Information

Chemical Safety Lab Safety Manual

Applicability

This policy applies to University of Louisville employees and students while on University owned property and or worksites

Administrative Authority

Senior Associate Vice President for Operations

Responsible Unit

Environmental Health & Safety
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History

Revision Date(s):
Reviewed Date(s):

Categories

Statement:

Chemical Hazards

Compressed Gases

USE

Many laboratories require the use of compressed gas. If it is not possible to have gas piped into the laboratory, gas cylinders are needed. If they are used, they must at all times be firmly attached to stationary structures or otherwise secured.

TYPES

A variety of gases are used in laboratories, including those that are:

- Flammable - any gas for which flammable limits in air are reported;
- Toxic - any gas that has an LC50° less than or equal to 5000 ppm;
- Asphyxiant - covers all inert gases, toxicity caused by oxygen-deficient levels;
- Oxidizer - gases that in the presence of an ignition source and a fuel, support and may vigorously accelerate combustion;
- Corrosive - most gases are not corrosive in the absence of water. However, since gases are released into moist air, the potential for corrosive hazard must be considered;
- Extremely cold - cryogenic liquids.

HAZARDS

If released into the laboratory, these gases may create hazards such as:

- Depletion of oxygen;
- Fire; and/or
- Adverse health effects.

DROPPED CYLINDERS

The most likely accident with a gas cylinder is that it will be knocked over or dropped. This may cause a painful injury to legs or feet. More serious consequences result if the valve is knocked off the cylinder. The gas is rapidly released and the cylinder becomes a potentially lethal and highly destructive projectile, which can pass through walls, doors, windows, etc. Personnel, even those in adjacent laboratories, may be harmed or killed if in the path of the cylinder.

SAFE PRACTICES

Follow these rules for the safe use of cylinders.

Always:

- Secure empty and full cylinders in racks or holders, or with clamping devices to prevent falling or rolling. Cylinders must be secured with devices that are non-combustible and will not melt in case of a fire. These securing devices include metal clamp stands, metal chains, and straps treated with flame retardant material. Materials such as rope and duct tape are not approved securing devices and should not be used.

- Check the label for proper contents before using a cylinder for any purpose. Color coding by suppliers may vary. The labels applied by the gas supplier to identify the container contents shall not be defaced or removed.
- Close valves and relieve pressure on the regulator when cylinders are not in use. Keep cylinders capped when not in use.
- Keep a minimal number of cylinders on hand.
- Store empty cylinders as if they were full. Remove empty cylinders from lab.
- Identify full and empty cylinders as such.
- Prevent sparks, flames, electrical apparatus, or circuits from coming into contact with cylinders.
- Use only regulators approved for the specific gas.
- Use only oxygen-compatible threading compounds such as Teflon tape on valve threads for oxygen service.
- Protect cylinders from abnormal mechanical shocks, which may cause damage when cylinders are moved.
- When opening a cylinder valve;
  - Direct cylinder opening away from personnel, and
  - Open valve slowly.
- Remove the cylinder to open space out-of-doors and away from any possible source of ignition if a cylinder develops a small leak at the valve, or if a leak occurs in any safety device
- Store flammable gases in well-ventilated areas away from oxidizers, open flames, sparks, and other sources of heat and ignition.
- Equip areas where corrosive gases are used with emergency showers/eyewashes. Provide the capability for prompt emergency medical treatment, including first aid.

- Direct cylinder opening away from personnel, and
- Open valve slowly.

Never:

- Move a gas cylinder UNLESS;
- You use an appropriate cart or hand truck,
- The cylinder cap is in place, or

- The cylinder is chained or otherwise secured to the cart.
- Store a cylinder in a hallway.
- Empty a cylinder by off-gassing it in a lab or hallway.
- Use oil, grease, or other lubricants on the regular valves or fittings.
- use oxygen as a substitute for compressed air.
- Lift cylinders by the cap, except with an approved cylinder cart designed for this purpose.
- Tamper with, attempt to repair, or replace safety devices on cylinder valves.
- Change a cylinder's contents by:
  - Refilling with a different gas;
  - Changing the cylinder's color; or
  - Changing the lettering on a cylinder.
- Use direct flames or heat lamps to raise the pressure of a cylinder.
- The cylinder for return to the manufacturer.
- Direct a gas stream toward any person. This could cause serious injury to the eyes or body.
- Force a valve connection that does not fit. Threads on regulator connections or other auxiliary equipment shall match those on the container valve outlet.
- Abandon a gas cylinder, unsecured, in a hallway or at a loading dock.

- Refilling with a different gas;
- Changing the cylinder's color; or
- Changing the lettering on a cylinder.

DEFINITION

A cryogenic material is any substance that must be cooled to a temperature of 130°C or lower to change from a gas to a liquid. Cryogenics have several distinguishing characteristics:

- They are extremely cold (-120 to -270°C);
- Their primary cooling mechanism is vaporization (latent heat), and
- They have an extremely high expansion ratio (averaging 800:1) when their physical state changes from liquid to vapor/gas.

Because of these special characteristics, cryogenic materials must be handled with care.

METHODS

The most common cryogen used is **liquid nitrogen**. Additional cryogens commonly used are:

- Helium;
- Hydrogen;
- Argon;
- Oxygen; and
- Methane.

GENERAL PRECAUTIONS

Personnel shall be thoroughly instructed and trained in the nature of the hazards associated with cryogenics and how to avoid those hazards.

- Any employee using cryogenics should have a thorough knowledge of:
  - Procedures;
  - Operation of equipment;
  - Safety devices;
  - Properties of materials used; and
  - Use of personal protective equipment.
- Equipment and systems should be kept scrupulously clean.
- Mixing of gases or fluids should be strictly controlled to prevent the formation of flammable or explosive mixtures. Extreme care should be taken to avoid contamination of a fuel with an oxidant or the contamination of an oxidant with a fuel.
- Proper consideration should be given to the properties of the gas involved when venting storage containers and lines. Venting of large storage vessels should always be done outdoors to prevent an accumulation of flammable, toxic, or inert gas in the work area. Smaller, lab sized containers can be vented into a chemical hood system.

- Procedures;
- Operation of equipment;
- Safety devices;
- Properties of materials used; and
- Use of personal protective equipment.

STORAGE CONTAINERS

Cryogenic fluids are usually stored in properly insulated containers designed to minimize the loss of product due to boil-off. **Note: Boil-off gases can freeze the skin or eyes faster than liquid or metal contact.**

- A Dewar flask is the most common container for cryogenic fluids. It is a double-walled, evacuated container made of metal or glass, with a vacuum between the walls.
- Larger quantities of cryogenic fluid require double-walled metal containers of evacuated construction.
- Exposed glass should be taped to minimize the flying glass hazard if the container should break or implode.
- Liquids should be transferred from the metal Dewar vessels with special transfer tubes or pumps designed for that particular application.

HAZARD FACTORS

Cryogens present many hazards. All may be present concurrently and must be considered when introducing a cryogenic system or project:

- Ultra cold temperatures;
- Flammability;
- High pressure gas, resulting in over-pressurization of containers and pressure vessels
- Displacement of oxygen/asphyxiation.

CRYOGENIC BURNS AND FROSTBITE HAZARDS

All cryogenics can cause cold burns or frostbite when in contact with human skin.

- Do not overfill containers.
- Never make direct contact with cryogenic liquids, uninsulated cryogenic pipes or equipment.
- Use tongs or isolate the hazard when appropriate.
- Stay out of the path of boil-off gases.
- Wear suitable personal protective equipment when handling any object that may be cold.
- Transfer or pour cryogens slowly to minimize boiling and splashing.
- Use a phase separator or special filling funnel when filling a Dewar or transferring cryogens.
- Ensure all secondary containers are secured when filling.

- Ensure that all Dewars are positioned so the pressure relief valves and rupture disks vent paths are directed away from personnel, critical equipment or designated work areas.
- Inspect and maintain cryogenic equipment, and remove equipment from service when it does not meet manufacturer's operating specifications.
- When hand-carrying cryogen-containing Dewars, ensure the Dewar is your only load (no books, coffee or other items). Watch carefully for people who may run into you, and ensure that the vessel is carried with both hands and as far away from you as possible.

FLAMMABILITY

Fire and explosion are hazards associated with cryogenics. The source and hazards are:

- Hydrogen, methane, and acetylene, where the gases themselves are flammable.
- Oxygen. Its presence will increase the flammability of ordinary combustibles. Keep all organic materials and other flammable substances away from contact with oxygen.
- Liquefied inert gases. Liquid nitrogen and helium can condense oxygen from the atmosphere, causing oxygen entrapment in unsuspected areas.
- Extremely cold surfaces can condense oxygen from the atmosphere.

HIGH-PRESSURE GAS

The hazard from high-pressure gas is always present when cryogenic fluids are used or stored.

- Since liquefied gases are usually stored at or near their boiling point, there is always some gas present in the container.
- The large expansion ratio from liquid to gas causes a buildup of high pressure due to evaporation of the liquid.
- Ensure pressure relief devices are utilized and are sized for maximum possible back pressure. Inspect at regular intervals for leakage, frosting and dirt accumulation.

DISPLACEMENT OF OXYGEN/ASPHYXIATION

- Ensure an oxygen alarm is present in the work area when appropriate.

- Periodically test and calibrate the oxygen alarm. (Note: If an oxygen monitor alarm goes off while you are in the work area, evacuate the room immediately. If it goes off in another room, do not enter the room.)
- Use natural ventilation and chemical hoods where appropriate.
- Avoid transporting containers in enclosed spaces such as elevators.

MATERIALS

Materials for cryogenic service must be carefully selected because of the drastic changes in the properties of materials when they are exposed to extremely low temperatures.

Suitable materials are:

Metals such as:

- Stainless steel (330 and other austenitic series);
- Copper;
- Brass;
- Bronze;
- Monel, and
- Aluminum.

Proper soldering of metals is important.

Non-metals such as:

- Dacron;
- Teflon; and
- KelF.

When dealing with non-metals, chemical reactivity between the fluid or gas and the storage containers and equipment must be carefully evaluated.

Flammable & Combustible Liquids: Standard for Solvents in Laboratories
This standard is based on the 2000 Kentucky Fire Prevention Code that references NFPA 30 and NFPA 45. University laboratories are classified as Class B (Moderate Fire Hazard) and the following listed quantities comply with that classification. The following applies to laboratories with fire suppression systems (sprinklers). For non-

sprinklered laboratories, contact the University Fire Marshal at 502.852.6111.

1. The total amount of solvents within the laboratory shall not exceed ten (10) gallons per 100 sq. ft.
2. The total amount of unprotected solvents within the laboratory shall not exceed five (5) gallons per 100 sq. ft.
3. Solvents in excess of the amounts listed in item #1 shall be in bulk storage rooms meeting NFPA 30.
4. Flammable solvents (i.e., flash point < 100°F) must not be stored in an ordinary refrigerator. Must use a flammable material storage refrigerator or explosion proof refrigerator.

Recommended Practices

- Glass containers should be limited to 1 pint in size whenever practical.
- Transferring of solvents should always be done in a laboratory hood or an approved bulk storage room.
- Rubber carboys should be used when carrying 1-gallon glass containers of liquid.
- All 5-gallon metal cans should be stored in an approved flammable liquid storage cabinet or in an approved bulk storage room.
- Glass containers not in use should be stored in flammable liquid storage cabinets.

The term "corrosive" refers to substances that rapidly attack skin, eyes, and other living tissue. Such chemicals commonly include strong acids or bases, dehydrating agents, and oxidizing agents.
Examples of corrosive chemicals are:

- **Acids**
  - Sulfuric
  - Nitric
  - Hydrofluoric (HF) Acid (An HF Guidance Document and an HF Emergency Response Procedure is provided at the end of this section, to give guidance on the safe handling and emergency procedures for HF Acid).
- **Bases**
  - Sodium Hydroxide
  - Ammonia
- **Dehydrating Agents**

  - Sulfuric acid
  - Sodium hydroxide
  - Phosphorus pentoxide
  - Calcium oxide
- **Oxidizing Agents**
  - Picric acid
  - Chromic acid
  - Perchloric acid
  - Peroxides
  - Nitrates
  - Nitrites

- Sulfuric
- Nitric
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- Sodium Hydroxide
- Ammonia

- Sulfuric acid
- Sodium hydroxide
- Phosphorus pentoxide
- Calcium oxide

- Picric acid
- Chromic acid
- Perchloric acid
- Peroxides
- Nitrates
- Nitrites

HAZARDS OF PERSONAL EXPOSURE

Strong acids and bases may cause serious damage to the skin and eyes. Inhaling the vapors of corrosive chemicals can cause severe bronchial irritation or pulmonary edema.

If the eyes or body of personnel may be exposed to corrosive material, suitable facilities for quick drenching or flushing of the eyes and body shall be provided within the work area for immediate emergency use. Such facilities shall comply with ANSI Z358.1-1990, "Standard for Emergency Eyewash and Shower Equipment." The emergency equipment must be located within 10 seconds walking time from the location of a hazard. Emergency eyewash/shower facilities must be clearly visible and unobstructed so that the unit is immediately available in case of a splash to the eyes/body. Lab personnel should be familiar with the location of this equipment so they can locate it readily in an emergency situation. The Physical Plant shall test the units monthly.

BOTTLED EYEWASH SOLUTIONS

An eyewash station must be able to deliver ample flushing to both eyes simultaneously at 4 liters per minute for a minimum of 15 minutes. Because bottled eyewash solutions cannot meet this requirement, they may only be used as a supplement to, but not a substitute for, plumbed eyewash stations. If a bottled eyewash is available, the wash solution must be replaced routinely (e.g. every six months) to keep bacterial growth in check. If this is not done they should be removed from the laboratory.

FIRST AID PROCEDURES

If exposure to a corrosive chemical occurs:

- Immediately remove any contaminated clothing;
- Wash the affected area with copious amounts of water; and
- Get first aid or medical help.

STORAGE GUIDELINES

To properly store corrosive chemicals, follow these guidelines:

- Strong oxidizers such as perchloric acid present fire and explosion hazards when in contact with organics. Store in glass containers in a metal tray, away from organic, flammable, dehydrating, or reducing agents.
- Separate acids from bases
- Separate acids from flammables
- Store all corrosives on a low shelf near floor level avoid storage on the floor.

PROTECTIVE CLOTHING GUIDELINES

When using corrosive chemicals, follow this rule:

Always wear rubber apron, gloves, and safety goggles, or a face shield.

ACCIDENT PREVENTION GUIDELINES

Remember: When diluting an acid, add the acid slowly to the water to reduce the reactive effect.

A

Always

A

Add

A

Acid

To The Water

DO NOT:

- Mix concentrated acids and bases together; or
- Use corks or rubber stoppers with strong oxidizing agents.

INTRODUCTION

Hydrofluoric acid (HF) is a strong inorganic acid with special chemical properties that make it especially hazardous to laboratory researchers. Accidental exposures to HF can cause severe surface burns, deep tissue burns, and possibly lead to life-threatening systemic poisoning. Because of its physiologically aggressive properties, HF should only be used in a laboratory setting by laboratory personnel who are trained in its proper handling techniques, associated hazards, and emergency response procedures. A complete HF emergency response procedure is provided for guidance and training of employees who use HF acid. A down loadable PDF version of the HF emergency response procedure is also provided for posting near the chemical hood in which HF acid is used. This should be posted for quick reference in the event of an emergency.

USES

Uses for hydrofluoric acid are primarily in industrial chemical and manufacturing processes. These processes include refinery alkylation, fluorocarbon production, aluminum production, metal pickling, glass etching, semiconductor etching, and rare metal processing. Other uses of HF include mineral identification, metal cleaning, fabric rust stain removal, and laboratory experimentation.

CHEMICAL PROPERTIES

Hydrogen fluoride (anhydrous hydrofluoric acid) and its solutions (hydrofluoric acid) are clear, colorless, non-combustible, highly corrosive, liquids. HF is known for its high level of corrosiveness. It readily reacts with glass, ceramics, concrete, rubber, and some metals. Even though HF is not a combustible substance, reactions of HF with certain metals may produce explosive hydrogen gas.

Hydrofluoric acid concentrations over 40% produce a pungent, acrid, irritating odor. Dilute HF concentrations (< 40%) do not produce significant odors or vapors unless heated.

TOXICOLOGY

Hydrofluoric acid is extremely corrosive to body tissues. Most HF exposures initially involve the skin, eyes, lungs, or mucous membranes.

Tissue exposures to HF concentrations greater than 50% produce immediate, severe, deep-seated, slow healing burns. Hydrofluoric acid burns differ from other acid burns because the fluoride ion is able to readily penetrate the skin, resulting in deep tissue layer destruction. On the skin, these burns present initially as painful areas of white discoloration that usually proceed to blister formation.

Exposures to HF concentrations less than 50% often do not produce immediate, detectable symptoms; however, as time passes, the exposed tissues may develop painful, red, and sometimes blistered areas. Skin exposures to HF concentrations between 20% and 50% typically do not show burn symptoms for 1 to 8 hours. Skin exposures to HF concentrations less than 20% may not show burn symptoms for up to 24 hours. Exposures to concentrations as low as 2% have been reported to cause symptoms.

Because the fluoride ion readily penetrates tissue, fluoride concentrations in the body can rapidly reach toxic levels as a result of hydrofluoric acid exposure. Systemic fluoride toxicity can result in various serious medical conditions such as abnormal mineral storage/utilization, enzyme inhibition, blood clotting defects, metabolic pathway interruption, and abnormal heart function. The ability of HF fluoride ions to bind calcium in body tissue can result in a potentially fatal condition called hypocalcemia. Hypocalcemia results when blood concentrations of calcium are markedly reduced.

As a note for the physiologically inclined, the severe throbbing pain classically associated with hydrofluoric acid burns is thought to be caused by irritated nerve endings. These nerves are irritated by increased levels of potassium ions entering the extracellular space to compensate for reduced concentrations of calcium ions that have been tightly bound by the HF fluoride ions.

WORK PRACTICES AND SAFETY

The specialized hazards associated with hydrofluoric acid warrant specialized work practices and safety procedures. Carefully reviewing and following these guidelines will help you in preventing accidents and reducing exposures. This information will also provide you with a clear plan of action if an accident involving hydrofluoric acid occurs in your laboratory.

1. Everyone who works in a laboratory where HF is used should know about its hazards and special emergency response procedures. This includes personnel who do not work directly with HF but will be working near areas where HF is used. Laboratory personnel who work directly with HF need to be additionally trained in its proper use and disposal.
2. Avoid working with hydrofluoric acid when working alone. It is important to have someone nearby who knows you are working with HF and knows what to do in case of an emergency.
3. Proper personal protective equipment (PPE) must be worn when working with hydrofluoric acid. Proper PPE for HF use includes:
    - Chemical splash goggles.
    - Closed toe shoes.
    - Long sleeved lab coat (no shorts or short skirts).

    - Acid resistant splash apron.
    - Neoprene gloves (best protection) or nitrile gloves (short duration protection only). Neoprene gloves will provide the best protection, but nitrile gloves may be used for short duration experiments or emergencies if changed frequently. Never use latex gloves with hydrofluoric acid for any reason because they do not provide effective protection.
4. Laboratories using hydrofluoric acid should have the Hydrofluoric Acid Emergency Response Procedure document posted and readily visible in areas where HF is used. This information sheet and an HF MSDS should also be available in the laboratory.
5. An emergency eyewash and shower must be nearby when working with hydrofluoric acid. Make sure you know where they are and that they are operational before starting any work with HF.
6. Have calcium gluconate gel on hand when working with HF. Be sure to check the gel expiration date before starting any work. Everyone who works in the laboratory where HF is used must know when and how calcium gluconate gel should be used. For further information on calcium gluconate gel, see the Emergency Response Procedure listed in the next section. If you need information on purchasing the gel, please contact the DEHS Laboratory Safety Coordinator at 8522830.
7. Work with HF should always be done in a chemical hood. Be sure the hood is operating properly and has a current inspection sticker.
8. Hydrofluoric acid should be stored in chemically compatible, properly labeled containers and separated from alkalis, metals, oxidizers, cyanides, glass, reducing materials, and sulfides. Use only chemically compatible containers when using or storing HF (polyethylene, Teflon, etc). Remember that glass, metal, and ceramic containers are not compatible with HF. Secondary containers constructed of polyethylene are advised, especially during transport.
9. Hydrofluoric acid should be disposed of via the DEHS website at http://www.louisville.edu/admin/dehs. If you have questions concerning waste disposal call the Hazardous Waste Coordinator at 502.852.2956.
10. In the event of a hydrofluoric acid spill:
    - Notify those in the immediate area that a spill has occurred.
    - Evacuate nonessential personnel from the spill area.
    - Turn off ignition and heat sources if safe to do so.
    - Attend to persons who may have been exposed to acid (see next section).
    - Notify your supervisor and Public Safety at 502.852.6111.

  - Establish exhaust ventilation if safe to do so.

11. Because of the special hazards associated with hydrofluoric acid, medical personnel must evaluate anyone exposed to HF. See the Emergency Response Procedure listed in the next section for further information on properly handling personnel HF exposures.

- Chemical splash goggles.
- Closed toe shoes.
- Long sleeved lab coat (no shorts or short skirts).
- Acid resistant splash apron.
- Neoprene gloves (best protection) or nitrile gloves (short duration protection only). Neoprene gloves will provide the best protection, but nitrile gloves may be used for short duration experiments or emergencies if changed frequently. Never use latex gloves with hydrofluoric acid for any reason because they do not provide effective protection.

- Notify those in the immediate area that a spill has occurred.
- Evacuate nonessential personnel from the spill area.
- Turn off ignition and heat sources if safe to do so.
- Attend to persons who may have been exposed to acid (see next section).
- Notify your supervisor and Public Safety at 502.852.6111.
- Establish exhaust ventilation if safe to do so.

Emergency Response Procedure for Hydrofluoric Acid
SKIN CONTACT

1. Move victim immediately under an emergency shower or other water source and flush affected area with large amounts of water. Remember to start flushing before removing clothing. Speed and thoroughness in washing is critical.
2. Carefully remove all contaminated clothing while continuing to flush affected area with water.
3. Continue to rinse affected, unclothed area for 5 minutes. While victim is being rinsed, someone should:
   - Contact Public Safety at 502.852.6111.
   - State there has been a person exposed to hydrofluoric acid.
   - State their location.
   - Public Safety should arrange for subsequent transport to a medical facility.
   - Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.

4. Immediately after thorough washing, start massaging 2.5% calcium gluconate gel into the affected skin area. Neoprene or nitrile gloves should be worn (not latex) while applying the gel to prevent possible secondary exposures. Liberally apply gel often and massage the burn site continuously.
5. While affected areas are being treated with calcium gluconate gel, the victim should be thoroughly examined for other burn sites that may have been overlooked.
6. Medical personnel should see the victim for followup care as soon as possible. During transport to medical facility or while waiting for emergency response, continue massaging burn sites with calcium gluconate gel. Try to keep burned areas elevated while in transport.

- Contact Public Safety at 502.852.6111.
- State there has been a person exposed to hydrofluoric acid.
- State their location.
- Public Safety should arrange for subsequent transport to a medical facility.
- Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.

EYE CONTACT

1. Move victim immediately to an emergency eyewash station and flush eyes gently with large amounts of water for at least 15 minutes. To aid in thorough cleansing, hold eyelids open and away from the eye while washing.
2. If the victim is wearing contact lenses, have the victim remove them if possible. Removal of contact lenses should not delay or interrupt flushing.
3. While victim's eyes are being flushed, someone should:
    - Contact Public Safety at extension 6111.
    - State there has been a person with an eye exposure to hydrofluoric acid.
    - State their location.
    - Public Safety should arrange for subsequent treatment or emergency response.
    - Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.
4. Medical personnel, preferably an eye specialist, should see the victim as soon as possible. During transport to medical facility, ice water compresses may be gently applied to the eyes.
5. Do not use 2.5% calcium gluconate gel in eyes.

- Contact Public Safety at extension 6111.
- State there has been a person with an eye exposure to hydrofluoric acid.

- State their location.
- Public Safety should arrange for subsequent treatment or emergency response.
- Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.

INHALATION OF VAPORS

1. Move victim immediately to an area with fresh air. Keep victim calm and comfortable.
2. While victim is breathing fresh air, someone should:
    - Contact Public Safety at extension 6111.
    - State there has been a person who has inhaled hydrofluoric acid vapor.
    - State their location.
    - Public Safety should arrange for subsequent treatment or emergency response.
    - Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.
3. Medical personnel should see the victim as soon as possible.

- Contact Public Safety at extension 6111.
- State there has been a person who has inhaled hydrofluoric acid vapor.
- State their location.
- Public Safety should arrange for subsequent treatment or emergency response.
- Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.

INGESTION

1. If the victim is conscious, have them immediately drink large amounts of water as quickly as possible. This may help to dilute the acid. Milk or an antacid tablet taken with water may also help in providing an antidote effect.
2. While the victim is ingesting water, someone should:
    - Contact Public Safety at extension 6111.
    - State there has been a person who has ingested hydrofluoric acid.
    - State their location.
    - Public Safety should arrange for subsequent treatment or emergency response.
    - Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.
3. Medical personnel should see the victim immediately because HF ingestion is a life-threatening emergency.

- Contact Public Safety at extension 6111.

- State there has been a person who has ingested hydrofluoric acid.
- State their location.
- Public Safety should arrange for subsequent treatment or emergency response.
- Obtain a hydrofluoric acid MSDS and send it with victim to medical facility.

NOTE: Because of the special hazards associated with hydrofluoric acid, it is important that the victim seek medical care even if the exposed area is small or the acid is dilute. Time is critical-do not delay medical treatment!

REFERENCES

1. Honeywell: Recommended Medical Treatment for Hydrofluoric Acid Exposure. pages 57, May, 2000.
2. Upfal M. & Doyle, C: Medical Management of Hydrofluoric Acid Exposure. Journal Occupational Medicine 32: 726731, August, 1990.
3. Dr Luigi Parmeggiani: Encyclopaedia of Occupational Health and Science. page 1086, 1983.
4. National Academy Press: Prudent Practices for Handling Hazardous Chemical in Laboratories. pages 4344, 1981.

Reactives

Reactivity of materials has been defined by state and federal statutes and has led to regulations regarding the storage and disposal of these materials. Definitions of reactivity include one or more of the following:

- Normally unstable and readily undergoes violent change without detonating; reacts violently with water;
- Forms potentially explosive mixtures with water;
- When mixed with water, generates toxic gases, vapors, or chemicals in a quantity sufficient to present a danger to human health or the environment;
- Cyanide or sulfide-bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or chemicals in quantity sufficient to present a danger to human health or the environment;
- Capable of detonating or exploding when subjected to a strong initiating source or if heated under confinement; and
- Readily capable of detonation or explosive decomposition or reaction at standard temperature and pressure.

TYPES OF REACTIVE CHEMICALS

Chemicals that exhibit the characteristic of reactivity can be grouped as follows:

- Pyrophoric Chemicals - readily oxidized, will ignite spontaneously in air. Examples of chemicals that are considered to be pyrophoric include such diverse substances as silane, diborane, lithium hydride, white phosphorus, etc.
- Water-Reactive Chemicals - react violently with water. Examples of chemicals that are considered waterreactive include the alkali metals, aluminum chloride, phosphorus pentachloride, phosphorus pentoxide, all hydrides, etc.
- Oxidizing Materials - react vigorously at ambient temperatures when in contact with reducing materials or may evolve oxygen at room temperature under slight heating. Examples of chemicals that are considered oxidizers include chlorates, permanganates, nitrates, peroxides, etc.
- Reducing Materials - react vigorously at ambient temperatures when in contact with oxidizing materials. They are compounds, which remove oxygen from other compounds or lower valence states, often with vigorous evolution of heat. Examples of chemicals that are considered reducers include all hydrides, all acetylides, alcohols, etc.
- Shock-Sensitive Materials - explosive at standard temperature or if heated under confinement. Highly reactive chemicals with explosive properties require special storage, handling, and disposal procedures. Examples of chemicals that are considered shock-sensitive include picrates, azides, polynitro compounds, peroxides, etc.

STORAGE OF REACTIVE MATERIALS

Use and storage of reactive chemicals requires expert knowledge and planning. It is recommended that the following sources be consulted for specific considerations: Prudent Practices in the Laboratory; Handbook of Reactive Chemical Hazards; Lab Safety's Chart of Safe Storage of Chemicals; and the Condensed Chemical Dictionary. These references are available by calling the UofL Lab Safety Coordinator at 502.852.2830.

SHOCK/HEAT SENSITIVE CHEMICALS

These highly reactive chemicals with explosive properties require special storage handling and disposal procedures.

Organic peroxides are a special class of compounds with unusual stability problems that make them among the more hazardous substances handled in the laboratory. Specific chemicals have a strong tendency to form peroxides on exposure to air. Their presence as a contaminant in a reagent or solvent may change the course of a reaction. The peroxides as a class are low-power explosives, hazardous because of their great sensitivity to shock, sparks, heat, or friction. Some laboratory chemicals that are capable of forming explosive levels of peroxides include:

- Diethyl ether
- Methyl isobutyl ketone
- 2propanol
- Tetrahydrofuran
- Dioxanes
- Acetaldehyde

Guidelines for the Safe Storage & Use of Peroxide-Forming Chemicals

A wide variety of organic compounds spontaneously form peroxides by a free radical reaction of the hydrocarbon with molecular oxygen. Under normal storage conditions, formed peroxides can accumulate in the chemical container and may explode when subjected to heat, friction or mechanical shock. For this reason, it is imperative that all researchers learn to recognize and safely handle peroxide--forming compounds.

Recommended storage limits and more specific guidance for common chemicals that can form peroxides are listed in Table 1. The chemicals listed in List A as **"peroxide hazard on storage - without concentration"** in the table can form peroxides that are difficult to detect and eliminate. These peroxides can come out of solution and form crystals or a gel in the bottom of the container. They are extremely unstable and can violently decompose with the smallest disturbance, sometimes even spontaneously. They can be hazardous even if not opened. Do not store these chemicals more than 12 months unless tests show that they contain less than 80 ppm of peroxides.

The chemicals listed in List B as **"hazard due to peroxide concentration"** can undergo explosive polymerization initiated by dissolved oxygen. This class of peroxide-forming chemicals has a propensity for exploding when used experimentally in operations such as distillations. Do not store these chemicals more than 12 months unless tests show that they contain less than 80 ppm of peroxides.

The chemicals listed in List C as **"autopolymerize as a result of peroxide accumulation"** may explode when relatively small quantities of peroxides are formed. It is common to distill these peroxide-forming solvents before use and this concentrates the dissolved peroxides and subjects them to heat and mechanical shock.

The chemicals listed in Table 2 represent other peroxide-forming chemicals which cannot be placed into the other categories but nevertheless require handling with precautions.

Practices for Control of Peroxide-forming Organic Materials

Inhibitors

Many methods can be used to stabilize or inhibit the peroxidation of susceptible chemicals. If it does not interfere with the use of the chemical and if available, peroxide scavengers (inhibitors) shall be added in small quantities, and peroxide-forming chemicals shall be ordered with inhibitor added.

Purchase

Ideally, purchases of peroxide-forming chemicals should be restricted to ensure that these chemicals are used up completely before they can become peroxidized. This requires careful experiment planning. Researchers should purchase no more material than is needed to complete an experiment within the chemical's safe shelf life.

Storage

Peroxide-forming chemicals shall be stored in sealed, air-impermeable, light-resistant containers and should be kept away from light (light can initiate peroxide formation). Peroxide-forming chemicals should be stored in their original manufacturer's container whenever possible. This is very important in the case of diethyl ether because the iron in the steel containers that the material is shipped in acts as a peroxide inhibitor.

Labeling and Shelf-Life Limitation

Peroxides tend to form in materials as a function of age. Therefore, it is imperative that researchers are keenly aware of the age of their peroxide-forming chemicals.

Researchers must date each container upon arrival in the laboratory. Containers must be dated again when opened for the first time. An appropriate expiration date based on the information found in Table 1 should also be on the label.

Testing and Deperoxidation

When the date on the container expires, the peroxide-forming chemical shall either be 1) tested for peroxide content or 2) assumed to contain excessive peroxides and disposed of as hazardous waste. The maximum allowable concentration of peroxide in chemicals is 80 ppm. If a value over 80 ppm is detected, the owner shall deperoxidize the chemical or dispose of it as hazardous waste. Materials which are older than the suggested shelf life but have been tested and have no detectable peroxides or peroxide concentrations less than 80 ppm may be retained but should be tested at least quarterly. All chemicals to be distilled must be tested prior to distillation regardless of age. Researchers should never test containers of unknown age or origin. Older containers are far more likely to have concentrated peroxides or peroxide crystallization in the cap threads and therefore can present a serious hazard when opened for testing.

The easiest method to test for peroxides is the use of peroxide test strips. These strips are simple to use and can be obtained from a variety of suppliers including Lab Safety and Fisher. For volatile organic chemicals, the test strip is immersed in the chemical for 1 second, then the tester breathes slowly on the strip for 15-30 seconds or until the color stabilizes. The color is then compared with a colorimetric scale provided on the bottle. Test strips must be kept refrigerated and must have an expiration date on the bottle.

Management and disposal of old containers

Older containers of peroxide-forming chemicals, or containers of unknown age or history, must be handled very carefully and should never be opened by researchers. Any peroxide-forming chemical with visible discoloration, crystallization or liquid stratification should be treated as potentially explosive. Older steel containers that have visible rust may also be extremely dangerous. If any of these conditions are observed on a peroxide-forming chemical container or if the origin and age are unknown, do not attempt to move or open the container. Contact DEHS to have the container inspected and if necessary disposed of properly.

Safe Distillation

- Eliminate the peroxides with a chemical reducing agent or pass the solvent through activated alumina.
- Add mineral oil to the distillation pot. This has the combined effect of "cushioning" any bumping, maintaining dilution and serving as a viscous reaction moderator in case the peroxides begin to decompose.

Carefully monitor the distillation process to ensure that it does not dry out completely, and then overheat. Distillation can concentrate peroxides, especially if taken to a dry state. Peroxides will be present mainly in the still bottoms.

Reducing Peroxides during Distillation

Small pieces of sodium metal can be added to the distillation vessel to reduce peroxides. Use benzophenone as an indicator for the presence of sodium metal (benzophenone in the presence of sodium metal forms a radical with a deepblue color). When the blue color disappears, add more sodium metal.
Peroxide Forming Chemicals Storage Guide
The yellow crystals of picric acid, or trinitrophenol, are shocksensitive and may readily detonate if the chemical is allowed to dry. Check containers of picric acid regularly to ensure the crystals remain moist with water and have not dried.

DO NOT ATTEMPT TO REMOVE THE LID OF A CONTAINER OF PICRIC ACID IF THE ACID IS DRY.

Contact with copper, lead, zinc, and other metals can form picrate salts that are much more shock sensitive than picric acid itself. Unstable salts may also be formed with concrete, ammonium, calcium, and bases.

Picric acid is a more powerful explosive than TNT and must be handled with extreme care. Call the Department of Environmental Health and Safety at 8522956 for special disposal arrangements.
Perchloric acid is a very strong oxidizing agent that can undergo vigorous, self-- sustained decomposition or explosive reactions when catalyzed or exposed to heat. The majority of accidents involving perchloric acid are due to its mixture with organic material or to the formation of the anhydrous acid, which is extremely

unstable and explodes upon contact with wood, paper, or organic solvents. Cold perchloric acid, at less than 70% HCLO4 by weight, is a less powerful oxidizing agent. As the percentage or the temperature increases, the oxidizing power of the perchloric acid also increases.

Combustible materials, such as wood or oil, contaminated with perchloric acid are highly flammable and dangerous. Such materials may explode spontaneously, upon impact, or when in contact with heat or flame.

Other perchlorates are also sensitive to heat and shock, such as heavy metal and organic perchlorates, hydrazine perchlorate, and ammonium perchlorate.

SPECIAL PRECAUTIONS FOR THE SAFE USE OF PERCHLORIC ACID

Whenever possible purchase the 60%byweight HClO4 grade. Perchloric acid should be stored on a nonmetal surface away from:

- Combustible materials;
- Organic solvents;
- Metal hydrides;
- Alcohols;
- Sulfuric acid; and
- Acetic anhydride.

Inspect monthly for signs of discoloration that indicate development of the anhydrous form of perchloric acid. Call the Department of Environmental Health and Safety 502.852.2956 for immediate disposal.

Wear goggles and rubber gloves whenever perchloric acid is handled.

To avoid a violent reaction in procedures requiring perchloric acid for wet digestion, pretreat the sample with nitric acid to destroy oxidizable material.

Procedures involving heated perchloric acid require use of a special chemical hood, termed a perchloric acid hood. This type of hood:

- Is constructed of stainless steel;
- Has a duct wash down system; and

- Has no exposed organic coatings or sealing compounds.

At this time there is only one perchloric acid hood at the University that meet this specification, located in the Belknap Research Building in the research laboratory of Dr. Teresa Fan (Room 336). Procedures involving heated perchloric acid are prohibited in all other hoods. There are a few other hoods of stainless steel construction that may be labeled as perchloric acid hoods, but none of them have the required wash down system.

The azide group of chemicals represents one of the few commercially produced explosives containing no oxygen. When compounded with other materials, azides are shock- and heat-sensitive. Copper and lead azides are more sensitive primary explosives than nitroglycerine. Sodium azide reacts with copper, lead, brass, or solder to form these explosive combinations.

DO NOT POUR SODIUM AZIDE DOWN THE DRAIN. Metal plumbing presents an explosion hazard.

OTHER EXPLOSIVE CHEMICALS

In general, other compounds containing the following functional groups tend to be heat and shock sensitive:

- Acetylide;
- Diazo;
- Nitroso; and
- Organic nitrates.

Hydrogen and chlorine gases react explosively in the presence of light.

Hydrazine can explode in contact with iron rust.

The chemicals encountered in the laboratory have a broad spectrum of physical, chemical, and toxicological properties and physiological effects. The risks associated with the use of laboratory chemicals must be well understood prior to their use in an experiment. The chemicals used in the laboratory can be grouped among several different hazard classes. Many chemicals display more than one type of hazard. Highly hazardous chemicals require special written procedures to ensure safe use in the laboratory.

Basic Concepts of Toxicology

Toxicity is the potential of a substance to produce adverse reaction on the health or well-being of an individual. Whether or not any ill effects occur depends on:

- The properties of the chemical;
- The route by which the substance enters the body;
- The dose (the amount of the chemical acting on the body); and
- The susceptibility of the exposed individual.

ROUTES OF ENTRY

There are four main routes of entry or means by which a substance may enter the body:

1. Inhalation;
2. Ingestion;
3. Absorption through the skin; and
4. Injection.

The most important route of entry is usually inhalation. Nearly all materials that are airborne can be inhaled.

DOSE-RESPONSE RELATIONSHIP

When a toxic chemical acts on the human body, the nature and extent of the adverse reaction or injurious response depends on the dose received - that is, the amount of the chemical that actually enters the body and the time interval during which this dose was administered.

Two standardized measurements, the LD50 and LC50, serve to quantify and express the degree of toxicity of a substance.

LD50 The quantity of a material that when ingested, injected or applied to the skin as a single dose will cause death of 50% of the test animals.

LC50 The concentration of a substance in the air that causes death of 50% of the test animals.

ACUTE EFFECTS

Acute toxic effects are usually produced by a single large dose received in a short period of time (usually less than 24 hours), and involve immediate results of some kind, such as irritation, allergy, illness or death. Acute exposures are usually related to an accident.

CHRONIC EFFECTS

Chronic toxic effects are usually produced by long-duration or repeated exposure to a substance. Damage to the body may not appear for many years since chronic toxins are known to have long latency periods. Carcinogens are considered to be chronically toxic substances.

ORGANIC SOLVENTS

Organic solvents are one of the most commonly encountered groups of toxic chemicals and constitute one of the major hazards in a laboratory. Most are highly volatile or flammable, such as ethers, alcohols, and hydrocarbons.

Chlorinated solvents such as chloroform are often non-flammable but, when exposed to heat or flame, may produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

Inhalation of solvent vapors may cause bronchial irritation, dizziness, central nervous system depression, nausea, headache, or coma. Prolonged exposure to high concentrations of solvent vapors may result in liver or kidney damage. Skin contact may produce defatting and drying.

Ingestion of a solvent could result in severe physiological effects. In case of ingestion, call the Poison Control Center (502.589.8222), or seek medical aid immediately.

With the following chemicals, the odor threshold is higher than the acceptable exposure limit:

- Chloroform;
- Benzene;
- Carbon tetrachloride; and
- Methylene chloride.

Certain solvents are known or suspected to be carcinogenic following prolonged exposure. See the section on Highly Hazardous Chemicals for special requirements for carcinogens. Examples of solvents that are known or suspect carcinogens include:

- Chloroform;
- Benzene;
- Carbon tetrachloride;
- Chlorinated ethers
- Methylene chloride; and
- Polyhalogenated hydrocarbons.

All volatile and flammable solvents should be used in a properly functioning chemical hood. Never use ether or other highly flammable solvents in a room with an open flame or other ignition source present. The safe handling of flammable materials is discussed in the section on physical hazards of chemicals later in this chapter.

IRRITANTS

Irritants are non-corrosive chemicals that cause reversible inflammatory effects (swelling and redness) on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic chemicals are irritants, and consequently, skin and eye contact with all chemicals in the laboratory should be avoided. Examples of irritants include: acetaldehyde, acetic acid, acrolein, ammonia, ethylene glycol, glutaraldehyde, sodium hydroxide, and xylenes.
A chemical allergy is an adverse reaction by the immune system to a chemical. Such allergic reactions result from previous sensitization to that chemical or a structurally similar chemical. Once sensitization occurs, allergic reactions can result from exposure to extremely low doses of the chemical. Allergic reactions can be immediate, occurring within a few minutes after exposure. Anaphylactic shock is a severe immediate allergic reaction that can result in death if not treated quickly. If this is likely to be a hazard for a planned experiment, advice on emergency response should be obtained. Allergic reactions can also be delayed, taking hours or even days to develop. The skin is usually the site of such delayed reactions, in which case it becomes red, swollen, and itchy.

It is important to recognize that delayed chemical allergy can occur even some time after the chemical has been removed. Contact with poison ivy is a familiar example of an exposure that causes a delayed allergic reaction. Also, just as people vary widely in the susceptibility to sensitization by environmental allergens such as dust and pollen, individuals may also exhibit wide differences in their sensitivity to laboratory chemicals. Examples of substances that may cause allergic reactions include diazomethane, dicyclohexylcarbodiimide, formaldehyde, various isocyanates, benzylic and allylic halides, and certain phenol derivatives.

Another allergen for lab personnel to be aware of is latex. Latex allergy can result from repeated exposures to proteins in natural rubber latex through skin contact or inhalation. Reports of work-related allergic reactions to latex have increased in recent years, especially among employees in the growing health-care industry, where latex gloves are widely used to prevent exposure to infectious agents.

At least 7.7 million people are employed in the health-care industry in the U.S. Once sensitized, workers may go on to experience the effects of latex allergy. Studies indicate that 8 percent to 12 percent of health-care workers regularly exposed to latex are sensitized, compared with 1 percent to 6 percent of the general population, although total numbers of exposed workers are not known.

Symptoms include skin rash and inflammation, respiratory irritation, asthma, and in rare cases shock. In some instances, sensitized employees have experienced reactions so severe that they impeded the worker's ability to continue working in their current job.

Wherever feasible, the selection of products and implementation of work practices that reduce the risk of allergic reactions, such as those listed below, is recommended.

- Non-latex gloves are recommended for tasks (such as food preparation, routine housekeeping, and maintenance) that are not likely to involve contact with infectious materials such as blood.
- Workers at high risk of allergic reaction should be screened periodically to detect symptoms early and control or eliminate latex exposure.
- Appropriate work practices should be followed. For example, workers should wash their hands with a mild soap and dry thoroughly after removing latex gloves. Areas contaminated with latex-containing dust should be identified and cleaned, and ventilation filters and vacuum bags used in those areas should be

changed frequently.
- Workers should be provided with education programs and training materials about latex allergy.
- Workers showing symptoms of latex allergy should consult a doctor experienced in treating the problem, and workers with a known allergy should avoid latex exposures, wear a medical alert bracelet, and follow their doctor's advice for dealing with allergic reactions.

Chemicals are considered highly hazardous for many reasons. They may cause cancer, birth defects, induce genetic damage, cause miscarriage, or otherwise interfere with the reproductive process. Or they may be a cholinesterase inhibitor, a cyanide, or other highly toxic chemical that, after a comparatively small exposure, can lead to serious injury or even death. Working with compounds like these generally necessitates implementation of additional safety precautions. Below are definitions of the classes of chemicals that are considered highly hazardous and descriptions of the safety precautions to consider when designing experiments involving them. Lab-specific written standard operation procedures are required for all highly hazardous chemicals. A comprehensive list of highly hazardous chemicals can be found at this link.

HIGHLY HAZARDOUS SUBSTANCES AS DEFINED BY OSHA

The OSHA Lab Standard specifically lists three categories of chemicals as "particularly hazardous." They include select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity.
Chemicals that are strongly implicated as a cause of cancer are termed carcinogenic. Substances defined by OSHA as select carcinogens fall into one of the categories listed below:

- OSHA Carcinogen - a chemical regulated by OSHA as a carcinogen; each has its own standard in subpart 2 of the OSHA General Industry Standards.
- Known Human Carcinogen - Classified as "known to be carcinogens", in the most recent Annual Report on Carcinogens issued by the National Toxicology Program (NTP), or listed under Group 1 "carcinogenic to humans" by the International Agency for Research on Cancer (IARC).
- Potential Human Carcinogen Listed under IARC Group 2A "probably carcinogenic to humans" or Group 2B "possibly carcinogenic to humans", or classified as "reasonably anticipated to be a carcinogen" by NTP, and causes

statistically significant tumor incidence in experimental animals under any of the following dosage criteria:
  - Inhalation exposure chronic exposure (for a significant portion of a lifetime); 6 7 hours/day, 5 days/week; dose <10mg/m3.
  - Skin exposure repeated skin exposure of <300mg/kg body weight per week.
  - Ingestion daily dose <50mg/kg body weight.

- Inhalation exposure chronic exposure (for a significant portion of a lifetime); 6 7 hours/day, 5 days/week; dose <10mg/m3.
- Skin exposure repeated skin exposure of <300mg/kg body weight per week.
- Ingestion daily dose <50mg/kg body weight.

Important! Remember that a chemical's lack of inclusion in one of these lists does not necessarily imply that it is free from carcinogenic activity. Substances such as ethidium bromide that are used extensively in research do not have a substantial industrial use and, consequently, have not undergone a rigorous analysis for carcinogenicity. Although ethidium bromide is a well-known, potent mutagen it is not included in any of the lists below. Laboratory staff are reminded to diligently research a chemical's toxicity and hazard potential rather than relying exclusively on its presence in a list.

Table 3 - OSHA Regulated Carcinogens and other select Carcinogens Used in UofL Laboratories

Chemicals of Unknown but Suspect Carcinogenic Potential

Most laboratories have a number of chemicals for which there is little epidemiological data regarding its carcinogenicity. Knowledge of a substance's general chemical classification can oftentimes aid the researcher in identifying underlying carcinogenic potential. While these compounds may not fall under the regulatory umbrella of an OSHA 'select carcinogen,' consideration should be given to implementing special precautions to keep exposures as low as possible.

For example, methyl chloromethyl ether is listed as a known human carcinogen by NTP. Consequently it falls under the OSHA select carcinogen designation and the special precautions for work with highly hazardous substances applies. The carcinogenicity of structurally similar compounds such as ethyl chloromethyl ether is not well established, however. The OSHA select carcinogen designation does not strictly encompass these compounds and the special precautions for work with highly hazardous substances may not apply. However, their close similarity to a well-established carcinogen should raise a red flag during the risk assessment process and special consideration should be given towards the need for incorporating additional safety precautions in the experimental design.

A table for delineating the various classes of carcinogenic compounds is provided for reference.

Table 4 - Classes of Carcinogenic Compounds. (PDF)
Chemicals that interfere in any way with the normal reproductive process are considered reproductive toxins. Adverse effects include reductions in libido, reduced fertility, embryo lethality, induction of chromosomal damage (mutations), malformations of the developing fetus (teratogenesis), and postnatal functional defects. Sometimes problems may become apparent only after a long latency period. The enormous number of chemicals, complexity of human reproductive biology, and the influence of other factors (i.e., smoking, diet, environment) makes isolating the effects of exposure to a given chemical very difficult.

Due to this uncertainty, a pregnant woman working in a lab should exercise caution when handling or working with any chemicals. Women should notify their supervisor when they become pregnant so the potential hazards in the lab can be assessed and appropriate protective measures can be taken. Embryo toxins damage the fertilized egg, embryo, or fetus in the early stages of gestation. These chemicals have their greatest impact in the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, women of childbearing potential are advised to be especially cautious when working with chemicals, especially those rapidly absorbed through the skin (e.g., formamide).

The Department of Environmental Health and Safety is available to assist staff in gathering information regarding the hazards of the chemicals with which they work. In consultation with the woman and her doctor, an assessment can result in one of three possibilities:

1. Continue to work in the lab without any change.
2. Continue to work in the lab with some changes to the type of work procedure performed, or to the work environment and protective equipment.

3. In rare instances, the doctor may recommend discontinuing work in the lab for the duration of the pregnancy.

Some changes that may need to be considered include:

- Examine chemicals used in the lab for possible teratogens and remove them from use or reassign work with these chemicals to another person.
- Take extra care to avoid exposure to and exercise caution whenever handling or working with any chemicals.
- Be especially vigilant about personal protective equipment. Use extra personal protective equipment if necessary.
- Perform all work with chemicals in a chemical hood, if possible, or using other suitable engineering controls.

Substances With A High Degree Of Acute Toxicity

Substances with a high degree of acute toxicity are those that can cause death, disability, or serious injury after a single, relatively lowlevel exposure. The following table denotes the OSHAdefined toxicity designations, for various routes of exposures. The criteria for "highly toxic" appears in bold letters.

Acute Toxicity Hazard Designations

OSHA Hazard Designation

Other Toxicity Rating [1]

Oral LD50

Skin Contact LD50 [2]

Inhalation LC50 [3]

Inhalation LC50

(rats, mg/kg)

(rabbits, mg/kg)

(rats, ppm for 1 hr)
(rats, mg/m [3]
for 1 hr)

Highly Toxic
Highly Toxic

< 50

< 200

< 200

< 2,000

Toxic
Moderately Toxic
50 to
500
200 to
1,000
200 to
2,000
2,000 to
20,000

Slightly Toxic
500 to
5,000
2,000 to
20,000
2,000 to
20,000
20,000 to
200,000

[1] Prudent Practices in the Laboratory: Handling and Disposal of Chemicals; National Academy Press, Washington, D.C., 1995
[2] LD50 The amount of a chemical that when ingested, injected, or applied to the skin of a test animal under controlled laboratory conditions will kill onehalf (50%) of the animals.
[3] LC50 The concentration of the chemical in air that will kill 50% of the test animals exposed to it.

Lab specific SOP's providing detailed information relevant to safety and health considerations are required when laboratory work involves the use of highly hazardous chemicals. Find the LD50 on a material safety data sheet (MSDS) or in the Registry of Toxic Effects of Chemical Substances (RTECS). Compare the LD50 to the table above to determine if it is highly toxic, requiring a written SOP.

Many drugs and physiologically active compounds are, by this definition, considered highly toxic. Oftentimes researchers, particularly those with clinical duties in addition to their research activities, underestimate the toxicity of materials frequently encountered in clinical practice. It is important to remember, however, that a drug supplied in a ready-to-use formulation presents a much different level of risk than the pure, undiluted compound that must be weighed or otherwise manipulated in order to prepare it for use. The hazards presented by drugs and other physiologically active compounds in the lab are more similar to those presented to pharmacists preparing drug formulations where considerable precautions are undertaken, than to those presented to clinicians dispensing pre-formulated prescription medications.

For more information on preparing SOPs, see Written Safety Procedures SOPs and SASPs on the DEHS website.

SELECT AGENTS

The Department of Environmental Health & Safety provides the University oversight of select agents as required by federal laws & regulation. As a consequence of the 9/11 terrorist attacks, legislation was passed by Congress and signed by the President on October 26, 2001, which affects the possession of biological agents and toxins with bioterrorism potential termed "Select Agents". The legislation entitled the USA PATRIOT Act extends previous laws that restricted the transport, but not the possession of these agents. Transfer, shipping or receiving of any select agent within or outside the University is prohibited without DEHS approval.

Due to ongoing national concerns regarding the security and possession of "Select Agents" additional legislation entitled the Public Health Security and Bioterrorism Preparedness and Response Act was passed and signed into law on June 12, 2002. The regulations became effective February 7, 2003 and included many new provisions with significant criminal penalties that extend to individuals for failure to comply. The Law requires that all persons possessing select biological agents or toxins register with the appropriate federal agency. For more information about Select Action Registration, see Biological Safety on the DEHS website.
Prudent experimental planning requires not only an accurate assessment of the risks involved, but also selection of appropriate work practices. General laboratory safety practices and procedures are usually sufficient for operations involving hazardous chemicals of mild to moderate risk. When highly hazardous chemicals are involved, however, it may be necessary to take additional steps to adequately reduce risk and protect the health and safety of laboratory workers.

The goal in developing and implementing these special precautions is to set up multiple lines of defense to minimize the risks posed by highly hazardous chemicals. Consider each of the following provisions when developing special procedures for highly hazardous chemicals; some or all of them may apply, depending on the particular circumstances in which the substance will be used. In some circumstances only select precautions may be necessary, such as when the total amount of an acutely toxic substance to be handled is a small fraction of the harmful dose. In other circumstances it may be necessary to implement a full array of precautions.

Substitution & Other Procedural Modifications

The most effective way to minimize the risk posed by highly hazardous chemicals is to reduce or eliminate their use or to alter the procedure in a way that reduces the risk that they pose. Whenever possible replace highly hazardous materials with less hazardous substitutes. If that is not possible try to modify procedures to minimize direct manipulation of hazardous materials. Diluent can be directly added to a container of known quantity to make a stock solution from which aliquots can be drawn or working solutions made, for example. Some highly hazardous materials can be obtained in a form or dilution that reduces the need for direct manipulation, another great risk reduction strategy. Acrylamide purchased in aqueous suspension is but one example. While still a highly hazardous material, the exposure potential, and thus the risk, is much less than when purchased as a powder that must be weighed out and transferred between containers.

Experiments utilizing substitution and similar procedural modifications are in need of fewer additional precautions as described below. It is vital that lab staff examine every experiment utilizing highly hazardous chemicals to determine if these types of modifications can be implemented as a first step in risk reduction. Consult with supervisors, colleagues, and reference documents for assistance in identifying suitable substitutes and other risk reduction strategies. DEHS can provide assistance in comparing risk levels associated with different materials and procedures.

Where use of highly hazardous materials cannot be avoided it is necessary to incorporate additional safety practices and procedures, including development of written SOPs. Listed below are some of the most common supplements to general laboratory safety that are used when working with highly hazardous materials. Selection of appropriate precautions is dependent upon the exposure potential inherent in a particular experimental situation. While all laboratory staff are responsible for conducting experimental procedures in a safe manner, the Principal Investigator is ultimately responsible for ensuring identification and implementation of appropriate precautions when dealing with highly hazardous materials.

Standards Operating Procedures (SOPs)

When working with highly hazardous chemicals it is necessary to develop lab-specific written standard operating procedures (SOPs) relevant to safety and health considerations. The purpose of the SOP is to outline the risks associated with the highly hazardous chemicals in use as well as to describe the steps that lab staff will take to mitigate those risks. SOPs for highly hazardous chemicals can be substance specific or procedure specific, depending on the needs of a particular laboratory.

DEHS provides consultative services to ensure the nature of the hazard is well understood and appropriate controls are incorporated in written SOPs.

Designated Area

Confine operations involving highly hazardous materials to a designated work area in the laboratory. This designated area can be the entire laboratory, an area of the laboratory, or a device such as a chemical fume hood. Warning signs are used to clearly indicate which areas are designated and the nature of the hazard. Use of designated areas need not be restricted to highly hazardous materials, as long as all lab staff are aware of the nature of the substances being used, and the special precautions, laboratory skill and safety discipline required to work in the area.

Access Control

Limit access to laboratories where highly hazardous chemicals are in use to appropriately trained and authorized personnel. Depending on the materials and the circumstances of use, access control can be achieved by a combination of administrative procedures (such as prohibiting unauthorized visitors) and/or physical barriers (such as closing laboratory doors while highly hazardous chemicals are in use or storing highly toxic chemicals in locked cabinets).

Containment

Procedures involving highly toxic chemicals that can generate dust, vapors, or aerosols must be conducted in a hood, glove box, or other suitable containment device. These devices should be checked for acceptable operation prior to conducting experiments with highly hazardous chemicals. If experiments are to be ongoing over a significant period of time frequent checks of hood function or the installation of a flow-sensing device with an audible or visual indicator of performance should be considered. Experiments conducted with highly hazardous chemicals may need to be carried out in work areas designed to contain accidental releases. Hood trays and other types of secondary containers should be used to contain inadvertent spills, and careful technique must be observed to minimize the potential for spills and releases.

Decontamination

Equipment used for the handling of highly hazardous chemicals may need to be suitably isolated from the general laboratory environment. Laboratory vacuum pumps used with these chemicals should be protected by high-efficiency scrubbers or HEPA filters and vented into an exhaust hood. Decontamination, when appropriate, should be conducted in a designated hood.

A number of pharmaceuticals manipulated at concentrations appropriate for patient therapy may pose a risk to lab workers through acute and chronic exposure. While the literature establishing these agents as occupational hazards deals primarily with cytotoxic drugs, documentation of significant exposures from other hazardous drugs is rapidly accumulating. Many hazardous drugs are known human carcinogens, particularly the chemotherapeutic drugs. Chemotherapeutic agents have also been linked to adverse reproductive outcomes. The American Society of Hospital Pharmacists describes four characteristics useful in determining if a medication poses a hazard to workers:

- Genotoxicity.
- Carcinogenicity.
- Teratogenicity or fertility impairment.
- Serious organ or other toxic manifestation at low doses in experimental animals or treated patients.

While no consensus or standardized reference exists, a number of commonly used drugs considered hazardous by the above criteria are listed in the table below. Treat analogues and derivatives of these agents as hazardous medications unless information to the contrary is available. This is not an all-inclusive list. You should also consult the manufacturer's literature and package inserts for additional information. Since investigational drugs are, almost by definition, new drugs with little information regarding potential toxicity, it is prudent to handle them as hazardous medications as well.

In the laboratory the greatest risk of occupational exposures to hazardous drugs occurs during procedures involving manipulation of materials in their pure form, for example, when weighing out finely divided powders. Surface contamination is also a concern, both from small spills that occur during the weighing process and from aerosolization that occurs during the preparation and administration of injections. As many hazardous drugs are absorbed through the skin, unapparent surface contamination can be a significant source of exposure.

An additional exposure concern is presented when hazardous chemicals/drugs are administered to experimental animals. Many of these chemicals and/or their hazardous metabolites are excreted in urine or feces for the first 48 hours or longer following their administration. Bedding collected during this period is considered contaminated and must be handled in a way that reduces the generation of dust and limits the exposure of animal care personnel. Unless researchers can document that the chemical or its hazardous metabolites are not excreted in the animal model, they must develop a Special Animal Safety Protocol (SASP) for chemicals/drugs administered to the animals. For more information on preparing SASPs, see Written Safety Procedures - SOPs and SASPs on the DEHS website.

The first step in designing a safe operating procedure is to become familiar with the potential health and physical hazards of the chemicals involved. Once appraised of the hazards, the researcher must then select appropriate control strategies to assure safe use and disposal of the chemicals. Engineering controls such as chemical hoods are required for processes releasing airborne contaminants. If work practice and engineering controls do not reduce the hazard to a safe level, then personal protective equipment may be required. Lab workers must all plan for the possibility of accidental spills and releases.

The following general guidelines are to be used when handling any chemical. All personnel are responsible for knowing these general rules, plus any other rules that apply to the specific chemical with which they are working.

IMPORTANT PRECAUTIONS
ALWAYS:

- Know the locations of safety showers, and eyewash stations, as well as other emergency equipment. Know details of their operation.
- Conduct procedures that involve hazardous volatile chemicals or that may result in the production of aerosols or dangerous gases in a properly functioning chemical hood. If this is not feasible, call the DEHS Lab Safety Coordinator at 502.852.2830 for a hazard assessment.
- Be alert to unsafe conditions, and call attention to them so that corrections can be made.
- Consider any unlabeled chemical solution hazardous until it is identified.
- Discard chemicals that have changed in color or appearance using approved disposal procedures.
- Allow only authorized personnel in the laboratory.
- Use mechanical devices for all pipetting procedures; never use mouth suction.
- Wash hands frequently always before leaving the laboratory and prior to eating, smoking, applying cosmetics, etc.
- Remove gloves before leaving the laboratory. Do NOT wear gloves out of the lab into elevators or while typing on lab computers.

Protect the face, skin, and eyes at all times by wearing appropriate protective clothing and equipment to avoid direct contact with the chemical (i.e. chemical goggles, gloves, apron or lab coat, etc.). Remove these items before leaving the laboratory. Do NOT wear lab coats or other potentially contaminated protective equipment out of the lab into elevators, during lunch breaks, or launder lab coats at

home.
The laboratory chemical hood is often the primary control device when using flammable and toxic chemicals in the laboratory. It is vital that lab personnel understand how chemical hoods work so they can use them properly and avoid exposure to hazardous chemicals.

Below is a safe operating procedure for chemical hood use which is also printable in a poster format. Following these basic steps will help ensure the hood is providing optimum protection. Lab personnel can print out one or more copies of the poster to be displayed on or near chemical hoods.

For a detailed understanding of chemical hoods the reader is directed to the "Chemical Hood User's Guide" on the DEHS website. This guide discusses the different types of chemical hoods and their advantages and limitations, and the differences between chemical hoods and biosafety cabinets, sometimes mistaken for chemical hoods. New laboratory workers and even experienced personnel will benefit from a thorough understanding of these important control devices.

Safe Operating Procedure for Chemical Hoods

- Confirm that the hood is operational. If fitted with a local on/off switch, make sure the switch is in the "on" position; check the airflow gauge if so equipped. In the absence of a gauge, observe the plastic "flow check ribbon" taped to the lower corner of the sash. Airflow can be visually assessed by noting that the ribbon is pulled gently into the hood. The most recent hood test data and optimum sash height are indicated on the yellow label affixed to the hood face. Never work with a malfunctioning hood; report problem hoods to Physical Plant Work Control. Advise DEHS of chemical hoods that malfunction repeatedly.
- Maintain operations at least 6" inside the hood face. Vinyl tape can be attached to the work surface to serve as a visual reminder. " Lower sash to optimum height. Optimum height is the sash height at which airflow is maximized without creating turbulence, generally 100 feet per minute. A yellow label placed on the hood face indicates the most recently recommended sash height. This does not apply to variable volume chemical hoods; these should be operated with the sash at or below the sash stop. With unattended or potentially explosive processes, conduct the operation behind a lowered sash or safety shield.
- Keep head out of hood except when installing and dismantling equipment.

- Keep hood storage to an absolute minimum. Keep only items needed for the ongoing operation inside the hood. Keep the back bottom slot clear at all times as it serves as an exhaust port for chemicals generated near the work surface. Raise large objects at least two inches off the hood surface to minimize air flow disruption.
- Minimize foot traffic around the chemical hood. A person walking past a chemical hood can create competing currents at the hood face, causing vapors to flow out. Other sources of competing air currents such as open windows and fans must also be avoided while using a chemical hood.
- Use extreme caution with ignition sources inside a chemical hood. Ignition sources such as electrical connections, Variac controllers and open flame can be used inside a chemical hood as long as there are no operations involving flammable or explosive vapors. If possible, ignition sources should remain outside the hood at all times.
- Replace hood components prior to use. Every component of a chemical hood, whether airfoil, baffle, or sash, plays a vital role in preventing the escape of hazardous materials from the hood. Any hood components removed to conduct maintenance or repair activities, or to set up experimental apparatus must be replaced prior to using the hood for contaminant control.

Personal protective equipment, or PPE, is designed to protect employees from injuries or illnesses resulting from contact with chemical, radiological, physical, electrical, mechanical, or other hazards. PPE includes a variety of devices and garments such as safety glasses, goggles, gloves, earplugs, coveralls, and respirators. Using PPE is often essential, but it should not be used as a substitute for engineering, work practice, and/or administrative controls to prevent exposure to hazards. Engineering controls involve physically changing the work environment. An example of an engineering control would be a chemical fume hood. Administrative controls involve changing how or when lab workers do their jobs, such as scheduling work and rotating workers to reduce exposures. Work practice controls involve training workers to perform tasks in ways that reduce their exposure to hazards.

DEHS has conducted a Hazard Assessment and Personal Protective Equipment Requirements for General Laboratory Operations. Print this Assessment and post in the lab. If other hazards are present, contact the Laboratory Safety Coordinator to conduct a more specific Personal Protective Equipment Hazard Assessment. Training on the use of PPE is covered during General Lab Safety training and during Lab Specific training by the Principal Investigator.

EYE AND FACE PROTECTION

Safety glasses with side shields that conform to ANSI standard Z87.1, at a minimum, are required for work with hazardous chemicals. Ordinary prescription glasses are not adequate protection. Contact lenses can be worn safely if appropriate eye and face protection is also worn. Although safety glasses can provide satisfactory protection from injury from flying particles, they do not fit tightly against the face and offer little protection against splashes or sprays of chemicals. Splash goggles should be worn if there is a potential for splash in any operation involving chemicals. Full face shields with splash goggles should be worn when handling large quantities of chemicals, explosive, or highly hazardous chemicals. If work in the lab could involve exposure to lasers, ultraviolet light, infrared light, or intense visible light, specialized eye protection should be worn. Consult the DEHS Laboratory Safety Coordinator or 502.852.2830 for guidance.

HAND PROTECTION

Gloves appropriate to the hazard should be used. It is important that the hands and any skin that is likely to be exposed to hazardous chemicals receive special attention. Proper protective gloves should be worn when handling hazardous chemicals, toxic materials, materials of unknown toxicity, corrosive materials, rough or sharp-edged objects, and very hot or cold objects. Before the gloves are used, it is important that they be inspected for defects.

The degradation and permeation characteristics of the glove material selected must be appropriate for protection from the hazardous chemicals being handled. Glove selection guides (available from most glove manufacturers) should be consulted. Some websites for glove manufacturer information on chemical resistance of glove materials:
Best Glove - https://www.showagloves.com/products

Ansell - http://www.ansellpro.com

You may also contact the Laboratory Safety Coordinator at 502.852.2830 for guidance on proper glove selection.

Disposable latex gloves are very permeable to most chemicals. They are designed for use with biological hazards, and they should not be used for chemical protection.

If latex gloves are used for biological hazards, be aware of latex allergy symptoms: skin rash, inflammation, respiratory irritation, and in rare cases, shock. Be sure to let your supervisor know if you have a latex allergy.

Gloves should be inspected before use, frequently during use, and replaced immediately if they are contaminated or torn. The use of double gloving may be appropriate in situations involving chemicals of high or multiple hazards. Hands should be washed after removing gloves. **Always remove gloves before leaving the laboratory.**

CLOTHING

Wear clothing that protects your skin. Wear long pants no shorts or short skirts. Wear a lab coat for further protection. Lab coats should be worn with the front fastened and the sleeves completely down, not rolled up. The coat sleeves keep splashes and aerosols from contacting your forearm and wrist. Have a plastic or rubber apron available for working with strong caustics or corrosives. Shoes should completely cover your feet; do not wear open-toed shoes, sandals or clogs.

REQUIRED USE OF RESPIRATORS

The primary method for the protection of laboratory personnel from airborne contaminants should be to minimize the amount of such materials entering the laboratory air. Engineering controls such as chemical hoods, biosafety cabinets, and local exhaust ventilation shall be used to contain and exhaust hazardous emissions. There should be very few instances in a laboratory when respiratory protection is necessary. Respirators may only be considered when engineering controls are not feasible or are inadequate to reduce exposures to acceptable levels. **Use of respirators of any kind must be approved by DEHS.** DEHS will perform a hazard assessment, including air monitoring if warranted.

Where respiratory protection is required to reduce potential exposure to acceptable levels, full compliance with the OSHA Standard for Respiratory Protection is mandated. See the UofL Respiratory Protection Program on the DEHS website for the requirements for respirator selection and use, medical approval, fit testing, training, and maintenance and care of respirators. Before using a respirator, employees must receive medical approval, training and fit testing.

VOLUNTARY USE OF FILTERING FACEPIECE RESPIRATORS (DUST MASKS)

There are times when lab staff may wish to use respiratory protection, even when exposures are below the regulatory exposure limit, to provide an additional level of comfort and protection. For example, dust masks are often worn as a precaution when weighing toxic powders, even though there is no quantifiable exposure. However, if a respirator is used improperly **(dust masks are not appropriate for volatile chemicals)** or not kept clean, the respirator itself can become a hazard to the worker. The PI is responsible for notifying DEHS of the voluntary use of filtering facepiece respirators to ensure the respirator does indeed protect against the contaminant of concern and does not in itself create a hazard. Voluntary use of dust masks in non-hazardous situations does not require medical evaluation or fit testing, but must be approved by DEHS. Every lab worker who uses a respirator on a voluntary basis must be provided with the basic advisory information contained in Appendix D of the OSHA Standard.
The quantities, types, and storage of chemicals are major factors in laboratory safety. A few basic rules will greatly reduce risks in the laboratory.

GUIDELINES FOR ORDERING

Always order the minimum amount of a needed chemical. A quantity of hazardous chemical not ordered is one to which workers are not exposed, for which appropriate storage need not be found, which need not be tracked in an inventory control system, and which will not end up requiring costly disposal when it becomes a waste.

Regularly check inventory and dispose of outdated or unnecessary chemicals out--dated, expired and unknown chemicals should be promptly disposed. Avoid a stockpile of unused chemicals.

GUIDELINES FOR LABELING

- Labels on incoming containers of hazardous chemicals shall not be removed or defaced. Chemicals in containers with deteriorated or illegible labels shall not be used.
- Label all secondary storage containers with the following information:
    - Chemical identity.

    - Hazard warning (e.g. flammable, carcinogen, corrosive, etc.).
- Labels should be understandable to laboratory personnel, emergency response teams, and others, and should be resistant to fading from aging and chemical exposure.
- Transfer containers are not required to be labeled, but if not emptied at the end of each day, a container is considered a storage container and must be labeled.
- Peroxidizable chemicals should be dated when received and when opened. It is good practice to do so for all chemicals.

- Chemical identity.
- Hazard warning (e.g. flammable, carcinogen, corrosive, etc.).

It is also good practice to properly identify the contents of containers not usually thought of as storage containers, such as reaction vessels, and process equipment, if they will contain hazardous chemicals for more than brief periods of time.

STORAGE LOCATIONS

Every chemical should have a specific site for storage and should be returned immediately after use. Most vendors now include detailed hazard and storage information on the container label, including the NFPA diamond and hazard symbol codes. Read these carefully for storage instructions and follow those instructions accurately. Incompatible chemicals shall not be stored where a leak or container rupture might result in contact of the chemicals.

The following guidelines should be used when storing any chemical:

- Store flammable liquids in a flammable material storage refrigerator.
- Do not use a chemical hood as a storage area for chemicals and solvents. Segregate acids from bases.
- Segregate corrosives from flammables. Segregate strong oxidizers from EVERYTHING.
- Most organic reactives must be segregated from inorganic reactives (metals) Segregate reactives from ignitables.
- Do not store chemicals more than two containers deep so you can read labels without moving the other chemicals around.
- Do not store glass bottles on the floor where they can be bumped and broken.

- Do not store corrosives on high shelves in order to avoid injury if the chemical were to leak or spill from the container.
- Avoid storing chemicals on bench tops, except for those chemicals currently in use.

STORAGE SYSTEM

Most often, alphabetical order is not the best storage system for chemicals. This may place incompatible chemicals next to one another, or may cause largesized glass bottles to be stored on a top shelf.

Retrieval of stored chemicals is best accomplished by maintaining a current chemical inventory. Such an inventory should denote:

- Name of chemical;
- Amount of chemical stored;
- Date received;
- Hazard profile (i.e. flammable or toxic); and
- Storage location.

Partial List of Incompatible Chemicals

INTRODUCTION

Incompatible chemicals are those that if inadvertently mixed, would produce toxic gases, explosive reactions, or spontaneous ignition. Such chemicals should never be stored or handled in a manner that might allow contact. DEHS has a chemical segregation guides available for many different classes of hazardous chemicals. While it may be consulted, always refer to each hazardous chemical's Safety Data Sheet (SDS) for a complete list of incompatible materials.

Definitions:

Solvent: any flammable or combustible liquid with a flash point below 200°F, including hazardous waste.

Unprotected Solvent: any solvent not in a flammable liquid storage cabinet or safety can.
Flammable Liquid Storage Cabinet: a metal cabinet meeting the design and construction requirements of NFPA 30 and having been tested and listed by Underwriters Laboratories (UL) or Factory Mutual (FM) Laboratories.

Safety Can: a metal can meeting the design and construction requirements of NFPA 30 and having been tested and listed by Underwriters Laboratories (UL) or Factory Mutual (FM) Laboratories. The safety can shall be a maximum 2gallon capacity.

Bulk Storage Room: a room constructed to meet the requirements of NFPA 30.