University of Florida

LABORATORY

SAFETY MANUAL

Division of Environmental Health and Safety
Office of Finance and Administration
University of Florida

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EMERGENCY TELEPHONE NUMBERS

Local Emergency Dispatch for fire, personal injury or local police
911 (Please be aware of the building's requirements to gain access to outside telephone lines by dialing "9" first.)

University Police Department
392-1111 for on campus incidents only

Chemical Spill or Accident
EH&S Hazardous Materials Management 392-8400 or EH&S main office 392-1591
After hours: call UPD 392-1111

Radiation Accident
EH&S Radiation Control Offices
392-7359 (Nuclear Science Center)
392-1589 (J. Hillis Miller Health Center)

Biological Accident
EH&S Biological Safety Officer 392-1591

Pesticide Accident or Treatment Request
EH&S Pesticide Office 392-1904

Asbestos Accident or Indoor Air Quality Concerns
EH&S Asbestos Program Manager 392-3393

I. Introduction

The University of Florida Division of Environmental Health and Safety (EH&S) has developed this manual to assist in the recognition, evaluation and control of chemical and physical hazards associated with University laboratory operations. This manual is intended to establish basic safe operating practices so that faculty, students and staff may carry out effective teaching and research programs in a safe and healthy environment.

This document must be used in conjunction with the University of Florida Chemical Hygiene Plan (CHP) http://www.ehs.ufl.edu/Lab/CHP/default.asp. The CHP provides specific information on hazard assessment, training requirements, exposure monitoring procedures, and accident reports. A laboratory specific CHP must be implemented in each laboratory.

This manual is not intended to be a complete or final listing of laboratory hazards or safe practices. Because of the diverse nature of work being conducted in University of Florida laboratories, additional procedures or requirements may be necessary. For example, laboratories working with biological agents, radioisotopes, animals, or labs generating chemical, biological or radioactive wastes all must adhere to strict policies and procedures. For information on these and other safety related policies please consult the resources listed below. Individuals having questions are urged to call upon EH&S for assistance.

The contents of this manual provides for safety guidelines and policies for all UF laboratories, both on-campus and off-campus locations. Please note that off-campus locations may be required to provide site-specific addendums and exceptions for related safety policies, such as waste disposal options and emergency response procedures. For more specific information concerning off-campus programs, please contact the EH&S Off-Campus Coordinator at 352-392-3393.

Environmental Health and Safety General Safety Information
http://www.ehs.ufl.edu/general/shop/general.htm

Chemical and Radioactive Waste Disposal
EH&S Hazard Materials Management
http://www.ehs.ufl.edu/HMM/default.asp

Radiation Safety
EH&S Radiation Control
http://www.ehs.ufl.edu/Rad/default.asp

Biological Safety
EH&S Biological Safety
http://www.ehs.ufl.edu/Bio/default.asp

Animal Handling/Protocol
IACUC/ACS Animal Care & Use
http://iacuc.ufl.edu

II. Assignment of Responsibility

Individual laboratory workers are responsible for their own safety and the safety of their co-workers and visitors to the laboratory. All staff, students and volunteers must demonstrate this responsibility in their actions and attitudes. It will be each laboratory worker's responsibility to wear the personal protective equipment (PPE) assigned to them, adhere to prescribed safety rules and regulations and to know and follow all emergency procedures. Lab staff must pre-plan their work to ensure their safety and the safety of those individuals who work around them.

In addition to UF safety policies, employees conducting research on non-UF property shall comply with all safety and emergency response policies of the host facilities.

The principal investigator (P.I.), laboratory supervisor or manager has the responsibility for controlling hazards in her/his laboratory. This shall include:

1. Completing a hazard assessment for all procedures
2. Instructing laboratory personnel on potential hazards
3. Correcting work errors and dangerous conditions
4. Encouraging a positive attitude towards safety
5. Selecting the proper personal protective equipment (PPE) and ensuring that it is worn and used correctly
6. Maintaining compliance with all applicable UF safety programs
7. Investigating the circumstances surrounding a laboratory accident and taking steps to avoid recurrence

The research department shall be responsible for supporting the PI and research staff with all resources necessary to ensure safety compliance. This will include providing training to PI and staff members and allowing for time away from work for training.

The research department will also be responsible for notifying EH&S of laboratory relocations, closings, and new lab space assignments and assigning a responsible party to control, maintain and supervise common use laboratories. This will include shared space, cold rooms, animal rooms, greenhouses, etc.

Environmental Health and Safety (EH&S) shall be responsible for monitoring compliance and implementation of all safety and environmental regulations for all main campus and off campus facilities. This will include, but is not limited to, regulation interpretation, implementation of programs, planning reviews, facility surveys and providing training and educational services. EH&S shall have enforcement authority when dealing with unsafe or illegal situations.

The University of Florida will provide assistance for the compliance efforts of all staff and researchers. It will foster an attitude that safety is of the utmost importance.

III. Laboratory Safety Guidelines

Each laboratory at the University is unique by virtue of the research being performed, the equipment in use, and the physical layout of the lab and utilization of space. Regardless of the characteristics, teaching and research laboratories at the University of Florida must adhere to the basic safety policies outlined in this manual.

Appropriate ventilation is required for any lab space used for chemical, biological, radiological, or animal work. Additional ventilation requirements may apply depending on the type of work conducted in the lab. Carpeting or rugs are not suitable flooring for labs; flooring must be of the type that can be easily cleaned and decontaminated in the event of a spill. Spaces such as offices, storage closets or walk-in cold rooms may not be converted into lab space without first consulting with EH&S.

An annual Laboratory Safety Survey is performed by EH&S to verify compliance with the policies set out in this manual as well as compliance with safety programs pertinent to the type of research conducted and agents used in the lab. If a safety issue is observed, the surveyor will offer recommendations to aid the staff in correcting the issue~~s~~. Further information on the survey process can be found at http://www.ehs.ufl.edu/Lab/lssurvey.htm.

A. Hazard Awareness

It is the responsibility of the PI and lab staff to strive for a safe working environment in their laboratory. Observed hazards or potential hazards must be identified and corrected immediately. See "How to Report a Hazardous Condition at UF" http://www.ehs.ufl.edu/RiskMgmt/haz.htm

Hazard Identification

Notice Boards
A notice board posted at all of the entrances to the lab will identify the categories of potentially hazardous materials that may be found in the lab at any given time and contact information for responsible individuals in case of an emergency.

Hazard warning stickers identify the potential chemical, biological or physical hazards that may be in the laboratory. These stickers can be added or removed as needed for the changes in the laboratory inventory.

The Emergency Call List identifies the individuals to contact in case of an emergency. The call list must have the home phone numbers of at least two individuals who can provide information about the lab to the University Police Department (UPD), EH&S or other emergency responders. If you do not wish to have home phone numbers posted at the lab, you may complete a privacy form. Both the Emergency Call List and the privacy form will need to be updated as needed when lab staff changes. This form is available from EH&S at the lab's request.

Labeling Chemicals
The manufacturer's label will provide the initial information on the handling of any substance. Directions found on the label must be followed. All bottles and chemical containers must be labeled, including, flasks, beakers, etc. If abbreviations are used, a reference list of the abbreviations must be posted in the lab. A placard of commonly used abbreviations can be adapted in Appendix A.

Chemical Inventories
A complete inventory of all chemicals at the worksite is required to be maintained at all times. Appendix B of the UF Chemical Hygiene Plan can be used for this purpose http://www.ehs.ufl.edu/Lab/CHP/default.asp.

An inventory must be updated at least annually to cross check against the previous inventory, sort unused or expired chemicals, and check the condition of caps, bottles and labels. This inventory must be available for lab staff, EH&S, or compliance officer review.

Health and Hygiene

Clothing and Footwear
Clothing that is extremely loose or tight fitting should be avoided. Overly tight clothes, such as leggings and body suits, are not recommended, as any spilled material will be held next to the skin by these garments. Overly loose clothing, long necklaces, ties, or scarves can get caught in equipment or knock over work materials. Personal clothing that is worn home must be covered by protective apparel when working with hazardous chemicals. Lab coats or other gowning must be worn when working in BSL-2 labs, with radioisotopes, or when personal clothing leaves skin exposed.

Long hair should be tied back so it does not come in contact with chemicals, biological or radiological substances or if there is a possibility of becoming entangled in equipment. Jewelry should not be worn under disposable gloves or when working on equipment.

Full coverage shoes that are non-skid and constructed of sturdy material must be worn at all times while in the lab.

Food and Drink
Food and drink cannot be stored or consumed in areas where chemical, biological or radioactive substances are being used or stored. Break rooms or lunchrooms must be used where available. Food and drink may only be consumed in prescribed and clearly designated areas of the lab's office area, away from lab equipment and potentially contaminated airflow. Transporting samples and chemicals is not permitted through the designated area. Equipment (e.g. microwaves), glassware or utensils that have been used for laboratory operations should never be utilized to prepare or consume food. Laboratory refrigerators and cold rooms may not be used for the storage of foods. Separate, clearly labeled appliances must be used. Sinks and drain boards used for washing food utensils should not be used for research purposes. Ice made in ice machines used to provide lab ice cannot be used for human consumption. Alcoholic beverages are not permitted on University property.

Smoking
Smoking is not allowed in any UF laboratory or within 50 feet of building entrances. The use of designated smoking areas is required. See the UF Smoking Policy at http://www.ehs.ufl.edu/RiskMgmt/Smoking.htm

Cross Contamination Prevention
Personal protective equipment (gloves, lab coats, etc.) is not permitted in public areas of the building such as restrooms, offices or cafeterias. In an effort to eliminate possible exposure or contamination of building fixtures and equipment, gloves shall be removed when leaving the lab. To transfer specimens or chemicals from one lab to another, use one gloved hand to handle the cart or container. The ungloved hand can be used to open doors, push elevator buttons, etc.

When working with chemical, biological or radioactive substances, hands shall be washed often, especially after gloves have been removed and before leaving the lab. Lip balm, cosmetics, or contact

lenses should not be applied or handled in the lab. Solutions must not be pipetted or siphoned by mouth. Only mechanical pipette and siphoning aids will be used.

Ergonomics
Laboratory workers are at risk for repetitive motion injuries during routine laboratory procedures such as pipetting, working at microscopes and hoods, operating microtomes, using cell counters and video display terminals. By becoming familiar with how to control laboratory ergonomic risk factors, you can improve your comfort and productivity while lowering chances for occupational injuries. Please see the EH&S Ergonomics page http://www.ehs.ufl.edu/General/ergo.htm for laboratory ergonomic resources.

Physical Hazards and Housekeeping

Physical hazards and poor housekeeping practices may put staff and visitors at risk of injury. Lab staff must correct or report any hazards found in the lab. Physical hazards or housekeeping issues observed outside of the lab should be reported to the appropriate maintenance division.

Trip Hazards
Trip hazards such as electrical or computer cords across floors, excess storage in walkways, etc. must be minimized. Irregular, bumpy or loose flooring should be reported to the maintenance department. Aisles, hallways and stairways must not be used for storage areas. Avoid excessive overhead storage. Shelves must be of sturdy construction, leveled, and if possible, attached to walls or cabinets so they do not tip. Do not overload shelves.

Spills and Cleanup
To minimize slips, falls, or other potential hazards, spills must be attended to immediately, no matter what the substance may be. Clean-ups should follow the completion of any operation or be done at the end of the day.

Lab Equipment
Refrigerators and freezers must be level to prevent samples and solutions from spilling when their doors are opened. Sharp edges or corners on equipment should be protected or equipment should be relocated to minimize injury. Microtome blades or other sharp objects must be removed from equipment or covered with a protective guard when not in use. Belt and pulley systems, such as on vacuum pumps, or any other pinch points must be covered by a protective guarding.

Shared and Common Use Labs
The responsibility for housekeeping and the minimization of physical hazards and injuries in any shared lab or support space is the duty of all staff using the lab. It is imperative that all users clean up after themselves.

Photography dark rooms must to be treated as any other laboratory support space. A chemical inventory and the Chemical Hygiene Plan SOPs are required. Personal protective equipment must be worn when handling chemicals. EH&S must be informed of dark room locations so that chemical disposal requirements may be addressed. For more information, please see
http://www.ehs.ufl.edu/HMM/photo.htm

Electrical Safety

The electrical demand in laboratories has grown tremendously since most buildings and labs were designed. It is imperative that the electrical systems in these buildings are not abused or overloaded. Lab staff cannot modify, install or remove electrical systems. Contact the Physical Plant Division or IFAS Facilities Operations to assess or modify the lab's electrical requirements.

Electrical Cords
Electrical cords and plugs must be inspected routinely to identify cracked insulation or broken plugs. Any equipment found with damaged cords or plugs must be removed from service until it is repaired. Wrapping broken insulation with electrical tape is not an acceptable repair method. Electrical cords can not be run across floors, under rugs, through walls, doors, windows, over ceiling tile or around sharp edges and corners where they can be damaged or cannot be inspected for damage.

Extension Cords
Extension cords are intended only for temporary use with portable equipment. Permanent use of extension cords is prohibited. Shop made cords with receptacle boxes may not be used, as they do not meet electrical codes. The use of multi plug electrical boxes is acceptable only if they have an internal fuse. These may not be plugged into one another in series. These should be attached to a solid surface such as a wall or table.

Surge Protection
The use of surge protection is recommended for all electrical equipment in all labs. These should have internal fuses and cannot be plugged into one another in series. These should be attached to a solid surface such as a wall or table.

Ground Fault Circuit Interrupters (GFCI)
A GFCI should be installed on all outlets located near wet areas such sinks, showers, wash down areas, etc. A GFCI is a fast acting device that interrupts current to protect against shocks and electrocution. GFCIs sense very small current leakages to ground and will shut off the electricity to that outlet. Freezers, refrigerators, and other important lab equipment that requires continuous power should not be plugged into GFCI outlets. For more information on GFCIs see
http://www.ul.com/media/newsrel/nr_spr02_gfci.html.

Sharps

Sharps (needles, broken glass, scalpels, razor blades, etc.) must not be disposed of in the regular waste stream. Needles and scalpels must be placed in red plastic "sharps" boxes and disposed of as biomedical waste, no matter if they are contaminated with a biological substance or not. Syringes must be disposed of in the red sharps box for biomedical waste disposal whether or not they are contaminated. Used needles cannot be recapped, broken, bent or sheared. Broken glass must be placed in a rigid puncture resistant container.

Uncapped needles must not be left where someone may sustain a needle stick. If the needle and syringe are to be used again, it should be placed in a wide mouth jar, beaker or otherwise secured so that staff using the area are protected from a needle stick injury. New needles (and syringes) should be stored in a secure cabinet.

Razor blades, microtome blades and other objects that may puncture trash bags or boxes, no matter if they are contaminated or not, must be disposed of into sharps boxes. Glassware disposal will vary depending on the building where it is generated. Biologically contaminated sharps must be properly inactivated

before disposal. See the UF Biological Waste Disposal Policy for more information on disposal of all biologically contaminated waste. http://www.ehs.ufl.edu/Bio/biowaste.htm

Laboratories in the following locations must adhere to strict biological and sharps waste disposal procedures. These are documented in the web links below by location:

Aerospace Engineering

Animal and Dairy Sciences

Basic Science Building

Fifield Hall

Health Science Center

McCarty Hall

Materials Science and Engineering

College of Veterinary Medicine and VMTH

Working Alone

Hazardous experiments shall not be performed alone in a laboratory. Persons working alone shall make arrangements with other persons in the building or with UPD to check on them periodically. It is vitally important not to cover or black out lab door windows so the lab may be observed.

Unattended Operations

Operations and experiments that continue unattended for several hours or overnight must be pre-approved by the PI or laboratory supervisor. Plans should be made to eliminate the risk of hazards in the event of a failure in power, water, gas or other service. Water cannot be left running. Do not cover or black out lab door windows. Room lights should be left on and a notice should be placed on the lab door with the name and number of the researcher running the experiment and any pertinent information about the process.

Laboratory Security

Laboratories must be locked if no one is in the lab. Lab doors should be closed at all times. Acute toxins, select agents, controlled substances and radioisotopes must be appropriately secured. Do not hesitate to politely question anyone who does not belong in the area. It is recommended that lab staff politely decline to answer questions about the lab, chemical and biological inventories, the nature of the research or the building posed to them by the general public or press. If there is any concern about lab security, inappropriate questions or suspicious individuals, please contact EH&S or UPD or the local responding agency immediately.

Visitors

Visitors to all laboratories **must**:

1. Be escorted by lab staff.
2. Be made aware of any potential hazards they may encounter in the lab.
3. Wear the correct personal protective equipment for the hazards present in the lab; no matter if they are visitors or maintenance workers or how long they will be in the lab.
4. Abide by laboratory regulations for access and control of hazards.
5. Pets are not allowed in labs. Only certified service animals may be allowed into UF buildings.

Minors

Minors under the age of 18:

1. Are not permitted to work in the laboratory unless they are a registered student or participating in a supervised UF sponsored "Scholars" program and the lab meets the following criteria:
    a. Parental permission is granted to participate.
    b. Hours of participation may be limited by project, school attendance, etc. Please coordinate participants work hours with program coordinator.
    c. The laboratory is in full compliance with all safety regulations and programs (UF Chemical Hygiene Plan, Biosafety Program, Radiation Control Program, Institutional Animal Care and Use Committee (IACUC), Institutional Biosafety Committee (IBC), etc.).
    d. The laboratory provides prerequisite safety and hazard awareness training to all staff including CHP SOPs.
    e. The scholars program participant works under the direct supervision of the PI or senior lab staff whenever they are performing laboratory or scientific procedures.
    f. The minor may not be left alone in the lab.
2. May not use or handle:
    a. Gas cylinders
    b. Explosives
    c. Select agents
    d. Highly toxic substances
    e. DEA controlled substances
    f. Level 3 or higher biological agents
3. May use or handle the following **only** under the following conditions:
    a. Radioactive materials: Approval of UF EH&S required.
    b. Lab Animals: Participation in the UF Animal Contact Program
    c. Corrosives: Requires compound specific training by host lab PI
    d. Biosafety Level 2 materials: Approval of EH&S and the IBC
    e. Recombinant DNA: Approval of EH&S and the IBC
4. May not operate farm equipment.
5. May not operate state vehicles.

B. Safety Equipment

All safety related equipment and information should be clearly labeled, and stored in an area where it can be easily found in an emergency.

First Aid Kits

A first aid kit must be located in a clearly visible place in each laboratory. A list of required items for the kits can be found at http://www.ehs.ufl.edu/Lab/fakmemo.htm. First aid kits are available for ordering through EH&S at the above link, or any laboratory or safety equipment supplier. Additional first aid items may be required depending on the chemicals used in the lab. Consult the Material Safety Data Sheets (MSDS).

Spill Kits

UF requires all labs to maintain spill control materials in the event of a chemical spill. Commercial spill kits including instructions, absorbents, neutralizers, and protective equipment can be purchased through a commercial laboratory supply company. A large centrally located spill kit may be used for a suite of labs under the same PI, provided it is placed near the area(s) with the highest potential for spills and is always available to staff.

Preplanning for chemical spills
Chemical spills can be handled effectively if preplanning has been conducted. Individuals should become familiar with, and trained in proper cleanup procedures before a spill occurs. This preplanning should include consideration of:

1. Likely location(s) of a spill
2. Estimated quantities that may be released
3. Chemical and physical properties of the material (e.g. physical state, vapor pressure, and air or water reactivity)
4. Potential health hazards of the spilled material
5. Personal protective equipment that will be needed
6. Type of spill absorbents that will be required (see below)

A chemical spill kit can be assembled and stored in a high-density polyethylene bucket. The bucket can be used for collection of the chemical and absorbent in the event of a spill. Label the spill kit clearly. The following list of items to include in the spill kit is offered as a general guideline:

1. Neutralizing agents such as sodium carbonate, sodium bicarbonate or sodium bisulfate for corrosive spills.
2. Inert clay absorbents such as vermiculite or cat litter can be used for most types of chemicals.
3. Inert absorbent pads and pillows can be purchased from a laboratory supply company.
4. Polypropylene absorbents must be used for hydrofluoric acid (HF) spills (expanded silicate absorbents may react with hydrofluoric acid). Polypropylene absorbents can be used for most other chemical spills as well. These can be purchased from a commercial laboratory supply company. The calcium gluconate antidote will also need to be kept available in each lab using HF.
5. A mercury spill kit (or vacuum line, flask, needle-nose pipette, and trap) for mercury spills and broken mercury thermometers.
6. Personal Protective Equipment (gloves, goggles, aprons, etc.) to wear during the cleanup.
7. Hazardous Waste labels, bags and a small scoop or shovel (for clay absorbents).

Paper towels, rags or sponges are not recommended for the reason that some chemicals (strong oxidizers) may ignite upon contact. Also, they are inadequate for large spills, as they do not absorb and reduce vapors as well as clay or commercial absorbents. For more information concerning chemical spill kit requirements for your lab, consult the Material Safety Data Sheets (MSDS) for the chemicals on the lab's inventory.

Fire Extinguishers and Fire Alarms

Appropriate fire extinguishers shall be supplied by EH&S Fire Equipment Services and shall comply with National Fire Protection Association (NFPA) codes 10 and 45. Stored items or equipment must not block access to fire extinguishers. Please address any questions concerning fire extinguisher types, locations or training to EH&S Fire Equipment Services at 392-1904, or visit http://www.ehs.ufl.edu/Fire/FES.htm for more information.

If a fire alarm sounds in the lab, consider it a fire situation and act accordingly. Shut down any processes and close all fume hood sashes. Leave the building and report to the designated rally point for a head count. See RACE : Section III-E.

Safety Showers and Eyewash Stations

ANSI Z358.1-1998 (American National Standards Institute) compliant safety showers and eyewashes must be located within ten seconds of travel time of the chemical work area. A safety shower or eyewash station located in an adjacent room may be used if it meets the above ANSI standard and is accessible at all times. Drench hoses do not meet the ANSI requirements for safety showers or eyewashes and are designed to support, not replace, eyewashes and safety showers. Faucet mounted eyewash devices may only be approved as interim equipment and a hard plumbed unit must be installed within twelve months.

Every laboratory worker must know the location and operation of the safety shower and eyewash. All safety showers and eyewash stations must be clearly identified by signs. In hallways, signs must be visible from all directions of travel. The access to the eyewash and safety showers must be clear at all times. There must be at least a 4 foot x 4 foot clear floor area directly beneath the unit.

The building's maintenance staff will periodically test all eyewash stations and safety showers. Each unit will be tagged to identify the date of the last test. Lab staff should flush faucet mounted eyewash stations weekly.

Sprinkler Systems

Combustible items must be kept below 18 inches of the sprinkler head level. Do not block or obstruct sprinkler heads in any way. Hanging or attaching objects to sprinkler piping or heads is not permitted. Partitions cannot be erected without permission from EH&S Fire Safety.

C. Engineering Controls and Work Practices

The facility will provide protection from health hazards in the lab by using engineering controls. Engineering controls are barriers or equipment used to isolate or remove a hazard from the workplace. The ventilation system controlling the air flow, fume hoods, biological safety cabinets, glove boxes, local exhaust and shielding, are some of the more commonly used engineering controls in a lab setting. It is the responsibility of the Principal Investigator to determine the need and type of engineering controls required for the lab. EH&S Laboratory Safety is available for assistance.

Safe work practices specific to the task being performed, combined with the general practices outlined in this manual, are the lab worker's next line of defense against health hazards. Lastly, when engineering controls and work practices cannot totally eliminate hazards, personal protective equipment (PPE) must be employed.

D. Personal Protective Equipment (PPE)

The department or laboratory shall provide PPE to each staff member. The PI or laboratory supervisor must determine the appropriate PPE needed for procedures in the lab by conducting a hazard assessment http://www.ehs.ufl.edu/General/ppe.htm. It will be the responsibility of each staff member to use the PPE correctly and to keep it clean and in good repair.

Gloves

Protective gloves shall be worn when working with hazardous materials or with materials of unknown toxicity. No glove will provide universal protection from all chemicals. The proper glove for the chemcial being used will not protect the wearer indefinitely. Gloves must be selected on the basis of the material being handled and their suitability for the particular laboratory operation. In cases of latex sensitivity, alternative gloves must be provided.

A glove compatibility chart must be consulted to ensure the proper glove selection. Glove compatibility charts are available at http://www.ehs.ufl.edu/Lab/CHP/gloves.htm. Please be aware that one manufacturer's chart may not be valid for another's brand of gloves.

Gloves must not be worn outside of the lab. If a compound must be transported to another location, use a secondary container and wear one glove on the hand holding the container. Use the un-gloved hand to open doors, push elevator buttons, etc.

Eye Protection

Eye protection shall be worn at all times when working with chemical, biological or radioactive substances. Safety glasses must have side shields and conform to ANSI Z 87.1. Ordinary prescription glasses will not provide adequate protection from injury to the eyes.

Safety goggles and face shields shall be utilized where there is a possibility of splashing chemicals, violent reactions or flying particles. Specific goggles shall be worn for protection against laser hazards, ultraviolet or other intense light sources.

Contact lenses are not to be worn in the work areas of any chemical, biological or radiological laboratories. If they are required for medical reasons, safety goggles must be worn. Standard safety glasses or face shields will not provide adequate protection.

Lab Coats

Laboratory coats or gowns must be worn over personal clothing and exposed skin when chemical, biological or radiological substances are being used. Lab coats should be buttoned or fastened closed and long enough to cover the wearer to below the knees. Lab coats should not be removed from the lab area. Laundering services are available through UF Laundry Services
http://www.bsd.ufl.edu/Laundry/default.asp

Respirators

The use of chemicals in labs or other situations does not usually require the use of respiratory protection. Do not purchase a respirator without calling EH&S to request a hazard assessment to determine if a respirator is required. All respirator wearers must be enrolled in the Respiratory Protection Program.
http://www.ehs.ufl.edu/General/resppol.pdf

Other PPE

Other types of PPE, such as aprons, dust masks, thermal protection, coveralls, hearing protection, etc. may be required as determined by the laboratory's hazard assessment.
http://www.ehs.ufl.edu/General/ppe.htm

E. Emergency Procedures

Medical Emergencies

1. Remain calm.
2. Initiate lifesaving measures as needed.
3. Summon medical help.
4. Do not move any injured person unless absolutely necessary.
5. Keep the injured person warm.

In all cases of a medical emergency or injury, it is advised that the victim seek medical attention from the campus Student Health Care Center, Shands Hospital Emergency Room or the emergency care provider in your area. Escort the victim to the facility; do not let them go alone.

First Aid

Provide on-site first aid treatment to stop bleeding, cool burns or in the event of chemical splash, by flushing with water at a safety shower or eyewash. Remove any jewelry in the affected area. If a delayed action of the chemical splash is possible (e.g. phenol, hydrofluoric acid, methyl and ethyl bromides) obtain medical attention promptly.

Chemical Splashes

1. **Over a large area of the body -** Immediately flood the exposed areas with water for at least 15 minutes; resume if pain returns. Quickly remove all contaminated clothing while under the safety shower. Wash off chemicals by using a mild detergent soap and water; do not use neutralizing chemicals or salves. Seek medical attention.
2. **On a confined area of the skin -** Immediately flush with cold water for at least 15 minutes and wash by using a mild detergent or soap and water. Seek medical attention.
3. **Eyes -**Immediately wash the eye and inner surface of the eyelid with copious amounts of water for 15 minutes. Check for and remove any contact lenses, if possible, without causing further injury. Hold the eye open to wash thoroughly behind the eyelids. Have injured worker move eye side-to-side and up and down during rinsing. Obtain medical attention immediately after rinsing.
4. **Hydrofluoric burns -** the area should be rinsed immediately with running water for 2-5 minutes. A calcium gluconate compound must be applied to the area. Seek medical treatment immediately.
5. **Phenol burns -** Phenol has the ability to penetrate the skin causing severe burns. It will anesthetize the area so little or no pain may be felt. In case of exposure, flush with water. Seek medical attention immediately. Substances such as polyethylene glycol may be used to neutralize and treat the burn in the hospital.
6. **Cryogen or dry ice burns (frostbite) -** Flood or soak with tepid water-do not use hot water. Seek medical attention.
7. **Contaminated clothing** should be disposed of.

Ingestion of a toxin
Dilute the poison by having the victim drink large amounts of water (do not give liquids to an unconscious or convulsing victim). Attempt to learn what the ingested substance was. Obtain medical treatment immediately. Save the label or container for transportation with the victim to the medical facility.

Inhalation of Chemical Fumes
Take the individual to fresh air, seek medical assistance immediately, and provide artificial respiration or CPR as needed.

Fire

If clothing is on fire, help the individual to the floor and roll him/her around to smother the flames. If a safety shower is immediately available, douse the person with water to cool the skin. Seek immediate medical attention.

In case of a fire emergency- remember the acronym **R*A*C*E**

R- Rescue- Without entering a hazardous situation or area, rescue and remove all individuals from the area.

A- Alarm- Activate alarms/alert occupants in the building

C- Confine- all doors, windows and access to the affected area must be closed to confine spread of the fire and smoke. All access must then be restricted to emergency response personnel only.

E- Evacuate - evacuate the area to allow the emergency response personnel to fight the fire. Report to the assigned rally point for a head count.

OR

E- Extinguish - attempt to extinguish the fire only if all of the following criteria can or have been met:

1. Both the 911 response and building alarm have been activated.
2. Training has been received on how to use a fire extinguisher.
3. The proper extinguisher is available.
4. The fire has not spread from its point of origin.
5. The fire is still small enough to be handled by the available fire extinguisher.
6. The fire can be fought with your back to the exit to ensure there is a means of escape in the event that the attempt to extinguish the fire fails.
7. If the fire is not extinguished after using one fire extinguisher, close all doors and leave the building.

Chemical Spills

Laboratory staff members should clean up only small incidental spills that constitute a minimum hazard. Large chemical spills will be handled by EH&S. All lab staff should become aware of procedures to follow and precautions to take for the chemicals they are using.

Incidental Chemical Spills
1. Alert personnel in the immediate area.
2. Avoid breathing vapors and try to determine what has spilled.
3. Turn off ignition sources in the immediate area.

4. If someone has been splashed with chemical, immediately flush the affected area with copious amount of water for at least 15 minutes (see Section III.E). Guidelines for personal injury/exposure incidents are at http://www.ehs.ufl.edu/RiskMgmt/emergncy/injury.htm.
5. Wear protective equipment including safety goggles, disposable gloves, shoe covers, and a long-sleeve lab coat.
6. Use a commercial kit or the materials discussed in Section III.B to pick-up spilled materials. Confine the spill to a small area by diking the perimeter of the spill first, continuing towards the center.
7. Place the used absorbent in a plastic bag or bucket and label it with a Hazardous Waste label. Include it in the next hazardous waste pickup.
8. Clean area with water.
9. For mercury spills see special procedures: http://www.ehs.ufl.edu/IH/mercury.htm
10. For acids or base spills: Neutralizing these spills may release hazardous fumes. If you are unsure of the resulting reaction, use an inert absorbent.
11. For alkali metals: smother the spill with a special Class D, dry powder extinguisher.

Large Chemical Spill/Release

1. Avoid breathing vapors.
2. Quickly identify the spilled material if it can be done safety.
3. If the spill involves a flammable liquid, turn off all ignition sources, if it can be done safely.
4. Immediately evacuate the area, closing all doors.
5. If someone has been splashed with the chemical, immediately flush the affected area with copious amounts of water for at least 15 minutes (see Section III.E). Guidelines for personal injury/exposure incidents are at http://www.ehs.ufl.edu/RiskMgmt/emergncy/injury.htm.
6. Keep all personnel away from the spill area until EH&S/Emergency personnel arrive to evaluate and control the situation. Place a sign at all doors to the spill location advising personnel **not** to enter the room.
7. Personnel most knowledgeable about the spilled material should be available to provide information to EH&S/Emergency personnel.

Emergency Procedures

Immediately request emergency response assistance through the University Police Department under any one of the following circumstances:

1. The release requires immediate attention because of imminent danger;
2. The release requires evacuation/control of employees beyond the immediate spill area (e.g. any toxic material spill in a hallway or other public area);
3. The release poses a serious threat of fire or explosion;
4. The release may cause high levels of exposure to toxic substances that are uncontained;
5. The situation is unclear or important information is lacking.

If the release does not meet any of the criteria describe above, yet exceeds the scope of incidental release, call EH&S at 392-8400 or 392-1591 for assistance.

Exposure Monitoring

Personnel monitoring will be performed if there is reason to believe that the exposure level of any chemical may exceed 50% of the action level, the Ceiling level, or the Permissible Exposure Limit (PEL). Monitoring will be performed by EH&S staff or a designee approved by EH&S. Results of the monitoring will be discussed with the affected employee(s).

Accident Reports

In the event of a laboratory accident, the laboratory supervisor must complete an "Occupational Injury Investigation Report" and a First Report of Injury or Illness form with the assistance of the injured employee. http://www.hr.ufl.edu/emprelations/reporting.htm
Once completed, the report should be forwarded to the Workers' Compensation Office.

Follow-up Investigations

EH&S will perform follow-up investigations for all exposures and injuries. Staff will be interviewed to ascertain the circumstances involved with the incident.

E. Laboratory Equipment

The types of equipment and instrumentation used in University lab settings are as diverse as the various research performed. Although each will have its own specific safety requirements, there are some general guidelines to follow whenever operating a lab equipment and instrumentation:

1. Always keep the manufacturer's operating manual with the instrument.
2. Follow recommended maintenance procedures outlined in the manual.
3. New operators should be trained by qualified lab personnel and familiarize themselves with the operating manual, including all pertinent safety information.
4. Never remove hazard-warning labels from an instrument.
5. Ensure that all equipment is grounded.
6. Have a certified technician perform or oversee repairs.
7. Disconnect equipment from the power-source whenever conducting maintenance on the instrument.
8. If the equipment is used near any source of water, ensure that it is plugged into an outlet equipped with a Ground Fault Circuit Interrupter (GFCI). Note: do not plug continuous running equipment such as freezers, into GFCI outlets. See Section III A on Electrical Safety for more information.
9. If compressed gases are used with the instrument, follow the UF Compressed Gas Rules.
10. Be aware of, and be trained in the unique hazards of your instrument. (i.e.: lasers, UV light, radiation sources, etc.)
11. Use protective equipment recommended by the manufacturer when using the instrument. (i.e.: hearing protection, face shield, etc.)

Refrigerators, Freezers, and Cold Rooms

Refrigeration systems, whether it is an appliance or building system, may not be modified or repaired by laboratory staff. Appropriate PPD personnel or certified refrigeration mechanic should be contacted to work on these systems.

Labeling
All refrigerators, freezers and cold rooms should be labeled with an Emergency Call List sticker to identify who should be called in case of equipment or power failure. This is especially important when the equipment is located in shared space, common rooms, alcoves, etc. These stickers are available from EH&S Lab Safety Program at 392-1591.

Every refrigerator, freezer and cold room must also be clearly labeled to indicate whether it is suitable for storage of flammables, biological or radiological materials. Household refrigerators and freezers must be labeled "Danger-Do not put flammable liquids in this refrigerator/freezer." Units must also be labeled for

contents e. g., ‘No Food,’ ‘Food Only.’ These labels are available by request from the Laboratory Safety Program at 392-1591.

Flammable Storage
Household refrigerators and freezers are not equipped with explosion-safe controls and may not be used to store flammable liquids. The flammable storage refrigerator/freezer is constructed with its controls mounted outside the storage compartment. This type of refrigerator is suitable for storing flammable liquids and is labeled by the manufacturer as such.

The explosion-proof refrigerator/freezer also has its controls mounted on the outside, but, in addition, the controls are of an explosion-proof design. This type of refrigerator/freezer is required in rooms or areas with potentially explosive atmospheres.

The use and storage of flammable liquids in cold rooms should be minimized. These rooms are not fire rated and are similar to a confined space, as they are not vented with fresh air. Please contact EH&S for an evaluation of these rooms and their use.

Centrifuges

Each operator must be trained on proper operating procedures. The use of centrifuges requires that they be balanced to prevent damage to the unit, the area or cause an injury to the operator. Any centrifuge that makes noise or vibrates must be stopped immediately and checked for balancing of the rotor. A log should be kept detailing operation for centrifuges and rotors.

1. Label centrifuges used for biohazards or radioisotopes.
2. Check the rotor for rough spots, pitting, and discoloration. If discovered, check with the manufacturer before using. Use professional rotor inspection services as required or recommended by the manufacturer..
3. Ultra centrifuge rotors require a log of rotor use and inspection. Damaged rotors must be removed from service immediately.

Vacuum Systems

Vacuum systems should not be used for any reason other than to pull vacuum on equipment. Do not use in-house plumbed or secondary vacuum pumps to remove water, dust or other materials.

All vacuum systems should be used with a secondary containment trap. Cold traps must be in place when flammable vapors are extracted by vacuum. It is strongly recommended that flow restrictors be used in line to minimize solvent loss.

A hydrophobic in-line filter should be placed between the last collection vessel and the vacuum port in systems used for aspirating liquids. This is recommended for both plumbed vacuum lines and for portable vacuum pumps. This filter will stop debris and liquid from entering the system and help to prevent contamination or degradation of the vacuum system.

Heating Equipment

Steam-heated devices shall be used rather than electrically heated devices or Bunsen Burners whenever possible. Steam-heated devices do not present shock or spark hazards and can be used with assurance that their temperature will not rise beyond 100°C.

Electrical Heating Devices
Only hot plates with heating elements enclosed in a glass, ceramic, or insulated case should be used in laboratories. All electrical equipment must be UL approved.

Heating mantles should be checked before each use for broken insulation and to assure that no water or other chemicals have been spilled into the mantle. Laboratory workers should be careful not to turn a variable transformer so high as to exceed the input voltage recommended for the mantle by the manufacturer.

Oil baths should always be monitored with a thermometer or other device to ensure that their temperature does not exceed the flash point of the oil being used. Smoke caused by the high temperature decomposition of the oil or of organic materials in the oil represents an inhalation hazard. Laboratory workers using an oil bath should guard against the possibility that water or another volatile substance could fall into the hot bath. Such an accident can splatter hot oil over a wide area. The oil bath should be supported on a solid surface.

Gas Burners
Where burners are used, distribute the heat with a wire gauze pad. Tubing for the gas should be checked to ensure it is properly attached with clamps and is not cracked. Burners should not be used in fume hoods or biological safety cabinets, as the continual high volume airflow through these units may extinguish the flame and go unnoticed. Burners must not be left on when not in use or when the user leaves the immediate area.

Cooling Equipment

Running tap water should not be used for cooling of any experiment or equipment for longer than 30 minutes, as per the UF PPD Utilities Policy. This is found on page 12, section H of the link http://www.admin.ufl.edu/ddd/Attachments/UF_Utility_Policy_2001.pdf If cooling water is needed for longer periods, a self-contained cooling system must be used.
Special care should be taken if dry ice or a cryogenic liquid, such as liquid nitrogen or helium is used in a cooling system. Follow the guidelines in Section III.H.1 for using these substances.

Glassware

Careful handling and storage procedures should be used to avoid damaging glassware. All glassware should be inspected prior to use. Damaged items should be discarded or repaired. Wear safety glasses and puncture resistant gloves when washing glassware.

Hoses

Prior to use, all tubing and connections must be inspected. Replace cracked or split tubing before use. Ensure that all connections are secured, and the use hose clamps are required.

Hand protection should be utilized when inserting glass tubing into stoppers or when placing rubber tubing on glass hose connections. Tubing should be fire polished or filed smooth and lubricated. A cloth should be wrapped around the glass. Hands should be held close together and the glass inserted with a slight twisting motion, avoiding excessive pressure.

Disposal of Used Equipment

All laboratory equipment used in conjunction with chemical, biological or radioactive substances must be certified that it is safe for disposal or storage prior to its removal from the lab. The department or lab will be responsible for the decontamination and/or disinfection of the equipment, draining all liquids and oils, and certifying that these procedures have been done properly.

- All equipment must be cleaned by the lab staff prior to the initiating the disposal process.
- Refrigerants (Freon) must be removed from any equipment prior to disposal. This may include refrigerators, freezers, centrifuges, etc. For refrigerant removal procedures see http://www.fa.ufl.edu/ups/.
- To dispose of a biological safety cabinet, it must be decontaminated by a certified technician (call EH&S for current contractor information) prior to disposal. If the equipment has been used with radiological substances, clean and decontaminate the apparatus and then call EH&S Radiation Services at 392- 1589 to have the equipment surveyed.
- If there are concerns that the equipment contains asbestos (such as with older ovens), contact the EH&S Asbestos Program Manager at 392-3393 to have the item sampled prior to disposal.

Contact Property Services at 392-2556 http://www.fa.ufl.edu/ups/ for disposal of any unwanted equipment.

F. Utility Systems

Laboratory staff may not perform any modifications of any utility systems in buildings or labs. No part of the ventilation, electrical, plumbing (water and gas) may be tapped into, repaired, removed, added to or tampered with in any way. If work is required on these systems, please submit a work order to the Physical Plant Division or IFAS Facility Operations.

If there are any concerns or need to upgrade a system within a lab area, contact Physical Plant Division (PPD) or IFAS Facilities Operations to assess the requirements and concerns.

Fume Hoods and Ventilation Systems

Ventilation systems for laboratories are normally designed to provide 6 - 12 air changes per hour at a slightly negative pressure relative to hallways and office space. It is important to keep lab doors and windows closed as much as possible for proper pressure balance and ventilation of the lab.

Chemical fume hoods are intended to remove vapors, gases and dusts of toxic, flammable, corrosive or otherwise dangerous materials. It is important for lab staff to understand how the chemical fume hood in the lab functions. All laboratory personnel must be trained in proper use of fume hoods. For complete guidelines on fume hood use see http://www.ehs.ufl.edu/Lab/fumehood.htm. If there are any questions or concerns about fume hood function, please contact EH&S Laboratory Safety.

Proper Use of Fume Hoods
With the sash lowered to the indicated level for proper airflow, laboratory fume hoods can also afford workers protection from such hazards as chemical splashes, sprays or fires. Sash heights are posted and updated annually on the EH&S sticker attached to each hood. To set the sash at the indicated level, measure from the floor of the hood, as the opening should include the area under the airfoil. See diagram in Appendix B.

If the hood's airflow alarm is sounding, the lab staff must immediately end all work in the hood, close all chemical containers and close the sash. Contact the building's maintenance department to have the ventilation system repaired. Do not mute, ignore or disconnect any fume hood alarm.

Profiling
EH&S will profile each hood annually as mandated by various regulations and fire codes. The EH&S profile sticker will provide information on the type of hood, intended use and sash height settings.

Fume Hood Repairs
If a hood needs to be repaired, the appropriate maintenance group will not perform any work unless a Fume Hood Repair Protocol is filed by EH&S. It will be the responsibility of the lab staff to stop all work in the hood that is not functioning properly, call in the work order, clear the hood of chemicals or equipment and clean the hood of any potential contamination. EH&S Radiation Control will swipe test hoods used for radioisotopes before repairs are conducted.

See http://www.ehs.ufl.edu/Lab/fumehood.htm for further information and contact numbers for the various maintenance groups.

Plumbing Systems

Flexible tubing, garden hoses and PVC piping are not acceptable as plumbing alternatives, including but not limited to tap, hot, chilled, waste water systems and steam lines. If additional water supplies are required, contact the appropriate PPD or IFAS Facility Operations for installation.

Tap water must not be left flowing to cool experiments for longer than 30 minutes or left unattended. A refrigerated re-circulating system must be used to cool experiments or equipment to minimize potential damage from leaks and flooding. The use of these closed loop system is required by the UF Utilities Policy found on page 12 section H
http://www.admin.ufl.edu/ddd/Attachments/UF_Utility_Policy_2001.pdf

Isolated or unused sinks and floor drains may be a source of foul odors if the traps dry out. Please ensure that all sinks have had water periodically run into them to fill the trap. If a sink is in an isolated area and will not be used for some time, please contact PPD to have it sealed or have the trap filled with mineral oil. Mineral oil will not evaporate and is environmentally safe.

Many UF buildings have plumbed gases, such as natural gas, air or nitrogen. These systems are regulated within the building and do not need additional regulators attached prior to use. All hoses or tubing leading from the stopcock to the use areas must be clamped and connections should be leak tested. The length of the tubing must be minimized and cannot be run across the lab, through doors or over the ceiling tiles.

IV. Chemical Handling and Processes

A. Transporting Chemicals

Individuals transporting chemicals must be familiar with the material's hazards and know what to do in the event of a release or spill. Material Safety Data Sheets (MSDSs) are a good source for this information. Materials that are unstable, explosive or acutely hazardous should not be moved before contacting EH&S.

If the lab is relocating to another building location, please see Appendix B of the UF Laboratory Close Out Policy before starting the move: http://www.ehs.ufl.edu/Lab/closeout.htm.

Within the lab

1. Always use appropriate chemical resistant gloves and eye protection.
2. Large containers or especially hazardous chemicals should be carried in a secondary container.
3. Never move visibly degrading chemicals and containers. Report these to your lab supervisor or PI. Contact EH&S Hazardous Materials Management at 392-8400 for advise or disposal.
4. Be aware of your surroundings: potential trip hazards, other workers, etc.

From Lab to Lab

1. Containers and bottles must be labeled.
2. Spill absorbent materials and MSDS for the chemicals must be available at all times.
3. When chemicals are carried, they should be placed in a secondary container such as an acid-carrying bucket, tub or other appropriate leak proof container to protect against breakage and spillage.
4. Use sturdy carts for transporting multiple, large, or heavy containers; the cart should have wheels large enough to negotiate uneven surfaces without tipping or stopping suddenly.
5. Carts used for secondary containment must have a liquid-tight tray with lips on four sides.
6. The chemicals should not be transported during busy times, such as during class changes, lunch break, etc.
7. Hazardous chemicals should be transported on freight elevators wherever possible to avoid exposure to persons on passenger elevators.
8. Remove gloves to open doors and push elevator buttons, etc.
9. Never leave chemicals unattended.

B. Chemical Storage and Compatibility

General Rules for Chemical Storage

1. Do not store liquid chemicals above shoulder height.
2. Flammable chemicals in amounts exceeding 10 gallons must be stored in flammable storage cabinets or safety containers.
3. Bottles may not be stored on the floor unless they are contained in tubs or other secondary containment.
4. Excessive chemical storage in hoods is not acceptable; this practice interferes with the airflow in the hood and reduces the available workspace.
5. Chemical waste shall be placed at the designated accumulation area, in appropriate receptacles, properly labeled and segregated by hazard class.

6. Chemicals should not be stored indefinitely. High humidity will cause powdered chemicals to harden. Liquid chemicals will evaporate. Potentially reactive or dangerous compounds must to be dated when they arrive into the lab. For all other chemicals, it is strongly recommended that they be dated for tracking purposes. If a manufacturer's label has an expiration date, these should be followed and the substance should be disposed of as hazardous chemical waste. All outdated, hardened or evaporated substances must be disposed of through EH&S.

The chemical compatibility chart in Appendix D can be posted near the lab's chemical storage area as a reference.

Solid or Powdered Chemicals

Most solid chemicals may be shelved alphabetically with the following exceptions:
1. Ensure that phenol crystals are separated from oxidizers
2. Cyanide compounds must not be stored near acids. (Accidental mixing may release cyanide gas.)
3. Flammable solids should be stored segregated from other solids or in Flammable Storage Cabinets.
4. Powdered metals should be stored as directed on the bottle label or MSDS. Storage of some metals may depend on the conditions in which they are packed (e.g., under a flammable solvent), which may require storage in flammable storage cabinets.

Liquid Chemicals

All liquid chemicals must be segregated by hazard classification and stored only with compatible substances. The following categories of liquid chemicals should be segregated from other categories:
1. **Acids -** Organic acids should be kept separate from inorganic (mineral) acids. For example, store acetic and formic acids separate from hydrochloric and sulfuric acids.
2. **Bases -** May react violently with acids, oxidizers or flammables.
3. **Oxidizers -** Keep away from acids, bases, organics and metals; keep cool. Examples of strong oxidizers: perchloric acid, nitric acid.
4. **Flammable liquids -** The excess over 10 gallons in any workspace must be stored in flammable storage cabinets or in safety containers. Keep separate from acids, bases, and oxidizers.
5. **Toxic or poisonous liquids** must be segregated and stored separately, as they can be released and/or intensified by reactions with other chemicals. An example of this is cyanide solutions. Other chemicals such as formaldehyde should be stored in plastic bottles at the lowest shelve or storage space to minimize the potential for spills.
6. **Mercury** must be stored in non-breakable bottles in secondary containers and kept on a bottom shelf of a closed cabinet.
7. **Non-hazardous or inert liquids** may be stored with any other category, but it is recommended that they also be segregated for consistency.
8. **Chemical waste accumulation area –** Liquid chemical waste must be stored by compatibility.

C. Flammable Chemicals

Flammable substances are the most commonly stored hazardous materials in the laboratory. The ability to vaporize, ignite, burn or explode varies with the specific type or class of the substance.

An indicator of the flammability of a solvent is its flash point, or the lowest temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air. Flammable liquids have flash points below 100°F (37.8°C); Combustible liquids have flash points between 100°F (37.8°C) and 210°F (93.3°C). This information is usually available on the label affixed to the chemical container or on the MSDS.

The most hazardous flammable liquids are those that have flash points at room temperature or lower, particularly if their range of flammability is broad (flash points and flammability limits of some common lab chemicals may be found in Appendix C.

For a fire to occur, three conditions must exist: a concentration of flammable vapor that is within the flammable limits of the substance, air and a source of ignition. Elimination of any one of these three conditions will prevent the start of fire. Because spillage of a flammable liquid is always a possibility, strict control of ignition sources is mandatory.

Close attention must be given to all potential sources of ignition when flammable materials are being used in a laboratory. The vapors of many flammable liquids are heavier than air and capable of traveling considerable distances. This possibility should be recognized, and special note should be taken to ensure that all possible ignition sources are eliminated.

Handling Flammables

The following guidelines should be observed when handling flammable liquids:

1. Flammable liquids should be handled only in areas free of ignition sources.
2. 'No Smoking' signs should be posted and obeyed when flammable liquids are handled or stored outside of the lab environment e.g., chemical storage facilities.
3. Never use an open flame near flammable liquids.
4. Flammables should not be heated with an open flame. Other types of heat sources, such as a steam bath, water bath or heating mantle should be used.
5. Transfer flammable liquids with caution. The friction created by flowing liquids may be sufficient to generate static electricity, which may cause a spark and ignition. Therefore, ground all large containers (5 gallons or more) to the building or special ground system. Bond all metal and other containers together before pouring from them. Where pouring into a plastic container, a copper rod that is bonded to the grounded supply container may be placed into the container and the flammable liquid poured over it. This will dissipate the charge.
6. Flammable liquids should be dispensed and used in a hood or well-ventilated area so that flammable vapors will not accumulate.
7. Substitute non-flammable liquids whenever possible.

Storage of Flammables

Storage of flammable materials should comply with those requirements specified in the NFPA 45 and EH&S regulations and guidelines:

1. Keep only small quantities (500 ml or less) of flammable materials available for immediate use.
2. Large amounts (greater than 500 ml) of flammable liquids should not be stored on the open bench top. Quantities greater than ten (10) gallons stored in a laboratory will require the use of safety cans or a flammable storage cabinet.
3. An approved safety can with a self-closing cover, vent, and flame arrestor is the best container for storing flammable liquids or waste solvents in small quantities. An ordinary five-gallon container does not provide adequate protection in case of fire.
4. Fifty-five (55) gallon drums are not allowed in labs unless they are stored in flammable storage cabinets with appropriate spill control and grounding. This must be approved in advance by EH&S.
5. For cold storage of flammables, only certified flammable storage or explosion proof refrigerators and cooling equipment must be used.
6. Storage of flammable liquids in cold rooms may be permitted under certain conditions. Please contact EH&S for further instructions and requirements.

7. All large metal containers (5 gallon or more) must be grounded and bonded to a grounding source.

D. Corrosive Chemicals

Inhalation of the vapors of these substances can cause severe respiratory tract irritation. Contact with these chemicals may cause burns to the skin, respiratory tract and eyes.

Acids and bases

The following are suggestions for safe use and storage:

1. Store separately in a cool ventilated area, away from metals, flammables and oxidizing material.
2. Secondary containment, such as chemical resistant tubs or bottle carriers should be used to isolate bottles.
3. The storage area should be checked regularly for spills and leaks.
4. Suitable spill clean-up materials must be available.
5. Always pour acids into water, never the reverse. Remember *"AAA- Always Add Acids"*
6. Cap bottles securely. The only exception to this will be the loose capping of mixtures if they generate gases during storage (ex: Aqua Regia). These should be stored in fume hoods or vented cabinets.
7. Clean up spills promptly. Do not leave residues on a bottle or lab bench where another person may come in contact with them.
8. Wear protective clothing and equipment when handling acids or bases. This shall include the proper chemical resistant gloves, apron and eye protection.
9. If you have been splashed with acids or bases, follow emergency procedures outlined on page 12.

Five acids deserve special attention because of the hazards they pose. These are: nitric acid, perchloric acid, picric acid, and hydrofluoric acid. Criteria for storage and handling are as follows:

1. **Nitric acid** is corrosive and its oxides are highly toxic. Because nitric acid is also an oxidizing agent, it may form flammable and explosive compounds with many materials (e.g., ethers, acetone and combustible materials). Paper towels used to wipe up nitric acid spills may ignite spontaneously. Nitric acid should be used only in a hood and should be stored away from combustible materials.

2. **Perchloric acid** may form unstable, and potentially highly explosive compounds with many organic compounds and metals. Unstable perchlorate crystals may collect in the ductwork of fume hoods and cause fire or violent explosions. Perchloric acid should be used with extreme caution and only in a fume hood designed for its use. A perchloric acid hood has corrosion-resistant ductwork and wash-down capacity. Minimum quantities of perchloric acid should be kept on hand and the container should be stored in a glass tray that is deep enough to hold the contents of the bottle. Perchloric acid must be dated when received into the lab and again when opened. It should be disposed of after one year since explosive crystals may form.

3. **Picric acid** can form explosive compounds with many combustible materials, especially when dry. When the moisture content decreases to less than 10%, picric acid will become unstable and may explode from being shaken, exposed to sudden changes of temperature, or from the friction created by opening the cap. Picric acid should be dated, stored as a flammable solid and not kept for extended periods.

4. **Hydrofluoric acid (HF)** is extremely corrosive and will weaken glass. All forms (dilute, concentrated, or vapor) can cause serious burns. Burns from hydrofluoric acid can be very painful, will heal slowly and can be fatal. Inhalation of HF mists or vapors can cause serious respiratory tract damage that may also be fatal. Therefore, hydrofluoric acid should be used in a suitable fume hood

with proper gloves, safety glasses and lab coat being worn. This compound may only be stored in compatible containers, such as high or low-density polyethylene or Teflon.

Any lab using HF must have calcium gluconate available as a remedy for exposures. Immediately after an exposure, the area should be rinsed with running water for 2-5 minutes. The calcium gluconate compound must be applied to the area. Medical treatment must be sought immediately.

More information on HF can be found at http://membership.acs.org/c/chas/Magazine/hf/

5. **Chromic Acid and Chromerge** solutions need to be handled with extreme care. If these are being used as cleaning solutions for glassware, it is recommended that they be replaced by other non-chromic acid compounds, such as "No-Chromix". The disposal of chromic acid containing solutions is very expensive. They may be used with care if there are no other alternatives.

Oxidizers

Included in this class of chemicals are nitrates, permanganates and oxides. These compounds present fire and explosion hazards on contact with organic compounds and other oxidizing substances. Suggestions for safe use and storage:

1. Oxidizing agents should be stored separately from flammable liquids, organics, dehydrating agents and reducing agents.
2. Strong oxidizing agents should be stored and used in glass or other inert containers. Corks and rubber stoppers should not be used.
3. Oxidizing agents should be used with caution in the vicinity of flammable materials.

Dehydrating agents

These include concentrated sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide. To avoid violent reactions and splattering, these chemicals should be added to water, never the reverse. Because of their affinity for water, these substances cause severe burns on contact with skin.

E. Compressed Gas Cylinders

Those individuals working with compressed gas cylinders should request a copy of the UF Safety Rules for Storage and Use of Compressed Gas Cylinders. These rules must be posted in a prominent place wherever compressed gases are used and stored.

All cylinders owned by the department or the University must be registered with EH&S to ensure that they will be periodically tested for internal integrity. This hydrostatic testing is mandated for all cylinders and will be the responsibility of the department. If a cylinder has past the deadline for hydrostatic testing, it must be taken out of service until it has been tested and recertified for use. It is important that caps are not misplaced. Cylinders cannot be transported or returned to the vendor without a valve cap.

The use of medical grade gases will require registration. Contact EH&S for assistance.

Cylinder Safety

The following rules are intended to highlight and summarize the most common safety concerns regarding the handling and storage of compressed gas cylinders. Please consult the UF Safety Rules for Storage and Use of Compressed Gas Cylinders or MSDS for specific information on the gases used in your lab.

1. Know the chemical and physical properties of the gases.
2. Cylinders must be secured by use of chains, straps, racks, base plates or carts (regardless of cylinder size) anytime they are in use, being moved or stored. Securing straps must be used in the upper 1/3rd of the cylinder.
3. All cylinders must be labeled with contents (do not rely on color codes) and stage of use (e.g., "full," "in use," "empty").
4. Store and use in well ventilated areas, away from heat or ignition sources.
5. Store oxygen away from flammable gases. Reactive gases should be stored separately
6. The use and storage of flammable gases must be minimized. Please contact EH&S for a consultation.
7. Do not strike or allow cylinders to strike against one another.
8. Metal cylinder caps for valve protection should be kept on at all times when the cylinders are not in use.
9. A proper pressure regulator is required during use; improvised adapters are not allowed
10. Use regulators specific for the type of gas contained in a cylinder; they are not interchangeable.
11. Do not use Teflon tape or lubricants on regulators.
12. Release pressure and close valve at the end of the day's use; do not rely on a regulator to stop the gas flow.
13. Handle empty cylinders with the same care as full cylinders.
14. Transport cylinders only on a hand truck or other cart designed for such purpose; cap valve must be in place when transporting cylinders.
15. Do not handle more than one cylinder at a time unless a cart designed for such purpose is utilized.
16. Store full cylinders in a cool, well ventilated and protected area, away from emergency exits
17. Cylinders should never be stored horizontally.
18. Do not let the temperature of the cylinders exceed 38° C (100° F).
19. Do not store corrosive gases for more than 6 months.
20. Never attempt to refill a cylinder.
21. Do not put cylinders into freezers.
22. Report all cylinders found in a questionable condition to the lab supervisor or EH&S.

Toxic Gases

The use of highly toxic gases (i.e.: arsine, fluorine, phosphine, etc.) will require containment in a vented gas cabinet. These cabinets must be vented from the building through a dedicated exhaust, monitored and alarmed for leakage and have an emergency power back-up system for the fan motor. Other gases such as carbon monoxide may require a monitoring system or device. Please call EH&S for consultation.

Cylinder disposal

It is highly recommended that the lab or department establish an account with suppliers who allow the return of unused gas and empty cylinders. Abandoned and aging cylinders must be picked up by EH&S before the integrity of the cylinder is compromised. This may incur cost to the department. Call EH&S Hazardous Materials Management at 392-8400 for information on cylinder disposal.

F. Cryogenic Liquids and Dry Ice

Cryogenic Liquids

The principal hazards of cryogenic materials are frostbite from contact with skin, asphyxiation caused by oxygen displacement and potential fire as the result of a release of a flammable gas.

The following is general safety precautions for the use and storage of cryogens typically used at the University such as liquid nitrogen or helium. Other types of cryogens (liquid oxygen, hydrogen, etc.) require further precautions. Please refer to MSDS and call EH&S.

1. Eye protection must be worn whenever cryogenic liquids are handled, as splashing is always a possibility. Face shields are strongly recommended.
2. Thermal protective gloves with tight fitting cuffs, extending to the mid forearm or elbow shall be worn. Avoid wearing jewelry if possible. If not, jewelry must be completely covered by the gloves.
3. Long pants (no cuffs), long sleeves and full coverage shoes should be worn.
4. Cryogenic gases are capable of causing asphyxiation by displacing breathable air and therefore should only be used and dispensed in well-ventilated areas.
5. A pressure relief valve should be installed on dewars to avoid quick and violent pressure changes when cryogens vaporize.
6. Exposed glass portions of the container should be taped to minimize the flying glass hazard if the container should break or implode.
7. If a dewar or similar cryogenic container ruptures or releases, vacate the area immediately. Vent the room and have EH&S test oxygen levels to ensure it is safe to re-enter.
8. Do not transport a cryogenic liquid in a closed vehicle. These must be secured to open beds or carts.
9. In case of a splash, immediately remove any clothes that may have been splashed. Flood or soak affected area with tepid water. Seek immediate medical attention for any cryogenic frostbite injuries.
10. Non-insulated metal pipes containing cryogenic fluids must be kept clear of combustible materials in order to minimize the fire potential caused by oxygen enrichment of condensed air.

For detailed information on cryogenic materials safety see
http://www.magnet.fsu.edu/users/safety/cryogenics/index.html

Dry Ice Storage and Handling

1. Wear safety glasses and thermally protective gloves when handling dry ice.
2. If dry ice has been in a closed room, walk-in unit or freezer, ensure to open the doors and allow adequate ventilation before entering or retrieving the dry ice.
3. Store dry ice in a thermally insulated container. The thicker the insulation, the slower it will sublimate to the vapor state.
4. It is important to remember that carbon dioxide is heavier than air, especially when obtaining dry ice from chest freezers or coolers. Do not lean into dry ice coolers, as there will be no oxygen.
5. Ensure the door is braced so it will not shut down on the person retrieving the ice.
6. Wear a face shield whenever grinding or crushing the solid dry ice.

7. Do not transport dry ice in an enclosed vehicle, as there needs to be adequate ventilation.
8. Leave the area containing dry ice if you start to feel dizzy or have shortness of breath. Ensure to seek fresh air and medical attention.

G. Highly Reactive and Potentially Explosive Chemicals

When chemical reactions are considered safe, it is generally because the reaction rate is relatively slow or can be easily controlled. Certain reactions proceed, however, at an extremely rapid rate and generate intense heat that they may result in explosion. Care should be taken to ensure there is sufficient cooling and surface area for heat exchange.

Many chemical reactions may be handled safely if preliminary planning has been adequate. Planning an experiment should include knowledge of the reactivity, flammability and toxicity of the chemicals used in and produced by the experiment. Care must be taken so as not to contaminate the reactive compound and triggering an uncontrolled or non-planned reaction.

Lab personnel should consult with the laboratory supervisor or principal investigator when planning an experiment in which hazardous materials are used or hazardous conditions may occur. Such planning shall include selection of the proper safety procedures and equipment as well as consideration of the possibility of a power failure, equipment breakdown or fire. A partial list of highly reactive and potentially explosive chemicals follows:

Pyrophoric Materials

These compounds (such as phosphorus or lithium) are air reactive and require specific storage and use conditions. Most should be stored under mineral oil or other conditions. Please consult the MSDS or EH&S for assistance with these substances.

Water Reactive Materials

Substances such as potassium and sodium metals will require special storage to prevent contact with water or high humidity conditions. Consult the MSDS or EH&S for assistance with these chemicals.

Peroxide Forming Compounds

Organic peroxides are a class of compounds that have unusual stability problems that make them among the most hazardous substances handled in laboratories. As a class, organic peroxides are considered to be powerful explosives. They are sensitive to heat, friction, impact, light as well as to strong oxidizing and reducing agents. All organic peroxides are flammable. Types of compounds known to form peroxides are listed in http://www.ehs.ufl.edu/Lab/perxlist.htm

Requirements for safe use and storage of ether and other peroxidizable materials:

1. Ethers and peroxidizable materials should be ordered only in small quantities.
2. All peroxidizable materials should be stored in a cool place, away from light.
3. Metal cans are preferable; do not store ethers in ground glass-stoppered bottles, as they do not seal adequately.
4. These must be dated upon receipt and again when opened.
5. They should be discarded within a year after receipt if unopened, or within six months of opening.
6. Containers that are showing signs of prolonged storage or age (such as label deterioration or corrosion) should be disposed of through EH&S as soon as possible.

7. Ethers must always be handled in a hood to assure proper ventilation. This will protect individuals from inhaling the vapors and prevent accumulation of explosive concentrations of the vapor.

H. Mercury

This toxic element must be stored in containers such as Nalgene bottles (500 ml maximum volume) that will withstand the weight of the substance and still be manageable to move and handle. The container should be stored in a secondary container, such as a pail or other similar tub to contain the mercury in the event the first container fails. This must be stored on the lowest shelf available to keep the excessive weigh from surprising staff when lifting the container from upper shelves. Under no circumstances should this compound be stored in open beakers, jars, etc. A mercury spill kit must be on hand in any lab that stores or uses this substance.

When using mercury in manometers or under pressure, it is vitally important to have all hoses secured with hose clamps. Any open end of the manometer will need to have tubing attached and placed in a collection bottle to protect from a spill caused by over pressurizing of the unit.

Sphygmomanometers (blood pressure meters) containing mercury should be inspected by EH&S to ensure they have been modified to minimize mercury spills. To have a unit inspected, please call the Clinic Safety Officer at 392-1591.

It is strongly recommended that all mercury be eliminated from labs. As thermometers are replaced, non-mercury thermometers should be purchased. If a mercury thermometer is broken in the lab, follow the guidelines found at http://www.ehs.ufl.edu/IH/mercury.htm

I. Metals

Alkali Metals

Alkali metals (e.g., sodium and potassium) react violently with water and decompose the water to give off hydrogen, which may be ignited by the heat of reaction. Alkali metals can ignite spontaneously in air, especially when the metal is in powdered form and there is highly humid air.

Suggestions for safe use and storage include:
1. Store alkali metals under mineral oil or kerosene.
2. Avoid using oils containing sulfur since a hazardous reaction may occur.
3. Only special class D dry powder fire extinguishers may be used on alkali metal fires. Consult with EH&S Fire Safety if your lab will require one of these.
4. Waste alkali metals must be placed in a labeled, leak-proof container, covered with mineral oil and disposed of through EH&S.

Metal Powders

Finely powdered metals that come in contact with acids may ignite and burn. Metal powders can also create a dust explosion hazard when the powders become airborne in an area where a spark or flame is present. In addition, metal powders are subject to rapid oxidation, which may result in a fire or explosion.

J. Controlled Substances and Acute Toxins

All DEA controlled substances and prescription drugs require specific procedures for storage, use and disposal. Please see the UF Controlled Substances Policy http://www.ehs.ufl.edu/Lab/control.htm or contact EH&S for explanation of these requirements. An outline of the policy is as follows:

1. Each PI must be licensed to procure and administer DEA controlled substances. Sharing of permits or allowing others not directly supervised by the permit holder to work DEA controlled substances is not allowable by law.
2. To procure and administer prescription drugs, a researcher must either hold a medical practitioner's license in the state of Florida or obtain a registration exemption number from the state of Florida.
3. Detailed records must be kept for purchase, use and disposal of DEA controlled substances. This inventory must be updated whenever the quantity of the substances changes, i.e.: use or disposal.
4. All laboratory staff members administering the substances must be authorized.
5. All DEA controlled substances and prescription drugs must be stored in a secure area.
6. All DEA controlled substances and prescription drugs must be disposed of properly. Contact EH&S Hazardous Materials Management 392-8400 for disposal information.

Acute toxins with a mammalian LD50 of 100 µg or less must be registered with the EH&S Biological Safety Officer http://www.ehs.ufl.edu/Bio/default.asp. Acute toxins are required to be securely stored in a locked cabinet or freezer/refrigerator.

K. Chemical Waste Disposal

Disposal of all chemical and radioactive waste generated by the University of Florida is managed by the EH&S Hazardous Materials Management Program. It is of utmost importance that labs abide by the policies set by EH&S. Minimization of chemical wastes should be an integral part of the laboratory setup and operating procedures. Please see the UF Waste Minimization Program http://www.ehs.ufl.edu/HMM/wmin.htm#Waste%20Minimization for more information.

Chemicals must not be disposed of down drains, as trash or by evaporation. Chemical wastes are required to be held at the generating location in a defined "accumulation areas" until ready for pick up.

A designated lab waste manager from each lab is required to attend mandatory classroom training provided by EH&S each year. Research departments will receive memos with instructions on how to schedule the training session.

Laboratories generating chemical wastes must familiarize themselves with the regulatory requirements and UF policies by visiting the EH&S Hazardous Materials Management web site http://www.ehs.ufl.edu/HMM/default.asp.
The following is a summary of the chemical waste accumulation and disposal process at UF.

Identification and Labeling

1. The chemical waste accumulation area must be identified with a "Waste Satellite Accumulation Area Requirements" poster found in Appendix C of the EH&S Chemical Waste Management Guide http://www.ehs.ufl.edu/HMM/HWguide.pdf.
2. Hazardous chemical waste containers must have the yellow Hazardous Waste label on them.
3. The label must list all constituents and the percentages of each, totaling 100%.
4. Hazardous waste labels are available free of charge by calling EH&S at 392-8400.

Waste Containers

1. All chemical wastes shall be accumulated in sealable containers.
2. Containers shall be kept closed during accumulation, except when adding waste to a container.
3. A funnel **cannot** be left in the container.
4. Do not over-fill containers; one inch of air space (from the top of the container) is required to allow for expansion.

Accumulation

1. Do not accumulate more than 55 gallons of waste or 1 quart of a P-Listed waste.
2. Keep solids and liquids separate.
3. Segregate chemical wastes by class: acids, bases, halogenated, non-halogenated, oxidizers, and reactives.

Chemical Waste Pick Up

Fill out and submit a Chemical Waste Pickup Request form. To submit the form electronically, go to http://www.ehs.ufl.edu/HMM/Pickups/chempick.asp

V. Laboratory Close-Outs

It is the responsibility of the research department to notify EH&S when a laboratory will be closing, relocating to another lab or transferring ownership. The researcher must adhere to the guidelines outlined in UF Laboratory Close-Out Policy. This close out policy may be found at http://www.ehs.ufl.edu/Lab/closeout.htm.

Proper disposition of all hazardous materials used in laboratories is the responsibility of the principal investigator or researcher to whom a laboratory is assigned. Before a researcher or graduate student leaves the University of Florida, all samples and chemicals used or generated by that person must be clearly labeled for content and disposed of prior to their departure. If samples are being saved for future analysis, they must be properly identified and there must be a clear time-line for disposal of these samples. Any chemicals or samples left behind for future use must be assigned to another researcher or department chair who will take responsibility for those items.

An appointment must be made with EH&S Laboratory Safety after the lab has been cleared and cleaned. At that time EH&S will assess the lab to confirm safe entry for custodial or maintenance personnel, contractors, and new occupants.

Appendix A - Chemical Abbreviation Placard

Chemical Abbreviations and Annotations
Used on Secondary Containers in the Work Area

ACIDS- Corrosive to skin, eyes, and respiratory tract

HCl	Hydrochloric Acid
HF	Hydrofluoric Acid (extremely hazardous)
TCA	Trichloroacetic Acid
H_2SO_4	Sulfuric Acid

BASES- Corrosive to skin, eyes, and respiratory tract

KOH	Potassium Hydroxide
NH_3OH	Ammonium Hydroxide
NaOH	Sodium Hydroxide

FLAMMABLE LIQUIDS-

Fire hazard, toxic by ingestion, irritant

EtOH	Ethyl Alcohol
MeOH	Methanol
IPA	Isopropyl Alcohol

TOXIC- Harmful by ingestion or skin absorption

DEPC	Diethyl Pyrocarbonate
DMSO	Dimethyl Sulfoxide (carries hazardous materials through the skin)

LOW HAZARD

SDS	Sodium Dodecyl Sulfate (detergent)
TAE	Tris Acetic acid + Ethylenediaminetetra acetic acid
TBE	Tris Boric acid + Ethylenediaminetetra acetic acid
PBS	Phosphate Buffered Saline
SSC	Sodium chloride Sodium Citric acid
TE	Tris Ethylenediaminetetra acetic acid
SSPE	Sodium chloride Sodium Phosphate + Ethylenediaminetetra acetic
STET	Sodium chloride Ethylenediaminetetra acetic acid Tris Triton X-100
TNT	Tris sodium chloride + Tween-20
TPE	Tris Phosphoric Ethylenediaminetetra acetic acid

Appendix B

FUME HOOD PROFILE

Environmental Health & Safety 352-392-1591

This fume hood should be set at: **100 lfm** **150 lfm**

☐ **This fume hood is a BYPASS hood. Velocity will be approximately the same for all sash heights**

☒ **This fume hood is a FULL SASH hood. Velocity will vary for all sash heights.**

Average Velocity (lfm) at 16" sash height:

98 102 ____ ____

For your protection, follow the posted sash heights:

General chemical use (100 lfm) set sash at:

16 16 ____ ____ in.

Radioactive and carcinogen use (150 lfm) set sash at:

10.7 10.7 ____ ____ in.

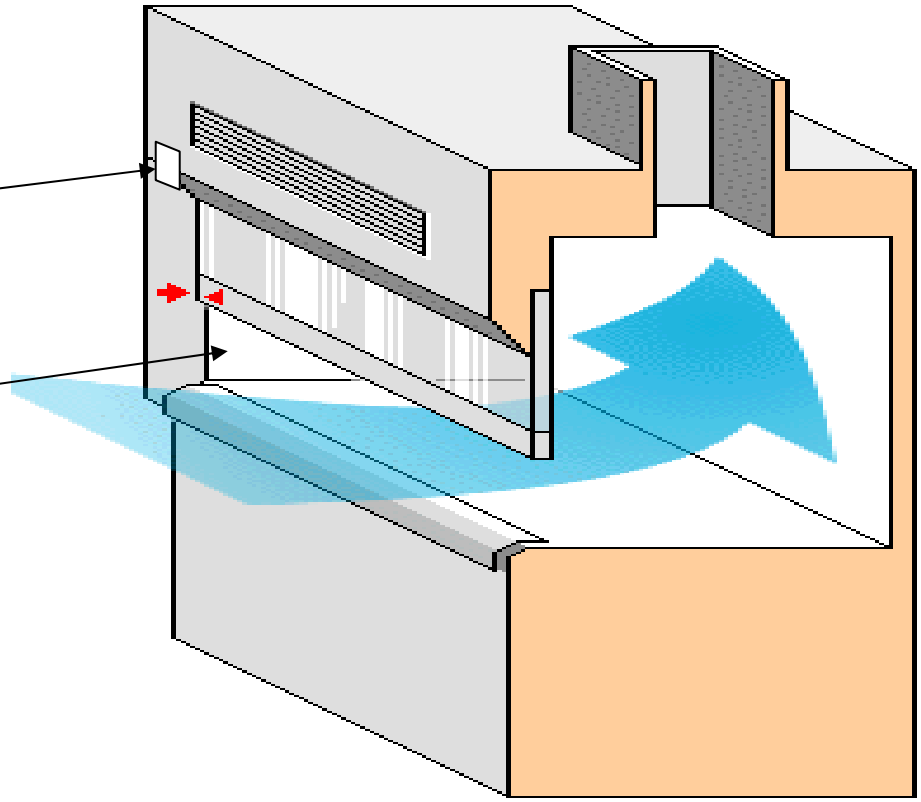
Velocity should never exceed 200 lfm. Keep sash above:

8 8 ____ ____ in.

Date: 2/03 2/04 ____ ____

EH&S Staff: A.Z. A.Z. ____ ____

Sash heights are posted and updated annually on the EH&S sticker attached to each hood. To set the sash at the indicated level, measure from the floor of the hood, as the opening should include the area under the airfoil. Always close the sash when running experiments and unattended operations. For complete guidelines see http://www.ehs.ufl.edu/Lab/fumehood.htm



Appendix C- Flammability Chart

Flash Points, Boiling Points, Ignition Temperatures, and Flammable Limits of Some Common Laboratory Chemicals

Chemical	NFPA Flam. Rating	Flash Point (°C)	Boiling Point Temp. (°C)	Ignition (°C)	Flammability Limit (% by volume of air) Lower	Upper.
Acetaldehyde	4	-37.8	21.1	175.0	4.0	60.0
Acetic Acid (glacial)	2	39.0	118.0	463.0	4.0	19.9
Acetone	3	-18.0	56.7	465.0	2.6	12.8
Acetonitrile	3	6.0	82.0	524.0	3.0	16.0
Benzene	2	-11.1	80.0	560.0	1.2	7.8
Carbon disulfide	3	-30.0	46.1	90.0	1.3	50.0
Cyclohexane	3	-20.0	81.7	245.0	1.3	8.0
Diethylamine	3	-23.0	57.0	312.0	1.8	10.1
Diethyl ether	4	-45.0	35.0	160.0	1.9	36.0
Dimethyl Sulfoxide	1	95.0	189.0	215.0	2.6	42.0
Ethyl alcohol	3	12.8	78.3	365.0	3.3	19.0
Heptane	3	- 3.9	98.3	204.0	1.05	6.7
Hexane	3	-21.7	68.9	225.0	1.1	7.5
Hydrogen	4		-252.0	500.0	4.0	75.0
Isopropyl alcohol	3	11.7	82.8	398.0	2.0	12.0
Methyl alcohol	3	11.1	64.9	385.0	6.7	36.0
Methyl ethyl ketone	3	- 6.1	80.0	515.6	1.8	10.0
Pentane	4	-40.0	36.1	260.0	1.5	7.8
Styrene	3	32.2	146.1	490.0	1.1	6.1
Tetrahydofuran	3	-14.0	66.0	321.0	2.0	11.8
Toluene	3	4.4	110.6	480.0	1.2	7.1
P-Xylene	3	27.2	138.3	530.0	1.1	7.0

From: Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press (1995)

Appendix D – Chemical Compatibility Guidelines

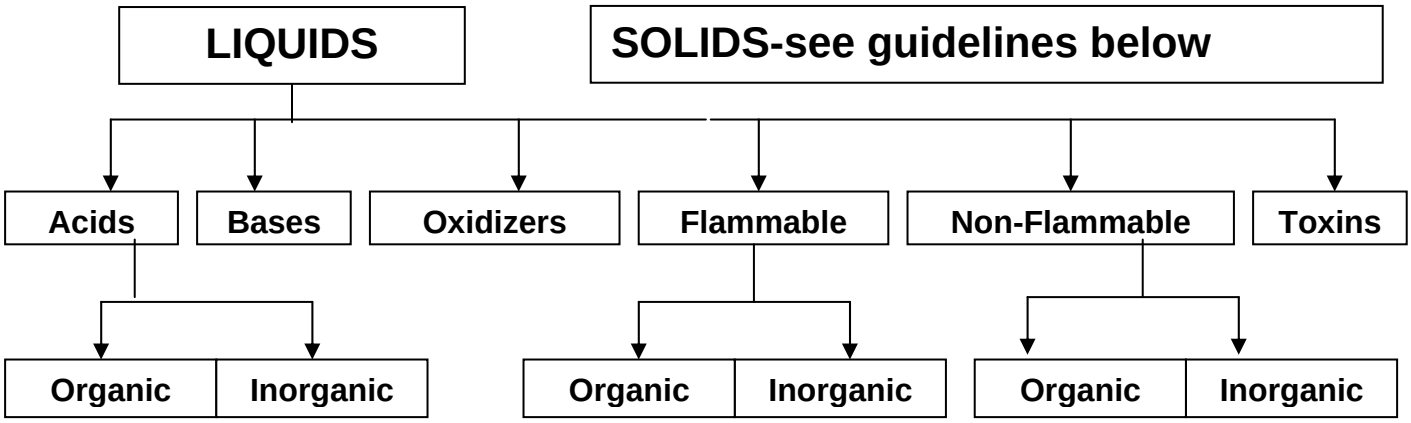
The following list is to be used only as a general guideline. Please refer to your Material Safety Data Sheets (**MSDS**) for specific incompatibilities.

Chemical:	**Incompatible with:**
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric and sulfuric acid mixtures
Alkali and alkaline earth metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, finely divided organic combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	See chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane(or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metal, turpentine
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	All other chemicals
Hydrocarbons (such as butane, propane, benzene)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Acids
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids and gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, and gases
Perchloric Acid	Acetic anhydride, bismuth and its alloys, alchohol, paper, wood, grease, oils
Peroxides, organic	Acids (organic or inorganic), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate see also chlorates	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals, such as sodium, lithium)
Tellurides	Reducing Agents

Appendix D– Cont.

CHEMICAL STORAGE GUIDELINES

STORE MATERIALS OUTLINED BY BOXES SEPARATELY



SOLIDS: Low tendency for reaction (when dry) so most can be shelved alphabetically, exceptions:

- **Sulfides** should be stored away from acids
- **Cyanide compounds** must be segregated from acids, especially liquid acids
- **Phenol crystals** must be stored separately from oxidizers
- Store **flammable solids** away from other solids or in flammable storage cabinet

LIQUIDS: Store liquid chemicals below shoulder height

Acids

- Separate organic acids from inorganic acids, e.g., acetic from nitric
- Perchloric acid should be stored alone

Flammable Liquids

- The excess of 10 gallons must be stored in safety cabinets or in safety cans
- Drums of flammable solvents are not allowed in buildings.

Oxidizers

- Keep away from acids, bases, organics, and metals
- Store in cool place

Chemical waste accumulation

- As much as possible, liquid chemical wastes should be stored by compatibility
- **Do not** accumulate more than 55 gallons of chemical waste, or more than one quart of acutely hazardous waste (P-listed wastes)

METALS:

- **Reactive metals** (ex: potassium, sodium etc) and all powdered metal should be stored in flammable storage cabinets
- **Mercury** must be stored in non-breakable secondary containers and kept on a bottom shelf of a closed cabinet