CHEMICAL SAFETY HANDBOOK

1.0 GENERAL LABORATORY PROTOCOL

Good Laboratory Practices should be in operation in all research labs. These good practices include the following:

1. Good housekeeping and tidiness.
2. Keep all aisles and exits clear of obstacles.
3. Reduce all tripping, slipping, and fall hazards.
4. Clean all workspaces within a reasonable amount of time after work is finished.
5. Label all containers with chemical content and responsible person name.
7. Know where spill kits are available.
8. Know evacuation routes.
9. Know where emergency contact numbers are posted.
10. Have reactive chemicals properly stored and well labeled.
11. Have appropriate personal protection equipment (PPE) available and in good condition. (goggles, gloves, lab coats etc)
12. Have MSDS and other safety information readily on hand.

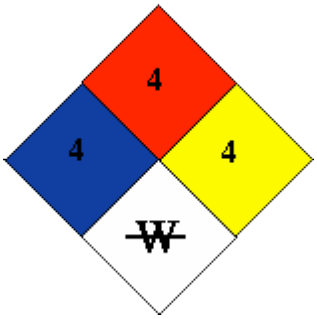
1.1 CHEMICAL HYGIENE

Many chemicals are routinely handled in the laboratory. The hazardous nature of a chemical depends not only on what it is, but also on how it is handled. In determining the hazardous nature of a chemical, please consider the characteristics of the chemical. Most chemicals fall into one of four categories:

IGNITABLE - a chemical with a flashpoint of less than 140°F
CORROSIVE - a chemical with pH less than 2 or greater than 12.5 (i.e. strong acid and bases)
REACTIVE - a chemical that is explosive, shock sensitive, reacts to produce heat, light or toxic products or combines violently with air or water
TOXIC - a chemical that has an adverse effect on organisms in relatively low doses or small quantities

The NFPA (National Fire Protection Association) system utilizes a diamond diagram, divided into four color coded sections:

blue	health hazard
red	fire hazard
yellow	reactivity hazard
white	other hazard information



Within each section, a number ranks the degree of hazard:

4	extreme hazard
3	serious hazard
2	moderate hazard
1	slight hazard
0	no or minimal hazard

The white section alerts the user to special hazards the material may possess, such as:

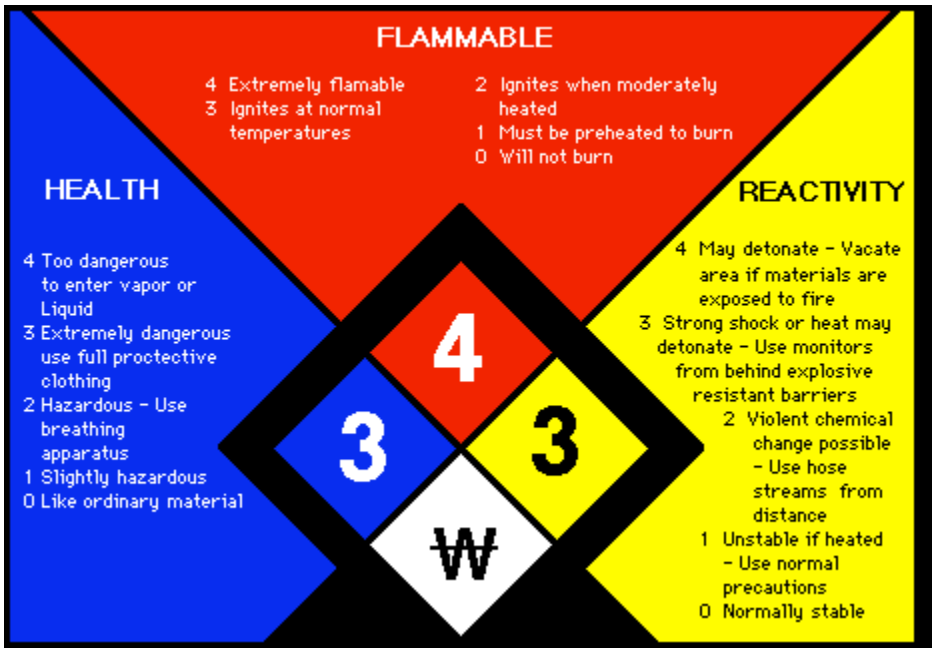
water reactivity 

strong oxidizer **Ox**

corrosivity 

radioactivity. 

Poison 



Examples:

Methanol

CAS No. 67-56-1

Flammable.
Causes skin and eye irritation.

Carbon Tetrachloride

CAS No. 56-23-5

Toxic

Nitric Acid

CAS No. 7697-37-2

Corrosive.
May ignite combustibles. May react on contact with water.

1.2 MIXING CHEMICALS

Mixing of chemicals can lead to dangerous conditions such as the release of toxic gases, release of flammable gases, violent heating and splattering, or explosive reactions. Before mixing any chemicals, refer to a chemical incompatibility list (such as the one below) and the chemicals' MSDS's. Some examples that could occur with chemicals common to the ERC are the mixing of nitric acid and methanol waste, which will result in an explosive mixture, or adding water to concentrated acid which is very exothermic and will result in splattering of the corrosive acid. **Do not mix any chemicals unless you know it is safe!** Be aware of what is in a waste bottle before disposing of your waste and label the waste properly.

CHEMICAL	INCOMPATIBLE CHEMICAL(S)
Acetic acid	aldehyde, bases, carbonates, hydroxides, metals, oxidizers, peroxides, phosphates, xylene
Acetylene	halogens (chlorine, fluorine, etc.), mercury, potassium, oxidizers, silver
Acetone	acids, amines, oxidizers, plastics
Alkali and alkaline earth metals	acids, chromium, ethylene, halogens, hydrogen, mercury, nitrogen, oxidizers, plastics, sodium chloride, sulfur
Ammonia	acids, aldehydes, amides, halogens, heavy metals, oxidizers, plastics, sulfur
Ammonium nitrate	acids, alkalis, chloride salts, combustible materials, metals, organic materials, phosphorous, reducing agents, urea
Aniline	acids, aluminum, dibenzoyl peroxide, oxidizers, plastics
Azides	acids, heavy metals, oxidizers
Bromine	acetaldehyde, alcohols, alkalis, amines, combustible materials, ethylene, fluorine, hydrogen, ketones (acetone, carbonyls, etc.), metals, sulfur
Calcium oxide	acids, ethanol, fluorine, organic materials
Carbon (activated)	alkali metals, calcium hypochlorite, halogens, oxidizers
Carbon tetrachloride	benzoyl peroxide, ethylene, fluorine, metals, oxygen, plastics, silanes
Chlorates	powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid	acetone, alcohols, alkalis, ammonia, bases
Chromium trioxide	benzene, combustible materials, hydrocarbons, metals, organic materials, phosphorous, plastics
Chlorine	alcohol's, ammonia, benzene, combustible materials, flammable compounds (hydrazine), hydrocarbons (acetylene, ethylene, etc.), hydrogen peroxide, iodine, metals, nitrogen, oxygen, sodium hydroxide
Chlorine dioxide	hydrogen, mercury, organic materials, phosphorous, potassium hydroxide, sulfur

Copper	calcium, hydrocarbons, oxidizers
Hydroperoxide	reducing agents
Cyanides	acids, alkaloids, aluminum, iodine, oxidizers, strong bases
Flammable liquids	ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	alcohol's, aldehydes, ammonia, combustible materials, halocarbons, halogens, hydrocarbons, ketones, metals, organic acids
Hydrocarbons (Such as butane, propane benzene, turpentine, etc.)	acids, bases, oxidizers, plastics
Hydrofluoric acid	metals, organic materials, plastics, silica (glass), (anhydrous) sodium
Hydrogen peroxide	acetylaldehyde, acetic acid, acetone, alcohol's carboxylic acid, combustible materials, metals, nitric acid, organic compounds, phosphorous, sulfuric acid, sodium, aniline
Hydrogen sulfide	acetylaldehyde, metals, oxidizers, sodium
Hypochlorites	acids, activated carbon
Iodine	acetylaldehyde, acetylene, ammonia, metals, sodium
Mercury	acetylene, aluminum, amines, ammonia, calcium, fulminic acid, lithium, oxidizers, sodium
Nitrates	acids, nitrites, metals, sulfur, sulfuric acid
Nitric acid	acetic acid, acetonitrile, alcohol's, amines, (concentrated) ammonia, aniline, bases, benzene, cumene, formic acid, ketones, metals, organic materials, plastics, sodium, toluene
Oxalic acid	oxidizers, silver, sodium chlorite
Oxygen	acetaldehyde, secondary alcohol's, alkalis and alkalines, ammonia, carbon monoxide, combustible materials, ethers, flammable materials, hydrocarbons, metals, phosphorous, polymers
Perchloric acid	acetic acid, alcohols, aniline, combustible materials, dehydrating agents, ethyl benzene, hydriotic acid, hydrochloric acid, iodides, ketones, organic material, oxidizers, pyridine
Peroxides, organic	acids (organic or mineral)
Phosphorus (white)	oxygen (pure and in air), alkalis
Potassium	acetylene, acids, alcohols, halogens, hydrazine, mercury, oxidizers, selenium, sulfur
Potassium chlorate	acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organic materials, sugars
Potassium perchlorate (also see chlorates)	alcohols, combustible materials, fluorine, hydrazine, metals, organic matter, reducing agents, sulfuric acid
Potassium permanganate	benzaldehyde, ethylene glycol, glycerol, sulfuric acid
Silver	acetylene, ammonia, oxidizers, ozonides, peroxyformic acid
Sodium	acids, hydrazine, metals, oxidizers, water
Sodium nitrate	acetic anhydride, acids, metals, organic matter, peroxyformic acid, reducing agents
Sodium peroxide	acetic acid, benzene, hydrogen sulfide metals, oxidizers, peroxyformic acid, phosphorous, reducers, sugars, water

Sulfides	acids
Sulfuric acid	potassium chlorates, potassium perchlorate, potassium permanganate

1.3 STORING CHEMICALS

In general, dry reagents, liquids and compressed gases should be stored separately, then by hazard class.

Segregate dry reagents as follows:

- Oxidizing salts
- Flammable solids
- Water-reactive solids
- All other solids

Segregate liquids as follows:

- Acids
- Bases
- Oxidizers
- Perchlorates
- Flammable or combustible liquids
- All other liquids

1.4 STORING FLAMMABLE CHEMICALS

1) Quantities should be limited to the amount necessary for the work in progress.
2) No more than 10 gallons of flammable and combustible liquids, combined, should be stored outside of a flammable storage cabinet unless safety cans are used. When safety cans are used, up to 25 gallons may be stored without using a flammable storage cabinet.
3) Storage of flammable liquids must not obstruct any exit.
4)Flammable liquids should be stored separately from strong oxidizers, shielded from direct sunlight, and away from heat sources.

1.5 WORKING WITH FLAMMABLE CHEMICALS

- Control all ignition sources in areas where flammable liquids are used. Smoking, open flames and spark producing equipment should not be used.
- Whenever possible use plastic or metal containers or safety cans.
- When working with open containers, use a fume hood to control the accumulation of flammable vapor.
- Use bottle carriers for transporting glass containers.
- Use equipment with spark-free, intrinsically safe induction motors or air motors to avoid producing sparks. These motors must meet National Electric Safety Code (US DOC, 1993) Class 1, Division 2, Group C-D explosion resistance specifications. Many stirrers, Variacs, outlet strips, ovens, heat tape, hot plates and heat guns **do not** conform to these code requirements.
- Avoid using equipment with series-wound motors, since they are likely to produce sparks.
- Do not heat flammable liquids with an open flame. Steam baths, salt and sand baths, oil and wax baths, heating mantles and hot air or nitrogen baths are preferable.

- Minimize the production of vapors and the associated risk of ignition by flashback. Vapors from flammable liquids are denser than air and tend to sink to the floor level where they can spread over a large area.
- Electrically bond metal containers when transferring flammable liquids from one to another. Bonding can be direct, as a wire attached to both containers, or indirect, as through a common ground system.
- When grounding non-metallic containers, contact must be made directly to the liquid, rather than to the container.
- In the rare circumstance that static cannot be avoided, proceed slowly to give the charge time to disperse or conduct the procedure in an inert atmosphere.

1.6 FUME HOOD SAFETY

The health and safety of laboratory personnel and building occupants must be the primary goal of laboratory management. Properly functioning fume hoods help achieve this goal with respect to the hazards of chemical vapors and other harmful airborne substances. **It is important to remember that a fume hood is not a storage area. Keeping equipment and chemicals unnecessarily in the hood may cause airflow blockage**. Here are a few health and safety tips concerning fume hoods:

- Substitute toxic chemicals with less hazardous materials whenever possible.
- Keep fume hood exhaust fans on at all times.
- Perform all work six inches inside the hood.
- Never place your head inside the hood.
- Keep the hood sash closed as much as possible at all times to ensure the optimum face velocity and to minimize energy usage.
- Keep lab doors closed to ensure negative room pressure to the corridor and proper air flow into the hood.
- Keep the slots of the baffle free of obstruction.
- Do not use the hood as a waste disposal mechanism (e.g., for evaporation of chemicals).
- Avoid rapid movements in front of the hood including opening and closing the fume hood sash rapidly and swift arm and body movements in front of or inside the hood. These actions may increase turbulence and reduce the effectiveness of fume hood containment.
- Do not override or disable mechanical stops on the sash.
- Have a general awareness of the operation of your hood and be aware of any differences in visual or audible cues that may imply a change in function.
- Make sure that equipment, heating mantles, or laboratory kits are not pushed all the way back to the back of the hood. This situation tends to hinder the flow of the more dense vapors from being expelled from the hood.
- Do not use the laboratory fume hoods as a chemical storage cabinet. If a hood contains a large quantity of bottled chemicals, it is time to do some housekeeping and return the chemicals to the chemical storeroom or the hazardous waste storage (whichever is appropriate).

1.7 CHEMICAL SPILLS

Chemical spills are to be cleaned up immediately using the proper procedure.
Safety goggles, gloves, and a lab coat should be worn during a spill clean up.

Spilled Liquids; acids, bases, and organic solvents – The specialty spill kits normally are used to adsorb 0.5-1.0 liter. These are located on the shelf adjacent to the stockroom computer. There are large boxes of adsorbent located in the bottom of the reactive chemical cabinet to be used on larger spills. One should make a dike around the spill to contain it and then use more of the adsorbent inside the adsorbent dike to complete the adsorption process. It is essential that the

hoods in the laboratory affected by the spill be turned on to reduce the amount of vapors remaining in the air in this room. If the chemical is toxic or vapors are filling the room (even if only a small amount of the chemical has been spilled out in the lab proper) the laboratory shall be evacuated. This does not necessarily mean that the entire building must evacuate.

1.8 WASTE

If you have Chemical waste to dispose of, check with someone in the lab who is certified to dispose of waste for the proper receptacle. Be aware of the chemical compatibility charts! It is best to neutralize acid and bases in a large amount of water. Never add water to a strong acid or strong base as it will rapidly heat and sputter. It is important to always label your waste and record anything that goes into the waste receptacle.

-NEVER dispose of liquid waste in the dumpster.

-Sharps must be placed in sealed, crush-proof containers prior to disposal.

-Non-hazardous solids may be disposed of in the dumpster.

-Hazardous waste must be disposed of through Environmental Health Services.

2.0 USE OF COMPRESSED GASES

Compressed gases can become dangerous projectiles if they fall and compromise safety.

2.1 STORAGE OF COMPRESSED GAS CYLINDERS

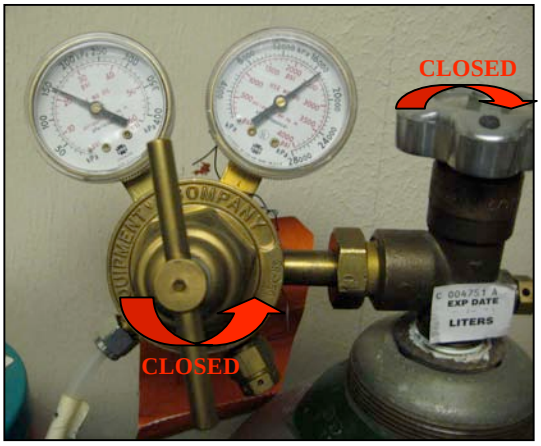
They should be stored with a secure, approved strap or chain. Always keep covers on compressed gas cylinders when not in use.

2.2 MOVING GAS CYCLINDERS

To move gas cylinders secure the cylinder in the tank dolly using the strap and make sure the cap is tightly fastened.

2.3 PROPER USE OF GAS GAUGES

The gauge on the right reads the pressure in the tank. The gauge on the left reads the pressure at the regulator. When attaching the regulator to the tank make sure the tank valve is closed clock wise (all the way to the right – righty tighty). To close the regulator valve requires counter clock wise rotation (NOTE: this is opposite of the tank valve). Be aware that when you connect a pressurized cylinder to a closed system, you can over pressurize the closed system resulting in an explosion. Always make sure the regulator is completely closed before opening the tank valve and then slowly open the regulator to a safe pressure. Know what the safe operating pressure is of the system you are using.



3.0 FINAL COMMENTS ON COMMON SENSE

Here at the ERC we mainly work with chemicals for cleaning including alcohols, acetone and acids. Please use common sense when working with these chemicals.

- If you are using any of these work in a well ventilated area. Don't pollute the labs with vapors.
- Know the proper place and method for disposing of these wastes. Be aware of mixing hazards.

- Be careful with concentrated acids. Wear protective clothing and don't add water to acid. It is a good idea to have some baking soda around when working with acids. If you get acid on your skin you can wash with lots of water and baking soda will help neutralize any residual acid.
- Keep the fume hoods clean and keep any equipment in the fume hoods away from chemicals.

4.0 Emergency Numbers and Locations

Emergencies give no warning - Be prepared

Fire, Police, Medical Emergency	911
Facilities Services	1-0077
Environmental Health Services	1-6745
Rocky Mountain Poison Control	8-1-800-332-3073
Fire Extinguishers	B wing Hallway (near B202/stair well & opposite wall of B303)
Fire Blankets	?
Emergency Evacuation Plan	?
Fire Alarm	Near All Stairwell Exits
Emergency Shower	Near B312 In Hallway
Flammables Storage Cabinet	?
Spill kits	?

CHEMICAL SAFETY TEST

1) What is wrong with the following picture:

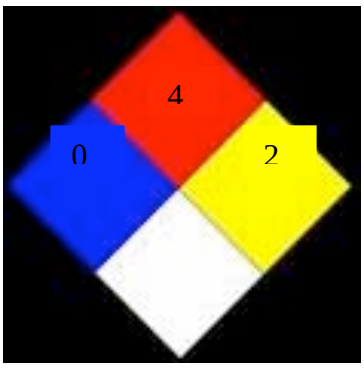
2) To dispose of waste properly you should:
   a) Pour it down the sink and flush with tap water.
   b) Leave it on a counter and wait for someone else to clean it.
   c) Consult a certified waste disposer for the proper container and label the waste.
   d) Place it in the dumpster outside.

3) Which of the following is true:
   a) One should mix chemical cleaners in order to achieve the best cleaning.
   b) Adding water to acid is a safe way to dilute acid.
   c) Chemicals should never be mixed, except in the waste container.
   d) Chemicals should never be mixed without checking chemical compatibility charts.

4) When working in a fume hood the sash should be kept:
   a) As low as possible.
   b) 12 inches open.
   c) High enough to get your head in.
   d) Removed to provide maximum flow.

5) When working in a fume hood one should avoid:
   a) Mixing chemicals.
   b) Storing chemicals.
   c) Using equipment that may produce sparks.
   d) All the above.

6) The following NFPA label shows that this chemical is:



a) A health hazard
b) Radioactive
c) Highly reactive
d) Highly flammable

7) When should eye protection used?
   a) Eye protection is not necessary when working with chemicals.
   b) Eye protection is only necessary when working with corrosives.
   c) Eye protection should always be used.

8) Which of the following should be preformed in a fume hood?
   a) Cleaning of parts with an ultrasonic cleaner using methanol.
   b) Washing of parts with soap and water.
   c) Cleaning of Optics with lens paper.

9) When working with flammable chemicals which of the following is true?
   a) Work should be done in a fume hood.
   b) Flames should be extinguished in the room.
   c) Vapors should be minimized.
   d) All the above

10) Before opening the tank valve on a compressed gas cylinder you should
   a) Open the regulator valve by turning it clockwise.
   b) Close the regulator valve by turning it counter clockwise.
   c) Close the regulator valve by turning it clockwise.
   d) Open the regulator valve by turning it counter clockwise.