TEXAS A&M UNIVERSITY
SAN ANTONIO

Chemical Safety Guidelines

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Environmental Health & Safety

Texas A&M University - San Antonio

Chemical Safety Program

Approval Document

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ANNUAL REVIEW

Annual review of the A&M-SA Chemical Safety Guidelines document is the responsibility of the Assistant Manager-EHS (Research and Academic EHS)

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July 2021	Complete Plan	Reformatted Plan,	Victor Pantusa

Texas A&M University-San Antonio
Chemical Safety Guideline

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Texas A&M University - San Antonio

Chemical Safety Guideline

I General Information

Chemicals are used in many places and in many different ways, including in factories, shops, laboratories, offices, farms and in the home and garden. The chemicals you use at work may include products you buy to use in your core business, or in maintaining your equipment, or in general cleaning. The following information is provided to assist Texas A&M University-San Antonio (A&M-SA) Departments in providing chemical safety requirements to protect employees, students, and the environment. 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 ways to work with chemicals which both reduce the probability of an accident and minimize the consequences should an accident occur.

Figure 1[1]

II Purpose

These Guidelines offer recommended minimum requirements that must be followed to minimize the risk of accidents resulting in injuries and/or damage to people, the environment and the University.

III Scope

This program applies to all employees, students, visitors and contractors/vendors at A&M-SA who handle chemicals on University property. Personnel working in laboratories (teaching and research) must also be familiar with the A&M-SA Laboratory Safety Program Guideline.

IV Risk Assessment

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 chemical(s), 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

[1] TAMU - Safety Manual Chap 3 / Section 1 – page 3-1. https://ehs.tamu.edu/manuals/

as dimethylmercury 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.

Risk = Hazard x Exposure

When it comes to chemical management, a distinction must be made between hazard and risk.

Hazard defines the inherent property of a chemical having the potential to cause adverse effects when an organism, system or population is exposed to that agent. **Risk** however, establishes the probability of the adverse effect occurring.

To be more specific, the risk of a chemical depends on the following 2 factors:

- The inherent toxicity of the chemical **(hazard**);
- How much of a chemical is present in an environmental medium (e.g., water, soil, air) and how much contact a person or ecological receptor has with the chemical substance (**exposure**).

A hazardous chemical substance poses no risk if there is no exposure. For example, sulfuric acid is very corrosive. It is of no or little risk to people who do not handle the chemical. For some people who may be exposed to sulfuric acid (scientists, workers), risk management measures (i.e, wearing goggles and gloves) can be taken to minimize the risk.

V Responsibilities

1. Environmental, Health & Safety (EHS) will:
   a. Assist in identifying safety procedures as necessary.
   b. Assist with training as appropriate.
   c. Monitor program compliance.
   d. Assist in the selection of monitoring equipment, personal protective equipment, and other necessary equipment.

2. The department/supervisor will:
   a. Identify personnel handling chemicals.
   b. Provide personal protective equipment and other engineering control equipment as needed.
   c. Provide proper training for persons procuring chemicals.

3. The employee will:
   a. Follow guidelines described in this program and other required programs to assure safe chemical use and storage.
   b. Attend all required safety training and renewals.
   c. Inform coworkers and supervisor of unsafe practices or conditions observed in workplace.
   d. Enroll and participate in the Occupational Health Program if required.

VI Hazard Communication

1. Hazard Communication Program

   A&M-SA has a written program (the A&M-SA Hazard Communication 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 through TrainTraq
    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 Safety Data Sheet (SDSs) and the hazards.
d. Availability of SDSs
e. Provision of personal protective equipment (PPE)
f. Work area chemical inventories
g. Recordkeeping requirements
h. Emergency response procedures

2. 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. Examples include:

a. The National Fire Protection Association (NFPA) diamond uses a scale of 0 – 4 to rate each hazard, with 0 indicating "no hazard" and 4 indicating the most extreme hazard.
b. Other labeling systems may also be used. For instance, the Department of Transportation (DOT) has a labeling system for the shipment of hazardous materials.

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

3. Safety Data Sheet (SDS)

Before using any chemical, read the appropriate Safety Data Sheet (SDS). An SDS 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)
      - Carcinogens
      - Reproductive Toxins
      - Teratogens
      - Mutagens
      - 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 SDS for all chemicals they use. "Access" may be:

i. A current hard copy kept in a work area file or binder.
ii. An electronic copy accessed through MSDSOnline®

VII General Chemical Safety Guidelines

1. Always follow these general guidelines when working with chemicals:
   a. Assume that any unfamiliar chemical is hazardous.
   b. Know all the hazards of the chemicals you are using (refer to SDS).
   c. Consider any mixture to be at least as hazardous as its most hazardous component.
   d. Never use any substance that is not properly labeled.
   e. Follow all chemical safety instructions precisely.
   f. Minimize your exposure to any chemical, regardless of its hazard rating.
   g. Use personal protective equipment.
   h. Use common sense at all times.
2. When working with chemicals, remember to do the following:
   a. Remove and use only the amount of chemicals needed for the immediate job at hand.
   b. Keep the containers in a well ventilated area.
   c. Check stored chemicals for deterioration and broken containers.
   d. Always use a secondary container when moving hazardous chemicals.
   e. Know what to do in an emergency and know where emergency contact information is located.

f. Learn how to dispose of chemicals safely and legally. Follow A&M-SA waste disposal requirements or contact EHS.

g. Clean up spills and leaks immediately.

h. Do not transport unprotected chemicals between the work area and other areas; use a tray, rack, cart or rubber carrier.

i. Do not put fellow workers or yourself in danger.

j. Employees should treat all chemicals and equipment with caution and respect. When working with chemicals, remember to do the following:
   i. Wear appropriate personal protective equipment (PPE) for the chemical hazard.
   ii. Remove and use only the amount of chemicals needed for the immediate job at hand.
   iii. Properly seal, label, and store chemicals in appropriate containers. Keep the containers clearly marked and in a well-ventilated area.
   iv. Segregate and store chemicals by their hazard class.
   v. Check stored chemicals for deterioration and for damage to the containers.
   vi. Learn how to dispose of chemicals safely and legally. Follow A&M-SA waste disposal requirements.
   vii. Clean up spills and leaks immediately.
   viii. Do not store chemicals near heat, in sunlight, or near substances which might initiate a dangerous reaction.
   ix. 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.
   x. Never pour any chemicals down the sink. Use proper hazardous waste disposal procedures for all excess or unused chemicals.

3. Chemical Storage Guidelines

   a. Proper chemical storage is as important to safety as proper chemical handling. The following guidelines are for safe chemical storage:
      i. Read chemical labels and SDSs for specific storage instructions.
      ii. Store chemicals in a well-ventilated area; however, do not store chemicals in a chemical fume hood unless EHS approval has been obtained.
      iii. Storage in direct heat or sunlight should be avoided.
      iv. Maintain an inventory of all chemicals in storage.
      v. Return chemical containers to their proper storage location after use.
      vi. Store glass chemical containers so that they are unlikely to be broken.
      vii. Store all hazardous chemicals below eye level.
      viii. Never store hazardous chemicals in a public area or corridor.

   b. Separating Hazardous Chemicals

      Accidental contact of incompatible chemicals can result in:
      i. Generation of heat (mixing acids & bases)
      ii. Violent reaction (mixing acrolein & acids or other catalyst
      iii. Formation of toxic vapors or gases (mixing cyanide salt & acid)
      iv. Formation of a flammable gas (mixing alkali metal & water)
      v. Fire or Explosion (mixing perchloric acid & acetic anhydride)

      Incompatible materials should be sufficiently segregated in storage to prevent mixing during fires, explosions, and natural disasters. Accidents with incompatible materials often occur during the commingling of wastes in laboratories.

c. Container Compatibility

The container used for hazardous waste collection must be compatible with the waste and must not contain residues of incompatible materials. The following table shows general chemical categories and compatible container types.

Take special care in choosing containers for the following wastes:

i. Nitric Acid: reacts with organics (including acetic acid) to produce heat and gas. If product containers for organics are used to collect nitric acid, be sure to rinse thoroughly to avoid potential over-pressurization and subsequent burst of the container.

ii. Perchloric Acid and Organic Peroxides: highly reactive with organics and organic material, such as wood. May also react with metals.

iii. Hydrofluoric Acid: Dissolves glass containers

VIII Work Place Hazards - Types of Chemical Hazards

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:

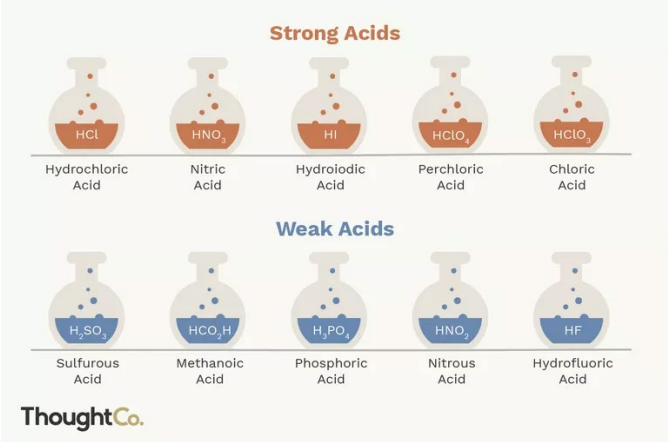

Figure 2[2]

a) Acidic corrosives:
   i. Inorganic Acids
      - Hydrochloric acid
      - Nitric Acid
      - Sulfuric acid
   ii. Organic Acids
      - Acetic Acid
      - Propionic acid

b) Alkaline, or basic, corrosives:
   i. Sodium hydroxide
   ii. Potassium hydroxide

c) Corrosive dehydrating agents:
   i. Phosphorous pentoxide
   ii. Calcium oxide

d) Corrosive oxidizing agents:
   i. Halogen gases
   ii. Hydrogen peroxide (concentrated)
   iii. Perchloric acid

e) Organic corrosive:
   i. Butylamine

Concentrated acids can cause painful burns that are often superficial. Inorganic hydroxides, however, 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 saponify fat and attack skin. 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.

[2] Thought Co. - List of Strong and Weak Acids https://www.thoughtco.com/list-of-strong-and-weak-acids-603642

b. Health Consequences

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

i. Concentrated acids can cause painful and sometimes severe burns.

ii. 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.

iii. 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.

iv. 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.

c. Safe Handling guidelines for corrosives

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

i. Always store corrosives properly. Segregate acids from bases and inorganics from organics. Refer to the Chemical Storage section of this chapter for more information.

ii. Always wear a laboratory coat, gloves and chemical splash goggles when working with corrosives. Wear other personal protective equipment, as appropriate.

iii. To dilute acids, carefully add the acid to the water, not the water to the acid. This will minimize any reaction.

iv. 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.

v. Work in a chemical fume hood when handling fuming acids or volatile irritants (e.g., ammonium hydroxide).

vi. 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.

vii. *Always add an acid (A) to water (W) not vice-versa … remember "A to W dilution."*

Figure 3[3]

2. Flammables

Figure 4[4]

a. 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.

b. Flashpoint, Boiling Point, Ignition Temperature, and Class Flammable chemicals are classified according to flashpoint, boiling point, fire point, and auto-ignition temperature.

i. Flash Point (FP) is the lowest temperature at which a flammable liquid's vapor burns when ignited.

ii. Boiling Point (BP) is the temperature at which the vapor pressure

[3] Scientific Materials Company https://scimatco.com/collections/acid-corrosive-cabinets/products/sc8063

[4] Wikimedia https://commons.wikimedia.org/wiki/File:GHS-pictogram-flamme.svg

of a liquid is equal to the atmospheric pressure under which the liquid vaporizes. Flammable liquids with low BPs generally present special fire hazards.

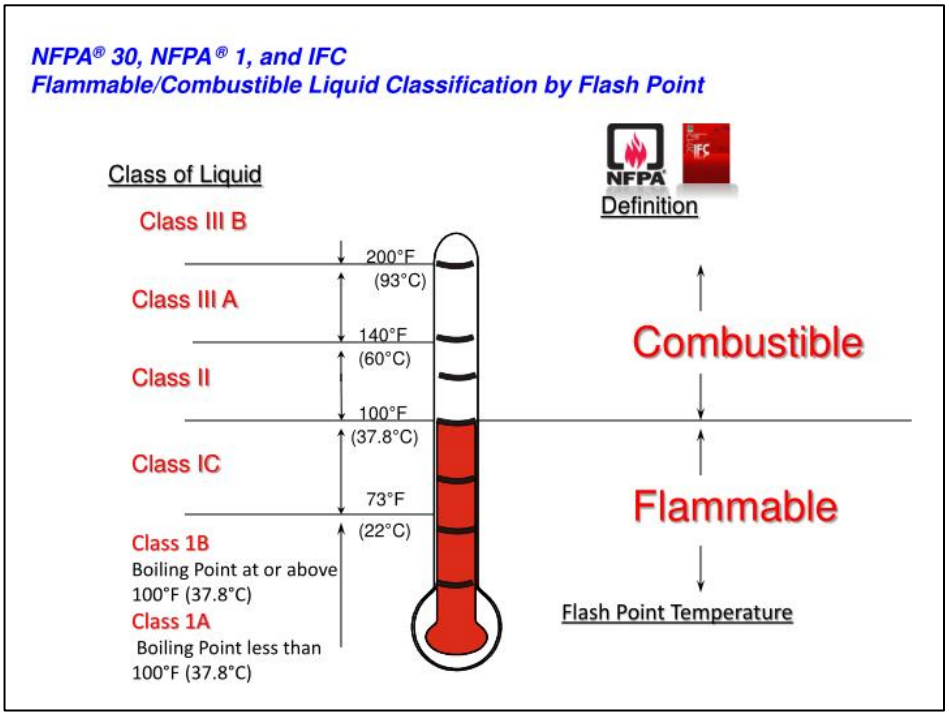

Figure 5[5]

iii. Fire Point is the temperature at which the flammable liquid will burn.

iv. Auto-ignition Temperature is the lowest temperature at which a substance will ignite without an ignition source.

[5] https://www.slideserve.com/oakley/class-of-liquid

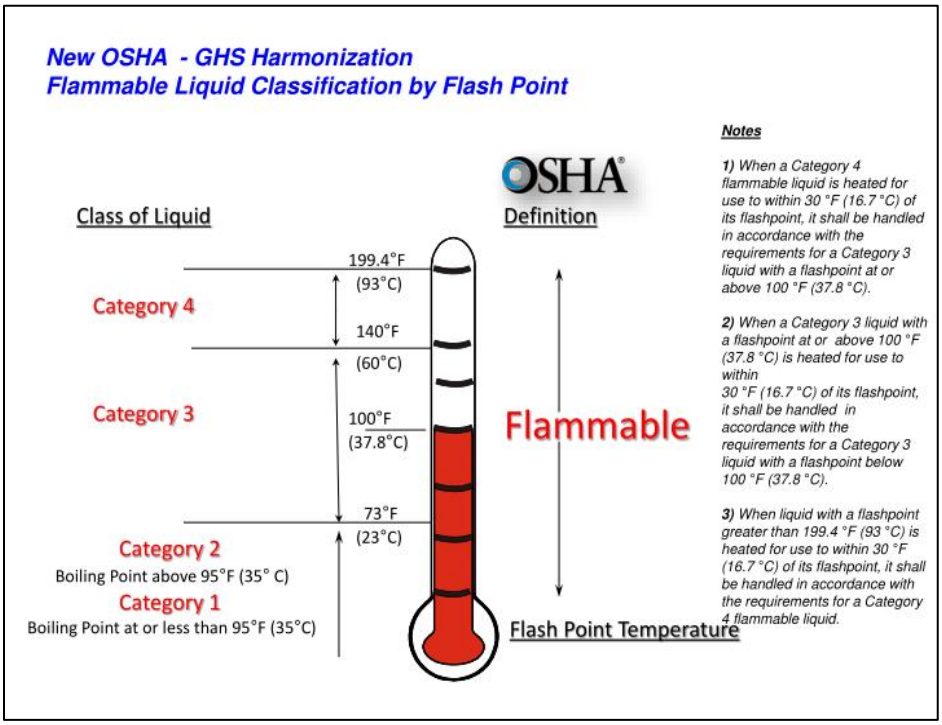

Figure 6[6]

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 (°F)	Boiling Point (°F)	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

[6] https://www.slideserve.com/oakley/class-of-liquid

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

Chemical	Flashpoint (^{O}F)	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

Chemical	Flashpoint (^{O}F)	Flammable Class
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.

Figure 7[7]

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

Safe Handling Guidelines for Flammables

Follow these guidelines when working with flammable chemicals:

a. Handle flammable chemicals in areas free from ignition sources. Never use highly flammable solvents in a room with open flames.

b. Never heat flammable chemicals with an open flame. Instead heat using a water bath, oil bath, heating mantle, hot air bath, 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

Figure 8[8].

c. Use ground straps when transferring flammable chemicals between metal containers to avoid generating static sparks.

d. Use a fume hood when there is a possibility of dangerous vapors. (Ventilation will help reduce dangerous vapor concentrations.)

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, and minimize the amount of flammables in a work area.

[7] User:Gustavb - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=618468
[8] Preiser Scientific https://www.preiser.com/images/view.aspx?productId=17479

f. Remove from storage only the specific amount needed for a particular experiment or task.

Organic solvents are often the most hazardous flammables in the work place. Solvents such as ether, alcohols, and toluene, for example, are highly volatile or flammable. Chlorinated solvents such as chloroform are nonflammable, but when exposed to heat or flame, may produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

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)

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.

Figure 9[9]

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:

i. 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.
ii. Skin contact with solvents may lead to defatting, drying, and skin irritation.
iii. 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:

1. Chloroform
2. Benzene
3. Carbon tetrachloride
4. 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 or below hazardous concentrations (e.g., xylene).

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

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

[9] TAMU Lab Safety Manual Chap 3 / 9.3 – Solvents p. 3-14 https://ehs.tamu.edu/manuals/

a. Inhalation: 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.
b. Skin Contact: may lead to defatting, drying, and skin irritation.
c. Ingestion: may cause severe toxicological effects. Get medical attention immediately.

Reducing Solvent Exposure:

To decrease the effect 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. The best all-around solvent is water; use whenever possible.

The odor threshold for the following chemicals exceeds acceptable exposure limits. Therefore, if you can smell it, you may be overexposed---increase ventilation immediately for the following chemicals: Chloroform, Benzene, Carbon tetrachloride and Methylene chloride. However, do not depend on your sense of smell alone to know when hazardous vapors are present.

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.

i. 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.
ii. 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 if splashing may occur.

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 disturb an enzyme system at some site remote from the site of contact. Any substance can be harmful to living things, but just as there are degrees of being harmful, there are also degrees of being safe.

Figure 10[10]

[10] Skin Online Blog https://www.skinonline.co.za/beauty/environmental-toxins/

The biological effects (beneficial, indifferent or toxic) of all chemicals are dependent on a number of factors:

a. dose (the amount of a substance to which one is exposed)

b. time (how often, and for how long during a specific time, the exposure occurs)

c. route of exposure (inhalation, ingestion, absorption through skin or eyes)

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

Figure 11[11]

d. Other factors (gender, reproductive status, age, general health, nutrition, lifestyle, sensitization, genetic disposition, and exposure to other chemicals).

   The most important factor is the dose-time relationship. The dose-time relationship forms the basis for distinguishing between two types of toxicity: acute toxicity and chronic toxicity.

   i. Acute toxicity, a chemical's ability to inflict systemic damage as a result (in most cases) of a one-time exposure to relative large amounts of the chemical. In most cases, the exposure is sudden and results in an emergency situation. Some chemicals are extremely toxic and are known primarily as acute toxins (hydrogen cyanide).

      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.

   ii. Chronic toxicity, 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. Some chemicals are known primarily as chronic toxins (i.e., lead). Other chemicals, such as some of the chlorinated solvents, can cause either acute or chronic effects.

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.

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

[11] TAMU Lab Safety Manual Chap 3 / 9.4 – Chemical Safety page 3-16 https://ehs.tamu.edu/manuals/

The toxic effects of chemicals can range from mild and reversible (e.g., a headache from a single episode of inhaling the vapors that disappears when the victim gets fresh air) to serious and irreversible (liver or kidney damage from excessive exposures to chlorinated solvents). Exposure to toxic chemicals can occur by: inhalation, skin absorption, ingestion, and injection.

Always minimize your exposure to any toxic chemical.

The following sections provide examples and safe handling guidelines for the following types of toxic chemicals:

General Safe Handling Guidelines

a. Read the appropriate SDS.
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.

a. Toxins

Do not work alone when handling acute toxins. Use a fume hood to ensure proper ventilation. Acute toxins can cause severe injury or death as a result of short-term, high-level exposure. Examples of acute toxins include the following:

Figure 12[12]

a. Hydrogen cyanide
b. Hydrogen sulfide
c. Nitrogen dioxide
e. Ricin
f. Organophosphate pesticides
g. Arsenic

Chronic toxins cause severe injury after repeated exposure. Examples of chronic toxins include the following: Mercury, Lead and Formaldehyde

b. Carcinogens

Carcinogens are materials that can cause cancer in humans or animals. Several agencies including OSHA, NIOSH, IARC, NTP and NIH 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. 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.

[12] TAMU Safety Manual Page 13-18 https://ehs.tamu.edu/manuals/

Examples of known carcinogens include the following:

a. Asbestos
b. Benzene
c. Tobacco smoke
d. Chromium, hexavalent
e. Aflatoxins
f. Benzene

c. Reproductive Toxins

Reproductive toxins are chemicals that can produce adverse effects in parents and developing embryos. Chemicals including heavy metals, some aromatic solvents (benzene, toluene, xylenes, etc.), and some therapeutic drugs are capable of causing these effects. In addition, the adverse reproductive potential of ionizing radiation and certain lifestyle factors, including excessive alcohol consumption, cigarette smoking, and the use of illicit drugs, are recognized.

Figure 13[13]

i. 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.

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

i. Ethidium bromide
ii. Nitrous acid
iii. Radiation

d. Sensitizers

Sensitizers may cause little or no reaction upon first exposure. Repeated exposures may result in severe allergic reactions. Examples of sensitizers include the following:

a. Isocyanates
b. Nickel salts
c. Beryllium compounds
d. Formaldehyde
e. Diazomethane

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.*

[13] TAMU Safety Manual – chemical safety section page 13-19 https://ehs.tamu.edu/manuals/

e. Irritants

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 do not include corrosives.

Figure 14[14]

Examples of irritants include the following:

a. Ammonia
b. Formaldehyde
c. Halogens
d. Sulfur dioxide

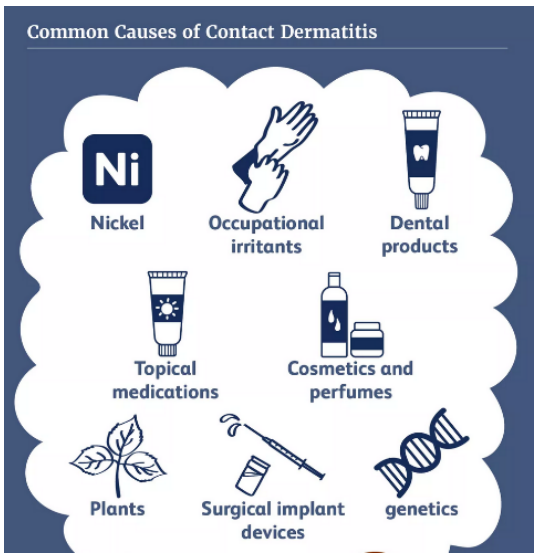

Figure 15[15]

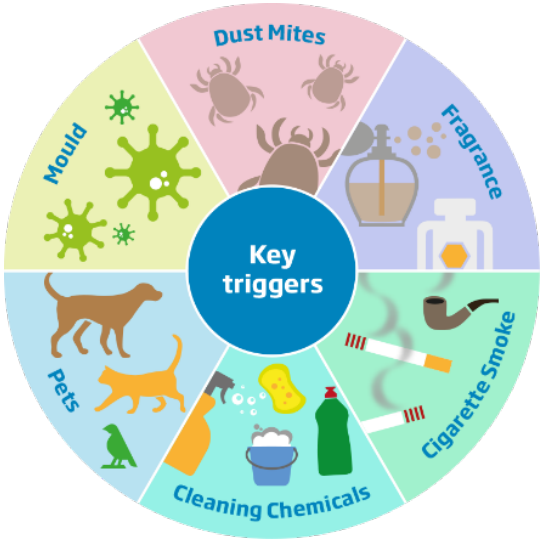

Figure 16[16]

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

i. Methanol
ii. Many snake and insect venoms
iii. Botulinum toxin

5. REACTIVES AND EXPLOSIVES

Highly reactive chemicals include those which are inherently unstable and susceptible to rapid decomposition as well as chemicals which, under specific conditions, can react alone, or with other substances in a violent uncontrolled manner, liberating heat, toxic gases, or leading to an explosion.

[14] TAMU Safety Manual page 13-20 Chemical safety https://ehs.tamu.edu/manuals/
[15] Very Well Health https://www.verywellhealth.com/contact-dermatitis-causes-83205
[16] BEKO Asthma Triggers https://www.beko.co.uk/lifestyle/asthma-proof-your-home

Reaction rates almost always increase dramatically as the temperature increases.

Therefore, if heat evolved from a reaction is not dissipated, the reaction can accelerate out of control and possibly result in injuries or costly accidents.

Air, light, heat, mechanical shock (when struck, vibrated or otherwise agitated), water, and certain catalysts can cause decomposition of some highly reactive chemicals, and initiate an explosive reaction. One must use specialized procedures and control equipment whenever working with reactive materials.

Figure 17[17]

a. can then ignite when mixed with air (alkali metals, organometallic compounds and some hydrides). Others give off large amounts of heat when mixed with water resulting in a violent reaction if the heat produced is not sufficiency dissipated.

b. Pyrophoric materials ignite spontaneously when exposed to the oxygen and or moisture in air at or below 130°F. These must be stored under water, mineral oil or an inert dry atmosphere depending on the substance. Examples: phosphorus, titanium dichloride, tributylaluminum, sodium, and lithium hydride.

c. An explosive material is substance or mixture of substances that when initiated by heat, light, friction, impact, or detonation undergoes a rapid chemical reaction giving off large volumes of hot gases. The reaction usually involves a decomposition of the substance(s) but may be caused by a rapid polymerization. Fires typically accompany an explosion.

d. Oxidizing agents in addition to their corrosive properties, are powerful oxidizing agents and present fire and explosion hazards on contact with organic compounds and other oxidizable substances. Organic peroxides are among the most hazardous substances used in the laboratory both fuels and oxidizers in one. They are typically low power explosives and very easy to initiate through sparks or shocks.

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

a. Read the appropriate SDS 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.

[17] Labelmaster https://www.labelmaster.com/shop/placards/hazard-class-1-placards

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 Benzvalene Prismane Butadiene Vinyl chloride
Polymerizable compounds	Butadiene; Vinyl chloride

6. Cleaning Agents

Figure 18[18]

Many of the chemicals contained in cleaning agents are corrosive. Follow these guidelines when working with any cleaning agent:
Always read and understand the label instructions or the MSDS before using any cleaning agent.

a. Mix solutions to the recommended strength.
b. When diluting acid with water, always add the acid to the water, not the water to the acid. (Concentrated acids may splatter when mixed improperly.)
c. Wear appropriate eye protection and gloves for the job (e.g., neoprene, nitrile, or rubber).
d. Do not leave aerosol cans in direct sunlight or areas where the temperature may exceed 120°F.
e. Heated aerosol cans may explode.

For more information on working with cleaning chemicals see the OSHA/NIOSH Infosheet Protecting Workers Who Use Cleaning Chemicals.

Cleaning Solutions

The cleaning solutions used in custodial work contain chemicals that are harmful if splashed in eyes, on skin, or inhaled. When various chemicals are left out carelessly or improperly sealed they pose a threat to employees. Chemicals should be stored at or below eye level; it is important to know what the chemicals are and what to do in case of an accident involving them.

[18] ECO Dry carpet cleaner https://www.cleanercarpetcanberra.com.au/carpet-cleaning-chemicals-professionals-use/

Know the nature of the chemicals being used. If you have any questions, talk to your supervisor or refer to the Safety Data Sheets (SDS) for chemicals. If chemicals should get splashed in your eyes or on your skin, it is important to know what to do to neutralize the chemical and prevent further harm.

a. Read and know what the warnings on chemical containers stand for and follow the precautions associated with each warning.
    i. Danger
    ii. Warning
    iii. Caution
    iv. Hazard

b. Wear protective gear when working with chemicals. Goggles and gloves are the best way to prevent a chemical spill or splash from causing serious bodily harm.

c. Store all chemicals in an approved, clearly labeled, properly sealed container at or below eye level.

d. Do not dispose of a chemical unless you know the procedure required to properly dispose of it and its container. Triple rinse all chemical containers before disposing of them.

e. If a chemical is found in the area and the contents are uncertain, leave it alone. If it has spilled or is unsealed, do not clean it up, do not put a lid on it, and do not touch it until it has been accurately identified. If you have questions, leave the area immediately and contact your supervisor.

f. If you smell anything suspicious, clear the area, and report the potential hazard to your supervisor immediately. Do not try to figure out what the smell is or what is emitting the odor.

IX Facilities Safety Equipment

A. Chemical Fume Hoods

emergency eye Chemical fume hoods provide primary containment in a chemical laboratory. They exhaust toxic, flammable, noxious, or hazardous fumes and vapors by capturing, diluting, and removing these materials. Fume hoods also provide the best protection when the fume hood sash is in the closed position. All chemical fume hoods must be ducted to the outside of the building. Safety instruction on chemical fume hood usage must be given to all employees/students working in the laboratory.

Figure 19[19]

The potential for glass breakage, spills, fires, and explosions is great within a fume hood. Due to the chance for fires or explosions, fume hoods should be located towards the back of a laboratory, away from primary and secondary exits. Practice safe work habits when working with fume hoods, including the following:

a. Air Flow and Ventilation: Employee traffic in front of a fume hoods or opening/closing laboratory doors can interfere with hood performance. Ensure that there is sufficient aisle space in front of fume hoods.

b. Fume Hood Type: All fume hoods are not appropriate for all types of work. Ensure that hazardous chemicals are used in the proper type or class of hood. For example, use perchloric acid only in fume hoods specifically designed for perchloric acid.

c. Fume Hood Use and Care

[19] Labconco https://www.labconco.com/category/fume-hoods-enclosures-remote-blowers#general-chemistry-hoods

To ensure safety and proper fume hood performance, follow these guidelines:

i. Use a fume hood when working with chemicals or procedures that may produce hazardous fumes or vapors.

ii. Know how to properly operate a fume hood before beginning work. Inspect the fume hood before starting each operation.

iii. Place equipment and chemicals at least six inches behind the fume hood sash. This practice reduces the chance of exposure to hazardous vapors.

iv. Do not allow paper or other debris to enter the exhaust duct of the hood.

v. Do not store excess chemicals or equipment in fume hoods.

vi. Do not block the baffle area of the fume hood.

vii. Elevate any large equipment within the hood at least three inches to allow proper ventilation around the equipment.

viii. When working in a fume hood, set the sash at the height indicated by the arrow on the inspection sticker. The only time the sash should be completely open is while setting up equipment.

ix. Wear personal protective equipment, as appropriate.

x. Do not alter/modify the fume hood or associated duct work.

xi. Clean up spills in the hood immediately.

IMPORTANT: If a power failure or other emergency occurs (e.g., building fire or fire within the fume hood), close the fume hood sash and call for emergency assistance.

d. Fume Hood Inspections

Fume hoods should be tested annually. Fume hoods should also be tested in the following circumstances:

i. When an employee requests an inspection

ii. When a procedural change requires a hood classification upgrade

iii. After major repair work

iv. After a fume hood is moved

A&M-SA Facilities Services oversees fume hood inspections and testing. The test includes an inspection of the hood system, airflow measurements, and an assessment of the use of the chemical fume hood. If you suspect a problem with your chemical fume hood, please contact EHS for more information.

2. Emergency Eyewash

Emergency Eyewash units are required in all areas where employees handle substances that are potentially injurious when in contact with the eyes, including areas where corrosive materials are used.

In an emergency scenario, an eyewash station can save your sight - if it's properly used. Such accidents are fortunately very rare, but it's paramount that you and your colleagues are prepared should the worst happen. Make sure you know the location of relevant safety fixtures before handling any hazardous substances. Read on to find out how to use an emergency eye wash unit the right way.

1) **Don't delay -** The second a hazardous material enters your eyes, you should make your way to an eyewash station. Don't hesitate, even if it's only a minor spill - the longer a hazardous substance is in contact with the eye, the more damage it does small Even amounts of contamination can cause serious injury and even permanent loss of vision. .

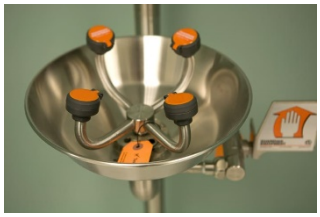

Figure 20[20]

2) **Activate the unit -** Push the activation lever on the eyewash station. All staff should already have been shown how eyewash stations are activated. When the lever has been pushed, the dust covers will pop open and each of the two eyewash nozzles will begin discharging water.
3) **Flush out your eyes -** Once activated, the eyewash station will continue to discharge water for a minimum of 15 minutes, meaning that it can be operated hands-free. Using your fingers to keep your eyelids open, lower your eyes into the stream of water issuing from the nozzles. Roll your eyes gently up and down and from side to side, ensuring that the water reaches as much of the eyeballs as possible.
4) **Contact lenses -** If you wear contacts, gently remove them once you have begun the flushing process. While failing to remove contact lenses can prevent the eye wash from properly irrigating the eyes, it is important not to delay flushing in order to take them out. Only do this once flushing has begun.
5) **Keep on flushing -** Continue to use the eyewash station in this manner for a full 15 minutes, and no less. This is the minimum amount of time that it takes to sufficiently clear the eyes of harmful chemicals - if you remove your eyes from the stream before this time has elapsed, you run the risk of permanent injury.
6) **After flushing -** When the 15 minute flushing period is over, seek medical assistance immediately. Have a colleague drive you to the accident and emergency department of your local hospital. Do not be tempted to drive yourself, as your vision may be impaired.
7) **Notify PI or lab supervisor** of the accident/incident/injury. Notify EHS and complete the online First Report of Injury via the Origami

3. Emergency Shower

Safety Showers are needed wherever there is a possibility that either highly corrosive or highly toxic chemicals may splash over substantial areas of the body

1) Whithout delay, make your way to the nearest safety shower and activate.
2) Flush skin or affected area for a minimum of 15 minutes and remove contaminated clothing.
3) Seek assistance from any other lab personnel in flushing the affected area or removal of clothing.
4) If an assistant is available, have the MSDS reviewed for any further first aid requirements for the hazardous material involved.

Figure 21[21]

[20] Raymond west Intralogistics solutions https://materialshandlingstore.com/products/guardian-wall-mounted-eyewash-stations

[21] Faucetdepot https://www.faucetdepot.com/prod/Guardian-Equipment-G1902-Safety-Station-with-Eye-Wash---Stainless-Steel-102312.asp

5) If an assistant is available, use an uncontaminated article of clothing or fire blanket to shield the affected individual to provide privacy and to offer body coverage.
6) Seek medical attention following flushing of the affected area (at least 15 minutes).If injury is severe, call 911.
7) Once the emergency has subsided, notify the research or lab supervisor of the accident/incident/injury
8) **Notify PI or lab supervisor** of the accident/incident/injury.
Notify EHS and complete the online First Report of Injury via the Origami

X Spill Response

Spills are likely whenever chemicals are used. Personnel should be trained and equipped to handle most of the spills in their work area. Contact the EHS Office for assistance or advice about a chemical spill.

A. Spill Prevention and Planning

Prevention is the best safety strategy for any environment. Use safe handling procedures and be aware of the potential hazards associated with chemicals. For example, before working with any chemicals, review the appropriate SDSs. Be prepared to respond to a chemical spill. To prepare for a potential spill, follow these guidelines:

1. Develop and periodically review written procedures for an emergency response plan.
2. Keep a fully stocked chemical spill response kit available.
3. Know the location and proper use of cleanup materials.
4. Know how to turn off equipment, heat sources, electrical panels, etc.
5. Review appropriate SDSs before beginning any project.

B. Spill Response Kit

Work areas that contain potentially hazardous chemicals should have a chemical spill response kit. This kit should include the following:

1. Disposable laboratory/surgical gloves
2. Disposable vinyl gloves
3. Safety goggles
4. Absorbents (e.g., spill pillows, vermiculite, litter box filler, etc.)
5. Plastic scoop
6. Plastic trash bags

C. Responding to Chemical Spills

The following sequence provides a brief overview of proper chemical response procedures:

1. Notify others in the immediate area that a spill has occurred. Evacuate the area if necessary.
2. Attend to injured and exposed people.
3. Identify the spilled chemical(s).
4. Based on the hazards and the personal protective equipment needed (e.g., respiratory protection), determine if you can safely clean the spill or if assistance is necessary. If you

determine that you CAN safely clean the spill without emergency assistance, follow these guidelines:

a) Wear appropriate protective clothing and equipment.
b) Have another person stand by during the cleanup.
c) Clean up the spill and collect all wastes for proper disposal.
d) Ventilate the area, as necessary, before it is reoccupied.
e) Decontaminate reusable cleanup supplies (i.e. scoops, rubber boots, etc.)
f) Restock the chemical spill kit and return it to the normal storage location.

Chemical Category	Container Type
Mineral Acids	Plastic
Bases	Plastic
Oxidizers	Glass
Organics, including acetic acid	Glass

g) Do not take unnecessary risks with chemical spills. Call the A&M-SA Emergency number at (210)784-1911 to report whenever a spill involves the following:
   i. Large volume of spilled material (greater than a liter)
   ii. Very hazardous material
   iii. Very hazardous conditions (e.g., fire, explosion, toxicity, etc.)
   iv. Strong odor
   v. Personnel injury or exposure

XI Waste Disposal

Hazardous Chemical Waste Disposal (Contact EHS for more information on waste disposal) All generators of hazardous chemical wastes are required to:

i. comply with A&M-SA hazardous waste disposal procedures,
ii. assure their employees are trained in proper disposal procedures, and
iii. properly identify and label all hazardous wastes generated.
iv. Refer to the Hazardous Waste Management Program or contact EHS for more information.

XII Transportation of Chemicals

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. Contact the A&M-SA Assistant Manager-EHS-(Research and Academic EHS) for more information on shipping or receiving hazardous chemicals.

XIII Training

Faculty and staff that have the potential to come into contact with hazardous substances and/or hazards as described above are required to take the Hazard Communication training on TrainTraq upon hire and are required to refresh the training if regulations change. A&M-SA EHS will follow the Texas A&M University System Policy 33.05 Required Employee Training.

Acronyms

IARC	International Agency for Research on Cancer
NIH	National Institutes of Health
NIOSH	National Institute for Occupational Safety & Health
NTP	National Toxicology Program
OSHA	Occupational Safety and Health Administration