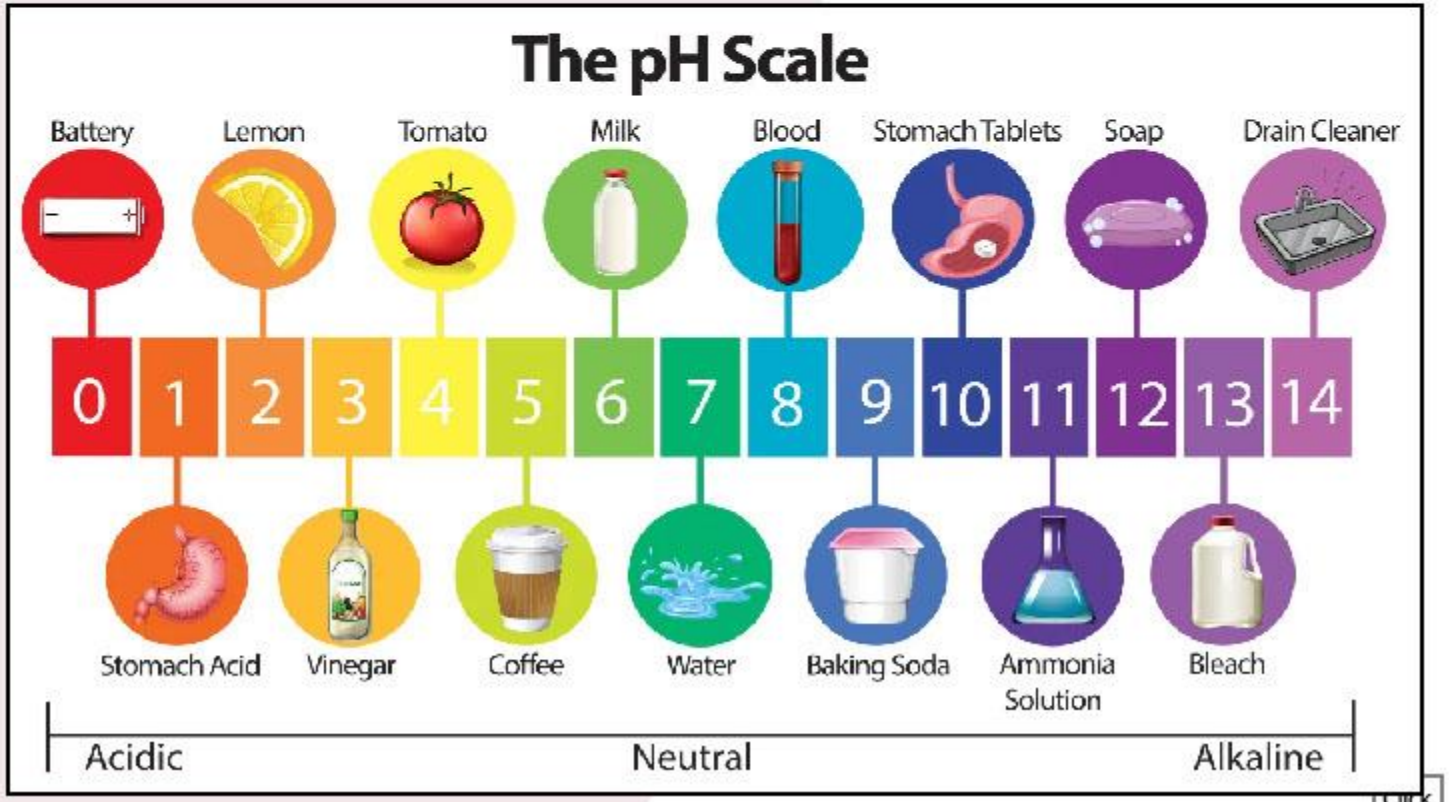
1.1.8 Potential of Hydrogen (pH)

The technical definition of pH incorporates the use of acids and bases. Acids are those compounds that release hydronium ions (H3O+1) when dissolved in water. Bases (also called caustics or alkalis) release hydroxide ions (OH-1) when dissolved in water. Students should be taught that the pH scale goes from 0 to 14, with 7 being neutral. Chemicals with a pH of 0 to 6.9 are acidic, while those with a pH of 7.1 to 14 are basic (or caustic or alkaline). However, when it comes to actually classifying corrosives, the Code of Federal Regulations, Title 40, Section 261.22 defines acids as those materials with a pH of 2 or less and bases as those with a pH of 12.5 or more.

Either way, the pH scale is a logarithmic scale, meaning each number reflects a ***ten-fold difference in corrosivity***. For example, a solution with a pH of 1 is ten times more acidic than one with a pH of 2 and a hundred times more acidic than one with a pH of 3. At the opposite end of the scale, a solution with a pH of 13 is ten times more alkaline than one with a pH of 12 and a hundred times more alkaline than one with a pH of 11.

The chart on this slide shows the pH of some common substances. These should be considered approximate values, since it's not unusual to see different values or a range of values, depending on the reference source.



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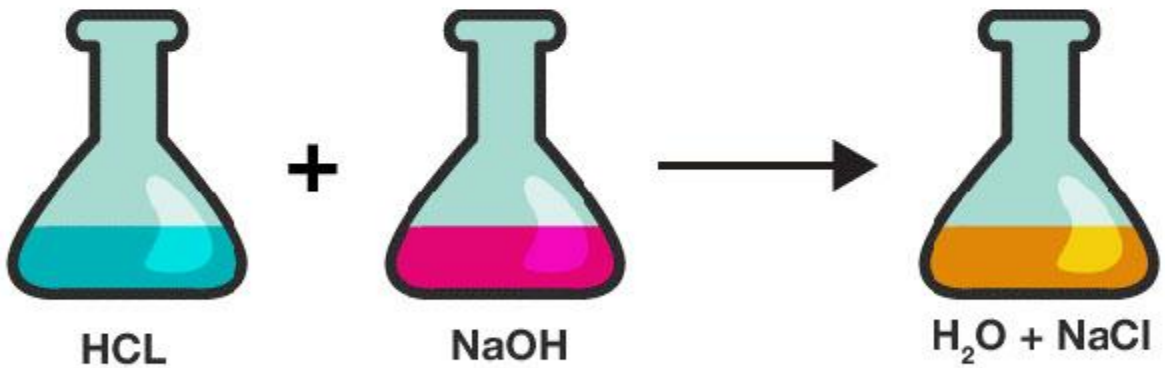
1.1.8 Potential of Hydrogen (pH)

One of the most significant differences between acids and bases is the way in which they damage human tissue. An acid in contact with the skin will cause the tissue to harden even as it eats away at that tissue, thereby limiting the damage to some degree. A base, on the other hand, will soften and dissolve the tissue, creating far more penetrating and severe injuries. In both cases, however, the damage will continue until the corrosive is thoroughly flushed from the body. And often the extent of the injury is not immediately obvious, something corrosive burns have in common with thermal burns.

NEUTRALIZATION REACTION EQUATION



ACID + BASE ⟶ H^+OH^- + SALT

Also, never mix a strong acid with a strong base; otherwise, you may get a violent neutralization reaction. Instead, if attempting to neutralize an acid, slowly mix with a weak base (such as sodium bicarbonate or potash). Conversely, if attempting to neutralize a strong base, add a weak acid such as vinegar. The byproducts of a neutralization reaction are water and some form of salt.

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1.2 Properties of Gases

Hazardous gases include both flammable gases and non-flammable gases. Even non- flammable, non-toxic gases are hazardous because they are stored and transported under pressure (compressed). If the vessel in which the gas is contained is heated, the gas will expand with the potential of rupturing the container. Also, some gases that are non-flammable and non-toxic can still displace air and thereby can be considered a simple asphyxiant.

Poisonous (or toxic) gases often have multiple hazards. Some gases may be both flammable and toxic, such as hydrogen sulfide.

1.2.1 Vapor Density

Vapor density is the relative weight of a vapor or gas compared with a similar volume of air. Air has a molecular weight of 29, but since it is the standard against which all other vapors and gases are measured, it is said to have a vapor density of 1. Vapors or gases with vapor densities greater than 1 (>1) are heavier than air and will settle in low-lying areas. Gases with vapor densities less than 1 (<1) are lighter than air. They will rise and dissipate more readily than those that are heavier than air.

A vapor is a dispersion of molecules in air from a material that is normally a solid or a liquid. All vapors are heavier than air. Gasoline vapors, for example, are almost four times heavier than air. In a gasoline spill, most of the vapors will be close to the ground and will likely accumulate in low-lying areas. Most gases are also heavier than air, with the exception of some very small compounds. Obviously, this type of property has a significant effect to employees who work in confined spaces.

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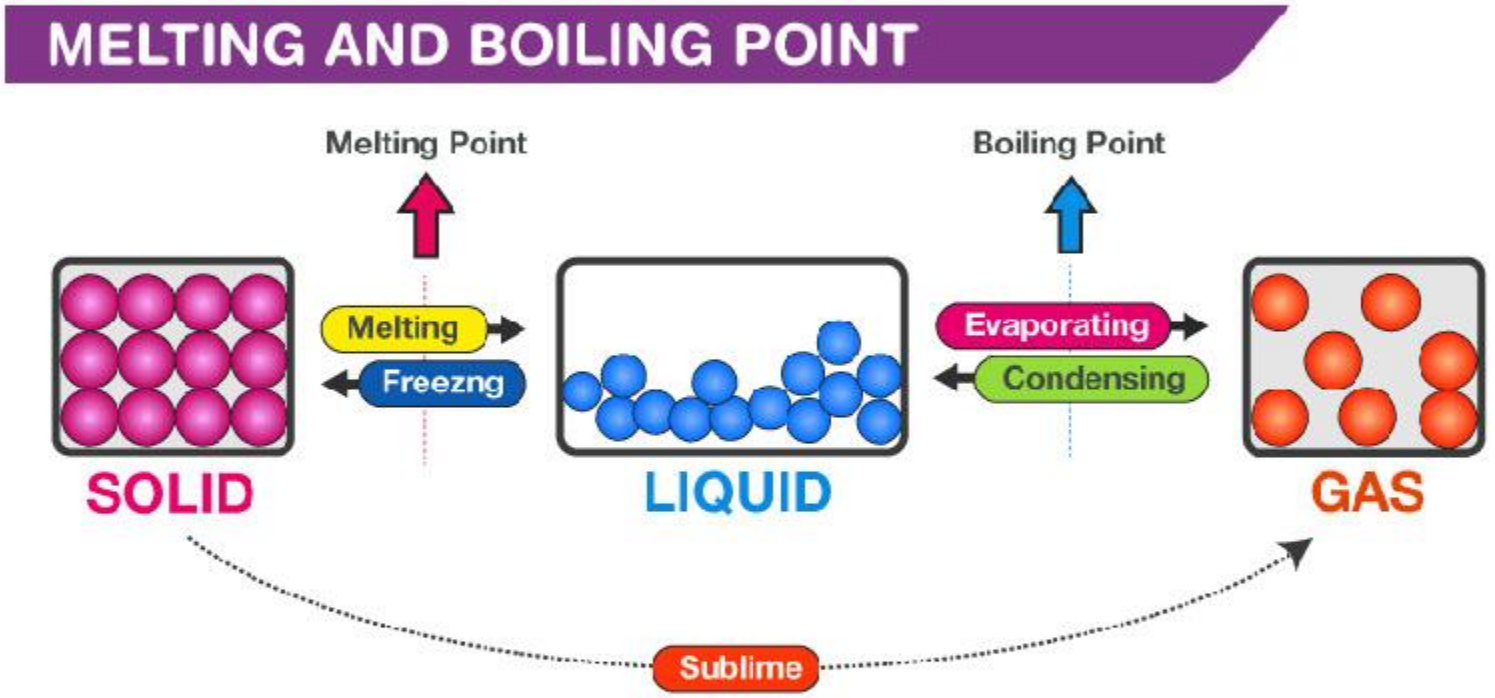
1.3 Properties of Solids



Flammable Solids are solids that readily ignite and burn vigorously. The ignition may be by friction, moisture absorption, or chemical reaction. The **melting point** is the temperature at which a solid changes to liquid. Inorganic materials usually have higher melting points than organic.

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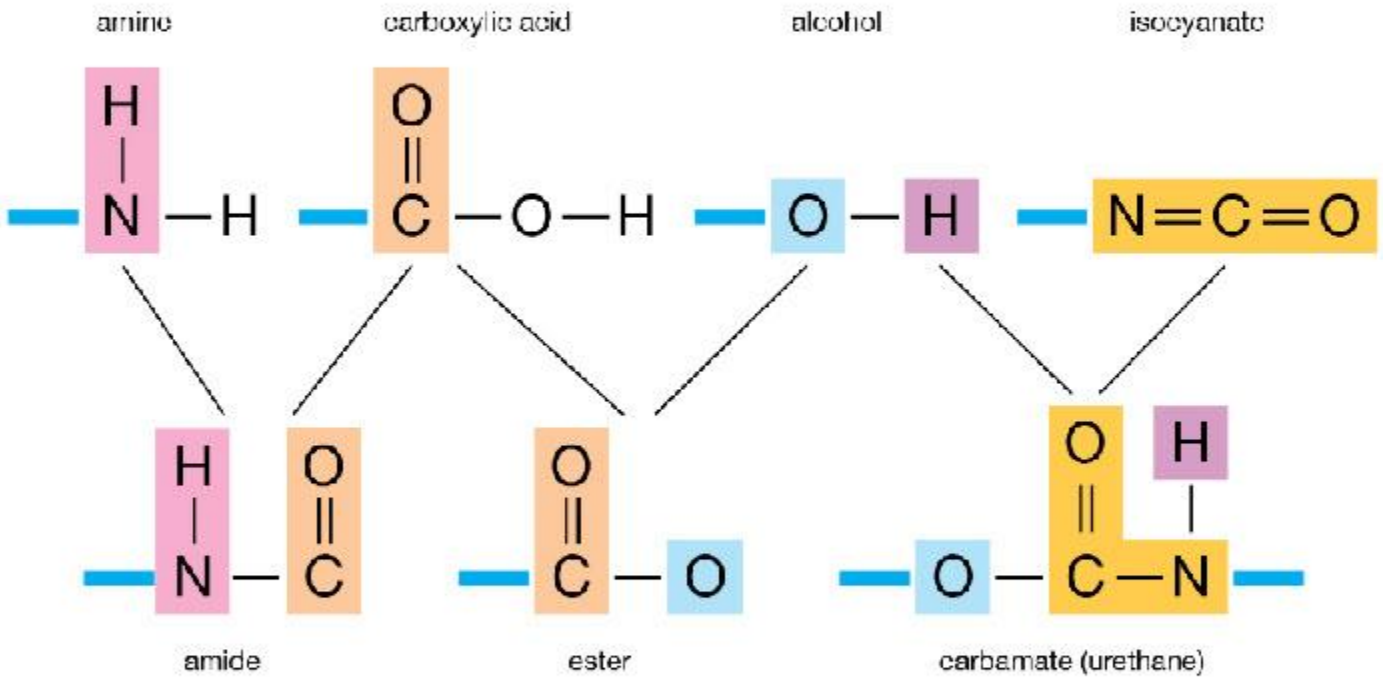
1.3.2 Polymerization

Functional groups in monomers and polymers



Polymerization is the combining of single chemical units (monomers) into chains (polymers). A material that polymerizes within a confined area, such as a closed container, can cause a serious overpressure similar to an explosion. A catalyst is a chemical that is used to speed a reaction but is not itself a part of the reaction. Catalysts can be used to control the speed of polymerization. An inhibitor is sometimes added to prevent polymerization.

Polymerization is not dangerous if conducted in a controlled manner. However, because polymers are not as dense as monomers, they take up more space. The reaction also generates heat. Heat and over-pressurization can cause catastrophic container failure in uncontrolled or runaway polymerization. An example of a controlled polymerization reaction is formation of PVC pipe or plastic.

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1.3.3 Physical State

When a substance changes in form (solid, liquid, or gas), but not in chemical composition (the elements that comprise it), it undergoes a physical change. An example is the way water, a liquid in its natural state, becomes a solid (ice) below 32˚F (0˚C) or a gas (steam) above 212˚F (100˚C). Water is still H2O in all three states, even though it has changed form and appearance.

The causative factor in physical change is temperature or pressure. Pressure is used to induce a change in state with liquefied compressed gases. Both temperature and pressure are used to transform gases into cryogenic liquids (liquids colder than-130˚F/-90˚C).

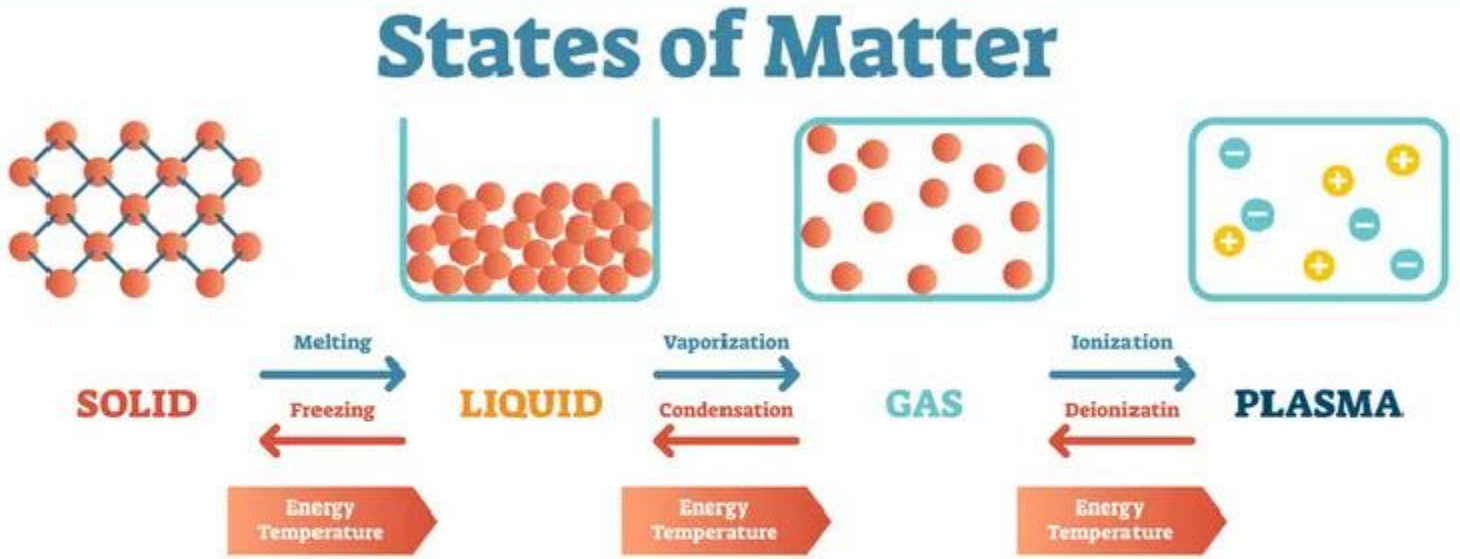
Melting is a change from solid to liquid, such as when ice melts to water. The temperature at which this happens is called the melting point. The opposite reaction, freezing, is a change from liquid to solid, such as when water becomes ice. The temperature at which this happens is called the freezing point.

Click Box

1.3.3 Physical State

The change from liquid to gas, such as when water is boiled to create steam, is called vaporization. The point of maximum vaporization (or vapor production) is called the boiling point.

The change from gas to liquid is called condensation. Steam from a hot shower condensing to leave moisture on a bathroom mirror is a good example of this.



Sublimation involves a change from the solid state to a vapor state without the material ever passing through the liquid state. As the temperature increases, so does the rate of sublimation. Sublimation is less common than the four reactions described above. However, examples of materials that sublime are dry ice (carbon dioxide) and naphthalene (used in mothballs). Deposition, a change from gas to solid, is extremely rare and lasts only for a very brief time. It can occur as a result of a nuclear blast.

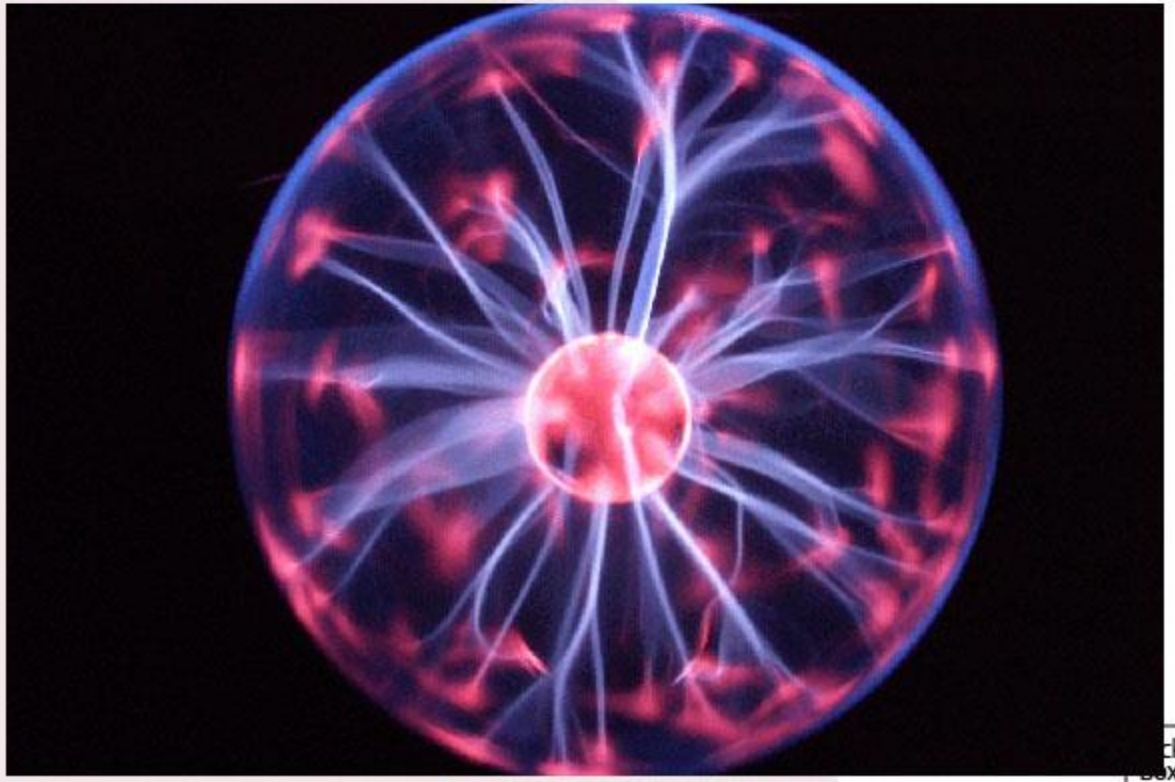
Temperature can change the viscosity of a liquid without changing its physical state. Viscous liquids are thicker liquids, like heavy oils. Thinner liquids, like water, are less viscous. Viscosity affects risk and product containment options because less viscous liquids flow more easily than viscous ones, expanding the endangered area. However, viscous liquids will flow more easily when heated.

Click Box

1.3.3 Physical State

Matter can exist in multiple states at the same incident, such as when a liquefied gas vaporizes as it escapes a breached container. It exists as a liquid inside the container and as a gas outside. Even within a container, there is often a liquid space at the bottom and a vapor space at the top. For example, fire impinging on the vapor space stresses a container far more so than fire impinging on the liquid space because the liquid helps absorb the heat, whereas vapors do not. The words gas and vapor were used interchangeably as they frequently are in the real world. For practical purposes, they mean the same thing. Technically, however, a gas is a material that exists as a gas in its normal state, whereas a vapor is something found as a liquid or solid at normal temperature and pressure.

The fourth state of matter, plasma, starts out as a gas. However, the gas is modified at the atomic level by the application of energy, often in the form of electricity. Extra energy applied to the gas causes some of the electrons to break away from the atoms, leaving an atmosphere of free electrons and positively charged particles (ions). The result is a glowing gaseous mass called plasma.



It takes a special environment to sustain plasma. Plasma exists in nature in stars which are big balls of gases whose extremely high temperatures charge the atoms that comprise the gas. However, plasma is also found in fluorescent lights and neon lights. Both contain tubes filled with gases that become plasma when the electricity is turned on.

1.4 Chemical Change

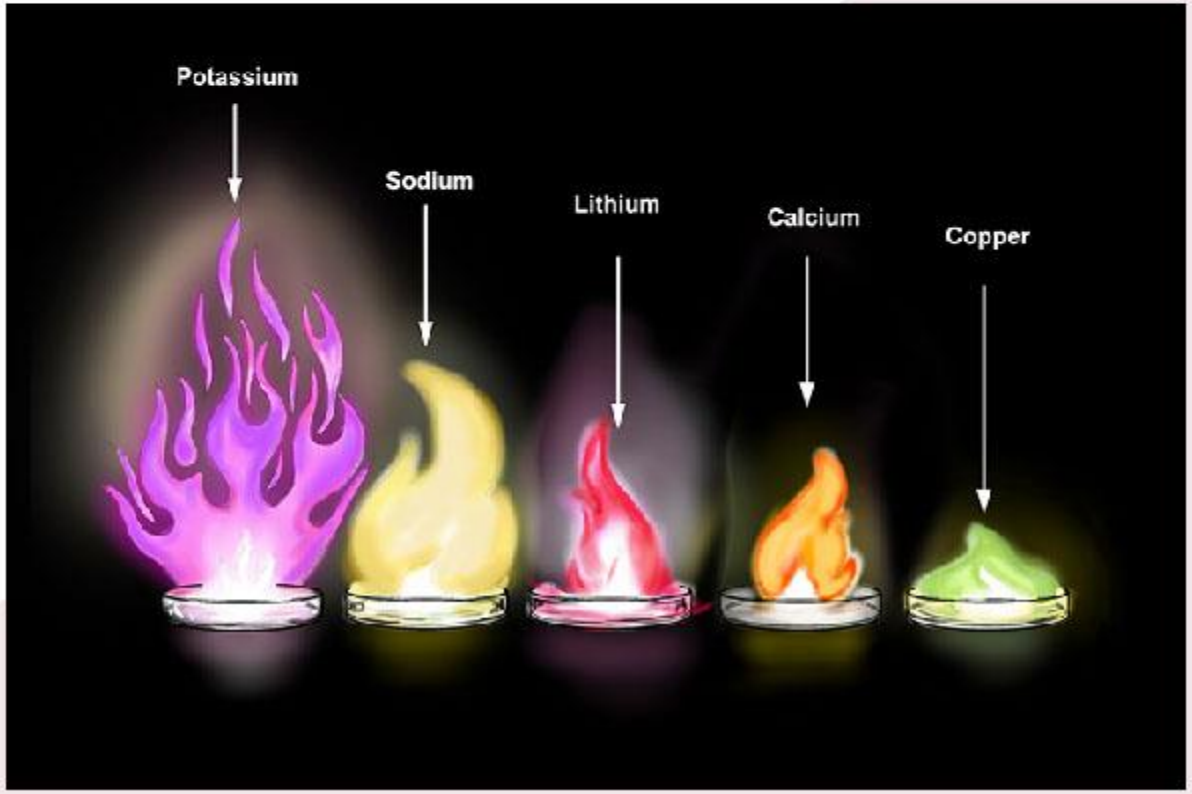
Reactivity series of metals	
Potassium	Most reactive
Sodium	
Calcium	
Magnesium	
Aluminum	
Zinc	
Iron	
Tin	
Lead	
Copper	
Silver	
Gold	
Platinum	Least reactive

Chemical reactivity describes a material's propensity to release energy or undergo change either on its own or in contact with other materials. What distinguishes chemical reactions from physical reactions is that with chemical reactions, the material undergoes a change in composition; a new substance is formed, one that has its own chemical and physical properties and hazards. There are four types of chemical reactivity: air reactivity, water reactivity, polymerization (previously reviewed), and chemical incompatibility.

Click Box

1.4.1 Air Reactivity

Materials that are air-reactive will ignite, decompose, or release energy when exposed to air. Some of these reactions can be quite violent. Air-reactive materials may also be referred to as pyrophoric. Technically, pyrophoric materials are those that react in dry air versus moist air. However, one should never assume that the word pyrophoric on a warning label, on a safety data sheet (SDS), or in a hazardous materials reference source is meant to exclude reactivity to moist air. Not everyone writing these documents will check the precise definition of a word before using it. Assume that pyrophoric materials will also react with moisture until you've determined otherwise.



Materials that are air-reactive but not water-reactive (white and yellow phosphorus, for example) may be stored under water to prevent contact with air. But when materials are also so water-reactive that they will react with moisture in the air (for instance, sodium and potassium), they must be stored under some other substance, such as an inert gas, mineral oil, or kerosene.

Click Box

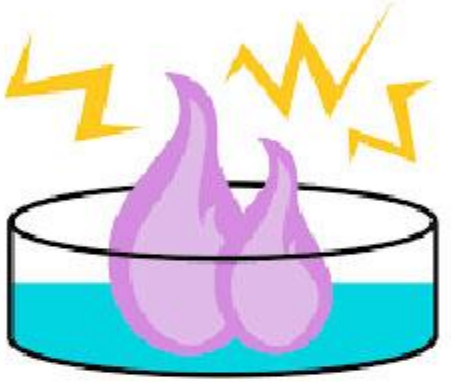
1.4.2 Water Reactivity

Water reactivity is the tendency of a material to react, or chemically change, upon contact with water. Reactions can range from mild to severe. The more reactive chemicals can release flammable gases, toxic gases, and/or corrosive solutions, generating a lot of heat in the process, a process which is called exothermic. Some materials can react explosively when exposed to water, ripping the water molecules apart to liberate oxygen. Examples of water-reactive substances include sulfuric acid, sodium, and aluminum chloride.

Water-reactivity has a big impact on how a spilled material will behave on rainy or humid days. Even on a dry day, water-reactive materials present a significant health risk when in contact with the moisture on skin, in eyes, or in the respiratory system.

Water reactivity also impacts how a fire emergency is handled. For example, Class D extinguishers can be used on a small fire involving combustible metals. A large fire may require using a defensive attack and protecting exposures instead or withdrawing to a safe distance while the incident runs its course. Using water on the burning material itself can be disastrous.

Potassium



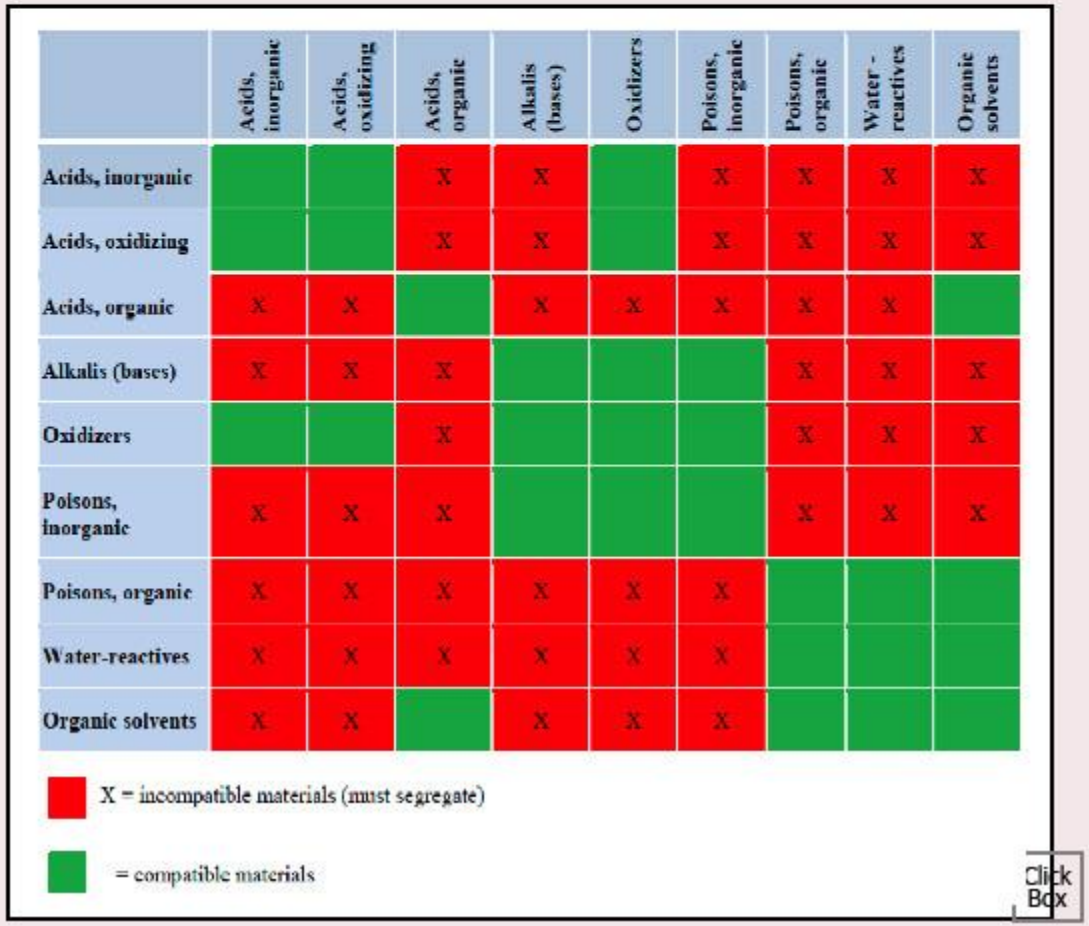
Sodium reacting with water

1.4.3 Incompatibility

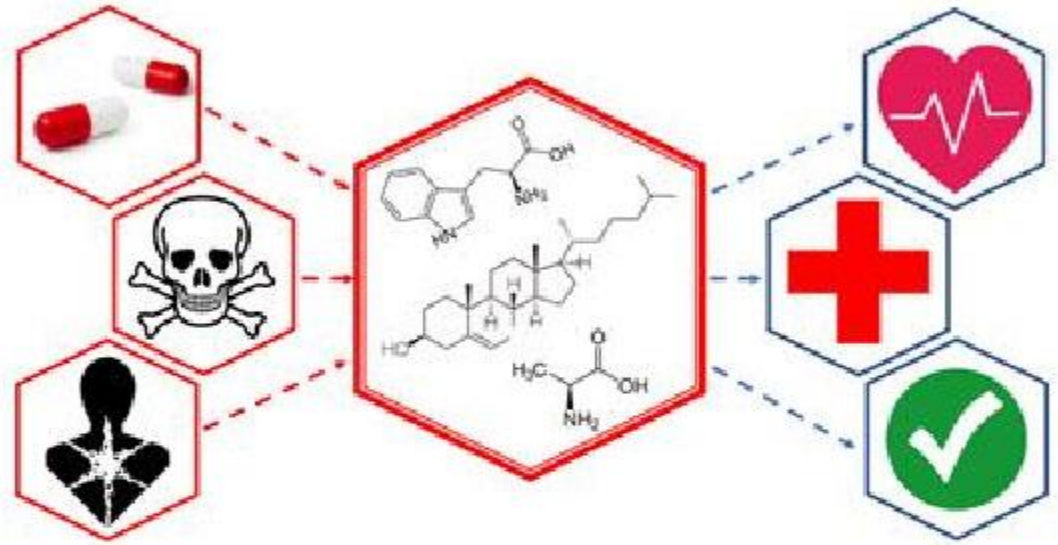
Incompatible chemicals are those that react with each other in ways that generally produce negative consequences. The reactions can range from relatively mild to catastrophic, depending on the type and quantity of chemicals involved. Acids and bases, for example, are incompatible with each other and if the two are mixed, they can generate a tremendous amount of heat. However, as discussed previously, under controlled conditions, weak corrosives can be added to neutralize a spill of the opposite pH (i.e., a weak acid added to a base or a weak base added to an acid). Doing so still involves mixing incompatible chemicals, but the reaction is less violent than one that would result from mixing strong corrosives.

Consideration should also be given to the incompatibilities with anything brought to the scene to manage an incident, including protective clothing, monitoring equipment, overpack containers, and other tools.

Some compatibility problems are not apparent right away. Rather, they show up at the next incident. For example, structural firefighting clothing contaminated with an oxidizer at one incident may burn furiously at a subsequent fire. Clothing or other equipment that cannot be adequately decontaminated must be disposed of and replaced.



2.0 Toxicology



Toxicology is the study of how chemicals affect living organisms. Almost any material, in the right quantity, can be toxic. For example, humans need water to survive. However, if too much water is ingested at any one time, a person can actually die. Knowing how a chemical affects the body is extremely important and is one of the key elements to an effective hazard communication program to be discussed later.

Click Box

2.1 Exposure and Contamination

The terms exposure and contamination are often used interchangeably, in part because a person can be both exposed and contaminated. However, the words mean different things. A contaminated person is one who has the hazardous material on his or her body, posing a risk of secondary contamination to others. Someone who is contaminated would also be considered exposed. Obviously, proper personal protective equipment can prevent exposure, even when an individual's outer garment is contaminated.

On the other hand, a person can be exposed without being contaminated. For example, a person who inhales a gas or vapor is seldom contaminated unless the concentration of gas or vapor is so heavy that it has condensed onto the person's skin, hair, or clothing. Similarly, a person can be exposed to radiation without being contaminated. A strong dose of gamma or x- ray radiation can cause tissue damage, but it doesn't make an exposed person radioactive. He or she would pose a threat to others only if a radioactive substance (e.g., powder, liquid, or gel) has contaminated his or her body.

2.1.1 Toxicological Values and Exposure Limits

When evaluating toxicity, it's necessary to use units of measure much smaller than percent by volume in air. The most common is parts per million (ppm) or parts per billion (ppb). These are straightforward representations of how much contaminant exists per million or billion units of the atmosphere. A concentration of 1% by volume in air is equal to 10,000 parts per million. This is a very useful conversion factor. Oxygen represents roughly one fifth of the normal atmosphere, so a 1% drop in oxygen is really a 5% displacement of the overall atmosphere. At the point where OSHA defines the atmosphere as being oxygen-deficient (19.5% oxygen), requiring the use of self-contained breathing apparatus, there can be as much as 70,000 ppm of a contaminant gas. Click play on the video tile to watch a short video that will help visually explain the size of 1 part per million.

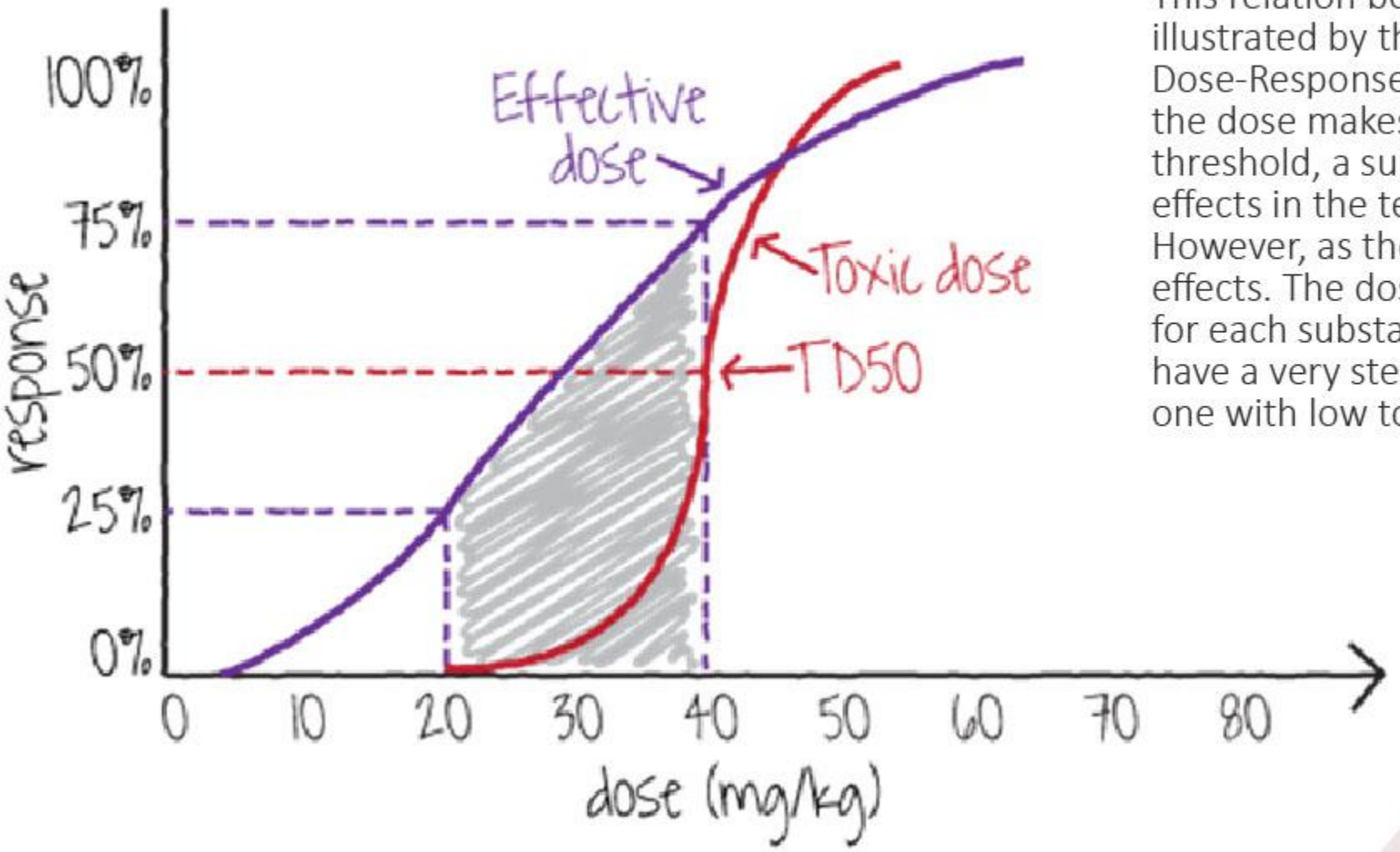
Click Box

2.1.2 Relation Between Contaminant Concentration and Oxygen Concentration

Toxicity is sometimes measured in milligrams per cubic meter (mg/m3), with one cubic meter equal to 1.3 cubic yards.) There is no easy correlation between this and either percent by volume or parts per million because milligrams per cubic meter is based on the molecular weight of the material, which is different for every substance. Milligrams per kilogram (mg/kg) measures dose in relation to a person's body weight rather than measuring the atmospheric concentration. One kilogram equals 2.2 pounds.

In all cases, the smaller the number, the more hazardous the material. It may seem unnecessary to emphasize this point, but it's easy to become confused because of the inverse relation between the dangers reflected in toxicity values versus atmospheric concentration or dose absorbed/ingested. Obviously, the more of a substance one is exposed to, the more harm it can cause. However, it's the substances that are deadly at lower concentrations that present the greatest risk.

2.1.2 Relation Between Contaminant Concentration and Oxygen Concentration

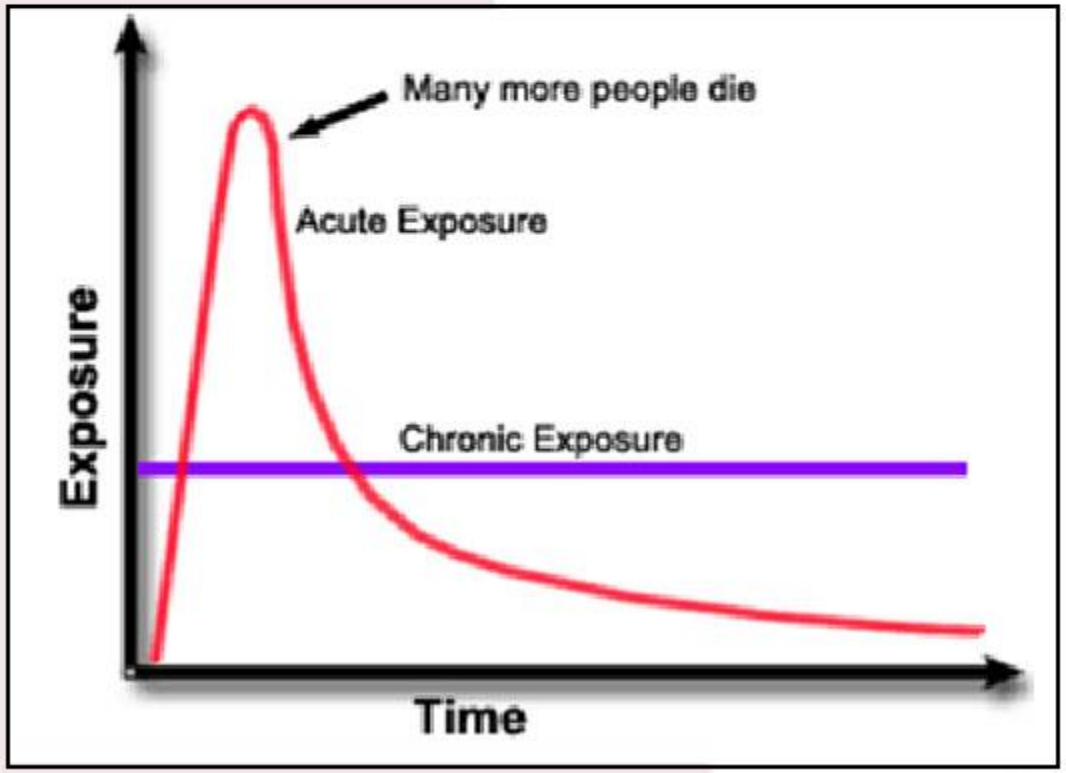


This relation between exposure and harm can be illustrated by the Dose-Response Relationship or the Dose-Response Curve. It's that old familiar saying: the dose makes the poison. Below a certain threshold, a substance won't cause detrimental effects in the test population being observed. However, as the dose increases, so do the health effects. The dose-response curve will look different for each substance. A highly toxic substance will have a very steep curve that climbs quickly, whereas one with low toxicity will have a very shallow curve.

Click Box

2.1.3 Acute vs. Chronic Effects

Acute effects from hazardous chemicals are immediate short-term effects. They are generally the biological effects of a single short-term exposure. Most chemicals affect the body in the same way; headache, dizziness, nausea and irritation of the eyes, nose, throat, lungs and/or skin. But it can also result in death. Chronic effects from hazardous chemicals are long term effects of repeated exposure. Combined acute and chronic effects are produced by some chemicals. One example is the solvent trichloroethylene. Acute effects of this substance may include those that were listed such as dizziness, drowsiness, nausea, vomiting, and blistering of skin, while it may also cause chronic effects such as liver damage and cancer. Latent effect is a special type of chronic effect, in which an adverse condition or disease arises many years after the original exposure to a hazardous substance. Certain cancers have latency periods of 20-40 years after exposure to a cancer-causing substance.



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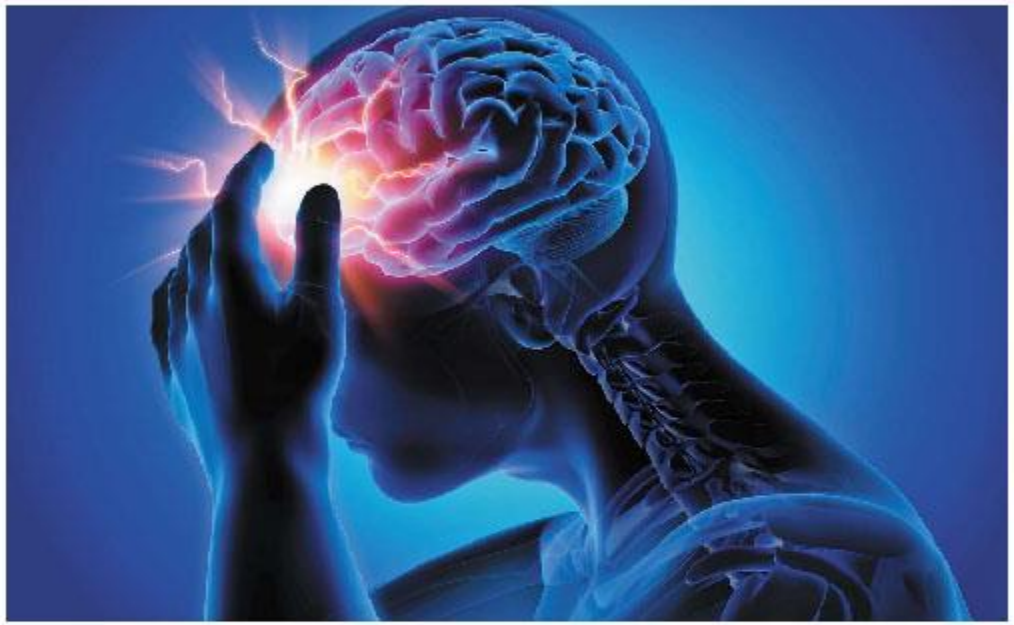
2.1.4 Local and Systemic Effects



Local effects are expressed when a chemical causes harm at its original contact point with the body, usually the skin, eyes, or lungs. A corrosive material (acid or base) may cause a skin burn which is considered a local effect. Symptoms of skin exposure may include: dryness and whitening, redness and swelling, rashes, blisters, and itching. Eye exposure may result in irritation or burning. Symptoms of respiratory tract exposure may include: headache, nose and throat irritation, increased mucus, dizziness, and disorientation. Systemic effects are expressed when chemicals pass through the original point of contact with the body and cause harm to other organ systems, such as the liver, kidneys, heart, nervous system, and muscles. The liver and kidneys are commonly affected sites when chemicals get beyond the original entry points. The liver modifies many chemicals, detoxifying many in the process. The kidneys filter impurities from blood for elimination from the body. As they perform these functions, the liver and kidneys may themselves be damaged by the chemicals. Carbon monoxide poison is an example of a systemic effect.

Click Box

2.1.4 Local and Systemic Effects

The Central Nervous System is made up of the brain and spinal cord. These organs connect with thousands of nerves, extending throughout the body, which control all sensation and activity. Brain functions can be affected by a lack of oxygen, caused by inhaling certain chemicals such as solvents or carbon monoxide. The first symptoms are typically dizziness and drowsiness, which may lead to unconsciousness. On a safety data sheet, a chemical such as this would be listed as a “CNS depressant”. Nerve function can be altered or stopped by certain chemicals which block nerve impulses, especially some pesticides and heavy metals, such as mercury and lead. The result may be loss of reflexes, loss of feeling, tremors, or even paralysis. These effects may be temporary or permanent.

Certain materials may create reproductive hazards by affecting either the female or male reproductive system or the fetus. Reproductive effects may result from exposure to certain types of chemicals, biological agents, or ionizing radiation.

Click Box

2.2 Agents

Scientists often categorize hazardous chemicals by the type of chemical or by the effects a chemical would have on people exposed to it. Click the circles inside of the petri dish to review the types of agents commonly found in toxicology.

1. Carcinogen

A ***carcinogen*** is a substance that causes cancer. Many substances are known or suspected carcinogens. It is important to note that it may take only one very small exposure to get cancer, yet the effects of exposure may not appear for years. Examples of known or suspected carcinogens include asbestos, vinyl chloride, benzene, some pesticides, and many of the materials used to manufacture plastics.

CLICK THE CIRCLES TO REVEAL A TYPE OF AGENT

2.2 Agents

Scientists often categorize hazardous chemicals by the type of chemical or by the effects a chemical would have on people exposed to it. Click the circles inside of the petri dish to review the types of agents commonly found in toxicology.

2. Mutagen

A ***mutagen*** is a chemical which directly affects the genetic material in human cells, causing changes in the cells called mutations. Mutagens can present two kinds of hazards: reproductive damage and cancer. Reproductive damage can affect both men and women. Exposure to a mutagen may damage or kill sperm or egg cells, which may prevent conception. If conception does occur, there may be a miscarriage or a fetus with genetic defects. Many mutagens are also carcinogens.

CLICK THE CIRCLES TO REVEAL A TYPE OF AGENT

2.2 Agents

Scientists often categorize hazardous chemicals by the type of chemical or by the effects a chemical would have on people exposed to it. Click the circles inside of the petri dish to review the types of agents commonly found in toxicology.

3. Reproductive Toxin

A ***reproductive toxin*** is a chemical which interferes with the reproductive system. It may, for example, prevent conception by causing menstrual problems in women, or lowered sperm count or sperm motility in men. In either, sex, it may cause decreased sex drive.

CLICK THE CIRCLES TO REVEAL A TYPE OF AGENT

2.2 Agents

Scientists often categorize hazardous chemicals by the type of chemical or by the effects a chemical would have on people exposed to it. Click the circles inside of the petri dish to review the types of agents commonly found in toxicology.

4. Teratogen

A ***teratogen*** (Latin for "monster-like") is a chemical that affects the developing fetus. The fetus may be more sensitive to some chemicals than its pregnant mother and may be exposed to chemicals through the mother's bloodstream. The fetus may suffer damage even if the mother experiences no problems. Reducing fetal exposure to chemicals is especially important. A drug called thalidomide was used in the late 1950s to ease morning sickness of women during pregnancy. Their children were born with severe deformities, including arms or legs that did not form. They were often referred to as 'flipper babies' and subsequently, the use of this drug was discontinued.

CLICK THE CIRCLES TO REVEAL A TYPE OF AGENT

2.2 Agents

Scientists often categorize hazardous chemicals by the type of chemical or by the effects a chemical would have on people exposed to it. Click the circles inside of the petri dish to review the types of agents commonly found in toxicology.

5. Biological Agents

Biological agents cause infections that are of particular concern for pregnant women. Most of these are viral infections such as rubella (German measles), varicella (chicken pox) or human parvovirus B19.

CLICK THE CIRCLES TO REVEAL A TYPE OF AGENT

2.2 Agents

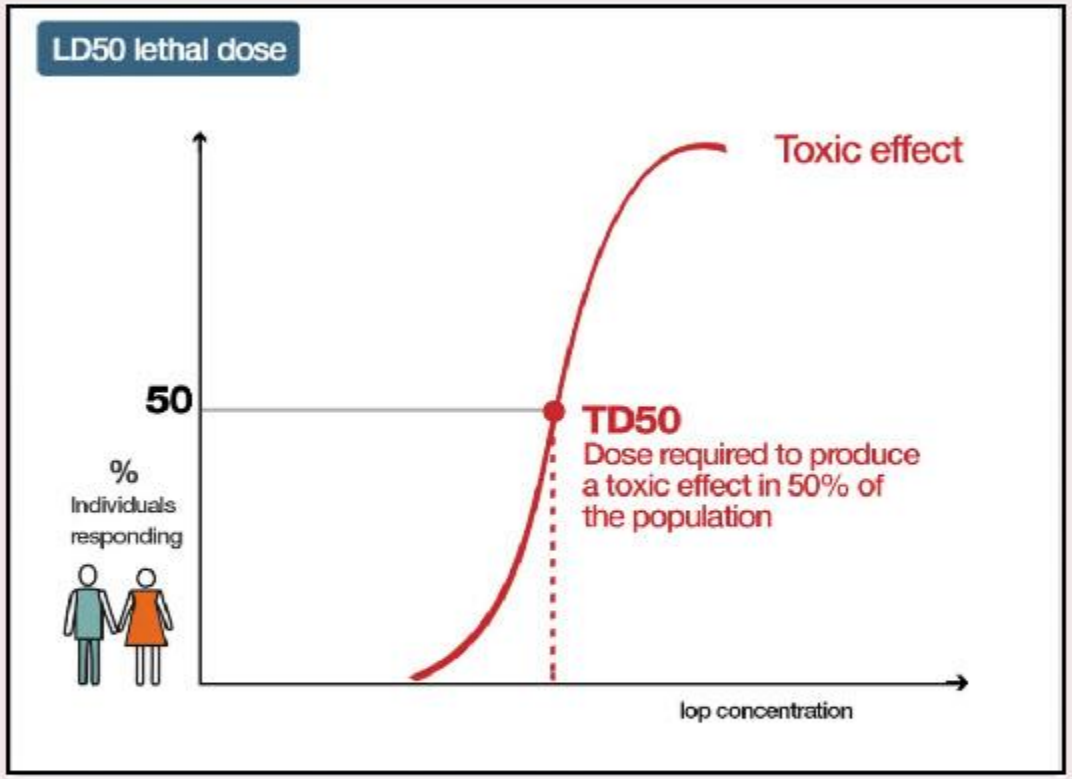
Scientists often categorize hazardous chemicals by the type of chemical or by the effects a chemical would have on people exposed to it. Click the circles inside of the petri dish to review the types of agents commonly found in toxicology.

6. Ionizing Radiation

Ionizing radiation can cause impairment of testicular and ovarian function and cause gene mutation and chromosomal damage. This damage is usually related to a high dose of ionizing radiation. Individuals who work with ionizing radiation are trained how to keep exposure as low as possible. Given proper precautions, most pregnant women can work with ionizing radiation without harm to themselves or their unborn child.

CLICK THE CIRCLES TO REVEAL A TYPE OF AGENT

2.3 Lethal Dose (LD) and Lethal Concentration (LC)



These terms reflect the exposure required to kill a given percentage of a test population. The term lethal dose is used for solids and liquids and is expressed in milligrams per kilogram (mg/kg) of body weight. Lethal concentration is used when describing gases and vapors and is usually expressed in parts per million (ppm) or milligrams per cubic meter (mg/m3). Lethal concentration is independent of body weight.

The subscript notation refers to the percentage of test population affected. LD50 or LC50 is the number most often cited in reference sources. It means that 50% of the test population died from exposure to the specified dose or concentration. LD100 or LC100 means that 100% died. LDlo or LClo is the exposure that kills the first individual in a test study.

These numbers are derived from laboratory studies on animals, so they're only an approximation of how humans may be affected. And the information is very limited. If the number cited in reference sources is the LD50 or LC50, there's no way to tell what exposure levels killed the first 49% of the test population. It's the first fatality (the LDlo or LClo) that matters most. Additionally, the data shows only fatalities, with no regard for debilitating health effects suffered by the survivors. It also shows only those fatalities that occurred within the test period (typically 14 days). So, if test subjects die a month later as a direct result of the exposure, they're not factored into the statistic. Much of this information is written in terms that only medical personnel or toxicologists can understand.

Click Box

2.4 Occupational Exposure Limits

Exposure limits, with the exceptions of the legally enforceable PELs, are guidelines and are useful when taking a risk-based approach, but it is prudent to avoid any unnecessary exposure through the proper use of engineering controls, administrative controls and personal protective equipment. Oftentimes, different exposure limits for the same chemicals are published. Each of the organizations that publish these figures has its own method for developing the exposure values, so some may be more conservative than others. NASP cannot emphasize enough, for the purpose of keeping employees safe, it is appropriate to use the lowest published exposure limit.

OSHA®

PEL | Permissible Exposure Limits

lick Box

2.4.1 Permissible Exposure Limit

PEL stands for Permissible Exposure Limits. This is an OSHA term and represents the maximum allowable exposure for a specific time period, typically an 8-hour day. The majority of OSHA PELs are based on recommendations that were made almost 40 years ago. The most significant effort to update the PELs occurred in 1989 when OSHA attempted to update many of its outdated PELs and to create new PELs for other substances in a single rulemaking covering general industry PELs. After public notice and comment, the Agency published a general industry rule that lowered PELs for 212 chemicals and added new PELs for 164 more. OSHA presented analyses of the risks associated with these chemicals, as well as the analyses of the economic and technological feasibility of the proposed limits for these chemicals. But the final rule was challenged by both industry and labor groups. The 1989 PEL update was vacated by the Eleventh Circuit Court of Appeals because it found that *"OSHA had not made sufficiently detailed findings that each new PEL would eliminate significant risk and would be feasible in each industry in which the chemical was used."*

Therefore, even though the laws of this country are expressed in the OSHA published PELs, it is well known that they are inadequate and outdated. An employer that chooses to comply with PELs that are higher than other published TWAs is choosing to risk the health of their employees.

Click Box

2.4.2 ACGIH Limits

The most widely accepted figures are from the American Conference of Governmental Industrial Hygienists (ACGIH). TLV stands for Threshold Limit Value. It is an occupational exposure limit which is the airborne concentration of a material that nearly all persons can be exposed day after day without adverse effects.

TWA stands for Time Weighted Average which is the TLV related to a specific time of exposure. The time of exposure is usually an 8-hour workday. If it is other than 8 hours, that time is specified.

STEL stands for Short Term Exposure Limit, which is based on a specific time period, often a 15-minute exposure, for a maximum of 4 times per day, with a minimum of 1 hour between exposures, provided the TLV and TWA are not exceeded.

C stands for Ceiling Limit which is the maximum concentration limit of potentially harmful substances, or its upper value to which an employee may be exposed.

ACGIH®

Defining the Science of Occupational and Environmental Health®

Contaminant	Permissible Exposure Limits (all values in mg/m³)					
	Cal-OSHA*		China**		Vietnam***	
	8-Hour TWA	STEL	PC-TWA	STEL	PC-TWA	STEL
Acetone (CAS# 67-64-1)	1200	1780	300	450	900	1000
Methyl ethyl ketone (MEK) (CAS# 78-93-3)	590	885	300	600	150	300
Cyclohexane (CAS# 110-82-7)	1050	-	250	-	500	1000
Ethyl Acetate (CAS# 141 78 6)	1400	-	200	300	-	-
Toluene (CAS# 108-88-3)	37	560	50	100	100	300
Xylene (CAS# 1330-20-7)	435	655	50	100	100	300

*California Occupational Health & Safety Administration, Table AC-1 (2015)
** GBZ 2.1-2007 Occupational exposure limits for hazardous agents in the workplace Chemical hazardous agents
*** No. 3733/2002/QD-BYT – Occupational exposure standards of Vietnam

TWA = Time Weighted Average
STEL = Short Term Exposure Limit
" " Indicates no exposure limit has been established

2.4.3 Immediately Dangerous to Life or Health

IDLH values were initially developed as part of a joint project by NIOSH and OSHA as a tool for selecting respirators in the workplace. As a safety margin, IDLH values were based on effects that might occur from a 30-minute exposure, but it was not meant to imply that employees should stay in the environment without proper protective equipment any longer than necessary. Instead, every effort should be made to exit immediately. IDLH should be thought of as an SCBA low-air alarm. It should be considered as a window for escape, not a window for squeezing in additional mitigation measures in the time remaining. Note that the IDLH will always be a higher number than the PEL because it is based on 30 minutes rather than a typical eight-hour day.

Also, the lowest level of protection in an IDLH atmosphere, would be Level B, which would include an SCBA or other supplied air. An air purifying respirator such as a cartridge or canister type, would not be sufficient, as the amount of contaminant in the air at IDLH level would quickly saturate the filter, breakthrough would occur, and exposure would be imminent.

2.5 Routes of Entry

Hazardous materials can enter the body through four routes of entry:

1. ***Inhalation*** is the most hazardous (and most common) route of entry because the lungs are so vulnerable to damage and because chemicals that enter the body through the lungs can be rapidly absorbed into the bloodstream and transferred to other organs or body systems. Increasing the exposure potential is the greater surface area of the lungs (approximately 900 square feet for the average person as compared to an average of 20 square feet surface area for the skin).

2. ***Absorption*** can occur through direct contact between a hazardous material (solid, liquid, or gas) and the skin or eyes. The eyes are particularly susceptible to absorption, as are parts of the body rich in hair follicles (e.g., scalp, underarm, and genital areas). Some hazardous materials are strictly a contact hazard, causing harm at the injury site only. Others can penetrate intact skin and be absorbed directly into the bloodstream. If skin is moist as it may be from sweating, it increases the risk of absorption.

3. ***Ingestion*** occurs most often due to poor hygiene when eating, drinking, or smoking before thoroughly washing one's hands after an exposure.

4. ***Injection*** can occur through a cut, scratch, pressurized air, or puncture wound from a contaminated object.

Click Box

2.6 Risk Factors

The health effects of most chemicals are fairly predictable. However, when two or more chemicals are involved, the synergistic effect can produce dramatically different signs and symptoms. Synergism is also a concern when employees have other injuries besides chemical exposure. The combination can be far more serious than either condition alone.

Generally, the more toxic a substance is, the more dangerous it is. However, other toxicological risk factors must be considered for an accurate hazard assessment:

- ***From of the material:*** Gases and vapors are the most hazardous due to their mobility and the inhalation hazard. Solids are generally the least dangerous. However, solids in a finely divided state (e.g., dusts and powders) can also be an inhalation and an explosion hazard.

- ***Dose (or concentration) to which an employee is exposed:*** All chemicals are toxic to some degree, even if toxicity is not the primary hazard. Dose makes the poison. A large exposure to a material with low toxicity can be just as harmful as a small exposure to a highly toxic material.

Click Box

2.6 Risk Factors

- *Duration and frequency of exposure*
- ***Gender:*** Females are more susceptible to teratogenic and mutagenic substances if pregnant (e.g., lead, formaldehyde, PCBs, and benzene). Males are more susceptible to toxins that target rapidly growing sperm cells (e.g., lead, ethylene dibromide, and hexane.)
- ***Age:*** In general, young children and the elderly are more susceptible to harm from chemical exposures. However, there are times when older persons have an advantage due to their slower metabolism.
- ***Individual susceptibilities:*** (e.g., allergies or pregnancy).
- ***State of health:*** Illness or poor health can make a person more susceptible to chemical exposures and can mask symptoms of exposure.

Once an exposure does occur, another factor that affects the degree of risk is whether the victim receives prompt, thorough, and appropriate decontamination, and follow-up medical care.

2.6.1 Chemical Terms and Concepts Conclusion

Knowing chemical and toxicological terms and concepts is vital to understand how materials behave and ultimately affect the body. After reviewing this section, the student should have a good understanding of these concepts and the knowledge to teach this subject matter to your employees. It is NOT an easy task. NASP recommends creating a “cheat sheet” of key chemical and toxicological terms and concepts that explains their meaning in basic, easy-to-understand language and placing these sheets along with SDSs in your Right-to-Know (and Understand) workstation. Now, let’s discuss more on the Hazard Communication Standard.

Click Box

3.0 Hazard Communication: Part I

To ensure chemical safety in the workplace, information about the identities and hazards of the chemicals must be available and understandable to employees. The HAZCOM standard was originally called the “Employee Right to Know” standard because it established the right of employees to know the hazards from workplace chemicals to which they may be exposed. One shortfall of the original standard was that employers felt justified to provide hazard information to employees without teaching the chemical terms and concepts necessary to understand this information.

The HAZCOM standard was updated in 2012 with some very significant changes, so it is imperative that the written program and employee training is up-to-date. The standard requires chemical manufacturers and importers to evaluate the hazards of the chemicals they produce or import and prepare labels and safety data sheets to convey the hazard information to their downstream customers. All employers must have labels and safety data sheets for their exposed employees, and train them to handle the chemicals appropriately.

3.0 Hazard Communication: Part I

The Hazard Communication Standard (HCS) is aligned with the Globally Harmonized System of Classification and Labeling of Chemicals known as the GHS. This provides a universal and coherent approach to classifying chemicals and communicating hazard information on labels and safety data sheets, which improves the quality and consistency of hazard information in the workplace, making it safer for employees by providing easily understandable information on appropriate handling and safe use of hazardous chemicals. The GHS is used internationally, so OSHA's adoption of it brings the US in line with other nations.

The Workplace Hazardous Materials Information System (WHMIS) is Canada's national hazard communication standard. The key elements of the system are hazard classification, cautionary labelling of containers, the provision of safety data sheets, and worker education and training programs.

With the incorporation of the Globally Harmonized System of Classification and Labelling for chemicals (GHS) in WHMIS, the hazard classification and communication requirements of WHMIS have been aligned with those used in the United States.

Click Box

3.1 HAZCOM Hazard Evaluation

An evaluation of chemical hazards by the chemical manufacturers and importers must be performed considering the available scientific evidence concerning such hazards. The hazard determination provisions of the HazCom Standard (HCS) have specific criteria for each health and physical hazard, along with detailed instructions for hazard evaluation and determinations as to whether mixtures or substances are covered. It also establishes both hazard classes and hazard categories for most of the effects. The classes are divided into categories that reflect the relative severity of the effect.

OSHA has included the general provisions for hazard classification in paragraph (d) of the rule, and added extensive appendixes, including Appendix A that addresses the criteria for each health or physical effect.

Click Box

3.2 Labeling

The HCS defines label as "an appropriate group of written, printed or graphic information elements concerning a hazardous chemical that is affixed to, printed on, or attached to the immediate container of a hazardous chemical, or to the outside packaging".

The chemical manufacturers and importers must provide a label that includes: the product identifier, supplier information, and the signal word, pictogram, and hazard statement for each hazard class and category. Precautionary statements must also be provided.

Click Box

3.2 Labeling

Labels must be legible and in English. There is no specific requirement to provide hazard information in the language of employees who do not speak English but since the intent of the standard is to make available hazard information, one must plan to provide this information to all employees. For example, one may require the services of a translator if the employees do not speak English or provide the use of bilingual labels.

There are two distinct types of labeling addressed in the standard. There is labeling for materials leaving the workplace (i.e. shipping) and labeling for materials to be used in the workplace known as in-house labeling or workplace labeling. Both forms of labeling must be in accord with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) in order to meet OSHA requirements.

Click Box

3.2 Labeling

Labels must be prominently displayed on each hazardous chemical container or readily available in the work area. Some exemptions include pipes or piping systems and some portable containers. Portable containers into which hazardous chemicals are transferred from labeled containers do not require a label if they are intended only for the immediate use of the employee who performs the transfer. However, this may present a serious problem since an employee may have to put the container down to perform another task or for whatever reason may fail to empty it. In this case, this exemption would not apply, since other employees could be exposed to that hazardous chemical without the protection intended by HCS.

Employers cannot remove or deface existing labels on incoming containers of hazardous chemicals, unless the container is immediately marked with the required information. If employees may be dependent on these interim labels for the necessary hazard information, they should be trained to understand them.

It is imperative that employees know not to open the container or use the chemical if the label is either missing or unclear as to the hazards of the material. Since a hazard warning label is not intended to be the sole or most complete source of hazard information, employees should be instructed to refer to the SDS that is to be made available to them for further details about the hazardous chemical.

Click Box

3.2 Labeling

Employees who work with hazardous chemicals should be instructed on how to read the important components of a label which are described below. Let's take a look at the six elements of a GHS-compliant label:

CLICK THE CIRCLES TO REVEAL THE LABEL ELEMENTS

1. Product Identifier

The product identifier is the name or number used on the label and on the SDS. It can be a chemical name, a product name, or some other unique identifier that allows an employee to locate the SDS quickly when necessary.

3.2 Labeling

Employees who work with hazardous chemicals should be instructed on how to read the important components of a label which are described below. Let's take a look at the six elements of a GHS-compliant label:

1

2-Propanol

2

DANGER

6

3

- **Highly flammable liquid and vapor.**
- **Causes mild skin irritation.**
- **Causes serious eye irritation.**
- **May cause drowsiness or dizziness.**

4

Keep away from heat/sparks/open flames/hot surfaces. - No Smoking. Avoid breathing dust/ fume/gas/mist/vapours/spray. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. May be harmful if absorbed through skin. Causes skin irritation. Causes eye irritation. May be harmful if swallowed.

5

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CLICK THE CIRCLES TO REVEAL THE LABEL ELEMENTS

2. Signal Word

Signal words are used to indicate the relative level of severity of hazard and to alert the employee to a potential hazard, determined by the hazard class and category of the chemical. The signal words used are to be either:

- "Danger" is used for the more severe hazards
- "Warning" is used for less severe hazards

When the signal word "Danger" appears, the signal word, "Warning" should not appear.

3.2 Labeling

Employees who work with hazardous chemicals should be instructed on how to read the important components of a label which are described below. Let's take a look at the six elements of a GHS-compliant label:

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5

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CLICK THE CIRCLES TO REVEAL THE LABEL ELEMENTS

3. Hazard Statement

A hazard statement is a standardized phrase assigned to a specific hazard class and category. It is used to describe the nature of the hazard(s) of a chemical, including, where appropriate, the degree of hazard. This may include statements such as "Highly Flammable", "Unstable Explosive", or "Toxic if Inhaled".

3.2 Labeling

Employees who work with hazardous chemicals should be instructed on how to read the important components of a label which are described below. Let's take a look at the six elements of a GHS-compliant label:

CLICK THE CIRCLES TO REVEAL THE LABEL ELEMENTS

4. Precautionary Statement

A precautionary statement is a standardized phrase that describes recommended measures to be taken to minimize or prevent adverse effects resulting from exposure to a hazardous chemical, or improper storage, handling, or disposal of a hazardous chemical. The statements are linked to each hazard class and category. Examples include, "Store in a locked container" and, "Wear protective gloves and clothing".

3.2 Labeling

Employees who work with hazardous chemicals should be instructed on how to read the important components of a label which are described below. Let's take a look at the six elements of a GHS-compliant label:

1

2-Propanol

2

DANGER

3

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- **Causes serious eye irritation.**
- **May cause drowsiness or dizziness.**

4

Keep away from heat/sparks/open flames/hot surfaces. - No Smoking. Avoid breathing dust/ fume/gas/mist/vapours/spray. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. May be harmful if absorbed through skin. Causes skin irritation. Causes eye irritation. May be harmful if swallowed.

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5. Supplier Identification

This contact information includes the name, address, and phone number of the chemical manufacturer, importer, or other responsible party.

CLICK THE CIRCLES TO REVEAL THE LABEL ELEMENTS

3.2 Labeling

Employees who work with hazardous chemicals should be instructed on how to read the important components of a label which are described below. Let's take a look at the six elements of a GHS-compliant label:

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6. Pictograms

Under HCS, a pictogram is a symbol on a white background with a red border that is intended to convey specific information about the hazards of a chemical. The pictograms that appear on the label are determined by the chemical's hazard classification. It is important to remember that many chemicals qualify for multiple pictograms.

There are nine pictograms under the GHS to convey the health, physical and environmental hazards. The Hazard Communication Standard (HCS) requires eight of these pictograms, the exception being the environmental pictogram, as environmental hazards are not within OSHA's jurisdiction.

CLICK THE CIRCLES TO REVEAL THE LABEL ELEMENTS

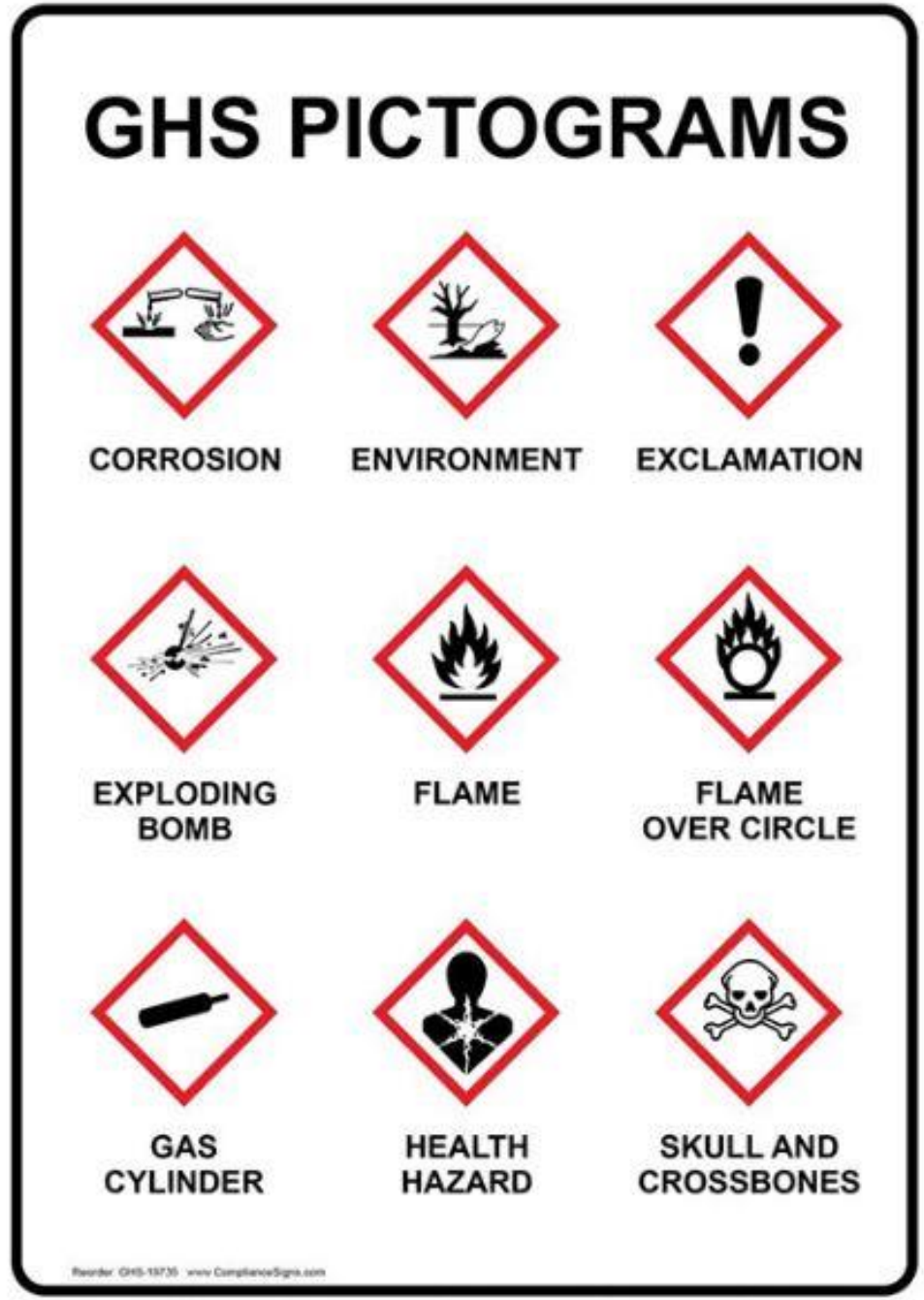
3.3 HCS Pictograms and Hazards

There are nine pictograms under the GHS to convey the health, physical and environmental hazards. The Hazard Communication Standard (HCS) requires eight of these pictograms, the exception being the environmental pictogram, as environmental hazards are not within OSHA's jurisdiction. Click on the hazard pictogram to learn about their corresponding hazards.

Corrosion

- Causes skin corrosion and burns
- Can cause eye damage
- Corrosive (destructive) to metals

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



3.3 HCS Pictograms and Hazards

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Environment

- Signifies aquatic toxicity
- Non-mandatory

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS

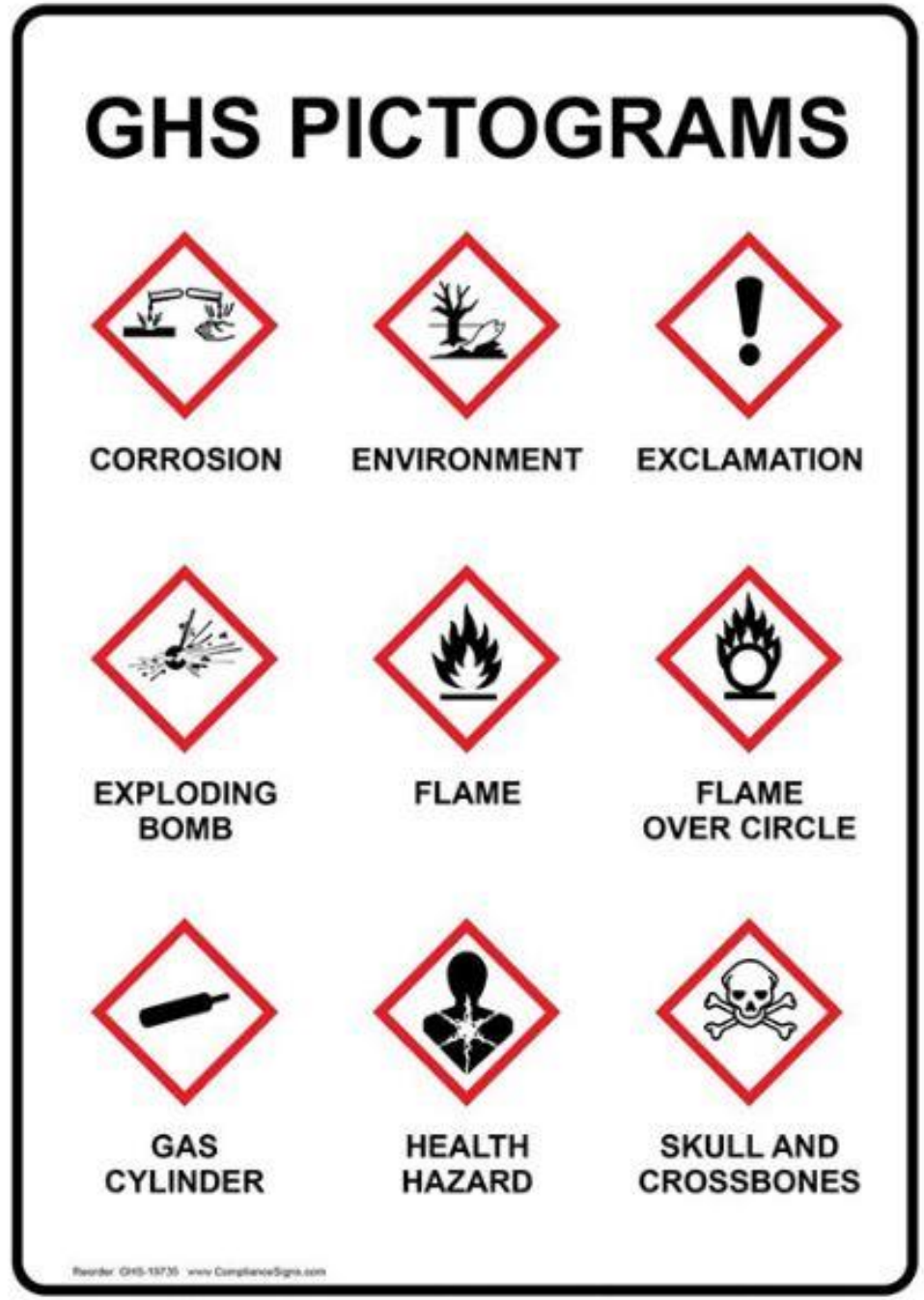
3.3 HCS Pictograms and Hazards

There are nine pictograms under the GHS to convey the health, physical and environmental hazards. The Hazard Communication Standard (HCS) requires eight of these pictograms, the exception being the environmental pictogram, as environmental hazards are not within OSHA's jurisdiction. Click on the hazard pictogram to learn about their corresponding hazards.

Exclamation

- Irritant: irritates the skin or eyes
- Skin sensitizer: which is an allergic response following skin contact
- Acute toxicity: which may be fatal or cause organ damage from a single short-term exposure
- Narcotic effects like drowsiness, lack of coordination, and dizziness
- Respiratory tract irritation
- Hazardous to ozone layer (non-mandatory)

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



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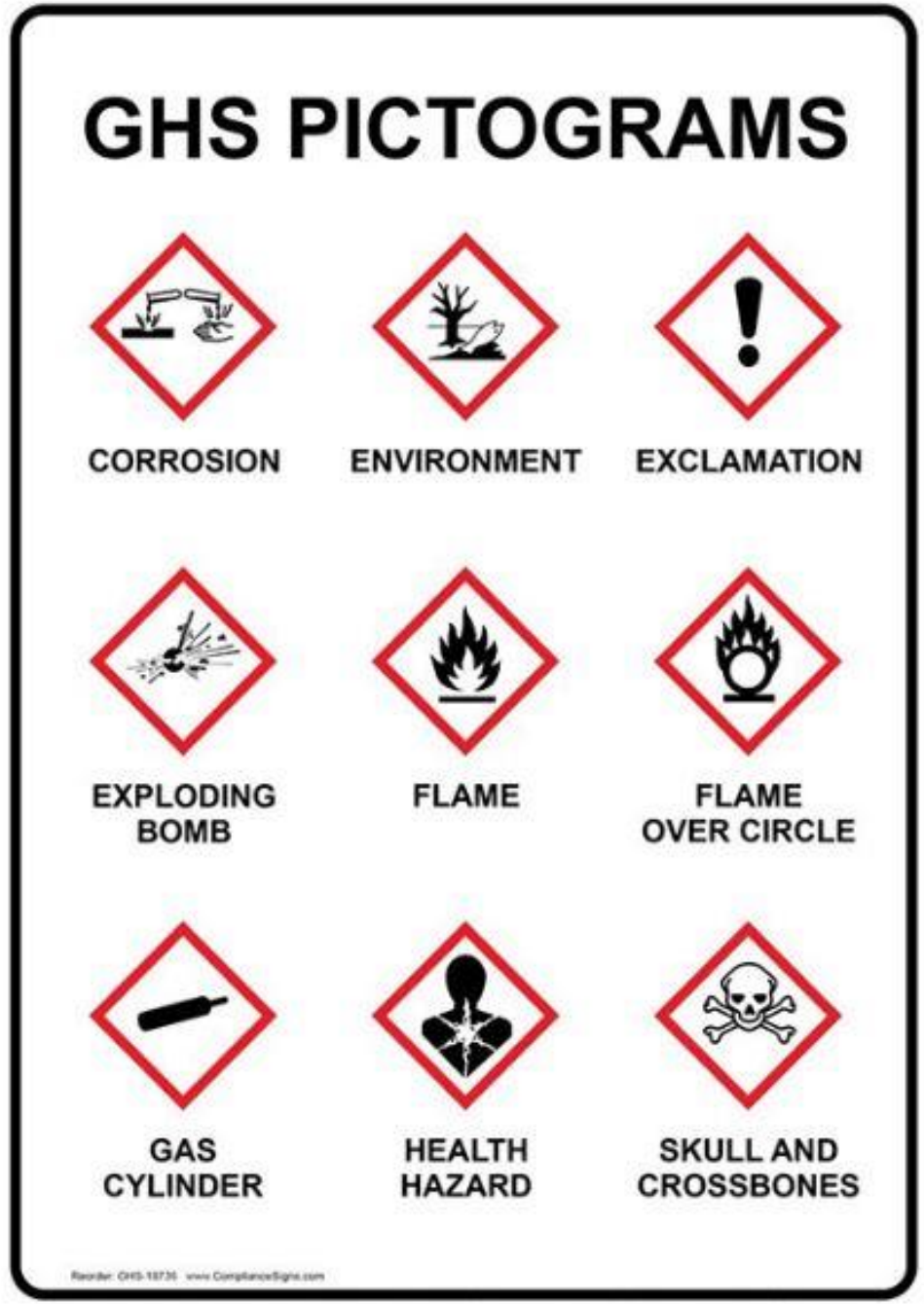
Exploding Bomb

- Explosives: which is a solid or liquid chemical capable of a chemical reaction that causes damage to the surroundings
- Self-Reactive: heating may cause fire or explosion without the need for air
- Organic peroxides: heating may cause fire or explosion

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



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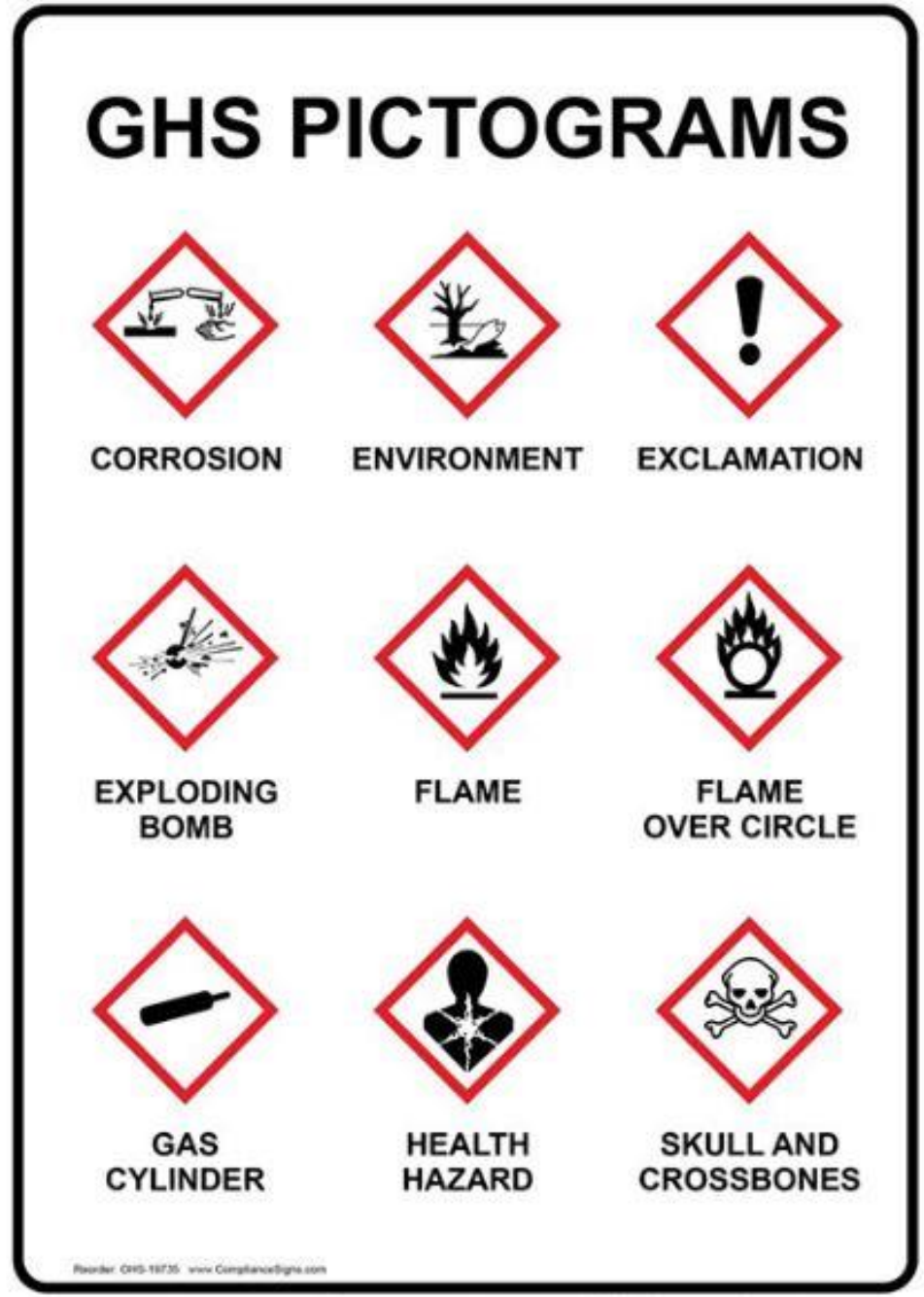
Flame

- Flammable: which are gases, aerosols, liquids, or solids that will burn or ignite under certain conditions,
- Self-Reactives: heating alone, without air, may cause fire or explosion
- Pyrophoric: in small amounts, may ignite within 5 minutes after contact with air
- Self-Heating: which may catch fire only in large amounts and after long periods of time when exposed to air
- Emitters of flammable gas
- Organic peroxides: which, when heated, may cause fire or explosion; may be sensitive to impact or friction; and may react dangerously with other chemicals

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



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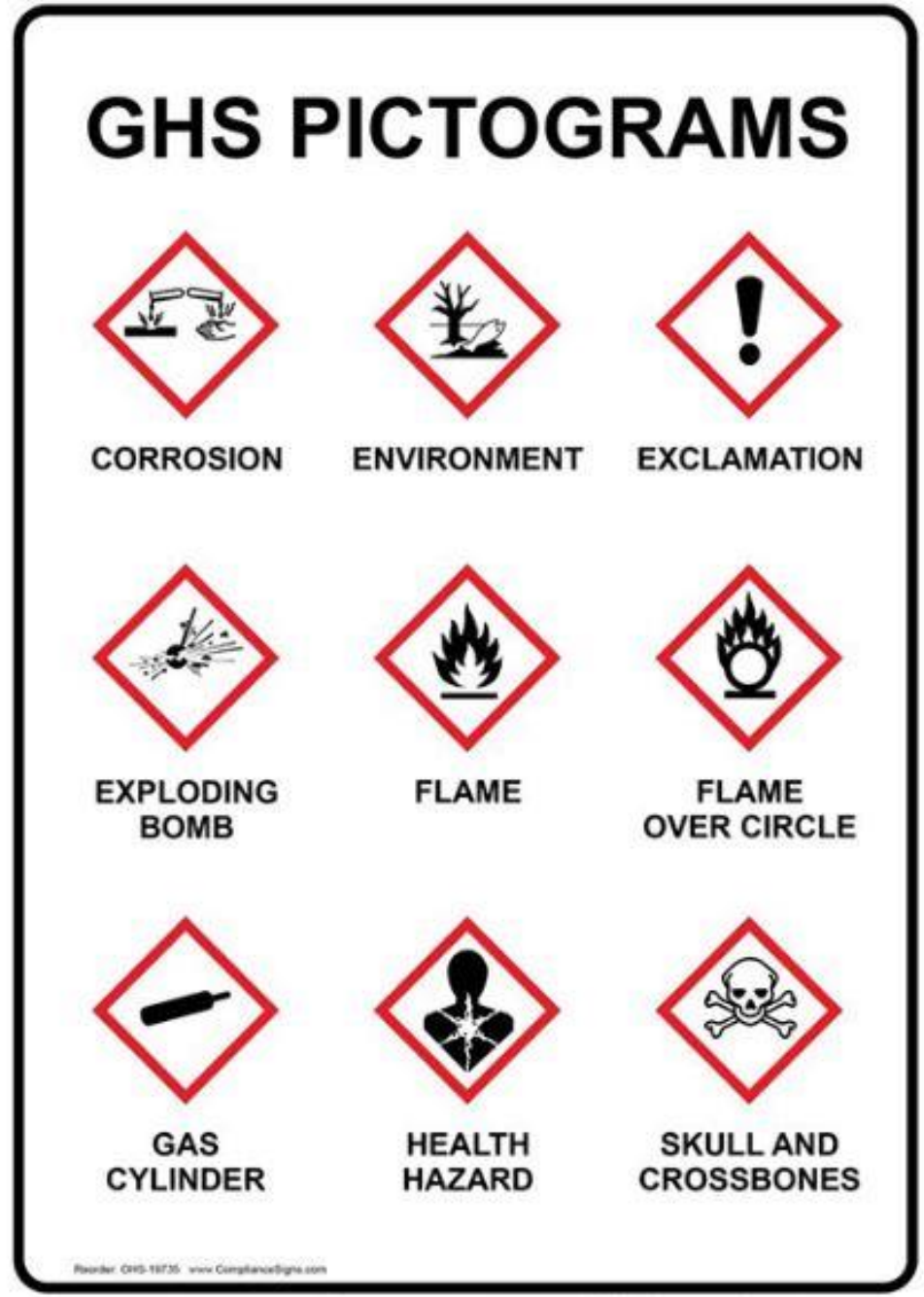
Flame Over Circle

- Oxidizer: may cause a fire by increasing the concentration of oxygen in the air

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



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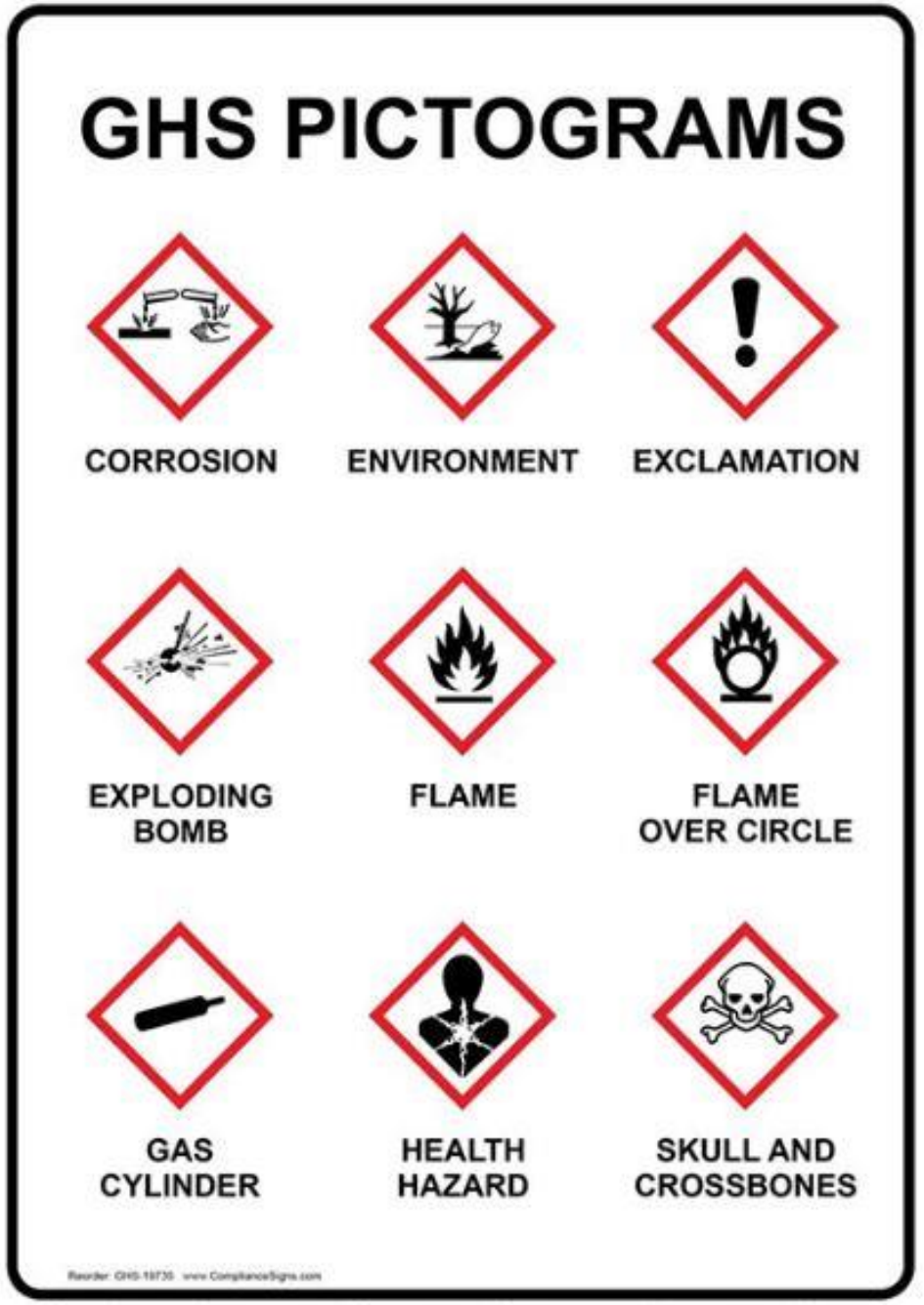
Gas Cylinder

- Compressed, liquefied, or dissolved gas under pressure at 29 pounds per square inch or more

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



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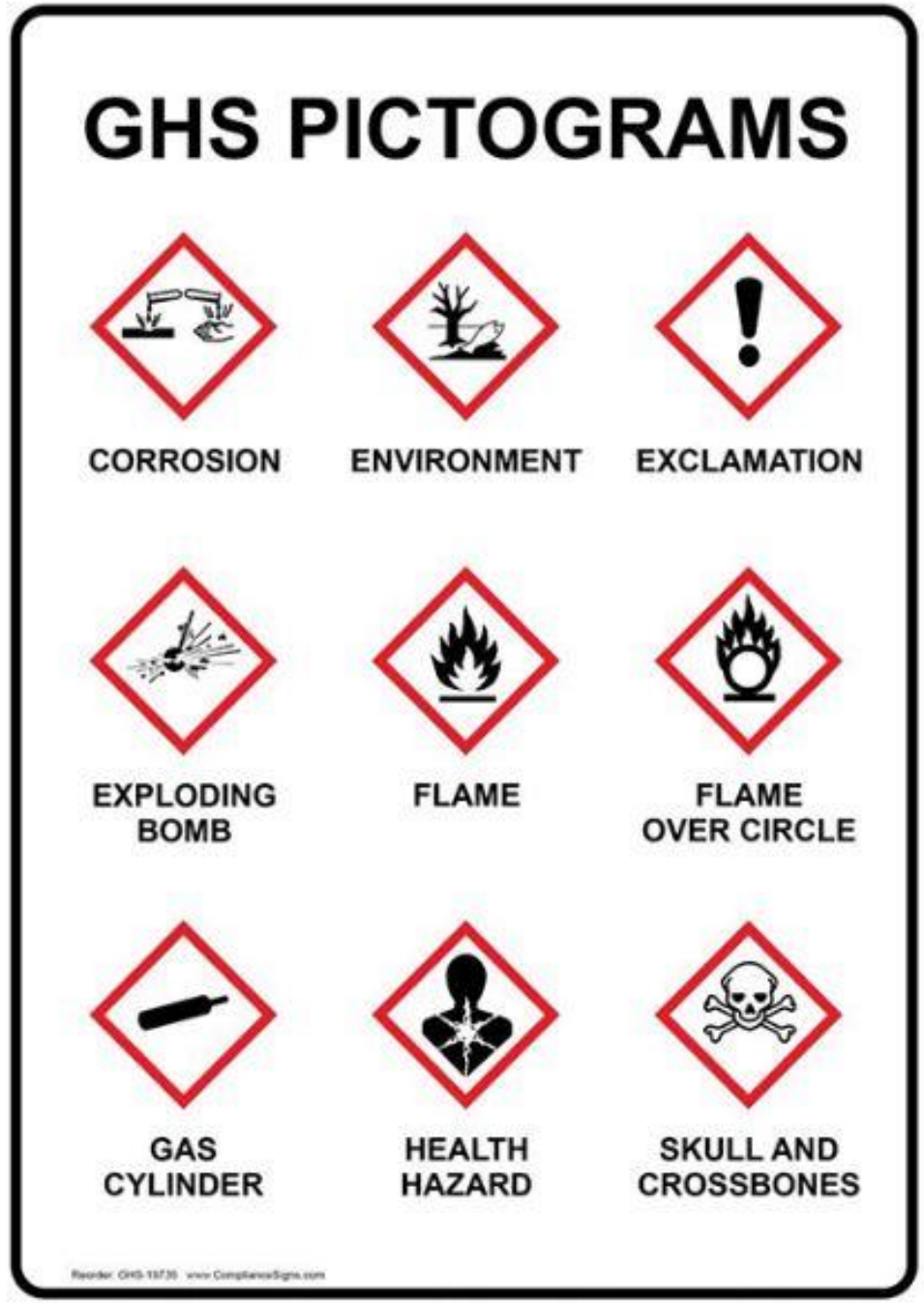
Health Hazard

- Carcinogen: may cause cancer
- Mutagenicity: may cause genetic defects
- Reproductive toxicity: may damage fertility or the unborn child
- Respiratory sensitizer: may cause respiratory irritation
- Target organ toxicity: may cause damage to bodily organs
- Aspiration toxicity: may be fatal if swallowed and it enters the airways

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



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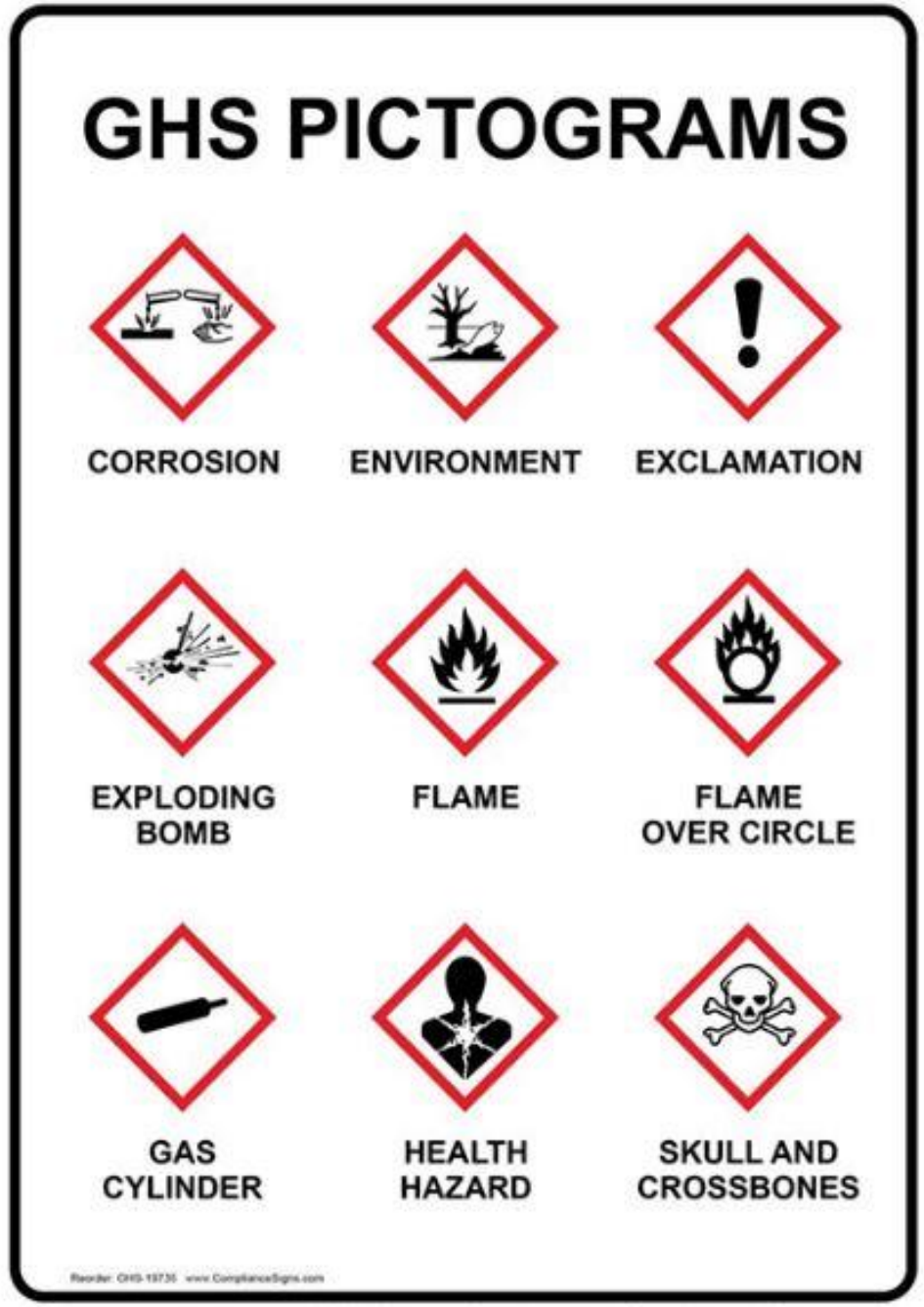
Skull and Crossbones

- Acute toxicity: exposure to a single dose of the chemical may be toxic or fatal if inhaled or swallowed, or if it comes into contact with the skin

CLICK THE PICTOGRAMS TO LEARN THEIR CORRESPONDING HAZARDS



3.3.1 In-house Labeling

HCS does not specify a particular label to be used. But it does specify the pictograms and the words to be used on the label. HCS provides employers with flexibility regarding the type of system to be used in their labeling. OSHA says, "Employers may choose to label workplace containers either with the same label that would be on shipped containers for the chemical, or with label alternatives that meet the requirements for the standard".

But we must keep in mind that DOT labels do not meet GHS requirements, so they do not meet OSHA requirements. GHS compliant labels are required. Alternative labeling systems that meet the requirements of the standard (with some modifications) include those commonly used under HCS 1994 such as the National Fire Protection Association (NFPA) 704 Hazard Rating and the Hazardous Material Identification System (HMIS) [also known as the Hazardous Material Identification Guide (HMIG)]. These and other similar systems are permitted for workplace containers. Employers may also develop their own labels if they wish. However, the information supplied on these labels must be consistent with HCS and GHS.

Click Box

3.3.1 In-house Labeling

OSHA's requirement for in-house labeling is that "the employer must ensure that each container of hazardous chemicals in the workplace is labeled, tagged or marked with either product identifier and words, pictures, symbols, or combination thereof, which provide at least general information regarding the hazards of the chemicals, and which, in conjunction with the other information immediately available to employees under the hazard communication program, will provide employees with the specific information regarding the physical and health hazards of the hazardous chemical".

Individual stationary process containers may be excepted from labels. The employer may use signs, placards, process sheets, batch tickets, operating procedures, or other written materials in lieu of affixing labels to them, as long as the alternative method identifies the containers to which they are applicable and convey the information required by HCS. These written materials must be readily accessible to the employees in their work area throughout each work shift.

3.3.1 In-house Labeling

Portable containers into which hazardous chemicals are transferred from labeled containers may also be excepted from labels. The employer is not required to label them if they are intended only for the immediate use of the employee who performs the transfer. This presents serious problems. If the employee puts the container down to go to the bathroom or lunch or for whatever reason fails to empty it, then this exemption does not apply. Other employees could be exposed to that hazardous chemical without the protection intended by HCS.

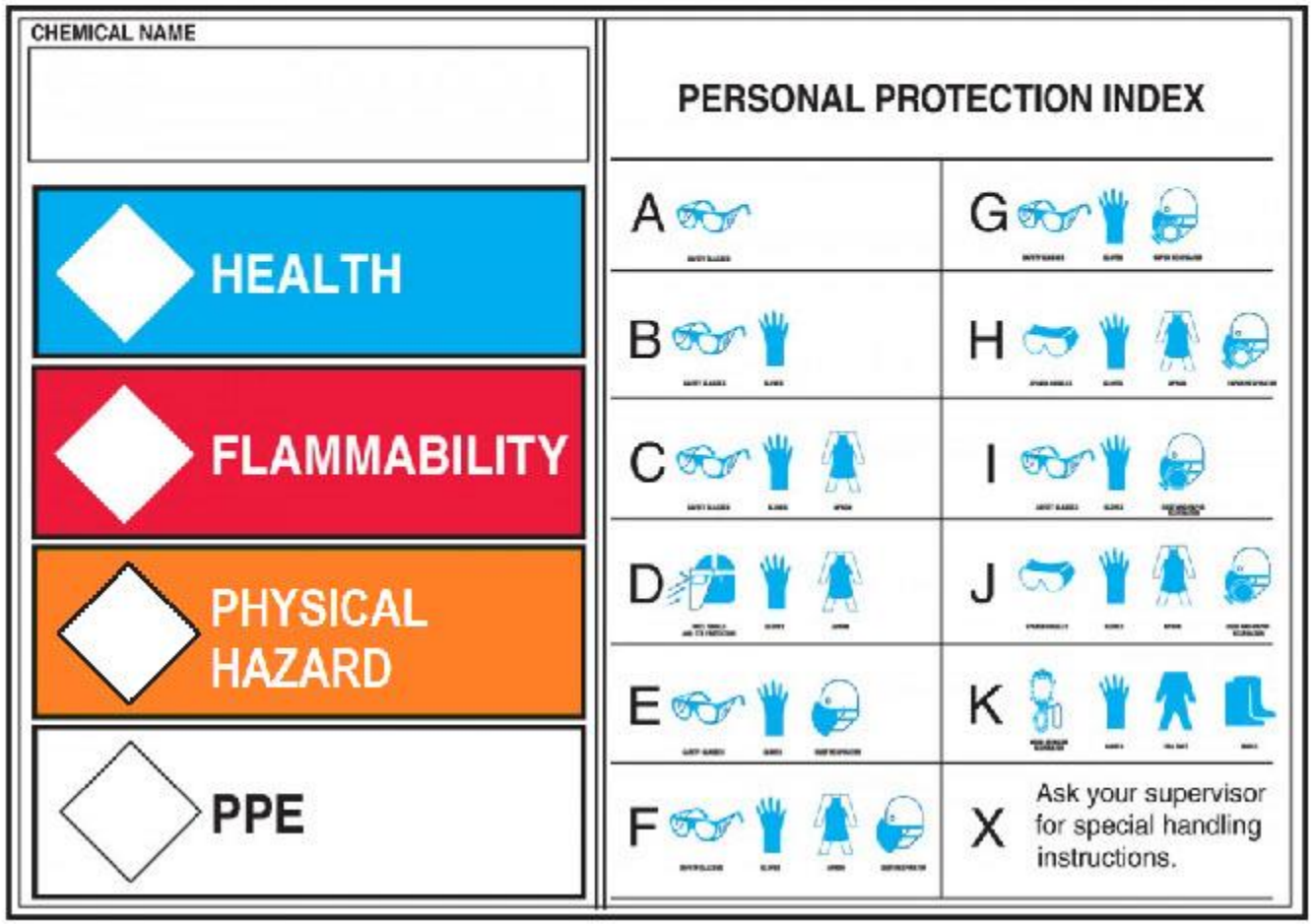
Employers cannot remove or deface existing labels on incoming containers of hazardous chemicals unless the container is immediately marked with the required information. If employees may be dependent on these interim labels for the necessary hazard information they should be trained to understand them.

For detailed guidelines for designing labels see Appendix C of the HCS.

Click Box

3.4 Hazard Materials Identification System

The HMIS Color Bar is similar to the fire diamond, created by the National Fire Protection Association (NFPA). Before 2002 the fire diamond and the color bar both had sections colored blue, red, white, and yellow. After April 2002, with the release of HMIS III, yellow in the color bar (which stood for reactivity) was replaced by orange, standing for physical hazard. The fire diamond was initially designed for emergencies when information about the effects of short, or acute, exposure was needed. The diamond is now used as an in-house labeling system. The color bar was never intended for emergencies and is used to convey broader health warning information.



Click Box

3.4 Hazard Materials Identification System

The four bars are color-coded, using the modern color bar symbols with blue indicating the level of health hazard, red for flammability, orange for a physical hazard, and white for personal protection. The number ratings range from 0-4.

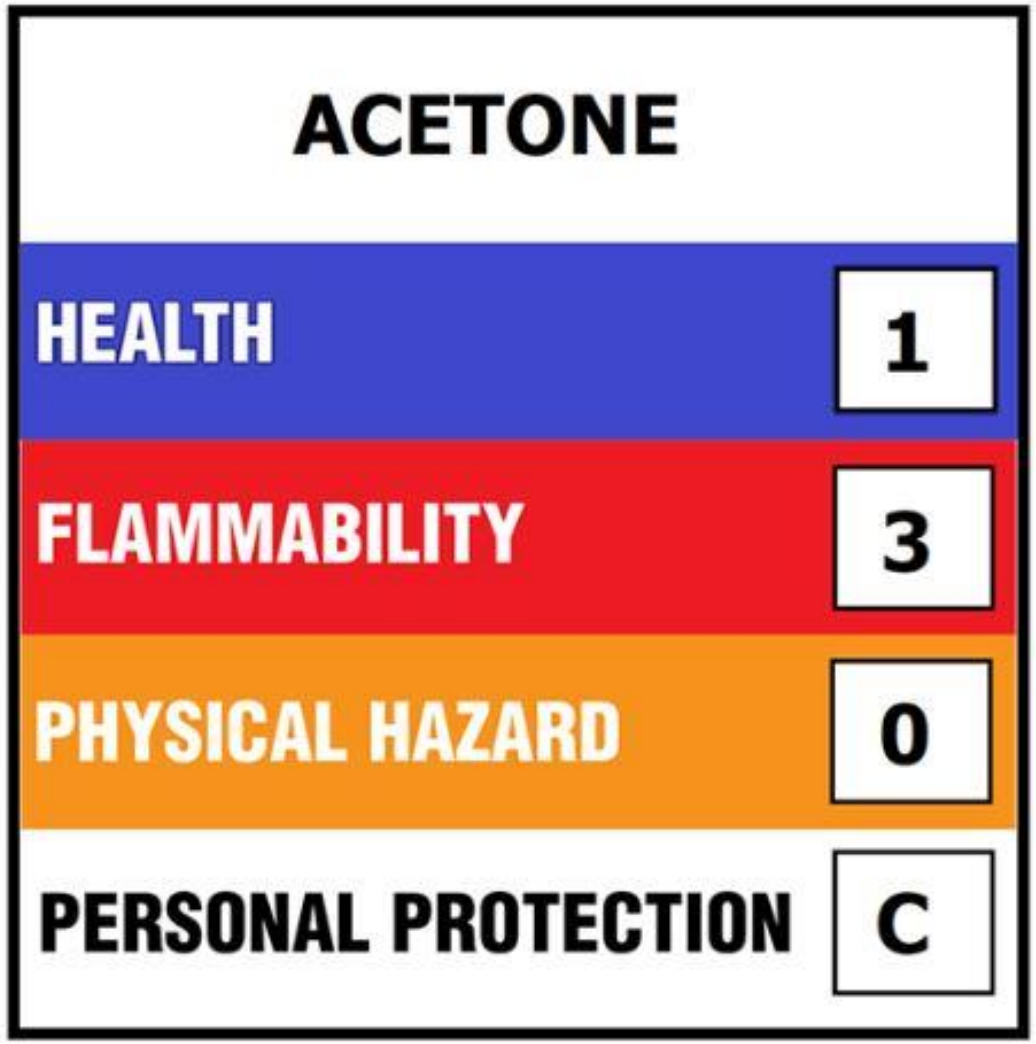
Blue/Health

The health section conveys the health hazards of the material. In the latest version of HMIS, the health bar has two spaces, one for an asterisk and one for a numeric hazard rating. If present, the asterisk signifies a chronic health hazard, meaning that long-term exposure to the material could cause a health problem such as emphysema or kidney damage.

CLICK EACH OF THE FOUR COLOR-CODED BARS TO MORE

3.4 Hazard Materials Identification System

The four bars are color-coded, using the modern color bar symbols with blue indicating the level of health hazard, red for flammability, orange for a physical hazard, and white for personal protection. The number ratings range from 0-4.



Red/Flammability

For HMIS I and II, the criteria used to assign numeric values (0 = low hazard to 4 = high hazard) are identical to those used by NFPA. In other words, in this category, the systems are identical. For HMIS III, the flammability criteria are defined according to OSHA standards.

CLICK EACH OF THE FOUR COLOR-CODED BARS TO MORE

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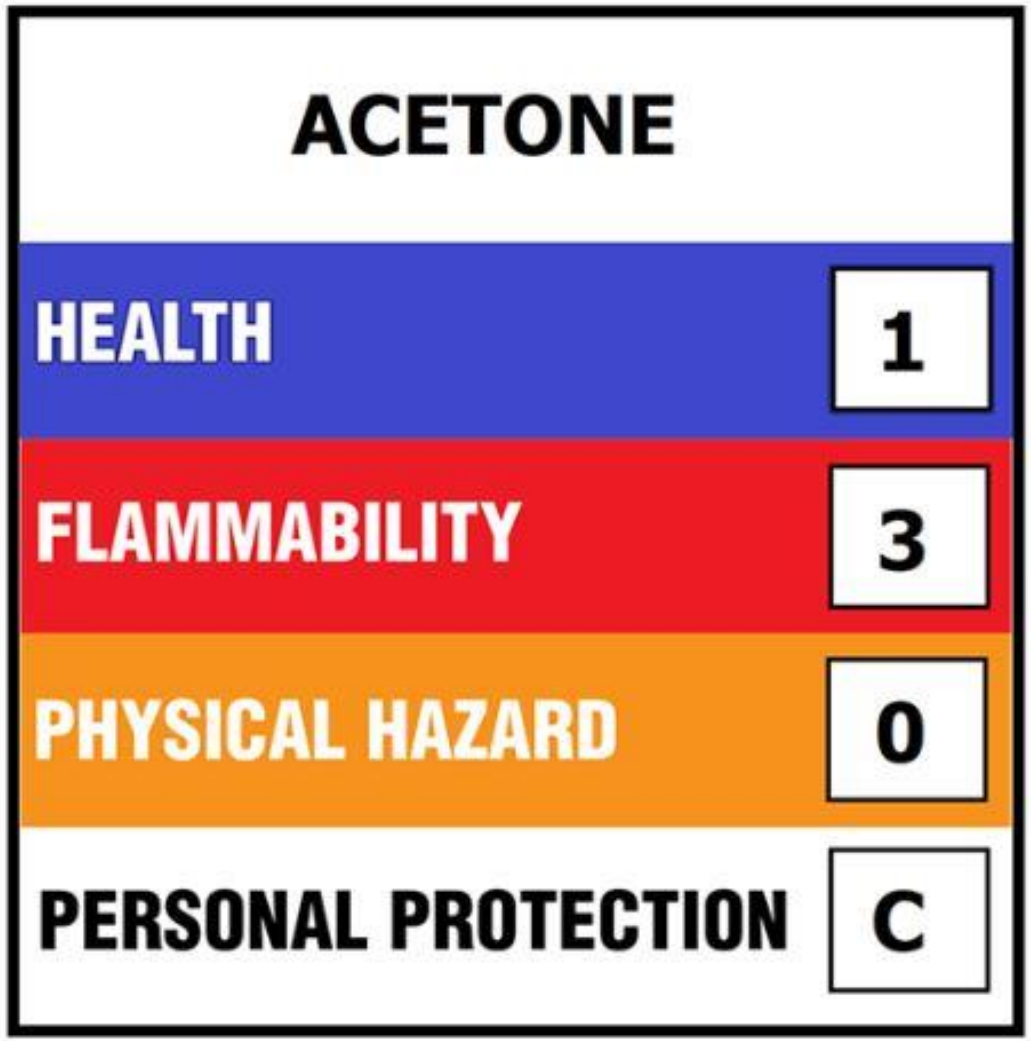


Orange/Physical Hazard

Reactivity hazards are assessed using the OSHA criterion of physical hazard. Seven such hazard classes are recognized:

- Water Reactives
- Organic Peroxides
- Explosives, Compressed gases
- Pyrophoric materials
- Oxidizers
- Unstable Reactives

CLICK EACH OF THE FOUR COLOR-CODED BARS TO MORE

3.4 Hazard Materials Identification System

The four bars are color-coded, using the modern color bar symbols with blue indicating the level of health hazard, red for flammability, orange for a physical hazard, and white for personal protection. The number ratings range from 0-4.

White/Personal Protection

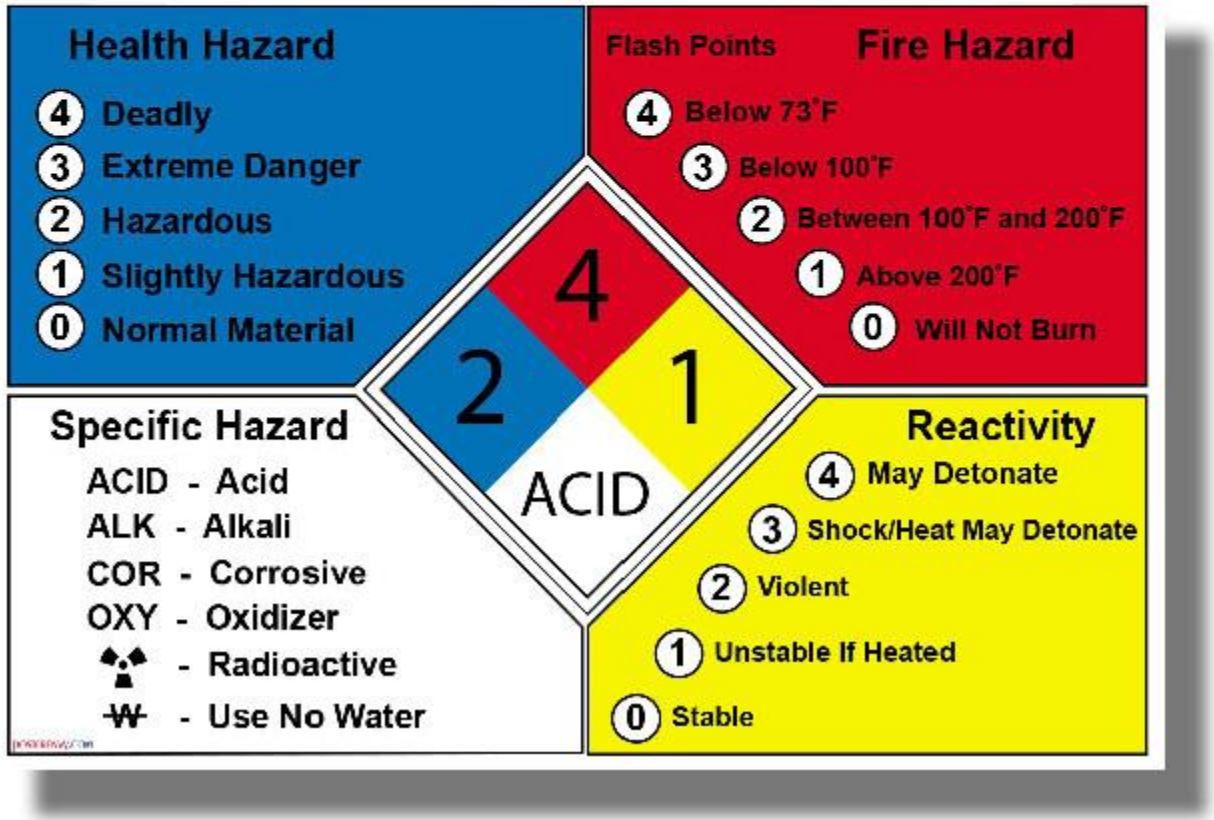
This is by far the greatest area of difference between the NFPA and HMIS systems. In the NFPA system, the white area is used to convey special hazards whereas HMIS uses the white section to indicate what personal protective equipment (PPE) should be used when working with the material. The letters A-K represent levels of PPE from least (A=glasses) to greatest (K=supplied air respirator and suit).

CLICK EACH OF THE FOUR COLOR-CODED BARS TO MORE

3.5 NFPA 704

The NFPA 704 (Standard System for the Identification of the Hazards of Materials for Emergency Response) is a standard maintained by the U.S.-based National Fire Protection Association. First "tentatively adopted as a guide" in 1960, and revised several times since then, it defines the colloquial "Fire Diamond" used by emergency personnel to quickly and easily identify the risks posed by hazardous materials. This helps determine what, if any, special equipment should be used, procedures followed, or precautions taken during the initial stages of an emergency response. It is also now used as an in-house labeling system.

The four divisions are typically color-coded the same as the HMIS with red indicating flammability, blue indicating level of health hazard, yellow for chemical reactivity, and white containing codes for special hazards. Each of health, flammability and reactivity is rated on a scale from 0 (no hazard) to 4 (severe risk).



3.6 DOT Labeling

HCS requires the "chemical manufacturer, importer, or distributor must ensure that each container of hazardous chemicals leaving the workplace is labeled, tagged or marked". Simply stated, if hazardous chemicals are shipped, HCS requires that they be labeled. But GHS labeling does not take the place of DOT labeling. DOT labels ***do not meet*** GHS requirements, which means they do not meet OSHA requirements.

The Department of Transportation (DOT) states that their specified labels must be used for hazardous materials when they are being transported. The DOT requires that any person who offers a hazardous material for transportation must label the package or containment device. The design and size of labels are based on international standards and are used to identify the hazards within the container.

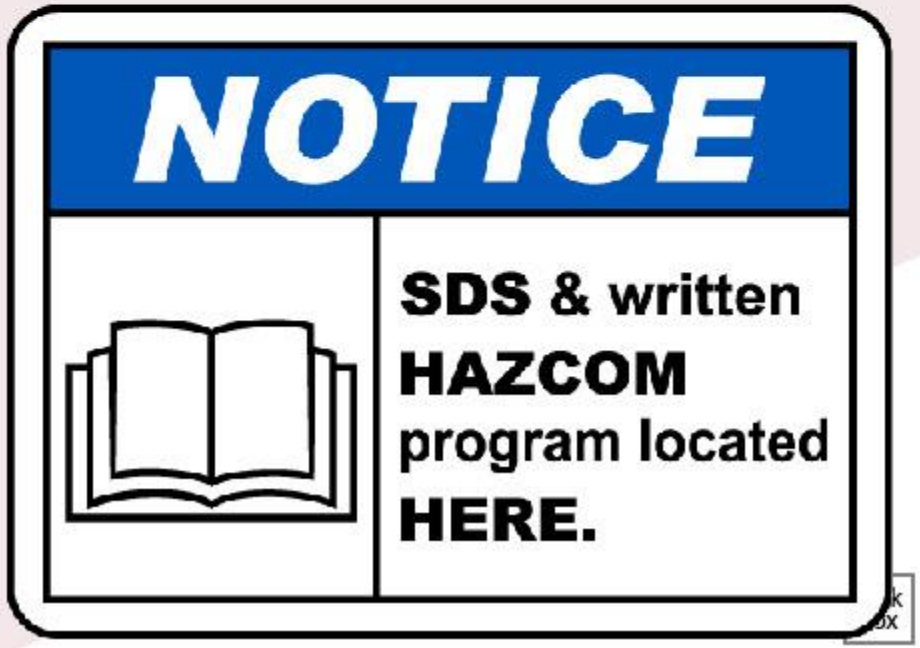
But OSHA explicitly forbids a package from having a GHS pictogram when the package is already required to have a DOT hazmat label. OSHA states, “Where a pictogram required by the Department of Transportation under Title 49 of the Code of Federal Regulations appears on a shipped container, the pictogram specified in C.4 (of HCS 2012) for the same hazard must not appear.” As a result, when shipping a hazardous chemical, one must meet the labeling requirements of HCS 2012 *and* of DOT, except that one should not use the GHS pictogram when a DOT label is already required. There are four elements to a DOT label. They are the name of the hazard, picture, hazard class, and color.

Click Box

4.0 Hazard Communication: Part II

The written Hazard Communication Program should provide employees the information they need to obtain hazard information on the chemicals they encounter in the workplace. The program must include the following elements:

- A comprehensive list of hazardous chemicals in the work area, with consideration to the work area in which the chemicals are used and/or stored.
- The methods the employer will use to inform employees of the hazards of non-routine tasks (for example, the cleaning of reactor vessels). Typically, this is when employees tend to become exposed, because they are tasked with a job, a process or a chemical that is unfamiliar to them, such as with maintenance personnel.
- The hazards associated with chemicals contained in unlabeled pipes in their work areas. OSHA does not state that ALL pipes containing chemicals must be labeled with the product which they contain (although some highly hazardous chemicals such as ammonia or chlorine do have specific labeling requirements). Most of the time, these chemicals or non-hazardous materials are color coded instead. Therefore, employees must know what these color coding requirements are. The diagram on the following slide shows ANSI/ASME A13.1 pipe marking requirements.



4.0 Hazard Communication: Part II

Content Type	Description	Required Colors	Example
FLAMMABLE	Fluids that are a vapor or produce vapors that can ignite and continue to burn in air.	Black on Yellow	HYDROGEN
COMBUSTIBLE	Fluids that may burn but are not flammable.	White on Brown	ACETIC ACID
TOXIC/CORROSIVE	Fluids that are corrosive or toxic or will produce corrosive or toxic substances.	Black on Orange	NITRIC ACID
FIRE QUENCHING	Water and other substances used in sprinkler fire-fighting piping systems.	White on Red	HALON
OTHER WATER	Any other water except for water used in sprinkler & fire-fighting piping systems.	White on Green	BOILER WATER
COMPRESSED AIR	Any vapor or gas under pressure that does not fit a category above.	White on Blue	COMPRESSED AIR
OTHER	Definable by user.	White on Purple	OTHER
OTHER	Definable by user.	White on Black	OTHER
OTHER	Definable by user.	Black on White	OTHER
OTHER	Definable by user.	White on Gray	OTHER

- Employees covered by this program. This includes every employee of the company and every employee of every other company who performs work within the facility. It is the safety manager's responsibility to inform employers of employees working in your facility who are not employees of the company of the training requirements for their employees before they perform work in the facility. Employers of these employees must certify that these employees have received Hazard Communication training conforming to HCS and have been properly trained in each form of labeling used in the facility and training covering the chemical terms and concepts found on labels and SDSs in the facility. Employers of these employees must also ensure that their employees have successfully completed the "Site Specific Training Course for Employees of External Employers".

Click Box

4.0 Hazard Communication: Part II

- Concerning labels and other forms of warning, for labels on containers of hazardous chemicals leaving the workplace, the individual responsible for developing and affixing the proper label to each container of hazardous chemicals leaving the workplace is designated in the program as the HCS Label Manager. The HCS Label Manager is responsible to follow the instructions and guidelines in 1910.1200 Appendix C "Allocation of Label Elements", and develop the proper label to include all of the following:
  - Product identifier
  - Signal word
  - Hazard statement(s)
  - Pictogram(s)
  - Precautionary statement(s)
  - Name, address, and telephone number of the chemical manufacturer, importer, or other responsible party.

Click Box

4.0 Hazard Communication: Part II

- For labels on each container of hazardous chemicals NOT leaving the workplace (generally called workplace labeling or in-house labeling), a labeling system should be chosen. Management may decide to use GHS labels, or they may adopt another form and format of labeling. The NFPA 704 labeling system or the Hazardous Material Identification System (HMIS) may be chosen, or one can be developed with the company's own form and format. Whatever system is used must be compatible with the Globally Harmonized System (GHS).

- A through explanation of the labeling system selected, including information needed to design and affix the labels.

- Information regarding employee information and training. Training frequency and type required training of outside employees, and all required courses and their content must be specified.

Click Box

4.1 Safety Data Sheet (SDS)

OSHA requires that employers provide employees with access to an SDS for each hazardous chemical that they use, as it is the primary source of hazard information for chemicals in the workplace. Each SDS must be printed in English and readily accessible in each work area during every work shift. The SDS should be consulted to:

- Verify the information on the container label regarding safety and hazards.
- Ensure that the appropriate personal protective equipment is used for the chemical in question.
- Determine if the symptoms experienced while working with a chemical can be attributed to the chemical.
- Save valuable time in the event of an emergency.

Click Box

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 1: Product and Company Identification

This section identifies the chemical on the SDS, as well as its recommended uses. It also provides the essential contact information of the supplier. The required information consists of:

- Product identifier used on the label and any other common names or synonyms by which the substance is known.
- Name, address, and phone number of the manufacturer, importer, or other responsible party.
- Emergency phone number.
- Recommended use of the chemical and any restrictions on its use

SECTION 1 PRODUCT AND COMPANY IDENTIFICATION

PRODUCT

Product Name: **BENZENE**
Product Description: Aromatic Hydrocarbon

Intended Use: Feedstock

COMPANY IDENTIFICATION

Supplier: **EXXONMOBIL CHEMICAL COMPANY**
SDS – LOC. 106
22777 Springwoods Village Parkway
Spring, TX 77389-1425 USA

24 Hour Health Emergency	(800) 726-2015
Transportation Emergency Phone	(800) 424-9300 or (703) 527-3887 CHEMTREC
Product Technical Information	(832) 624-8500
Supplier General Contact	(832) 624-8500

4.1 Safety Data Sheet (SDS)

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Section 2: Hazard(s) Identification

This section identifies the hazards of the chemical and the appropriate warning information associated with those hazards. The required information consists of:

- The hazard classification of the chemical (e.g., flammable liquid)
- Signal word
- Hazard statement(s)
- Pictogram(s)
- Precautionary statement(s)
- Description of any hazards not otherwise classified
- For a mixture that contains an ingredient(s) with unknown toxicity, a statement describing how much (percentage) of the mixture consists of ingredient(s) with unknown acute toxicity. It is to be noted that this is a total percentage of the mixture and not tied to the individual ingredient.

SECTION 2 HAZARDS IDENTIFICATION

This material is hazardous according to regulatory guidelines (see (M)SDS Section 15).

CLASSIFICATION:

Flammable liquid: Category 2.
Skin irritation: Category 2. Eye irritation: Category 2A. Germ Cell Mutagen: Category 1B. Carcinogen: Category 1A.
Specific target organ toxicant (repeated exposure): Category 1. Aspiration toxicant: Category 1.

LABEL:
Pictogram:

Signal Word: Danger

Hazard Statements:
H225: Highly flammable liquid and vapor. H304: May be fatal if swallowed and enters airways. H315: Causes skin irritation. H319: Causes serious eye irritation. H340: May cause genetic defects. H350: May cause cancer. H372: Causes damage to organs through prolonged or repeated exposure.

Precautionary Statements:
P201: Obtain special instructions before use. P202: Do not handle until all safety precautions have been read and understood. P210: Keep away from heat/sparks/open flames/hot surfaces. -- No smoking. P233: Keep container tightly closed. P240: Ground / bond container and receiving equipment. P241: Use explosion-proof electrical, ventilating, and lighting equipment. P242: Use only non-sparking tools. P243: Take precautionary measures against static discharge. P260: Do not breathe mist / vapours. P264: Wash skin thoroughly after handling.

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 3: Composition/Information of Ingredients
This section identifies the ingredient(s) contained in the product, including impurities and stabilizing additives. It includes information on substances, mixtures, and all chemicals where a trade secret is claimed. The required information consists of:

Substances:
- Chemical name.
- Common name and synonyms.
- CAS number and other unique identifiers.
- Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance.

Mixtures:
In addition to the information required for substances:
- The chemical name and concentration (exact percentages) of all ingredients which are classified as health hazards and are:
  - Present above their cut-off/concentration limits, or
  - Present a health risk below the cut- off/concentration limits.
- The concentration (exact percentages) of each ingredient must be specified except concentration ranges may be used in the following situations:
  - A trade secret claim is made,
  - There is batch-to-batch variation, or
  - The SDS is used for a group of substantially similar mixtures.

Chemicals Where a Trade Secret is Claimed:
A statement that the specific chemical identity and/or exact percentage (concentration) of composition has been withheld as a trade secret is required.

SECTION 3 COMPOSITION / INFORMATION ON INGREDIENTS

This material is defined as a substance.

Hazardous Substance(s) or Complex Substance(s) required for disclosure

Name	CAS#	Concentration*	GHS Hazard Codes
benzene	71-43-2	100 %	H225, H303, H304, H340(1B), H350(1A), H315, H319(2A), H372, H401, H412

* All concentrations are percent by weight unless material is a gas. Gas concentrations are in percent by volume.

As per paragraph (i) of 29 CFR 1910.1200, formulation is considered a trade secret and specific chemical identity and exact percentage (concentration) of composition may have been withheld. Specific chemical identity and exact percentage composition will be provided to health professionals, employees, or designated representatives in accordance with applicable provisions of paragraph (i).

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 4: First Aid Measures

This section describes the initial care that should be given to an individual who has been exposed to the chemical. The required information consists of:

- Necessary first aid instructions by relevant routes of exposure (inhalation, skin and eye contact, and ingestion)
- Description of the most important symptoms or effects, and any symptoms that are acute or delayed.
- Recommendations for immediate medical care and special treatment needed, when necessary.

SECTION 4 FIRST AID MEASURES

INHALATION

Immediately remove from further exposure. Get immediate medical assistance. For those providing assistance, avoid exposure to yourself or others. Use adequate respiratory protection. Give supplemental oxygen, if available. If breathing has stopped, assist ventilation with a mechanical device.

SKIN CONTACT

Wash contact areas with soap and water. Remove contaminated clothing. Launder contaminated clothing before reuse.

EYE CONTACT

Flush thoroughly with water for at least 15 minutes. Get medical assistance.

INGESTION

Seek immediate medical attention. Do not induce vomiting.

NOTE TO PHYSICIAN

If ingested, material may be aspirated into the lungs and cause chemical pneumonitis. Treat appropriately. This material, or a component, may be associated with cardiac sensitization following very high exposures (well above occupational exposure limits) or with concurrent exposure to high stress levels or heart-stimulating substances like epinephrine. Administration of such substances should be avoided.

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 5: Firefighting Measures

This section offers recommendations for fighting a fire caused by the chemical.
The required information consists of:

- Suitable extinguishing media.
- Specific hazards that develop from the chemical during the fire.
- Recommendations on special protective equipment or precautions for firefighters.

SECTION 5 FIRE FIGHTING MEASURES

EXTINGUISHING MEDIA

Appropriate Extinguishing Media: Use water fog, foam, dry chemical or carbon dioxide (CO2) to extinguish flames.

Inappropriate Extinguishing Media: Straight Streams of Water

FIRE FIGHTING

Fire Fighting Instructions: Evacuate area. If a leak or spill has not ignited, use water spray to disperse the vapors and to protect personnel attempting to stop a leak. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply. Firefighters should use standard protective equipment and in enclosed spaces, self-contained breathing apparatus (SCBA). Use water spray to cool fire exposed surfaces and to protect personnel.

Unusual Fire Hazards: Highly flammable. Incomplete combustion may create large amounts of soot. Vapors are flammable and heavier than air. Vapors may travel across the ground and reach remote ignition sources causing a flashback fire danger. Hazardous material. Firefighters should consider protective equipment indicated in Section 8.

Hazardous Combustion Products: Incomplete combustion products, Oxides of carbon, Smoke, Fume

FLAMMABILITY PROPERTIES

Flash Point [Method]: -11°C (12°F) [ASTM D-56]
Flammable Limits (Approximate volume % in air): LEL: 1.2 UEL: 7.8
Autoignition Temperature: 498°C (928°F) [Technical literature]

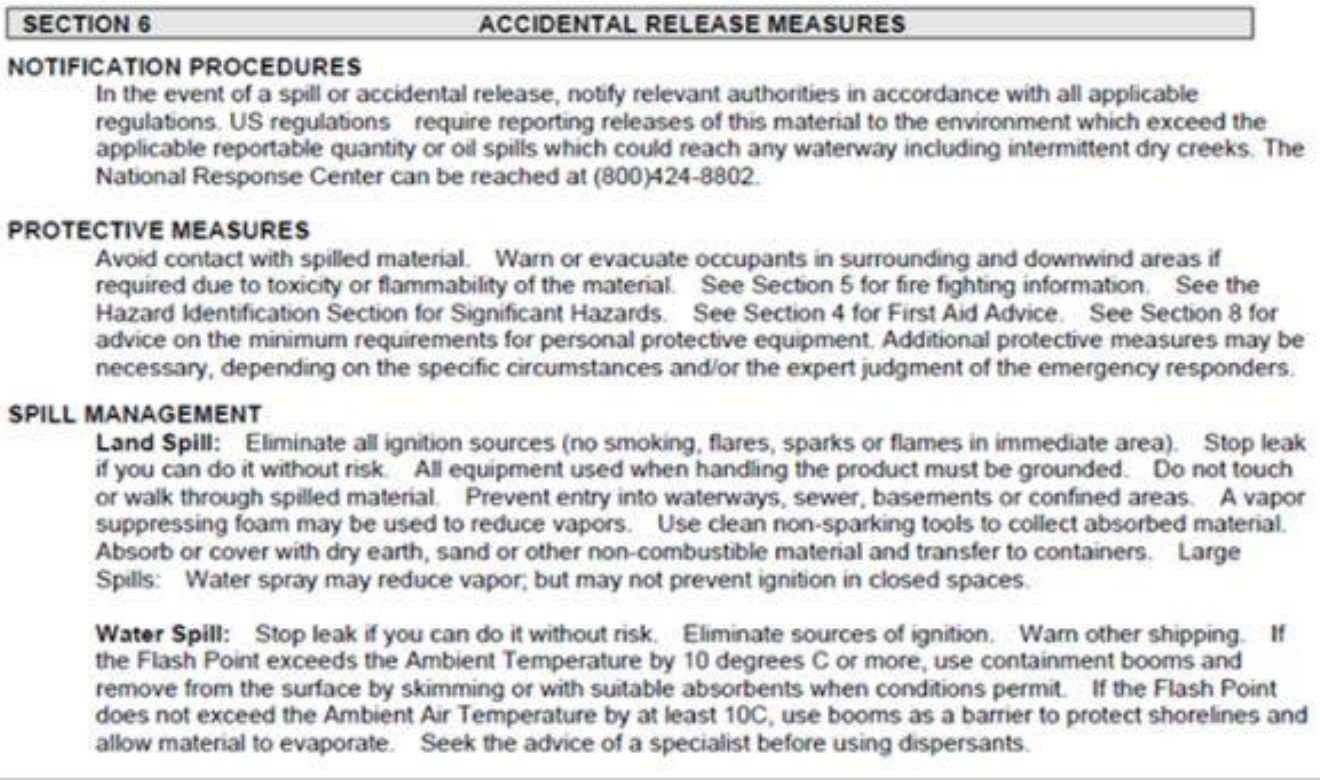
4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 6: Accidental Release Measures

This section includes recommendations on the appropriate response to spills, leaks, or releases, including containment and cleanup practices and recommendations for:

- Precautions and personal protective equipment.
- Emergency procedures, including instructions for evacuations, and appropriate protective clothing.
- Methods and materials used for containment.
- Cleanup procedures.



SECTION 6 ACCIDENTAL RELEASE MEASURES

NOTIFICATION PROCEDURES

In the event of a spill or accidental release, notify relevant authorities in accordance with all applicable regulations. US regulations require reporting releases of this material to the environment which exceed the applicable reportable quantity or oil spills which could reach any waterway including intermittent dry creeks. The National Response Center can be reached at (800)424-8802.

PROTECTIVE MEASURES

Avoid contact with spilled material. Warn or evacuate occupants in surrounding and downwind areas if required due to toxicity or flammability of the material. See Section 5 for fire fighting information. See the Hazard Identification Section for Significant Hazards. See Section 4 for First Aid Advice. See Section 8 for advice on the minimum requirements for personal protective equipment. Additional protective measures may be necessary, depending on the specific circumstances and/or the expert judgment of the emergency responders.

SPILL MANAGEMENT

Land Spill: Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Stop leak if you can do it without risk. All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Prevent entry into waterways, sewer, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Use clean non-sparking tools to collect absorbed material. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Large Spills: Water spray may reduce vapor; but may not prevent ignition in closed spaces.

Water Spill: Stop leak if you can do it without risk. Eliminate sources of ignition. Warn other shipping. If the Flash Point exceeds the Ambient Temperature by 10 degrees C or more, use containment booms and remove from the surface by skimming or with suitable absorbents when conditions permit. If the Flash Point does not exceed the Ambient Air Temperature by at least 10C, use booms as a barrier to protect shorelines and allow material to evaporate. Seek the advice of a specialist before using dispersants.

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 7: Handling and Storage

This section includes guidance on the safe handling practices and conditions for safe storage of chemicals. The required information consists of:

- Recommendations for handling incompatible chemicals, minimizing the release of the chemical into the environment, and providing advice on general hygiene practices.
- Recommendations on the conditions for safe storage, including any incompatibilities. Provides advice on specific storage requirements.

SECTION 7 HANDLING AND STORAGE

HANDLING

Avoid all personal contact. Prevent exposure to ignition sources, for example use non-sparking tools and explosion-proof equipment. Prevent small spills and leakage to avoid slip hazard. Material can accumulate static charges which may cause an electrical spark (ignition source). Use proper bonding and/or ground procedures. However, bonding and grounds may not eliminate the hazard from static accumulation. Consult local applicable standards for guidance. Additional references include American Petroleum Institute 2003 (Protection Against Ignitions Arising out of Static, Lightning and Stray Currents) or National Fire Protection Agency 77 (Recommended Practice on Static Electricity) or CENELEC CLC/TR 50404 (Electrostatics - Code of practice for the avoidance of hazards due to static electricity).

Loading/Unloading Temperature: [Ambient]

Transport Temperature: [Ambient]
Transport Pressure: [Ambient]

STORAGE

Ample fire water supply should be available. A fixed sprinkler/deluge system is recommended. The type of container used to store the material may affect static accumulation and dissipation. Keep container closed. Handle containers with care. Open slowly in order to control possible pressure release. Store in a cool, well-ventilated area. Outside or detached storage preferred. Storage containers should be grounded and bonded. Fixed storage containers, transfer containers and associated equipment should be grounded and bonded to prevent accumulation of static charge.
Storage Temperature: [Ambient]
Storage Pressure: [Ambient]

Suitable Containers/Packing: Tankers; Tank Trucks; Barges; Tank Cars
Suitable Materials and Coatings (Chemical Compatibility): Carbon Steel; Stainless Steel; Polypropylene; Epoxy Phenolic; Fluorinated Silicone Rubber
Unsuitable Materials and Coatings: Rubber; Compatibility with epoxy/resin compositions will vary; Polyethylene; PVC

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 8. Exposure Controls/Personal Protection

This section indicates the exposure limits, engineering controls, and personal protective measures that can be used to minimize employee exposure, consisting of:

- OSHA permissible exposure limits (PELs), ACGIH Threshold Limit Values (TLVs), and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet, where available.
- Appropriate engineering controls (e.g., the use of local exhaust ventilation, or use only in an enclosed space).
- Recommendations for personal protective measures and PPE.
- Any special requirements for PPE, such as special glove materials and their breakthrough time.

SECTION 8 **EXPOSURE CONTROLS / PERSONAL PROTECTION**

EXPOSURE LIMIT VALUES

Exposure limits/standards (Note: Exposure limits are not additive)

Substance Name	Form	Limit / Standard			NOTE	Source
benzene		OSHA Action level	0.5 ppm		N/A	OSHA Sp.Reg.
benzene		STEL	5 ppm		N/A	OSHA Sp.Reg.
benzene		TWA	1 ppm		N/A	OSHA Sp.Reg.
benzene		STEL	1 ppm		N/A	ExxonMobil
benzene		TWA	0.5 ppm		N/A	ExxonMobil
benzene		STEL	2.5 ppm		Skin	ACGIH
benzene		TWA	0.5 ppm		Skin	ACGIH

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 9. Physical and Chemical Properties

This section includes both physical and chemical properties associated with the substance or mixture. The minimum required information consists of:

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

SECTION 9 **PHYSICAL AND CHEMICAL PROPERTIES**

Note: Physical and chemical properties are provided for safety, health and environmental considerations only and may not fully represent product specifications. Contact the Supplier for additional information.

GENERAL INFORMATION

Physical State: Liquid
Form: Clear
Color: Colorless
Odor: Aromatic
Odor Threshold: N/D

IMPORTANT HEALTH, SAFETY, AND ENVIRONMENTAL INFORMATION

Relative Density (at 20 °C): 0.877 [In-house method]
Density (at 20 °C): 877 kg/m³ (7.32 lbs/gal, 0.88 kg/dm³) [In-house method]
Flammability (Solid, Gas): N/A
Flash Point [Method]: -11°C (12°F) [ASTM D-56]
Flammable Limits (Approximate volume % in air): LEL: 1.2 UEL: 7.8
Autoignition Temperature: 498°C (928°F) [Technical literature]
Boiling Point / Range: 80°C (176°F) [Technical literature]
Decomposition Temperature: N/D
Vapor Density (Air = 1): 2.7 at 101 kPa [Technical literature]
Vapor Pressure: 10 kPa (75 mm Hg) at 20 °C | 100 kPa (750 mm Hg) at 79.9°C [Technical literature]
Evaporation Rate (n-butyl acetate = 1): N/D
pH: N/A
Log Pow (n-Octanol/Water Partition Coefficient): 2.13 [Technical literature]
Solubility in Water: Slight

The SDS may not contain every item on the above list because information may not be relevant or is not available. When this occurs, a notation to that effect must be made for that chemical property.

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 10: Stability and Reactivity

This section describes the reactivity hazards of the chemical and the chemical stability information. The required information is presented in three parts: reactivity, chemical stability, and other:

- Reactivity: A description of the specific test data for the chemical(s), which can be for a class or family of the chemical if such data adequately represents the anticipate hazard.
- Chemical Stability: An indication of whether the chemical is stable or unstable under normal ambient temperatures and conditions. A description of any stabilizers that may be needed to maintain chemical stability. An indication of any safety issues that may arise should the product change in physical appearance.
- Other: An indication of the possibility of hazardous reactions, including a statement whether the chemical will react or polymerize, which could release excess pressure or heat, or create other hazardous conditions. A list of all conditions that should be avoided, such as static discharge or shock. A list of classes of incompatible materials with which the chemical could react to produce a hazardous situation. A list of any known or anticipated hazardous decomposition products as a result of use, storage, or heating.

SECTION 10	STABILITY AND REACTIVITY

REACTIVITY: See sub-sections below.

STABILITY: Material is stable under normal conditions.

CONDITIONS TO AVOID: See Footnote

MATERIALS TO AVOID: See Footnote

HAZARDOUS DECOMPOSITION PRODUCTS: Material does not decompose at ambient temperatures.

POSSIBILITY OF HAZARDOUS REACTIONS: Hazardous polymerization will not occur.

[Footnote: This product is intended for industrial use. Exposure to heat, air, oxidizing agents and other chemicals not part of an industrial process should be avoided.]

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 11: Toxicological Information

This section identifies toxicological and health effects information or indicates that such data are not available. The required information consists of:

- Information on the likely routes of exposure (inhalation, ingestion, skin and eye contact).
- An indication if the information is unknown.
- A description of the delayed, immediate, or chronic effects from short- and long-term exposure.
- The numerical measures of toxicity associated with lethal doses.
- A description of the symptoms related to the physical, chemical and toxicological characteristics.

Other information listed in this section includes whether the substance is a carcinogen and any medical conditions that may be aggravated by exposure.

SECTION 11 **TOXICOLOGICAL INFORMATION**

INFORMATION ON TOXICOLOGICAL EFFECTS

Hazard Class	Conclusion / Remarks
Inhalation	
Acute Toxicity: (Rat) 4 hour(s) LC50 43767 mg/m3 (Vapor)	Minimally Toxic. Based on test data for the material. Test(s) equivalent or similar to OECD Guideline 403
Irritation: No end point data for material.	Elevated temperatures or mechanical action may form vapors, mist, or fumes which may be irritating to the eyes, nose, throat, or lungs.
Ingestion	
Acute Toxicity (Rat): LD50 > 2000 mg/kg	Minimally Toxic. Based on test data for the material. Test(s) equivalent or similar to OECD Guideline 401
Skin	
Acute Toxicity (Rabbit): LD50 > 5000 mg/kg	Minimally Toxic. Based on test data for the material. Test(s) equivalent or similar to OECD Guideline 402
Skin Corrosion/Irritation: Data available.	Irritating to the skin. Based on test data for the material. Test(s) equivalent or similar to OECD Guideline 404
Eye	
Serious Eye Damage/Irritation: Data available.	Irritating and will injure eye tissue. Based on test data for the material. Test(s) equivalent or similar to OECD Guideline 405
Sensitization	
Respiratory Sensitization: No end point data for material.	Not expected to be a respiratory sensitizer.

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 12: Ecological Information

This section provides information to evaluate the environmental impact of the chemical (s) if it were released to the environment and may include:

- Ecotoxicity (aquatic and terrestrial, where available).
- Persistence and degradability.
- Bioaccumulative potential.
- Mobility in soil.

SECTION 12 ECOLOGICAL INFORMATION

The information given is based on data for the material, components of the material, or for similar materials, through the application of bridging principals.

ECOTOXICITY

Material -- Expected to be toxic to aquatic organisms. May cause long-term adverse effects in the aquatic environment.

MOBILITY

Material -- Highly volatile, will partition rapidly to air. Not expected to partition to sediment and wastewater solids.

PERSISTENCE AND DEGRADABILITY

Biodegradation:

Material -- Expected to be readily biodegradable.

Hydrolysis:

Material -- Transformation due to hydrolysis not expected to be significant.

Photolysis:

Material -- Transformation due to photolysis not expected to be significant.

Atmospheric Oxidation:

Material -- Expected to degrade at a moderate rate in air

BIOACCUMULATION POTENTIAL

Material -- Potential to bioaccumulate is low.

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 13: Disposal Considerations

This section provides guidance on proper disposal practices, recycling or reclamation of the chemical(s) or its container, and safe handling practices, to include:

- A description of appropriate disposal containers to use.
- Recommendations of appropriate disposal methods to deploy.
- A description of the physical and chemical properties that may affect disposal activities.
- Language discouraging sewage disposal, to include any special precautions for landfills or incineration activities.

SECTION 13 DISPOSAL CONSIDERATIONS

Disposal recommendations based on material as supplied. Disposal must be in accordance with current applicable laws and regulations, and material characteristics at time of disposal.

DISPOSAL RECOMMENDATIONS

Product is suitable for burning in an enclosed controlled burner for fuel value or disposal by supervised incineration at very high temperatures to prevent formation of undesirable combustion products.

REGULATORY DISPOSAL INFORMATION

RCRA Information: Disposal of unused product may be subject to RCRA regulations (40 CFR 261). Disposal of the used product may also be regulated due to ignitability, corrosivity, reactivity or toxicity as determined by the Toxicity Characteristic Leaching Procedure (TCLP). Potential RCRA characteristics: IGNITABILITY. TCLP (BENZENE)

Empty Container Warning Empty Container Warning (where applicable): Empty containers may contain residue and can be dangerous. Do not attempt to refill or clean containers without proper instructions. Empty drums should be completely drained and safely stored until appropriately reconditioned or disposed. Empty containers should be taken for recycling, recovery, or disposal through suitably qualified or licensed contractor and in accordance with governmental regulations. DO NOT PRESSURISE, CUT, WELD, BRAZE, SOLDER, DRILL, GRIND, OR EXPOSE SUCH CONTAINERS TO HEAT, FLAME, SPARKS, STATIC ELECTRICITY, OR OTHER SOURCES OF IGNITION. THEY MAY EXPLODE AND CAUSE INJURY OR DEATH.

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 14: Transport Information

This section provides guidance on classification information for shipping and transporting of hazardous chemical(s) by road, air, rail, and sea:

- UN number.
- UN proper shipping name.
- Transport hazard class(es).
- Packing group number, if applicable.
- Environmental hazards (e.g., marine pollutant).
- Transport in bulk.
- Special precautions which an employee should be aware of or needs to comply with, in connection with transport or conveyance within or outside their premises.

SECTION 14 TRANSPORT INFORMATION

LAND (DOT)

Proper Shipping Name: BENZENE
Hazard Class & Division: 3
ID Number: 1114
Packing Group: II
Product RQ: 10 LBS - benzene
ERG Number: 130
Label(s): 3
Transport Document Name: UN1114, BENZENE, 3, PG II, RQ

LAND (TDG)

Proper Shipping Name: BENZENE
Hazard Class & Division: 3
UN Number: 1114
Packing Group: II

SEA (IMDG)

Proper Shipping Name: BENZENE
Hazard Class & Division: 3
EMS Number: F-E, S-D
UN Number: 1114

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 15: Regulatory Information

This section identifies the safety, health, and environmental regulations specific for the product that is not indicated anywhere else on the SDS, including any national and/or regional regulatory information.

SECTION 15 REGULATORY INFORMATION

OSHA HAZARD COMMUNICATION STANDARD: This material is considered hazardous in accordance with OSHA HazCom 2012, 29 CFR 1910.1200.

Listed or exempt from listing/notification on the following chemical inventories: AICS, DSL, ENCS, IECSC, ISHL, KECI, PICCS, TCSI, TSCA

SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302

CERCLA:

Chemical Name	CAS Number	Typical Value	Component RQ	Product RQ
benzene	71-43-2	100 %	10 LBS	10 LBS

SARA (311/312) REPORTABLE GHS HAZARD CLASSES: Aspiration Hazard, Carcinogenicity, Flammable (gases, aerosols, liquids, or solids), Germ cell mutagenicity, Serious eye damage or eye irritation, Skin Corrosion or Irritation, Specific Target Organ toxicity (single or repeated exposure)

SARA (313) TOXIC RELEASE INVENTORY:

Chemical Name	CAS Number	Typical Value
benzene	71-43-2	100 %

4.1 Safety Data Sheet (SDS)

The HCS requires that the information on the SDS be presented using specific headings in a specified sequence. The format of the ANSI-approved 16-section SDS includes the following sections, click each section to see a sample excerpt from a SDS and the accompanying description of that section.

Section 16: Other Information, including Date of Preparation or Last Revision

This section indicates when the SDS was prepared or when the last known revision was made. The SDS may also state where the changes have been made to the previous version. Other useful information also may be included here.

The SDS contains Sections 12-15 to be consistent with the United Nations' Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Although the headings for Sections 12-15 are mandatory, OSHA does enforce the content of these four sections because they are within other agencies' jurisdictions.

With a special note to trade secrets, the specific chemical identity may be withheld from the employee and the employer if the manufacturer can "support" a claim that its disclosure may hurt their business. In this case, healthcare personnel may discover the specific chemical identity from the manufacturer or distributer after the employee is injured or within strict guidelines, without an injury occurrence.

SECTION 16 OTHER INFORMATION

⚠ **WARNING:** Cancer and Reproductive Harm - www.P65Warnings.ca.gov.

This warning is given to comply with California Health and Safety Code 25249.6 and does not constitute an admission or a waiver of rights.

N/D = Not determined, N/A = Not applicable

KEY TO THE H-CODES CONTAINED IN SECTION 3 OF THIS DOCUMENT (for information only):
H225: Highly flammable liquid and vapor; Flammable Liquid, Cat 2
H303: May be harmful if swallowed; Acute Tox Oral, Cat 5
H304: May be fatal if swallowed and enters airways; Aspiration, Cat 1
H315: Causes skin irritation; Skin Corr/Irritation, Cat 2
H319(2A): Causes serious eye irritation; Serious Eye Damage/Irr, Cat 2A
H340(1B): May cause genetic defects; Germ Cell Mutagenicity, Cat 1B
H350(1A): May cause cancer; Carcinogenicity, Cat 1A
H372: Causes damage to organs through prolonged or repeated exposure; Target Organ, Repeated, Cat 1
H401: Toxic to aquatic life; Acute Env Tox, Cat 2
H412: Harmful to aquatic life with long lasting effects; Chronic Env Tox, Cat 3

4.2 Hazard Communication Training

From the inception of the Hazard Communication standard, many have failed to grasp the true extent of the necessary training. Employers have been providing employees with labels and SDSs that they could not understand. The intent of this standard is found in its nickname- "Employee Right to Know". It's not the "Employee Right to be Told" standard. The employee needs to know (i.e., understand) the hazards of the chemicals to which they may be exposed. That means they need to understand the chemical terms and concepts they will see on labels, SDSs, and any other form of hazard warning they may encounter during their jobs. In fact, with the changes in the GHS standard, the nickname for “Right to Know” has been updated to “Right to Know AND Understand”. Many employers have squeaked by OSHA compliance officers without teaching employees everything necessary for them to truly understand what labels and SDSs say but those employers certainly have not made their employees safer.

Click Box

4.2.1 Training Frequency

OSHA specifically states the following: “Employers shall provide employees with effective information and training on hazardous chemicals in their work area at the time of their initial assignment, and whenever a new chemical hazard the employees have not previously been trained about is introduced into their work area.” And while OSHA does not require it, NASP believes that all employees should receive a refresher hazard communication course annually. As previously mentioned, the course must contain chemical terms and concepts. A brief overview for those who have had the training the year before will NOT suffice to cause them to remember the difficult chemical terms and concepts they must understand if they are to understand the forms of hazard warnings available to them.

4.2.1 Training Frequency

All employees should receive hazard communication update training when any hazard or hazard information pertinent to their work area changes. The 2012 Hazard Communication standard allows up to 6 months to update SDSs when new information is available. But the ethical and liability failures of having information that has not been given to affected employees after one has experienced an injury that could have been prevented by that knowledge is something no employer should risk.

All employees should receive hazard communication refresher training at any time they demonstrate a lack of the knowledge necessary to work safely with a hazardous chemical. The content of this training should be determined by the need demonstrated. This is a strictly performance-oriented position that is intended to ensure that employees retain the knowledge necessary to understand the forms of hazard warnings available to them. For example, if an employee demonstrates that they do not recall a chemical terms or concept found on a label, SDS, or other form of hazard warning found in their workplace, this information should immediately be reviewed with them until they demonstrate understanding.

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4.2.2 The Annual Hazard Communication Course Content

The following elements should be included in the annual training course:

- Chemical Terms and Concepts
- Hazard Identification & Classification
- Labels and other Forms of Warning
- Engineering and Administrative Controls, PPE and Emergency Procedures
- Safety Data Sheets (content and location)

4.2.3 Hazard Communication Refresher Course Content

The content of the refresher training should be determined by the supervisor or safety manager based upon the demonstrated failure of the employee to have the knowledge necessary to work safety when dealing with chemicals in the workplace.

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