XIII. CHEMICAL SAFETY

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CHAPTER 13

CHEMICAL SAFETY

SECTION 1: OVERVIEW

Almost everyone works with or around chemicals and chemical products every day. Chemical safety is inherently linked to other safety issues including engineering controls, laboratory procedures, personal protective equipment, electrical safety, fire safety, and hazardous waste disposal. Many chemicals have properties that make them hazardous: they can represent physical hazards (fire, explosion) and/or health hazards (toxicity, chemical burns, and dangerous fumes). However, there are many ways to work with chemicals which can both reduce the probability of an accident and minimize the consequences should an accident occur.

Risk minimization depends on safe practices, appropriate engineering controls for chemical containment, the proper use of personal protective equipment, the use of the minimum quantity of material necessary, and/or substitution of less hazardous chemicals. Before beginning an operation, one should ask "What would happen if . . .?" The answer to this question requires an understanding of the hazards associated with the chemicals, equipment and procedures involved. The hazardous properties of the material and its intended use will dictate the precautions to be taken.

It is important to distinguish the difference between *hazard* and *risk*. The two terms are sometimes used as synonyms. In fact, the term “hazard” is a much more complex concept because it includes conditions of use. The hazard presented by a chemical has two components: (1) its inherent capacity to do harm by virtue of its toxicity, flammability, explosiveness, corrosiveness, etc.; and (2) the ease with which the chemical can come into contact with a person or other object of concern. The two components together determine “risk” – the likelihood or probability that a harmful consequence will occur. Thus, an extremely toxic chemical such as strychnine cannot cause poisoning if it is in a sealed container and does not contact the handler. In contrast, a chemical that is not highly toxic can be lethal if a large amount is ingested.

It should be noted that not all chemicals are considered *hazardous*. Examples of nonhazardous chemicals include pH neutral buffers, sugars, starches, agar, and naturally occurring amino acids. This chapter will focus on hazardous chemicals.

SECTION 2: HAZARD COMMUNICATION PROGRAM

TAMUG has a written program for hazardous chemicals that complies with the Texas Hazard Communication Act (THCA). This program is available from Environmental Health & Safety. It requires the following:

a. Employee training (including recognition of signs of exposure)

    i. General – Provided by EHS
    ii. Work Area Specific – Provided by individual's supervisor (PI, laboratory manager, etc.)

b. Employee supervision
c. Labeling requirements

    i. Primary container labels – Must have the original manufacturer's label, which includes the chemical name, hazards, and manufacturer's information.
    ii. Secondary container labels – Must identify the chemical as it is on the Material Safety Data Sheet (MSDS) and the hazards.

    Exemptions – *Research laboratories are exempt from the secondary container labeling requirements under THCA. However, TAMU requires that all containers be labeled so as to somehow identify the contents.*

d. Availability of MSDSs
e. Provision of personal protective equipment (PPE)
f. Work area chemical inventories
g. Recordkeeping requirements
h. Emergency response procedures

Refer to the TAMU Hazard Communication Program and other sections in this manual for more information on these topics.

SECTION 3: HAZARD IDENTIFICATION

An integral part of hazard communication is hazard identification. Everyone who works with hazardous chemicals should know how to read and interpret hazard information. Signs, labels, placards, and symbols alert employees to the known hazards in a particular location.

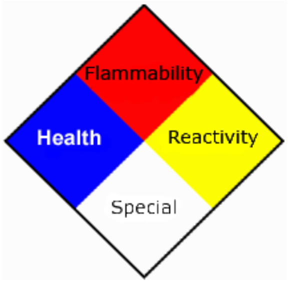
The National Fire Protection Association (NFPA) diamond in the illustration below is one method of identifying chemical hazards. NFPA uses a scale of 0 – 4 to rate each hazard, with 0 indicating "no hazard" and 4 indicating the most extreme hazard. The following is a detailed explanation of the NFPA hazard classification codes:

a. Health (Blue):

4 - Can cause death or major injury despite medical treatment
3 - Can cause serious injury despite medical treatment
2 - Can cause injury. Requires prompt medical treatment
1 - Can cause irritation if not treated
0 - No hazard

b. Flammability (Red):

4 - Very flammable gases or liquids
3 - Can ignite at normal temperatures
2 - Ignites with moderate heat
1 - Ignites with considerable preheating
0 - Will not burn



c. Reactivity (Yellow):

4 - Readily detonates or explodes
3 - May detonate or explode with strong initiating force or heat under confinement
2 - Normally unstable, but will not detonate
1 - Normally stable. Unstable at high temperature and pressure.
0 - Normally stable and not reactive with water.

d. Specific Hazard (White):

Oxidizer - OX
Acid - ACID
Alkali - ALK
Corrosive - COR
Use No Water - ~~W~~
Radioactive - (see image at right)

Many chemicals fall under more than one hazard class. Extra care should be taken when handling or storing chemicals with multiple hazards.

Other labeling systems may also be used. For instance, the Department of Transportation (DOT) has a labeling system for the shipment of hazardous materials. Examples of DOT placards are shown within the text of this chapter.

SECTION 4: CHEMICAL SAFETY GUIDELINES

Always follow these guidelines when working with chemicals:

a. Assume that any unfamiliar chemical is hazardous and treat it as such.
b. Know all the hazards of the chemicals with which you work. For example, perchloric acid is a corrosive, an oxidizer, and a reactive. Benzene is an irritant that is also flammable, toxic, and carcinogenic.
c. Never underestimate the potential hazard of any chemical or combination of chemicals. Consider any mixture or reaction product to be at least as hazardous as – if not *more* hazardous than – its most hazardous component.
d. Never use any substance that is not properly labeled. It may not be what you think it is!
e. Date all chemicals when they are received and again when they are opened.
f. Follow all chemical safety instructions, such as those listed in Material Safety Data Sheets or on chemical container labels, precisely.
g. Minimize your exposure to any chemical, regardless of its hazard rating, and avoid repeated exposure.
h. Use personal protective equipment (PPE), as appropriate for that chemical.
i. Use the buddy system when working with hazardous chemicals. Don't work in the laboratory alone.

SECTION 5: MATERIAL SAFETY DATA SHEETS

Before using any chemical, read the appropriate Material Safety Data Sheet (MSDS). An MSDS is a document that details information about chemicals and along with the container label is a good source of information for chemical safety. It provides the following information:

a. Identity of the chemical
b. The manufacturer's name and address
c. Hazardous ingredients
d. Exposure limits

    i. Permissible Exposure Limit (PEL) or Recommended Exposure Limit (REL) – This is the amount of a chemical that a person can be exposed to, averaged over an eight hour period, before it causes him/her harm.
    ii. Short Term Exposure Limit (STEL) – This is the amount of a chemical that a person can be exposed to, averaged over a 15 minute period, before it causes him/her harm.
    iii. Immediately Dangerous to Life and Health (IDLH) – This is the amount of chemical that immediately puts a person a risk of serious injury or death.

If this level is reach or exceeded, the area should be evacuated immediately!

e. Physical characteristics, such as:

    i. Boiling point
    ii. Vapor pressure

f. Chemical hazards, including the following:

    i. Flammability
    ii. Explosiveness
    iii. Reactivity

g. Health hazards, including chemicals that are:

    i. Toxins (both acute and long-term)

        1. Carcinogens
        2. Reproductive Toxins
        3. Teratogens
        4. Mutagens
        5. Neurotoxins

    ii. Irritants

h. Routes of Entry
i. Emergency and first-aid procedures
j. Proper leak, spill, and disposal techniques
k. Proper storage and handling procedures
l. Other special provisions

Each person working with chemicals should have access to the MSDS for all chemicals they use. “Access” may be:

- A current hard copy kept in a work area file or binder.
- An electronic copy.

SECTION 6: SAFE HANDLING GUIDELINES

Employees should treat all chemicals and equipment with caution and respect. When working with chemicals, remember to do the following:

a. Wear appropriate personal protective equipment (PPE) for the chemical hazard.
b. Remove and use only the amount of chemicals needed for the immediate job at hand.

c. Properly seal, label, and store chemicals in appropriate containers. Keep the containers clearly marked and in a well-ventilated area.
d. Segregate and store chemicals by their hazard class.
e. Check stored chemicals for deterioration and for damage to the containers.
f. Learn how to dispose of chemicals safely and legally. Contact EHS Office and follow TAMUG waste disposal requirements.
g. Clean up spills and leaks immediately.
h. Develop a Plan of Action for how to respond in an emergency. Review this plan regularly to be familiar with it.
i. Do not store chemicals near heat, in sunlight, or near substances which might initiate a dangerous reaction.
j. When transporting chemicals between the work area and other areas, use secondary containment (such as a tray, rack, cart or rubber carrier) to protect against spills, leaks or container breakage. Always use a secondary container when transporting hazardous or highly odorous chemicals on an elevator.
k. Never pour any chemicals down the sink. Use proper hazardous waste disposal procedures for all excess or unused chemicals.

SECTION 7: CHEMICAL STORAGE GUIDELINES

Proper chemical storage is as important to safety as proper chemical handling. Often, seemingly logical storage ideas, such as placing chemicals in alphabetical order, may cause incompatible chemicals to be stored together.

7.1 GENERAL STORAGE GUIDELINES

Follow these guidelines for safe chemical storage:

a. Read chemical labels and the MSDS for specific storage instructions.
b. Store chemicals in a well-ventilated area; however, *do not* store chemicals in a fume hood.
c. Date all chemicals when they are received and again when they are opened.
d. Maintain an inventory of all chemicals in storage. A copy of the inventory should be maintained at a location outside of the laboratory.
e. Return chemical containers to their proper storage location after use.
f. Store glass chemical containers so that they are unlikely to be broken. Glass containers should never be stored directly on the floor.
g. Store all hazardous liquid chemicals below eye level of the shortest person working in the laboratory.
h. Never store hazardous chemicals in a public area or corridor. Hazardous chemicals must be kept in a secured area.

7.2 SEPARATING AND STORING HAZARDOUS CHEMICALS

In addition to the guidelines above, there are storage requirements for separating hazardous chemicals. Follow these guidelines to ensure that hazardous chemicals are stored safely:

a. Group chemicals according to their hazard category (i.e., corrosives, flammables, toxins, etc.), not alphabetically, and separated by some sort of physical barrier. An alphabetical storage system may place incompatible chemicals next to each other.
b. Separate acids from bases and inorganic acids or bases from organic acids or bases. Store these chemicals near floor level.
c. Isolate perchloric acid from all other chemicals and from organic materials. Do not store perchloric acid on a wooden shelf or spill paper.
d. Separate highly toxic chemicals and carcinogens from all other chemicals. This storage location should have a warning label and should be locked.
e. Time-sensitive chemicals, such as those that form peroxides, should not be kept longer than twelve months from purchase or six months after opening. If stratification of liquids, precipitate formation, and/or change in color or texture is noted, contact EHS immediately.
f. Picric acid *must* be stored under a layer of liquid, as picric crystals are highly explosive. If picric acid dries out (forming yellow crystals), do not touch the container! Contact EHS immediately!
g. If flammables need to be chilled, store them in a laboratory-safe refrigerator, not in a standard (household style) refrigerator.
h. Chemicals may be stored in the cabinets underneath a chemical fume hood provided the cabinetry is designed for that use.
    i. Cabinetry designed for flammable storage vents into the fume hood exhaust duct.
    ii. Cabinetry designed for corrosives storage vents directly into the fume hood. Flammable chemicals should *never* be stored in this type of cabinets!
    iii. Some cabinetry is only designed for general storage or with a drying rack. These cabinets are not meant to be used for hazardous chemical storage.
i. Flammables should be stored in a well ventilated area and large quantities in a flammable storage cabinet. Contact EHS for more information on allowable storage of flammable liquids per NFPA Code.

The following table provides examples of incompatible chemicals:

CHEMICAL	INCOMPATIBLE WITH . . .
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric and sulfuric acid mixtures
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine
Cyanide	Acids
Fluorine	Most other chemicals
Nitrates	Sulfuric acid
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils,
Sodium	Carbon tetrachloride, carbon dioxide, water
Sulfides	Acids

Contact EHS for more information on segregating incompatible chemicals and other storage guidelines.

SECTION 8: HYGIENE AND CHEMICAL SAFETY

Good personal hygiene will help minimize exposure to hazardous chemicals. When working with chemicals, follow these guidelines:

a. Wash hands frequently and before leaving the laboratory. Also, wash hands before eating, drinking, smoking or applying makeup.
b. Wear appropriate personal protective equipment (PPE). <u>Always</u> wear protective gloves when handling any hazardous chemicals.
c. Remove PPE before leaving the laboratory and before washing hands.

d. Remove contaminated clothing immediately. Do not use the clothing again until it has been properly decontaminated.
e. Follow any special precautions for the chemicals in use.
f. Do not eat, drink, smoke or apply makeup around chemicals.
g. Tie back long hair when working in a laboratory or around hazardous chemicals.
h. Do not keep food, beverages, or food and beverage containers anywhere near chemicals or in laboratories where chemicals are in use.
i. Do not use laboratory equipment, including laboratory refrigerators/freezers, to store or serve food or drinks.
j. Do not wash food and beverage utensils in a laboratory sink.
k. Do not sniff or taste chemicals.
l. Do not touch door knobs, telephones, computer keyboards, etc. with contaminated gloves.

SECTION 9: TYPES OF CHEMICAL HAZARDS

9.1 CORROSIVES

Corrosive chemicals destroy or damage living tissue by direct contact. Some acids, bases, dehydrating agents, oxidizing agents, and organics are corrosives. Examples of the different types of corrosive chemicals are listed below:

- Acidic corrosives:
    - Inorganic Acids
        - Hydrochloric acid
        - Nitric Acid
        - Sulfuric acid
    - Organic Acids
        - Acetic Acid
        - Propionic acid
- Alkaline, or basic, corrosives:
    - Sodium hydroxide
    - Potassium hydroxide
- Corrosive dehydrating agents:
    - Phosphorous pentoxide
    - Calcium oxide
- Corrosive oxidizing agents:
    - Halogen gases
    - Hydrogen peroxide (concentrated)
    - Perchloric acid
- Organic corrosive:
    - Butylamine

Health Consequences

Extreme caution should be taken when handling corrosive chemicals, or severe injury may result.

a. Concentrated acids can cause painful and sometimes severe burns.
b. Inorganic hydroxides can cause serious damage to skin tissues because a protective protein layer does not form. Even a dilute solution such as sodium or potassium hydroxide can attack skin by reacting with the fat tissues and forming a soapy, slick film.
c. At first, skin contact with phenol may not be painful, but the exposed area may turn white due to the severe burn. Systemic poisoning may also result from dermal exposure.
d. Skin contact with low concentrations of hydrofluoric acid (HF) may not cause pain immediately but can still cause tissue damage if not treated properly. Higher concentrations of HF (50% or greater) can cause immediate, painful damage to tissues.

Safe Handling Guidelines for Corrosives

To ensure safe handling of corrosives, the following special handling procedures should be used:

a. Always store corrosives properly. Segregate acids from bases and inorganics from organics. Refer to the Chemical Storage section of this chapter for more information.
b. Always wear a laboratory coat, gloves and chemical splash goggles when working with corrosives. Wear other personal protective equipment, as appropriate.
c. To dilute acids, carefully add the acid to the water, not the water to the acid. This will minimize any reaction.
d. Corrosives, especially inorganic bases (e.g., sodium hydroxide), may be very slippery; handle these chemicals with care and clean any spills, leaks, splashes, or dribbles immediately.
e. Work in a chemical fume hood when handling fuming acids or volatile irritants (e.g., ammonium hydroxide).
f. A continuous flow eye wash station should be in every work area where corrosives are present. An emergency shower should also be within 55 feet of the area.

Corrosive Example: Perchloric Acid

Perchloric acid is a corrosive oxidizer that can be dangerously reactive. At elevated temperatures, it is a strong oxidizing agent and a strong dehydrating reagent. Perchloric acid reacts violently with organic materials. When combined with combustible material, heated perchloric acid may cause a fire or explosion.

Cold perchloric acid at less than 70% concentration is not a very strong oxidizer, but its oxidizing strength increases significantly at concentrations higher than 70%. Anhydrous perchloric acid (>85%) is very unstable and can decompose spontaneously and violently.

When using perchloric acid, remember the following:

a. Be thoroughly familiar with the special hazards associated with perchloric acid before using it.
b. If possible, purchase 60% perchloric acid instead of a more concentrated grade.
c. Always wear rubber gloves and chemical splash goggles while using perchloric acid. Consider also wearing a face shield and rubber apron if splashing is likely.
d. Store perchloric acid inside secondary containment (such as a Pyrex dish) and segregated from all other chemicals and organic materials. Do not store bottles of perchloric acid in wooden cabinets or on spill paper.

IMPORTANT: *Heated digestions with perchloric acid require a special fume hood with a wash-down system. A perchloric acid fume hood should also be used when handling highly concentrated (greater than 70%) perchloric acid. Refer to the "Laboratory Ventilation Equipment" section for more information on these hoods.*

9.2 FLAMMABLES

A flammable chemical is any solid, liquid, vapor, or gas that ignites easily and burns rapidly in air. Consult the appropriate MSDS before beginning work with flammables.

Flashpoint, Boiling Point, Ignition Temperature, and Class

Flammable chemicals are classified according to flashpoint, boiling point, fire point, and auto-ignition temperature.

a. Flash Point (FP) is the lowest temperature at which a flammable liquid's vapor burns when ignited.
b. Boiling Point (BP) is the temperature at which the vapor pressure of a liquid is equal to the atmospheric pressure under which the liquid vaporizes. Flammable liquids with low BPs generally present special fire hazards.
c. Fire Point is the temperature at which the flammable liquid will burn.
d. Auto-ignition Temperature is the lowest temperature at which a substance will ignite without an ignition source.

Flammable liquids are classified according to how easily they burn. The following table illustrates flammable class characteristics as defined by NFPA 45:

FLAMMABLE CLASS	FLASHPOINT (ºF)	BOILING POINT (ºF)	EXAMPLES
1A	<73	<100	Diethyl ether "Flammable" aerosols
1B	<73	≥100	Acetone Gasoline Toluene
1C	≥73	<100	Butyl alcohol Methyl isobutyl ketone Turpentine
2	100 - 140	---	Cyclohexane Kerosene Mineral spirits
3A	140 - 199	---	Butyl cellosolve
3B	>200	---	Cellosolve Ethylene glycol Hexylene glycol

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The following table provides examples of common flammables and their flashpoint and class.

CHEMICAL	FLASHPOINT (ºF)	FLAMMABLE CLASS
Acetone	0	1B
Benzene	12	1B
Butyl Acetate	>72	1C
Carbon Disulfide	-22	1B
Cyclohexane	-4	1B
Diethylene Glycol	225	3B
Diethyl ether	-49	1A
Ethanol	55	1B
Heptane	25	1B
Isopropyl Alcohol	53	1B

Methanol	52	1B
Pentane	<-40	1A
Toluene	40	1B

Conditions for a Fire

Improper use of flammable liquids can cause a fire. The following conditions must exist for a fire to occur:

- Flammable material (i.e., fuel) must be present in sufficient concentration to support a fire.
- Oxygen or an oxidizer must be present.
- An ignition source (i.e., heat, spark, etc.) must be present.

When working with flammables, always take care to minimize vapors which act as fuel.

Safe Handling Guidelines for Flammables

a. Handle flammable chemicals in areas free from ignition sources.
b. Never heat flammable chemicals with an open flame. Use a water bath, oil bath, heating mantle, hot air bath, hot plate, etc. Such equipment should be intrinsically safe, with no open sparking mechanisms.

NOTE: *When using an oil bath, make sure the temperature is kept below the oil flash point.*

c. Use ground straps when transferring flammable chemicals between metal containers to avoid generating static sparks.
d. Work in an area with good general ventilation and use a fume hood when there is a possibility of dangerous vapors. Ventilation will help reduce dangerous vapor concentrations, thus minimizing this fire hazard.
e. Restrict the amount of stored flammables in the laboratory, and minimize the amount of flammables present in a work area.

NOTE: *The NFPA has established formal limits on the total amounts of flammable liquids that may be stored or used in laboratories. (NFPA 30 and 45)*

f. Only remove from storage the amount of chemical needed for a particular experiment or task.

9.3 SOLVENTS

Organic solvents are often the most hazardous chemicals in the work place. Solvents such as ether, alcohols, and toluene, for example, are highly volatile and flammable. Perchlorinated solvents, such as carbon tetrachloride (CCl_4), are non-flammable. But most hydrogen-containing chlorinated solvents, such as chloroform, are flammable. When exposed to heat or flame, chlorinated solvents may produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

Always use volatile and flammable solvents in an area with good ventilation or preferably in a fume hood. Never use ether or other highly flammable solvents in a room with open flames or other ignition sources present, including non-intrinsically safe fixtures.

Solvent Exposure Hazards

Health hazards associated with solvents include exposure by the following routes:

- Inhalation of a solvent may cause bronchial irritation, dizziness, central nervous system depression, nausea, headache, coma, or death. Prolonged exposure to excessive concentrations of solvent vapors may cause liver or kidney damage. The consumption of alcoholic beverages can enhance these effects.
- Skin contact with solvents may lead to defatting, drying, and skin irritation.
- Ingestion of a solvent may cause sever toxicological effects. Seek medical attention immediately.

The odor threshold for the following chemicals exceeds acceptable exposure limits. Therefore, if you can smell it, you may be overexposed — *increase ventilation immediately!* Examples of such solvents are:

- Chloroform
- Benzene
- Carbon tetrachloride
- Methylene chloride

NOTE: *Do not depend on your sense of smell alone to know when hazardous vapors are present. The odor of some chemicals is so strong that they can be detected at levels far below hazardous concentrations (e.g., xylene).*

Some solvents (e.g., benzene) are known or suspected carcinogens.

Reducing Solvent Exposure

To decrease the effects of solvent exposure, substitute hazardous solvents with less toxic or hazardous solvents whenever possible. For example, use hexane instead of diethyl ether, benzene or a chlorinated solvent.

Solvent Example: DMSO

Dimethyl sulfoxide (DMSO) is unique because it is a good solvent with many water-soluble as well as lipid-soluble materials. Due to these properties, dimethyl sulfoxide is rapidly absorbed and distributed throughout the body.

DMSO can facilitate absorption of other chemicals – such as grease, oils, cosmetics – that may contact the skin.

- While DMSO alone has low toxicity, when combined with other, more toxic chemicals it can cause the more toxic chemical to be absorbed more readily through the skin.
- Some medications, such as liniment, also contain DMSO.

While relatively stable at room temperature, DMSO can react violently to other chemicals when heated.

Wear impervious clothing and personal protective equipment (laboratory coat, gloves, etc.) to prevent skin exposure. Use chemical splash goggles and/or a face shield if splashing may occur.

9.4 TOXINS AND IRRITANTS

The toxicity of a chemical refers to its ability to damage an organ system (kidneys, liver), disrupt a biochemical process (e.g., the blood-forming process) or disrupt cell function at some site remote from the site of contact. Any substance, even water, can be harmful to living things under the right conditions.

The **biological effects** – whether beneficial, indifferent or toxic – of all chemicals are dependent on a number of factors, including:

- Dose (the amount of chemical to which one is exposed)
- Duration of exposure (both length of time and frequency)
- Route of entry:
    - Ingestion
    - Absorption through the skin
    - Inhalation
    - Injection

__NOTE:__ Inhalation and dermal absorption are the most common methods of chemical exposure in the workplace.

- Individual response and history
- One's exposure to other chemicals
- Mixing the toxin with other chemicals

The most important factor in toxicity is the dose-time relationship. In general, the more toxin to which an individual is exposed, and the longer they are exposed to it, the stronger their physiological response will be. However, an individual's response can also depend on several other factors, including:

- Health
- Gender
- Genetic predisposition
- An individual's exposure to other chemicals
- Previous sensitization

  __NOTE:__ When a person becomes sensitized to a chemical, each subsequent exposure may often produce a stronger response than the previous exposure.

- Chemical mixtures

  __NOTE:__ Combining a toxic chemical with another chemical can increase the toxic effect of either or both chemicals.

IMPORTANT: *Minimize exposure to any toxic chemical.*

General Safe Handling Guidelines

a. Read the appropriate MSDS.
b. Be familiar with the chemical's exposure limits.
c. Use a chemical fume hood.
d. *Always* wear appropriate PPE.
e. *Never* eat, drink, or use tobacco products around toxins or store them near any hazardous chemicals.
f. Avoid touching your face or other exposed skin with contaminated gloves or other contaminated materials.
g. Store toxic gases in a gas exhaust cabinet.

Acute Toxins vs. Chronic Toxins

The dose-time relationship forms the basis for distinguishing between acute toxicity and chronic toxicity.

The **acute toxicity** of a chemical is its ability to inflict bodily damage from a single exposure. A sudden, high-level exposure to an acute toxin can result in an emergency situation, such as a severe injury or even death. Examples of acute toxins include the following:

- Hydrogen cyanide
- Hydrogen sulfide
- Nitrogen dioxide
- Ricin
- Organophosphate pesticides
- Arsenic

IMPORTANT: *Do not work alone when handling acute toxins. Use a fume hood to ensure proper ventilation, or wear appropriate respiratory protection if a fume hood is not available*.

Chronic toxicity refers to a chemical's ability to inflict systemic damage as a result of repeated exposures, over a prolonged time period, to relatively low levels of the chemical. Such prolonged exposure may cause severe injury. Examples of chronic toxins include the following:

- Mercury
- Lead
- Formaldehyde

Some chemicals are extremely toxic and are known primarily as acute toxins. Some are known primarily as chronic toxins. Others can cause either acute or chronic effects.

The toxic effects of chemicals can range from mild and reversible (e.g. a headache from a single episode of inhaling the vapors of petroleum naphtha that disappears when the victim gets fresh air) to serious and irreversible (liver or kidney damage from excessive exposures to chlorinated solvents). The toxic effects from chemical exposure depend on the severity of the exposures. Greater exposure and repeated exposure generally lead to more severe effects.

Types of Toxins

Carcinogens are materials that can cause cancer in humans or animals. Several agencies including OSHA (Occupational Safety & Health Administration), NIOSH (The National Institute for Occupational Safety and Health), and IARC (International Agency for Research on Cancer) are responsible for identifying carcinogens. There are very few chemicals known to cause cancer in humans, but there are many suspected carcinogens and many substances with properties similar to known carcinogens.

Examples of known carcinogens include the following:

- Asbestos
- Benzene
- Tobacco smoke
- Hexavalent Chromium
- Aflatoxins
- Carbon tetrachloride

Zero exposure should be the goal when working with known or suspected carcinogens. Workers who are routinely exposed to carcinogens should undergo periodic medical examinations.

Reproductive toxins are chemicals that can adversely affect a person’s ability to reproduce. **Teratogens** are chemicals that adversely affect a developing embryo or fetus. Heavy metals, some aromatic solvents (benzene, toluene, xylenes, etc.), and some therapeutic drugs are among the chemicals that are capable of causing these effects. In addition, the adverse effects produced by ionizing radiation, consuming alcohol, using nicotine and using illicit drugs are recognized.

While some factors are known to affect human reproduction, knowledge in this field (especially related to the male) is not as broadly developed as other areas of toxicology. In addition, the developing embryo is most vulnerable during the time before the mother knows she is pregnant. Therefore, it is prudent for all persons with reproductive potential to minimize chemical exposure.

Sensitizers may cause little or no reaction upon first exposure. Repeated exposures may result in severe allergic reactions.

Examples of sensitizers include the following:

- Isocyanates
- Nickel salts
- Beryllium compounds
- Formaldehyde
- Diazomethane
- Latex

NOTE: *Some people who often use latex-containing products may develop sensitivity to the latex. A sensitized individual’s reaction to latex exposure can* *eventually include anaphylactic shock, which can result in death. To minimize exposure to latex, use non-latex containing gloves, such as nitrile gloves.*

Irritants cause reversible inflammation or irritation to the eyes, respiratory tract, skin, and mucous membranes. Irritants cause inflammation through long-term exposure or high concentration exposure. For the purpose of this section, irritants <u>do not</u> include corrosives.

Examples of irritants include the following:

- Ammonia
- Formaldehyde
- Halogens
- Sulfur dioxide
- Poison ivy
- Dust
- Pollen
- Mold

Mutagens can alter DNA structure. Some mutagens are also carcinogens. Examples of mutagens are:

- Ethidium bromide
- Nitrous acid
- Radiation

Neurotoxins are chemicals that affect the nervous system. Examples of neurotoxins include:

- Methanol
- Many snake and insect venoms
- Botulinum toxin

9.5 Reactives and Explosives

Reactive chemicals may be sensitive to either friction or shock, or they may react in the presence of air, water, light, heat, or other chemicals. Some reactive chemicals are inherently unstable and may quickly decompose on their own, releasing energy in the process. Others form toxic gases when reacting. **Explosive chemicals** decompose or burn very rapidly when subjected to shock or ignition. Reactive and explosive chemicals produce large amounts of heat and gas when triggered, and thus are extremely dangerous.

Follow these guidelines when handling and storing reactive and explosive chemicals:

a. Read the appropriate MSDS and other pertinent fact sheets on the chemical. Be familiar with chemical specific handling and storage requirements.
b. Follow Standard Operating Procedures and to have a Plan of Action established for how to handle emergency situations.
c. Isolate the chemical from whatever causes a reaction.

    i. Store reactives separate from other chemicals.
    ii. Store reactives in a cool/dry area.
    iii. Keep reactive chemicals out of sunlight and away from heat sources.

d. Know where emergency equipment is located and how to use it.

Examples of reactive compounds include the following:

REACTIVE CLASSIFICATION	**CHEMICAL EXAMPLES**
Acetylenic compounds	Acetylene Copper(I) acetylide
Azides	Benzenesulfonyl azide Lead (II) azide
Azo compounds	Azomethane Diazomethane
Chloro/perchloro compounds	Lead perchlorate Potassium chlorite Silver chlorate Perchloric Acid (Anhydrous)
Fulminates	Copper (II) fulminate Silver fulminate
Nitro compounds	Nitromethane Trinitrotoluene (TNT)
Nitrogen-containing compounds	Silver amide Silver nitride
Organic peroxide formers	Diethyl ether Isopropyl ether
Picrates	Picric acid (dry) Lead picrate
Peroxides	Diacetyl peroxide Zinc peroxide
Strained ring compounds	Benzvalene Prismane

Polymerizable compounds	Butadiene Vinyl chloride

SECTION 10: PROTECTING ONESELF WHEN WORKING WITH CHEMICALS

For information on ways to protect oneself when working with chemicals, including information on personal protective equipment, engineering controls, and how to respond to chemical spills and exposures, see Chapter 6 of this manual, which is titled, “How to Protect Yourself.”

SECTION 11: CHEMICAL WASTE DISPOSAL

Chemical waste must be disposed of as hazardous waste. For information on chemical waste disposal, contact the EHS office.

SECTION 12: TRANSPORTING HAZARDOUS MATERIALS

The U.S. Department of Transportation regulates the shipment of hazardous materials. Anyone who packages, receives, unpacks, signs for, or transports hazardous chemicals must be trained and certified in Hazardous Materials Transportation. Warehouse personnel, shipping and receiving clerks, truck drivers, and other employees who pack or unpack hazardous materials must receive this training as well. Contact EHS.