UNIVERSITY of HOUSTON

General Laboratory Safety Manual

Guidelines for the Common Laboratory Hazards

Prepared by:

Environmental Health and Life Safety (EHLS)
http://www.uh.edu/ehls/

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INTRODUCTION

A variety of hazards exist in the laboratories at the University of Houston. The risks associated with these hazards are greatly reduced or eliminated if proper precautions and practices are observed in the laboratory. To manage these risks, and in response to a heightened concern for safety in the workplace, the University of Houston has developed this General Laboratory Safety Manual (GLSM). We have included information on hazard communication, general standard operationg procedures and control measures, safe handling requirements in laboratories with chemical/biological/radiation hazards, emergency and medical procedures, and the proper methods of waste disposal. The manual is intended to be the cornerstone of a safety program designed to aid the UH community in maintaining a safe environment in which to teach, conduct research, and learn.

All Laboratory Personnel on the UH campus including Principal Investigators, Laboratory Managers/Supervisors, Research Scientists, Postdoctoral Fellowships, Temporary Visiting Researchers, Graduate Students, Undergraduate Students, High School Students and Volunteers working in the laboratory must be familiar with this manual and together share the responsibility for creating a safe and healthy work environment. It is important to recognize that this manual does not cover all the risks and hazards in every laboratory. There are a wide variety of hazardous materials handled in laboratories at the University of Houston. The Principal Investigator and designee know the most about the unique hazards in their laboratory. It is expected that the Principal Investigator will add any supplementary safety information to this manual pertinent to their specific laboratory.

In addition to the manual, Laboratory Personnel shall be cognizant of, and adhere to the procedures outlined in Chemical Hygiene Plan, Biological Safety Manual, Radiation Safety Manual and Hazardous Waste Manual. These documents are available on the Environmental Health and Life Safety website at http://www.uh.edu/ehls/about/manuals/ . Further information is available by calling Environmental Health and Life Safety (EHLS) at 713-743-5858.

HELPFUL TELEPHONE NUMBERS AND USEFUL INFORMATION

Environmental Health and Life Safety	*(713) 743-5858*
Fax	*(713) 743-8035*
University Health Center	*(713) 743-5151*
Plant Operations Customer Service (FixIt)	*(713) 743-4948*
University of Houston Police Department	
Emergency	*911*
Non-Emergency	*(713) 743-3333*

- *EHLS Office Hours: Monday through Friday 8:00 a.m. - 5:00 p.m.*
- *Please contact the University of Houston Police Department in the event of an after hours chemical, biological, or radioactive laboratory accident or incident.*
- *The Environmental Health and Life Safety maintains an on-call mechanism to provide expertise in response to emergencies that occur after hours and require assistance.*

1.0 SCOPE AND APPLICATION

This document serves as a guideline for the University of Houston compliance with the standard safety practices in laboratories and with the requirements contained therein. All Laboratory Personnel and departments at the University of Houston engaged in laboratory use, as defined by this document, must comply with the practices contained in this General Laboratory Safety Manual.

EHLS defines "Laboratory Personnel" as Principal Investigators, Laboratory Managers/Supervisors, Research Scientists, Postdoctoral Fellowships, Temporary Visiting Researchers, Graduate Students, Undergraduate Students, High School Students and Volunteers working in the laboratory. If there is any confusion about whether a particular workplace is considered a laboratory that utilizes hazardous chemicals, or whether someone is considered Laboratory Personnel, EHLS will make this determination upon request.

The General Laboratory Safety Manual is intended only to address those universal safety measures necessary for achieving a generally safe and healthy work environment. Where the scope of hazards is not adequately addressed by this general document, specific Standard Operating Procedures must be developed by the Principal Investigator or designee.

1.1 Definition of Laboratory

At University of Houston, a laboratory is defined as, but is not limited to, any location where research or teaching is conducted using hazardous chemicals, biohazardous or biological materials, radioactive materials, and/or radiation producing devices.
A location used for teaching or research that contains physical hazards may also be considered a laboratory, even if none of the materials listed above are routinely used in the area. Examples include:

- electronics labs
- fabrication labs
- art studios
- magnetics labs

A storage room containing the above materials is considered a laboratory if the materials are stored in support of teaching or research.

The following areas are typically NOT considered laboratories under the Laboratory Safety Manual; however, persons working in these areas are required to follow all applicable health and safety regulations:

- shops, mechanical, and custodial areas under the control of Plant Operations.

- departmental storage rooms, offices, meeting rooms, and other ancillary spaces
- computer use areas containing multiple workstations, even if teaching and research is occurring, unless located inside a space that meets the definition of a laboratory
- private offices, unless contiguous with or in a space that meets the definition of a laboratory

1.2 General Laboratory Safety Manual Objective

It is the intent of the University of Houston to provide a safe and healthy laboratory environment to all laboratory occupants through the establishment and maintenance of a General Laboratory Safety Program.

The General Laboratory Safety Manual (GLSM) provides control measures essential for protecting all laboratory occupants from potential health and physical hazards. These controls consist of, but are not limited to, policies, guidelines, training requirements, standard operating procedures, personal protective equipment, and laboratory inspections.

The GLSM describes a minimum level of safe practices that are expected from all Laboratory Personnel involved in the laboratory operations.

1.3 Program Responsibilities

Environmental Health and Life Safety's main purpose is to support the University of Houston in its mission of higher education and research. The Department's efforts are directed at assisting the University in identifying safety hazards and controlling such hazards through protective equipment, hazard mitigation methods, development and presentation of safety training programs.

Deans, Directors, and Heads of Academic and Administrative Units

- Ensure compliance with all requirements for laboratory safety within their departments and colleges;
- Collaborate with faculty and staff to adapt this General Laboratory Safety Manual to include lab-specific guidelines and to develop strategies to implement the Manual; and,
- Make budget arrangements for health and safety improvements.

Principal Investigator and Designee in Charge of Supervising Laboratories

- Perform hazard assessments, develop/approve lab-specific standard operating procedures (SOPs) for all-high risk procedures;
- Inform and train Laboratory Personnel concerning laboratory safety as required by this Manual and retain training records and all documentation;

- Implement and enforce rules and standards concerning health and safety for laboratories;
- Ensure compliance of Laboratory Personnel with this Manual;
- Ensure the availability and enforce the use of: appropriate personal protective equipment, Safety Data Sheets (SDSs), and relevant reference materials;
- Remain cognizant of chemicals stored and used in laboratories and their associated hazards;
- Dispose of chemicals no longer needed by submitting an on-line waste pick up request to Environmental Health and Life Safety;
- Conduct internal inspections of laboratories for health and safety concerns; and,
- Request assistance from Environmental Health and Life Safety as needed.

Laboratory Personnel

- Complete General Laboratory Safety Orientation and other Lab-specific Trainings provided by EHLS or Principal Investigator before undertaking any activity in the laboratory.
- Plan and conduct laboratory operations in accordance with this Manual and lab-specific documents;
- Report all hazardous conditions to his/her Principal Investigator or Designee;
- Wear or use appropriate Personal Protective Equipment (PPE);
- Report any job-related injuries or illnesses to his/her Principal Investigator or Designee and seek treatment immediately;
- Refrain from the operation of any equipment or instrumentation without proper instruction and authorization;
- Remain aware of the hazards of the chemicals in the laboratory and how to handle, store and segregate hazardous chemicals safely; and,
- Request information and training when unsure how to handle a hazardous chemical or procedure.

Environmental Health and Life Safety (EHLS)

- Provide technical assistance to Laboratory Personnel concerning appropriate storage, handling and disposal of hazardous chemicals;
- Provide general and specialized laboratory safety training;
- Conduct exposure assessments and laboratory surveillance as needed or upon request;
- Make routine, as well as special, health and safety audits;
- Provide technical assistance concerning personal protective equipment and laboratory safety equipment;
- Remain current on industrial best practices, standards, rules and regulations.

2.0 SAFETY TRAININGS

2.1 General Laboratory Safety Training

All new Laboratory Personnel who will work in a laboratory must be familiar with notifications used for hazard communication via signs and labels. This information is provided in EHLS General Laboratory Safety Training. This training is mandatory to all Laboratory Personnel and should be completed before conducting laboratory acitivities at UH.

Laboratory Personnel are to keep documentation of all certificates of required training for working in a laboratory. Training requirements can vary depending on the type of research being conducted.

In addition to the General Laboratory Safety Training the EHLS also conducts regularly scheduled training classes for specific hazards such as hydrofluoric acid, radioactive materials, lasers, biosafety, etc. Please consult the EHLS web site http://www.uh.edu/ehls/training/ for the training list and schedule.

EHLS may develop and provide additional trainings to address emergent and specific issue as necessary.

2.2 Chemical Specific Training

It is the responsibility of the Principal Investigator or the designee to ensure that Particularly Hazardous Substances (PHSs) and other reactive chemicals determination is conducted on all existing chemical inventories and on all future chemical purchases.

Prior to beginning work with a PHS or a reactive chemical, or once the PHS determination is made, Principal Investigator or Designee shall complete a lab-specific PHS Standard Operating Procedures (PHS SOPs). The PHS SOPs must clearly indicate specific physical and health hazards of materials used in the work area and other laboratory specific safeguards, rules, practices or pocedures necessary for the Laboratory Personnel to work safely with the PHS in that location. Laboratory Personnel must be trained, understand, and implement the procedures as directed in the SOP. For more information please see Chapter 5 Particularly Hazardous Substances in the UH Chemical Hygiene Plan.

2.3 Biological Safety Training

Biological Safety with Bloodborne Pathogens Training: This course is mandatory for all personnel and students working in Biosafety laboratories. The content of the course provides an understanding of the principles of biological safety up to BSL-2 and the training required for working with Bloodborne Pathogens. This course is recommended for all PIs and their staff that have a Memorandum of Understanding and Agreement for

working with biohazards and/or recombinant or synthetic nucleic acid molecules. Refresher training may be required at the end of the 5-year MUA approval cycle. http://www.uh.edu/ehls/training/eh12/ .

Bloodborne Pathogens: This is a one hour course mandatory for all personnel who have exposures to blood or any other bodily fluids over the course of their job duties. The content of the course fulfills all the training requirements established by the Texas Administrative Code regarding work with Bloodborne Pathogens.

Bloodborne Pathogens Refresher Training: This course must be completed every year by all personnel who handle bloodborne pathogens, or who may have occupational exposures to bodily fluids. The training can be viewed online by accessing http://www.uh.edu/ehls/training/. The content of the course fulfills all the training requirements established by the Texas Administrative Code regarding work with Bloodborne Pathogens.

2.4 Radiation Safety Training

The Radiation Safety Committee (RSC) requires all users of radioactive material, Class 3b and 4 lasers, X-ray machines, and other ionizing radiation producing devices requiring registration to complete the applicable radiation safety course. This includes all Authorized Users (AU) and Principal Investigators (PI).

Initial Radiation Safety classroom courses are currently offered at least once a semester by EHLS for Radioactive Material, X-ray, and Laser Safety with an exam requiring a passing score of at least 70%. Completion of these initial courses does not automatically qualify an individual as an Authorized User. To work with specific radioactive material and/or radiation producing devices as an AU, an individual must be added to a PI's sublicense or subregistration through an amendment application, and receive protocol-specific, on-the-job training from the PI or designee.

Persons who have completed the initial classroom training and are authorized to use radioactive material or radiation producing devices must maintain their training annually by passing the applicable online refresher course (Radioactive Material Safety, X-ray Safety and/or Laser Safety) with a score of at least 80%. Non-completion of the refresher training will lead to suspension from working with any source of radiation at the University.

Additional details regarding training requirements for the use of radioactive material and radiation producing machines are available on the EHLS Radiation Safety Manual website at http://www.uh.edu/ehls/research-lab/radiation-safety/manual/.

2.5 Record Keeping

General Laboratory Safety training and other trainings provided by EHLS will be documented by Environmental Health and Life Safety. EHLS will maintain these training

records through *EHS Assistant* Software. Attendees will receive a certificate upon completion of any EHLS training. Chemical-specific, lab-specific and/or hazard-specific training must be documented and maintained by the Principal Investigator or designee, and be available upon request.

3.0 STANDARD OPERATING PROCEDURES

The General Laboratory Safety Manual offers generic safety guidelines and standard operating procedures for the safe handling of hazardous chemicals on campus. Be aware that this document contains a minimum set of guidelines, regulations, and recommendations required to maintain a safe working environment, and does not provide laboratory workers, research students, or teaching assistants with specific standard operating procedures necessary to work in their respective laboratories. It is the responsibility of the Principal Investigator to develop specific standard operating procedures for his/her laboratory.

Standard operating procedures must be readily available to all Laboratory Personnel. The following guidelines have been established to minimize or eliminate hazards in the laboratory. These guidelines, which are in accordance with the Chemical Hygiene Plan, have also been provided to maintain a safe laboratory environment. It is the responsibility of each person that enters into the laboratory to understand the safety and health hazards associated with the chemicals and equipment in the laboratory. It is also the individual's responsibility to practice the following general safety guidelines at all times:

3.1 Eating, Drinking, and Smoking

Eating, drinking, smoking, chewing gum, and taking medicine in laboratories is strictly prohibited.

1. Food, beverages, cups, and other drinking and eating utensils shall not be stored in areas where hazardous chemicals, radioactive materials or biohazardous materials are handled or stored.
2. Glassware used for laboratory operations shall never be used to prepare or consume food or beverages.
3. Laboratory refrigerators, freezers, ice chests, cold rooms, ovens, microwaves, etc. shall not be used for food storage or preparation.
4. Laboratory water sources and deionized water shall not be used for drinking water.
5. Laboratory chemicals shall never be consumed or tasted.

3.2 Hygiene Practices

There are generalized precautions and personal hygiene practices that have been established to protect laboratory employees from chemical, radiological or biological hazards. The following basic safety precautions will minimize the possibility of hazard exposure:

1. Do not apply cosmetics in a laboratory environment. (This includes lip balm or chapstick).

2. Wash hands and wrists thoroughly before leaving the laboratory, after contact with any hazardous material, before eating, etc., even if gloves were worn during the work day.
3. Lab coats should be removed and left in the laboratory before exiting into non-laboratory areas, such as hallways.
4. Lab coats must not be taken home to be cleaned, nor should they be taken to a laundry service that is not equipped to handle lab coats. If there is obvious contamination on the lab coat, use a laundry service that specializes in cleaning contaminates, or dispose of the lab coats as waste.
5. Never wear or bring lab coats, jackets or aprons into areas that are designated for the consumption of food.
6. Always use the appropriate personal protective equipment to avoid direct contact with any hazardous materials.
7. Laboratory Personnel should know the symptoms of exposure related to the hazardous material(s) they are working with.
8. Replace personal protective equipment as needed to maintain its integrity.
9. Never mouth pipet chemicals when transferring solutions. Instead, you should always use a pipet bulb to transfer solutions.

EHLS strongly recommends that each individual laboratory prepare a written chemical hygiene plan in accordance with the OSHA *Occupational Exposure to Hazardous Chemicals in Laboratories* 29 CFR 1910.1450. A chemical hygiene plan includes standard operating procedures to ensure safety, verify proper functioning of equipment and steps for working with particularly hazardous substances. Laboratory operating procedures for work with biological agents or radioactive material should also specify required practices to ensure exposure is minimized.

3.3 Personal Protective Equipment (PPE)

Personnel in every laboratory must have access to Personal Protective Equipment (PPE) appropriate for the hazards present. Appropriate PPE should be determined by the Principal Investigators or designee in consultation with EHLS. The Principal Investigators or designee must ensure that all Laboratory Personnel, including visitors, wear appropriate PPE where chemicals or hazardous materials are stored or used. Wearing appropriate PPE and practicing good personal hygiene, as described below, will minimize exposures to hazardous chemicals/biological agents/radioactive materials during routine use and in the event of an accident.

For additional details please see “Appendix 1 UH Laboratory Dress Code Policy” in the University of Houston Chemical Hygiene Plan.

Attire

Legs and feet must be covered by closed-toe shoes, long pants or skirts which fully cover the legs (no sandals, open-toed shoes, or shorts), long hair must be confined and loose clothing and jewelry must be secured before beginning work. Wear a properly fastened lab coat or apron specific for the hazards of the procedures performed in the laboratory. This includes, but is not limited to, using flame resistant clothing for use with pyrophorics, acid resistant protection when working with acids (especially HF or other strong acids), and protective items when working with hot or cold materials. The Principal Investigator or designee is responsible for enforcing the protective clothing needed.

Eye Protection

Safety glasses or chemical goggles must be donned before entering any wet bench laboratory including cell culture labs and any laboratory where soldering or machining/grinding occur. This applies to all Laboratory Personnel, visitors, and facility maintenance staff and contractors. Goggles are recommended when liquid chemical, biological or radioactive materials are used and splashes are possible. Safety glasses or goggles must be worn over prescription glasses and must be of a type intended to be worn over prescription glasses. The Principal Investigator or Designee will determine the level of eye protection required. All eye protection used must meet ANSI Z87.1 requirements. Safety glasses should be chosen to conform to the wearer's face and minimize gaps around the glasses. Prescription safety glasses are acceptable as long as they have side shields for splash protection and conform to the wearer's face. Consult EHLS for assistance in selecting proper eye protection.

Contact lenses offer no protection against eye injury and do not substitute for safety glasses and chemical splash goggles. They should not be worn where chemical vapors are present or a chemical splash or chemical dust is possible because contact lenses can be damaged under these conditions. If, however, an individual chooses to wear contact lenses in the laboratory, chemical splash goggles must be worn.

Special requirements for eye protection may exist for individuals using lasers. For details regarding laser lab eye safety, please refer to the UH Laser Safety Manual at http://www.uh.edu/ehls/research-lab/radiation-safety/manual/.

Face shields worn over safety glasses may be required for certain processes as determined by the Principal Investigator (PI) or designee. Full-face shields must be worn when conducting a procedure that may result in a violent reaction. Full-face shields with bottom caps to protect under the chin are preferred due to the tendency to raise the chin when a splash occurs.

Hand Protection

Gloves are essential when working with any type of hazardous substance. Never take used gloves out of laboratory. Always dispose of gloves properly. Never open doors with

gloves. Gloves are worn when handling infectious materials (two pairs may be appropriate at BSL2). The proper gloves will prevent skin absorption, infection or burns. All glove materials are not equally effective in protection from laboratory hazards. For example, latex examination gloves may provide sufficient protection against radiological or biological hazards, but may not be adequate to protect the hands from certain hazardous chemicals. To select the appropriate gloves, consult the Safety Data Sheet (SDS) of the chemical, the OSHA guideline Chemical Resistance Selection Chart for Protective Gloves, or contact EHLS for assistance.

Hearing Protection

Hearing protection will be provided for anyone working in an area where the sound levels exceed 85 dBa. Contact EHLS to measure noise levels, to recommend proper hearing protection, and to evaluate the need for noise reduction engineering controls.

Respirators

In a laboratory environment, respirators may sometimes be relied on if the engineering controls and laboratory design do not adequately limit the potential exposure to hazardous air contaminants. Individuals planning to use respiratory protection should contact EHLS for consultation. The proper type of respirator used should be based on a thorough analysis of the specific activity planned. EHLS will assist the respirator user in evaluating his or her individual circumstances. In addition, all individuals who wear respirators other than a dust mask must first be medically approved by a physician and then should be fit-tested by EHLS.

3.4 Laboratory Surveillance

1. Laboratory Personnel shall never perform any hazardous work when alone in the laboratory. At least two people should be present.
2. Undergraduate students, first-year graduate students, minors, volunteers must be supervised (watched) by an instructor (PI or the designee) at all times.
3. Never perform unauthorized work, preparations or experiments.
4. Use equipment and hazardous chemicals only for their intended purposes.
5. Never remove chemicals from the facility without proper authorization.
6. Practical jokes or other behavior that might confuse, startle, or distract Laboratory Personnel is not permitted.
7. When inserting glass tubing into stoppers, lubricate the tubing and protect hands from being cut in the event the tubing slips and breaks.
8. Use a certified fume hood whenever there is a possibility of poisonous or irritating fumes being emitted from the chemicals being utilized.

9. Never leave an experiment unattended while it is being heated or is rapidly reacting. Laboratory experiments must be placed in potentially low hazard condition before leaving them unattended.
10. Keep equipment away from the edge of the lab bench to prevent spillage. Chemical fumes in the front of the hood are not captured efficiently and can escape into the room. Chemicals must be kept at least 6 inches back from the edge of the air foil sill.
11. Support all beakers and flasks with clamps. Do not use cracked or chipped glassware.
12. Read all labels on chemicals carefully before using them in the lab. More see "Chapter 4.8.1 Chemical Handling and Labelling" and "Appendix 2 Hazardous Chemial Classification Systems" in University of Houston Chemical Hygiene Plan.
13. Report any accident/incident/near miss, however minor immediately. In the event of a chemical/biological agent/radioactive material spill which is beyond the capability of the Laboratory Personnel, please call the main number at 713-743-5858. For large spills/leaks, incidents involving injury or after hour incidents call 713-743-3333 or 911 from a campus phone and evacuate the area. For more information see Chapter 3.7 and 3.8 in this manual and also University of Houston Hazardous Waste Manual.
14. Be familiar with the location of emergency equipment - fire alarm, fire extinguisher, emergency eye wash and safety shower. Know the appropriate emergency response procedures.
15. Generally it is not good practice to return reagents to stock solution.
16. Room Lighting Laboratories shall be provided with light fixture on emergency power at the entrance/exit door. Hallway and corridor emergency light shall be provided based on the local code requirements.
17. Safety cautions on handling Candle/Open flame:
    - Open flames shall not be used in a Biosafety Cabinet.
    - Tie back long hair and roll up long sleeves when working near an open flame.
    - Confine loose clothing.
    - Do not reach across an open flame.
    - Know the location and proper use of fire blankets and fire extinguishers.
    - Use the proper procedures when lighting a Bunsen burner.
    - Turn off heat sources when they are not in use.
    - When heating with a laboratory burner, gently move the test tube over the hottest part of the flame.
    - Point test tubes away from yourself and others when heating substances in them.
    - When heating flasks or beakers over the laboratory burner, use a ring-stand setup with a square of wire gauze.
    - To avoid burns, do not handle heated glassware or materials directly.
    - Use tongs, test-tube holders, or heat-resistant gloves or mitts.
    - For heating, use glassware that is meant to be used for that purpose.

- Use a water bath to heat solids.
- Do not pour hot liquids into plastic containers.

18. Doors Restriction of access to the laboratory and animal facility:

- To ensure the safety and security of the UH community, short-term students and visitors, must not be exposed to any hazardous chemicals, biological agents or radioactive materials unless they are trained in safe operating procedures and familiarized with the safety plan of the laboratory. Non-essential visitors and children are not allowed access to laboratories where hazardous chemicals, biological agents or radioactive materials may be present.
- Doors to any laboratory containing a designated infectious agent must be posted.
- Laboratory doors must be kept closed when work is in progress.

19. Electrical hazards and outlet receptacles

The electrocution hazards of electrically powered instruments, tools, and other equipment are almost eliminated by taking reasonable precautions below. More information please contact Fire Marshal's Office at 3-5858.

- Electrical receptacles above counter tops within six feet of sinks, safety showers,or other sources of water, should have GFCI circuit protection.
- Avoid contact with energized electrical circuits.
- Only qualified electrical workers may install, service or repair electrical equipment.
- Electrical outlets should have a grounding connection and accept three-prong plugs. Multiple plug outlet adapters are not allowed.
- Learn the location of your electrical panels and shut-off switches so you can quickly disconnect power in the event of an emergency.
- Be sure to always leave at least a 3-foot clearance around electrical panels for ready access.
- Think about potential vapor/gas release from vapor-generating processes or chemical fume hoods if power is lost.
- Conduct a periodic inspection of laboratory electrical equipment to be sure it is in good condition.Check all electrical equipment for worn cords or loose plugs before using. Remove equipment from service if in poor condition and replace or have it repaired by a qualified repair person.
- Keep flammable materials away from electrical equipment. The equipment may serve as a source of ignition for flammable or explosive vapors.
- Receptacles providing power for equipment used inside a fume hood should be located outside the hood.
- Make sure that equipment used where flammable vapors may be present is specially rated to not produce sparks. Many household appliances such as

hot plates, vacuum cleaners, and drills don't meet this requirement so they should be used only under very controlled conditions.

- If refrigeration or freezing is needed, flammable materials should only be stored in explosion safe or explosion proof equipment. These do not contain any spark sources such as lights and switches.
- Do not plug heating mantles directly into a 110-volt outlet as they can overheat, leading to fire hazard. They need a variable autotransformer to control the input voltage.
- Be aware that if drying ovens are used to dry organic materials, vapors may accumulate inside the oven and/or escape into the lab atmosphere. Take care to prevent developing explosive mixtures in air by not drying organic materials that can create these conditions.
- Keep your work area dry. Carefully place power cords so they don't come in contact with water or chemicals. Contact with water is a shock hazard. Corrosives and solvents can degrade the cord insulation. Do not allow cords to dangle from counters or hoods in such a manner that equipment could be unplugged, fall or cords could be tripped over.
- Do not allow cords to contact hot surfaces to prevent melting insulation.
- Do not lift a piece of electrical equipment by the cord or pull the cord to disconnect from the outlet in order to prevent damage.
- No more than two high current draw devices such as ovens and centrifuges should be plugged into the same outlet to prevent an overloaded circuit. Overloading can lead to overheated wires and arcing. This can cause electrical shock injury and fire.
- Fuses and circuit breakers prevent over-heating of wires and other electrical components. This overload protection is useful for equipment that may be left on for a long time such as stirrers, drying ovens, vacuum pumps, Variacs, etc.
- Ground-fault circuit interrupters, or GFCIs, disconnect current if a ground-fault is detected and protect the user from electric shock. GFCI outlets or portable GFCIs are used near sinks and potentially wet locations. Keep electrical equipment (and yourself while you are using electrical equipment) away from water/chemical or their spills unless you are sure the equipment is rated for this type of use.
- Portable power supplies are commonly used in the lab. These devices are extremely high electrical energy sources and must be used carefully. Never attach an exposed connector such as an alligator clip to a power supply.
- Power cords must have grounding plugs (3 prong) and be properly insulated.
- Extension cords are not allowed in the laboratory for permanent use. The only exception is that electrical power surge protectors are allowed only for personal computers and their components.

3.5 Housekeeping and Maintenance

In the laboratory, keeping things clean and organized can help provide a safer environment. Keep drawers and cabinet doors closed and electrical cords off the floor to avoid tripping hazards. Keep aisles clear of obstacles such as boxes, chemical containers, and other storage items that might be put there. Avoid slipping hazards by cleaning up spilled liquids promptly and by keeping the floor free of loose equipment such as stirring rods, glass beads, stoppers, and other such hazards. Never block or even partially block the path to an exit or to safety equipment, such as a safety shower or fire extinguishers. Use the required procedure for the proper disposal of chemical wastes and solvents.

Supplies and laboratory equipment on shelves should have sufficient clearance so that, in case of a fire, the fire sprinkler heads are able to carry out their function. It is required that there is an 18 inch clearance to the ceiling to comply with NFPA codes for fire sprinkler systems and a 24 inch clearance in rooms which are not equipped with sprinklers. Minimizing the "stacking" of material will affect the water spray from the fire sprinkler head and may not put out the fire which may not contain the fire to one laboratory unit in the event of a fire. Contact the EHLS for information on required clearances.

The work area should be kept clean and uncluttered, with chemicals and equipment properly stored. Clean the work area upon completion of a task and at the end of the day. The custodial staff is only expected to perform routine duties such as cleaning the floor and emptying the general trash.

In preparation for any maintenance service such as fumehood repair, plumbing, electrical, etc, the Laboratory Personnel must prepare the laboratory before the maintenance personnel arrive. Whenever possible remove hazards that maintenance personnel may encounter during their work activities. For example, infectious agents, radioactive materials or chemicals must be moved to a secure area prior to initiation of maintenance work. Additionally, the Principal Investigator or Designee must inform maintenance personnel of the presence of any hazardous materials to which they might become in contact with during their work. EHLS recommends that maintenance personnel be escorted at all times while in the laboratory.

All contaminated work surfaces are decontaminated after completion of procedures, immediately or as soon as feasible after any spill of chemicals/biological agents/radiative materials, blood or other potentially infectious materials, and at the end of the work shift.

Protective coverings (e.g., plastic wrap, aluminum foil, etc.) used to cover equipment and environmental surfaces are removed and replaced as soon as feasible when they become contaminated or at the end of the work shift.

All bins, pails, cans, and similar receptacles are inspected and decontaminated on a regularly scheduled basis. Any broken glassware which may be contaminated is not picked up directly with the hands.

3.6 Hazardous Waste Storage and Disposal

Individual users of hazardous materials have specific duties and responsibilities under state and federal law, state law, and university policy regarding hazardous waste handling and disposal. These responsibilities include hazardous waste identification and waste minimization as well as proper waste storage and disposal. EHLS is charged with the responsibility for ensuring that hazardous waste generated on campus is disposed of in accordance with all applicable regulations. More information please see UH Hazardous Waste Manual.

Hazardous waste must be handled through the EHLS hazardous waste program generated unless an approved protocol for on-site treatment or recycling is in place. This process is onerous and forms intensive, and the generator must complete the UH Hazardous Waste Pickup Request Form online to facilitate EHLS removing and safely handling the waste.

All waste must be labeled properly. Container labels must match the information which appears on the hazardous waste pickup request form. Hazardous waste containers shall be labeled as required in the Hazardous Waste Manual as soon as waste is introduced to the container.

All sharps are discarded immediately after use in sharps containers located in each work area.

Biomedical and biohazardous waste other than sharps is placed in appropriate containers that are closable, leak resistant, labeled with a biohazard label during storage. Prior to requesting pickup, all waste must be transferred in closed bags or containers to EHLS-provided containers. Containers must be securely closed prior to removal. EHLS-provided containers shall be stored in a manner to prevent contamination of the outside of the container, with any exceptions or incidences of contamination reported to EHLS immediately.

All waste must be packed in sturdy, compatible containers weighing no more than 50 pounds. Containers must be in good condition and compatible with the chemicals they contain. EHLS is unable to accept containers that are damaged or show evidence of leakage as regular hazardous waste for pickup. These containers are treated as potential spills or releases and treated accordingly if discovered, including reporting to the appropriate Dean or Department Chair. Containers should not be consolidated into boxes or other packaging.

3.7 Spills

Spill Kits

Each laboratory is required to purchase and maintain the required spill kit(s), as needed. Principal Investigator is responsible for the purchase, proper stocking, and maintenance of

spill kit supplies specific to the hazardous substances used or stored in the laboratory. Laboratory Personnel is responsible for maintaining knowledge and understanding of spill kit contents, location and use.

General Spill Kit – A spill kit that contains items to control most manageable chemical spills. The kit typically includes Personal Protective Equipment (PPE), absorbent materials (Vermiculite or Litter box filler), neutralizing agents for acids and caustics, clean-up materials (i.e. tongs, Plastic scoop,plastic trash bags, a backet, etc.) and waste label, as specified in Chemical Spill Procedures.

Some substances that require additional spill kit supplies outside of the requirements of a general spill kit (i.e. mercury, hydrofluoric acid, and radioactive materials). More information see Chemical Spill Procedures in Appendix A.

Important Procedures for Spills

It is the responsibility of each individual using hazardous material to become familiar with the emergency response procedures, if any, which govern his or her facility.

The following general rules (also can be found in UH Hazardous Waste Manual) should be followed in the event of a major (i.e. greater than 5 gallons of a typical solvent; much less for more toxic materials) hazardous materials spill or other emergency.

1. ACTIVATE FIRE ALARM, IF NECESSARY, FOR THE BUILDING
Be familiar with the sound of the alarm system in your facility. If the incident could threaten the health of individuals in the building activate the alarm.

2. CALL FOR HELP, AND CALL THE UNIVERSITY DPS, IF NECESSARY, 911
Get as much information as you can about the chemical. If possible, locate a Safety Data Sheet (SDS). Be sure the UHDPS have been accurately informed as to the nature and location of the spill, and whether there are injuries requiring the assistance of an ambulance. UH DPS will contact Environmental Health and Life Safety.

3. ATTEND TO LIFE-THREATENING INJURIES
The primary concern in the event of an emergency is to protect life.

4. PREVENT ACCESS TO THE AREA
Barricades of some sort should be set up to prevent inadvertent access to the area of the spill. This action may be necessary to prevent injury and to control the spread of contamination.

5. CONTAIN THE SPILL TO PREVENT RELEASE TO THE ENVIRONMENT
If the spill can be safely contained, prevent release to the sanitary sewer system, the storm sewer, and/or the ground. Do not jeopardize your own safety.

6. INITIATE MATERIAL SPECIFIC CLEAN-UP PROCEDURES
EHLS will assist in spill cleanup beyond the capabilities of Laboratory Personnel. However, accountability for the spill and disposal of spill residue belongs to the individual or department.

3.8 Accident & Incident/Near Miss Reporting

1. For Accidents involving injuries:
   - Report to EHLS Department at 713-743-5858
   - Also file report of First Injury with Risk Management 713-743-0414

2. For accidents involving Property Damage
   - Notify Risk Management at 713-743-0414

3. For Workplace Incidents or Near Misses
   - Notify EHLS at 713-743-5858 or email at ehs@uh.edu

4. For Emergencies, call UHPD at 713-743-3333.

3.9 Inspections

EHLS performs laboratory safety inspections routinely to ensure that adequate safety equipment is available and functioning, personal protection is available, chemicals, biological agents or radioactive materials are properly used and stored, SDSs are readily accessible and good housekeeping is being practiced. Inspections may be performed more frequently as deemed necessary by EHLS. Follow-up inspections will be performed as necessary, to confirm completion of corrective actions. During routine surveys conducted by EHLS, the reprensentative will talk with the Principal Investigator, Designee or Laboratory Personnel and ensure they have no specific safety concerns. If Principal Investigator, Designee or Laboratory Personnel raise concerns, the EHLS representative will make every effort to address the issue either personally, by way of a Safety Manager, or the Director.

Internal housekeeping and chemical hygiene inspections shall be conducted by the Principal Investigator or Designee at least quarterly. Refer to the format used in the EHLS inspections.

4.0 STANDARD LABORATORY CONTROL MEASURES

Laboratories on campus are designed to limit specific hazards in a controlled environment. Once new hazards are introduced into a laboratory environment, the laboratory may need to be modified in some respect to mitigate or avoid an undesirable or adverse condition arising from the new hazard. There are a variety of facility designs and engineering controls that can be utilized in a laboratory to control chemical or biological hazards. Engineering controls consist of various measures for reducing a hazard at its source or for separating personnel from the hazard. Engineering controls might consist of isolating a particular chemical operation, enclosing a potentially explosive reaction, or utilizing local exhaust such as a fumehood for an operation which produces airborne chemicals. Since engineering controls function to reduce or eliminate a hazard at its source or before it is created, they should be fully considered whenever possible as the first step in chemical or biological control measures within the laboratory.

It is the responsibility of the Laboratory Personnel to become familiar with the specific functions and proper use of the control measures provided in the laboratory. However, the Principal Investigator or the Designee is responsible for ensuring that the facility engineering controls are functioning properly at all times. Any malfunctions in the safeguards should be reported to Facilities Management by calling 713-743-4948 (FIXIT) or submitting a service order via FIXIT Facility Work Order System.

4.1 Ventilation

The importance of clean uncontaminated air in the laboratory work environment is well known. Ventilation controls should be readily available and easily accessible to ensure that the laboratory air is continuously replaced and that concentrations of toxic substances do not increase during the workday. Additionally, the ventilation system should ensure that the toxic substances are not recirculated from laboratory to laboratory or within the building. There are two main types of ventilation systems, HVAC and local ventilation.

1. Heating, ventilation and air conditioning (HVAC) systems are designed primarily for temperature, humidity, and air quality.
2. Local exhaust ventilation systems are designed to remove the contaminants generated by an experiment or device to the exterior of the building.

It is the responsibility of the Principal Investigator or Laboratory Personnel to immediately report any problems with the local ventilation systems (i.e. fume hoods) in the laboratories to Facilities Management (3-4948). EHLS should be contacted regarding any concerns on biosafety cabinets.

4.2 Safety Equipment

All laboratories should be equipped with safety showers, eyewashes, and appropriate fire extinguishers. Adequate ventilation, wash sinks, and approved waste disposal receptacles are also necessary. All of these should be conveniently located, properly maintained, and frequently tested. Special consideration should be given to ensure accessibility to safety equipment as well as ease of evacuation of physically disabled individuals.

Ladder or Step Stool

To make chemicals and other items readily accessible and to reduce accidents caused by overreaching, do not store materials on shelves higher than 5 ft (~1.5 m). If retrieving materials stored above head level, use a ladder or step stool of approapriate height.

Fume Hoods

Laboratory air flow should be balanced at the time of fume hood installation to achieve designed fume hood face velocities and uniformity of airflow patterns. To assure the safety of the fume hood user, the following guidelines for fume hood use should be observed:

1. Observe notices posted by Building Maintenance/Building Coordinators specifying schedules for shutdown of fume hood exhaust fans for routine maintenance and/or repairs.
2. Ensure working condition of exhaust fan prior to fume hood use.
3. Always wear proper personal protetive equipment (gloves, safety glasses and a lab coat) when working at or near the fume hood.
4. Remove all items from the fume hood which are not necessary for the immediate operation or experiment.
5. Place all equipment necessary for the performance of experiments at least six inches inside the front face of the fume hood.
6. Perform all work that will release noxious vapors, fumes or aerosols at least six inches inside the front face of the fume hood.
7. Limit the quantity of chemicals and/or number of activities conducted within the fume hood that have potential for creating an explosion or fire situation.
8. Place the fume hood sash at the proper working height for procedures involving the handling of hazardous materials within the fume hood area. Typically this is 18 inches.
9. Do not use the fume hood for handling and/or storage of hazardous materials during scheduled periods of fume hood maintenance and/or repair.
10. Submit fume hood modification plans to Facility Planning and Construction and EHLS for pre-approval. Unauthorized modifications to fume hoods, fume hood exhaust ducts or fume hood exhaust fans are prohibited.

Laboratory fume hoods should be inspected for proper operation and adequate face velocity annually and after maintenance/repair or adjustment. A fume hood sticker with information indicating date of inspection, expiration date, the inspector, face velocity of the fume hood, approved use, and approved sash working height will be attached in a prominent location on the front of the fume hood after completion of each inspection by EHLS personnel.

A standard evaluation form will be used by EHLS for all fume hoods. The completed form will be used to document that the fume hood is functioning properly, needs adjustment, or has other problems. The laboratory fume hood guidelines can be accessed on EHLS website.

Hand Wash Stations

Principal Investigators or the designee should designate an area in the laboratory for a hand wash station. These areas are usually located in one or two of the sinks in the laboratory. The hand wash stations should be properly labeled and equipped with soap and towels.

These stations should be utilized by individuals who come in contact with chemical, biological, or radioactive agents in the laboratory. Everyone who works with hazardous agents on a routine basis should wash their hands before and after using the agents using soap. The stations MUST never be used to dispose of hazardous waste. (*Example*: do not pour chemical, biological, or radioactive material down the drains). It is the responsibility of the Principal Investigator or Designee to ensure that the handwash stations are available, accessible and properly equipped at all times.

Safety Showers

Each laboratory area should be accessible to a safety shower. The ANSI/ISEA Z358.1-2014, *Emergency Eyewash and Shower Equipment*, requires that emergency showers be located no more than 10 seconds in time or greater than 55 feet from the hazard. The shower must be readily accessible, be kept clear of obstructions, and clearly labeled. The valve must open readily and remain open until intentionally closed. Although an associated floor drain is desirable, its absence should not prohibit installation of a safety shower. EHLS will be responsible for inspecting the safety showers on a regular schedule.

Eyewash Stations

Eyewash stations must be easily accessible from any location in the laboratory. When possible, all laboratory users should practice activating the eyewash stations. While EHLS prefers permanent station with plumbing, a hand-held portable eyewash station is better than no station at all.

Eyewashes, like safety showers, must be located no more than 10 seconds or greater than 55 feet in distance from the hazard. Their location should be clearly labeled. The ANSI standard Z358.1 requires that eyewashes be activated weekly. It is the responsibility of the Principal Investigator or Designee to ensure that all eyewash units are checked on a weekly basis.

Fire Extinguishers

Fire extinguishers are very important component of safe laboratory operation. Each laboratory should be equipped with the appropriate type for the expected fire emergency and be capable of immediate utilization. Currently EHLS is utilizing multi-purpose (Class ABC) extinguishers for the majority of laboratories on campus. Labs using combustible metals must have an appropriate Class D fire extinguisher in the lab to fight a combustible metal fire.

The basic operation of fire extinguishers is covered in the online General Laboratory Safety Training. All fire extinguishers, excluding specialty fire extinguishers, will be installed, maintained, and inspected by Fire Marshal's Office. Specialty fire extinguisher maintenance and inspection are the responsibility of the lab or the college.

Safety Containers for Flammable Liquids

An approved container with a spring-closing lid and spout cover should be used to store flammable and combustible liquids. The safety container is designed so that it will safely relieve internal pressure when subjected to fire exposure. The safety container utilized in the laboratories must not exceed 19 Liter (5 gallon) capacity.

These general safety practices must be followed by every individual working with flammable liquids in the laboratory.

- Chemicals in safety cans must be stored in designated storage areas in the laboratory. Storing safety cans in the laboratory work areas, on the floor, or in the hallway is unacceptable.
- All flammable liquids must be stored in a laboratory storage area that protects the material from sources of ignition.
- The safety container lid must be kept closed tightly except when adding or removing liquid flammables.

Flammable Storage Cabinets

The safe storage of flammable materials should always be provided in a laboratory environment. There must also be adequate security provided at all times to prevent unauthorized access to flammable chemicals. Storage facilities and equipment must be stable and secure to prevent sliding or collapse, and not subject to flooding. The purpose

of flammable storage cabinets is to protect the chemicals it holds from the heat and flames of external fire rather than to confine burning liquids within. A UL-Listed flammable storage cabinet that meets NFPA 30 Guidelines on Flammable Liquids must be used to store flammable materials. Quantities for storage are based on flammable class and location within the building.

In all laboratory work with flammable liquids the requirements of 29 CFR 1910. 1450, NFPA 30, and NFPA 45 shall be followed. EHLS has the current versions of these codes for persons wishing to review the documents. More information please contact Fire Marshal's Office at 3-5858.

Corrosive Storage Cabinets

Corrosives should be kept in corrosive storage cabinets specifically designed to hold them. Do not store corrosives in flammable storage cabinets because they are not coated with an epoxy enamel to guard against chemical attack. Polyethylene trays may be used to collect small spills and to provide additional protection from corrosion for the shelves.

Compressed Gas Cylinder Cabinets

Cylinders containing the compressed gases listed must be kept in a continuously, mechanically ventilated enclosure. For more information please see Appendix B.

Biological Safety Cabinets

A biological safety cabinet is used to provide containment of infectious splashes or aerosols generated by many microbiological procedures. They are three types of biological safety cabinets (Class I, II, III) used in microbiological laboratories. Class I and II biological safety cabinets are primary barriers which offer varying levels of protection to Laboratory Personnel and to the environment (when used with good microbiological techniques). For additional information please refer to the EHLS Biosafety Manual.

Autoclaves

Autoclaving usually is considered to be the method of choice for decontaminating cultures, laboratory glassware, pipettes, syringes, or other small items known to be contaminated with infectious agents. The location of the autoclave within the laboratory minimizes storage and transport problems. It provides a technically proved treatment method for rendering infectious material safe. Autoclaves must be loaded carefully to allow the steam to penetrate the wrapping, since the steam has to contact the pathogens in order to destroy the hazard. The length of time required for sterilization of biological

material is determined by the quantity of the load, the volume of liquid in the load, and the density of the material. Safe work practices when utilizing an autoclave include the following:

- Steam Sterilization (Autoclave): Steam sterilization utilizes pressurized steam at 250 to 270 °F (121 to 132 °C) to kill pathogenic organisms that are present in the infectious . waste. Steam sterilization process. does not destroy the waste. Instead, it renders it noninfectious.
- Properly sterilized waste can be disposed of in the regular trash after placing the autoclaved bag containing the waste in a regular black household garbage bag.
- Standard operating procedures must include the following criteria:
- The proper bags must be utilized.
- The temperature of the autoclave must be at least 121°C (250°F).
- The pressure must be at least 15 psi.
- Waste must be treated for a minimum of 45 minutes.
- A sterilization indicator strip that changes color when operating parameters are achieved should be run with every cycle.
- Routine biological monitoring using the appropriate Bacillus species should be conducted.
- Biological indicators can be in the form of either an ampule or strip containing the spore Bacillus stearothermophilus.
- All autoclaves should be tested at least once a month.
- For those autoclaves in which a continuous read out of operating procedures is available, routine parameter monitoring can be substituted for biological monitoring.
- Once the waste has been treated, it should be double bagged in 2 ml thick black
- Treated waste can then be disposed of into a municipal solid waste landfill.

Refrigerators

Refrigerators procured for the purpose of flammable materials storage must be in compliance with the specifications for a Flammable Materials Storage Refrigerator as described in the NFPA 45, "Fire Protection for Laboratories Using Chemicals**."**

Domestic refrigerators may be used for the storage of flammable liquids when properly modified and listed. An independent testing agency tests and certifies the refrigerator for the storage of flammable liquids. Any PI that decides to modify a domestic refrigerator for the storage of flammable liquids **MUST** have that unit independently tested by a testing agency and certified for its new use. If the PI cannot prove this was done the refrigerator must be taken out of service and replaced with a refrigerator listed for the storage of flammable liquids. Fire Marshal's Office shall be contacted prior to modifying any domestic refrigerator.

Refrigerators that have been modified without obtaining prior approval from Fire Marshal's Office that does not meet current codes shall be placed out of service.

4.3 Activities Subject to Approval

Principal Investigators must identify those activities which warrant prior approval before initiation by Laboratory Personnel. These include work with potentially biohazardous materials, radioactive materials, lasers, animal research, dangerous drugs and controlled substances, UH Controlled Chemicals and human subject research listed on Addendum B for Requisitions.

Radiation Safety Committee

Users of radioactive materials and radiation producing devices such as x-ray machines or lasers must be authorized by the Radiation Safety Officer and the Radiation Safety Committee. Principal Investigators are issued sublicenses and/or subregistrations citing specific approvals and conditions for work with radiation. The Radiation Safety Committee must also approve all structures and laboratories in which the use of radioactive material or radiation producing devices are planned.

Specific approvals required from the Radiation Safety Committee and/or Radiation Safety Officer regarding work with radiation are detailed in the EHLS Radiation Safety Manual .

Biosafety Committee

The Institutional Biosafety Committee (IBC) reviews the scope of all proposed research including those involving recombinant/synthetic DNA, human or non-human primate tissue, blood or other potential infectious materials, and select agents or bio-toxins, which are conducted and are supported by the university, ensuring that they are in compliance with NIH guidelines prior to approval. Information and forms are available from the EHLS Biosafety Manual.

Elements of review include, but not limited to:

- Classification of agents
- Risk assessment/management
- Assessment of experimental design, including procedures, practices, facilities, and training requirements for all laboratory personnel.
- Approving proposed use of biohazardous agents
- Containment requirements and safety plan development

The following guidelines have been adopted as the minimum safety standards for research involving biological agents and materials at the University of Houston:

1. Biosafety in Microbiological and Biomedical Laboratories, U.S. Department of Health and Human Services, Public Health Service Centers for Disease Control and National Institutes of Health, HHS Publication No. 93-8395.
2. NIH Guidelines for Research Involving Recombinant DNA Molecules, Office of Recombinant DNA Activities.

Institutional Animal Care and Use Committee (IACUC)

The Institutional Animal Care and Use Committee (IACUC), as mandated by federal law, oversees and evaluates all aspects of the institution's animal care and use program. The IACUC assures that animal research conducted at the University of Houston remains in full compliance with federal, state and local regulations and institutional policies. http://www.uh.edu/research/compliance/iacuc/

Animal & Human Subjects

It is the responsibility of each Principal Investigator to identify all research involving the use of human beings as subjects of research and register the research protocol with the Committee for the Protection of Human Subjects. Information and forms are available from the Research & Intellectual Property Management Division.

Visitors/Minors Working on UH Campus

Persons working in the laboratory who are not affiliated with the University must be registered with EHLS by completing either the Visiting Researchers or Minors in laboratories application prior to performing lab activities. Persons intending to visit the laboratory for more than one day for purposes of gaining academic or research experience must apply either as a Visiting Researcher or Minor working in UH laboratories. Application forms can be found on EHLS website.

Dangerous Drugs and Controlled Substances

Certain drugs and controlled substances (i.e. narcotics) are regulated by the Drug Enforcement Administration (DEA). Researchers who desire to work with these substances must secure permission from the DEA. The DEA regulations require that licensed researchers have a separate DEA registration for each location where controlled substances are received, stored or used. More information please refer to UH Guidelines.

Hazardous Substances on Addendum B

EHLS shall be contacted for the requisitions with hazardous substances listed on "Addendum B for Requisitions". The completed Addendum B, purchase requisition, and related paperwork (vendor quote, etc.) must be scanned and emailed to ehs@uh.edu for EHLS approval. No container shall be accepted without an adequate identifying label. Delivery must be refused for leaking containers.

5.0 SAFE HANDLING REQUIREMENTS IN THE LABORATORY

Operational requirements for safe handling of chemicals in the laboratory when followed, will greatly reduce the chance of an accident due to human error. Operational requirements such as hazard identification, labeling, and specific chemical category requirements are required by state and federal laws.

It is the responsibility of each Laboratory Personnel to become familiar with the safe handling requirements in the laboratory described in this section. However, the Principal Investigator is responsible for ensuring their employees have sufficient knowledge to avoid recognized hazards in their laboratory.

The National Research Council published *Prudent Practices in the Laboratory, Handling and Disposal of Chemicals* which describes a minimum standard of care in a laboratory.

5.1 Hazard Identification

EHLS requires that flammable liquids, toxic chemicals and highly reactive chemicals must be handled in a manner which poses no substantial hazard to human health and will not be deliberately discarded with the general waste or by any route into the sanitary sewer system.

The Texas Hazard Communication Act requires the employees utilizing a hazardous chemical receive Hazard Communication (HAZCOM) Training. Contact EHLS for initial HAZCOM training, which is included in the General Laboratory Safety Training, that is manadatory for all Laboratory Personnel. The Texas Hazard Communication Act gives employees the right to be informed about hazardous chemicals in the work place, to have access to information regarding the hazards associated with those chemicals, and to be trained in safe work practices.

While chemical hazards are probably the most widely recognized in the laboratory environmental there are other potential hazards which need to be identified. These include biological, radioactive, electrical, mechanical and physical hazards. It is important that all potential hazards in the laboratory environment be evaluated and controlled as much as possible.

5.2 Labeling

There are generalized labeling practices that have been established to protect laboratory Laboratory Personnel from physical and health hazards associated with working with hazardous chemicals. Additional information on labeling is covered on “Chapter 4.5 Labelling and Signage” in University of Houston Chemical Hygiene Plan and also HAZCOM Training.

5.3 Chemical Storage and Segregation

Chemicals must be stored by compatibility, not by alphabetical arrangement. Separate chemicals into organic and inorganic families and then into related and compatible groups. Suggested chemical storage schemes and compatibility lists can be found in a number of lab safety resources available from the National Institute of Occupational Safety and Health (NIOSH) website and "4.8 Handling, Storage & Segregation of Chemicals" and Appendix 3 in University of Houston Chemical Hygiene Plan. A quick and very general rule of thumb is to separate inorganics from organics, flammables from oxidizers (including gases as well as liquids), acids from bases, and reactives from air or water.

5.4 Compressed Gas Hazards

Compressed gas cylinders are under great pressures, often exceeding 2000 pounds per square inch or 136 atmospheres. To prevent the accidental and uncontrolled release of energy it is important to protect cylinders from toppling over and rupturing the valve stem. All compressed gas cylinders, including lecture bottles, "empty" cylinders, and cylinders in transit, must be secured in racks, clamping devices, stands, or other protective structure. Cylinder valves must always be protected with the standard safety caps when not in use (empty or full). Compressed Gas Cylinder Safety online training is available on UH website. This class is mandatory for all UH Laboratory Personnel who handle compressed gases.

5.5 Radiation Hazards

Radioactive materials emit energy that can cause varying levels of damage to human tissue depending on radiation dose, body location, health of the individual, exposure rate, and other factors. Chronic exposure to radiation may result in late health effects such as cancer, while acute exposure may result in both late effects and/or early effects such as radiation sickness or cataracts. X-ray machines also have the potential to produce high intensity ionizing radiation beams and/or backscatter radiation fields that can deliver radiation dose to individuals operating the units.

Class 3b and 4 lasers produce a beam of amplified light (non-ionizing radiation) that present a hazard to the skin and eyes through thermal or pressure wave interactions. The retina and cornea in the eyes are especially vulnerable to injury from direct, reflected or scattered laser light at certain wavelengths.

The guiding safety principle in radiation protection for minimizing dose from radioactive hazards is ALARA (As Low As Reasonably Achievable), which emphasizes reducing time near radiation sources, maximizing distance from radioactive sources, and employing

shielding controls when possible. Safety guidelines for working with radioactive materials, x-ray machines and lasers are provided in the UH Radiation Safety Manual .

5.6 Biological Harzards

All biohazard laboratories must establish written emergency procedures based on the biohazardous agents used as well as other hazards that may be present. Emergency procedures must take into consideration the use of radioactive materials and chemicals. These procedures must be outlined in your approved MUA.

6.0 EMERGENCY AND MEDICAL PROCEDURES

An emergency situation is declared if an equipment malfunction release or spill of a hazardous substance occurs that poses a significant threat to the health and safety of the faculty, staff, or students in the vicinity of the release.

The most important fact to remember in an emergency situation is to remain calm. Step away from the incident momentarily, to access the magnitude of the situation and to determine the following information:

- *Is the situation life threatening?*
- *Are there people injured?*
- *Is there a persisting danger (Example: fire)?*
- *What agent caused the emergency situation (biological, chemical, or radiological)?*

Once this information is ascertained, notify the campus police department by dialing 911 from campus phone or 713-743-3333. Instruct the police to send medical assistance if injuries have occurred. If minor injuries occurred due to the incident, the injured person should seek medical attention as soon as possible. EHLS should be notified of any hazardous substance release or spill.

6.1 Basic Emergency Response

Major Release

1. Assess the situation
2. If there is an immediate danger to life and health call 911
3. Pull the fire alarm and evacuate the area immediately
4. Evacuate and secure the area as much as possible without risking injury
5. Assist emergency responders by giving as much info as possible upon their arrival
6. Record events as much as possible for post emergency response work

Controllable Release

1. Notify all personnel in the vicinity of the spill or release
2. Confine spill or release as soon as possible
3. If personnel are contaminated, personnel decontamination should proceed immediately using proper techniques (Example: safety shower, eye wash)
4. Notify EHLS for assistance at (713) 743-5858

5. Collect contaminated materials and personal protective equipment (PPE) for waste pick up from EHLS.

6.2 First Aid Kits

Every laboratory is required to have a first aid kit, with its location known to all Laboratory Personnel. A first aid kit in a hazardous chemical laboratory should follow recommendations in below table from the American National Standards Institute (ANSI/ISEA Z308.1-2015)

ITEM	MINIMUM QUANTITY
Absorbent compress, 32 sq. in.	1
Adhesive bandages, 1 in. x 3 in.	16
Adhesive tape, 3/8 in. x 2.5 yd. total	1
Antibiotic treatment,0.14 fl. Oz. (0.5 g)	6
Antiseptic,0.14 fl. Oz. (0.5 g)	10
Burn treatment, 1/32 oz. (0.9 g)	6
First-aid guide	1
Medical exam gloves	2 pairs
Sterile pads, 3 in. x 3 in.	4
Triangular bandage, 40 in. x 40 in. x 56 in.	1

Hydrofluoric acid is a strongly corrosive chemical. HF readily penetrates the skin and mucous membranes, and can cause deep tissue destruction. HF First aid kit is a must-have kit for all the locations where hydrofluoric acid is used or stored or other possible exposure to the fluoride ion can occur.

HF first aid kit must contain Calgonate®Gel which contains 2.5% calcium gluconate and one (1) roll of calcium carbonate tablets (TUMS®).

6.3 Injury and Illness

For medical treatment due to an injury received in a laboratory environment, the affected person must seek immediate medical attention and report the injury to the Workers Compensation Coordinator Claim Coordinator within 24 hours of the incident.

For minor injuries first aid kits should be accessible and fully equipped for use. The first aid kits should be periodically checked by the Principal Investigator or designee to ensure the availability of proper first aid treatment supplies in case of an accident. It is the Principal Investigator's responsibility to:

1. Always have the first aid equipment readily available and ensure the contents within expiration date.
2. Keep essential supplies in the first aid kit at all times.

3. Ensure all Laboratory Personnel know the location of the first aid kit.

It is the responsibility of Laboratory Personnel to notify the Principal Investigator or Department Chair if they become ill or injured from exposure to any chemical, biological, or radiological agent utilized in the laboratory. The Principal Investigator or designee, Department Chair or an individual acting on their behalf the day the incident is reported should:

1. Document the work related injury or illness.
2. Ensure that the injured person(s) receive prompt medical treatment.
3. Report the illness or injury to the Workers Compensation Claim Coordinator within 24 hours.

EHLS prefers that all incidents be reported, even those which do not result in injury, if there is a potential for personal injury in the future. For more information please see 3.8 Accident & Incident/Near Miss Reporting.

6.4 Medical Consultation and Examinations

An opportunity to receive medical consultation shall be provided under the following circumstances: if an employee develops any symptoms thought to arise from chemical overexposure; after an event such as a major spill, leak or explosion which may have resulted in an overexposure; or, if an overexposure is identified as the result of an evaluation of the facility by EHLS.

These suspected or actual exposures requiring medical evaluation can and should be treated as a regular Worker's Compensation claim. A “Supervisor’s First Report of Injury” form should be filled out and signed by the supervisor and submitted to a the Risk Manager’s office within 24 hours. Additional employee injury forms are required to be completed by the employee and filed with Risk Management within 48 hours. Following notification of overexposure, arrangements for an appropriate medical examination by a medical provider within the University’s certified medical network, (Injury Management Organization) must be completed before the exposed individual may return to work. If an emergency situation exists, treatment at any hospital emergency center will be accepted.
Any medical examination required by this Chemical Hygiene Plan shall be provided without cost to the employee provided the University’s workers compensation administrator determines the exposure is directed related to the employee’s employment.

Appendix A – Chemical Spill Control Procedures

INTRODUCTION

There are numerous different chemicals used throughout the University of Houston on daily basis. These chemicals are used in a variety of settings such as laboratories, building maintenance operations, construction/renovation projects and so forth. The range of individuals using chemical substances at the University also varies greatly from students, faculty, staff and contractors.

Each chemical user should consult the Safety Data Sheet (SDS) for the specific chemical that he/she plans to work with and consider response options in case of a spill or release *beforehand.* With the high level of chemical activity (i.e. laboratory use, plant operations functions etc.) around the campus there is a high probability that a "spill" will occur. These general controls are designed to aid the users in responding to small spills in which the user has a thorough knowledge of the chemical substances and there is no immediate threat to the safety and health to the user or others in the vicinity.

However, in the event of a spill or a release of any compound that the user can not control or has any concerns about controlling he/she should immediately call Environmental Health and Life Safety (EHLS) for assistance.

Contact EHLS during business hours: Monday through Friday from 8:00 am till 5:00 pm at (713) 743-5858.

At any other time call the UH Police at 911 for Emergencies and (713) 743-3333 for Non-emergencies

Spill Response Kit Availability

The University of Houston Research Stores located Lamar Fleming building, Room 70 (basement) has several spill response kits available that users may want to utilize in their specific chemical area.

As stated previously, users are expected to handle small spills (i.e. typically up to 5 gallons and 3 or less known chemicals involved) in a safe manner without assistance. The chemical response kits available from Research Stores are designed to handle these types of situations. These kits include the following:

Chemical Spill Kit Contents

ITEM	QUANTITY
5 Gallon Polypropylene or high-density polyethylene Bucket with top	1
Sock/Boom, 3" x 4 '	2
Spill Pillows, 2 liter	2
Disposal Bag	2
4H Gloves, Size 11	2 pair
Nitrile Gloves	2 pair
Safety eyewear	2 pair
Tyvek QC Coveralls, XL	2
1 Quart Scoop	1
Scraper	1
4 lb. Citric Acid (for basic spills)	1
4 lb. Sodium Sesquicarbonate (for acidic spills)	1
5 lb. Vermiculite	1
Wipes	4
Litmus (pH) paper	1
Biohazard Bag	1
Biohazard Mask	2
Biohazard Gloves	4 pair
Biohazard Wipes	2
Hazardous Waste Label	2
Ziploc Bag	4

The EHLS recommends the following helpful hints when using this kit:

- Get help and bring your chemical spill kit to the actual site. This is a two-person operation.
- The responsibility of the second person is to stay clean and to hand the supplies as needed to the first responder. This person should also be ready to summon help if needed.
- Put on Nitrile or 4-H gloves.
- Put on safety goggles. They are not provided on the spill kit; however, you should have your own on site.

Depending on what chemical has been spilled you may need to wear a respirator with special filters. Read the SDS for the chemical spilled to see if this is recommended. A respirator is not supplied with the spill kit and if you have no training in the use of respirators you should seek outside assistance.

A spill response is not the time for your initial respirator use and training.

Another spill response kit available from Research Stores is the mercury spill kit. These kits include the following:

Mercury Spill Kit Contents

ITEM	**QUANTITY**
Zinc Shavings (Mercury Absorb)	**1 container**
Sponges	**4**
Safety Glasses	**1 pair**
Disposal Bag	**1**
Vinyl Gloves	**2 pair**

EHLS recommends the following helpful hints when using this kit:

- Inside the spill kit there is a box marked Hg Absorb Sponges. These sponges are for small mercury spills only.
- Use the Hg Absorb Sponges to remove small droplets of mercury from surface areas.
- Activate sponges before use by moistening with a small amount of water.

- Place the sponge, rough side up, on a level surface. The rough side of the sponge contains the active material which will amalgamate mercury forming a silvery surface.
- *Caution***:** Excessive water may reduce the ability of the sponge to pick-up mercury.
- Spread the water evenly with a gloved finger. After 1 minute the sponge is ready to use. Slowly move the sponge, activated side down, over the surface to be cleaned. The capacity of the sponge can be increased with a small amount of moistened Hg Absorb powder rubbed into the surface of the activated sponge.
- After finishing with the Hg Absorb Sponge, it should be stored in a plastic bag and disposed of through EHLS. Label spill with red and white Hazardous Waste label with contents name and date.

Hydrofluoric Acid (HF) spill kit

ITEM	**QUANTITY**
Copy of the HF Recommended Treatment Guide, HF Standard Operating Procedures, and Safety Data Sheet.	**1**
Calcium gluconate gel	**1 (25 g tube)**
Calcium carbonate tablets (TUMS®)	**1 roll**
Safety goggles	**2 pair**
nitrile or neoprene gloves	**2 pairs**
Aprons	**2**
Haz-Mat Boot Covers	**1 pair**
HF acid neutralizer	**1**
HF specific absorbent pads **(Caution:** silica such as sand, vermiculite, Floor-Dri or kitty litter must NOT be used)	**1**
pH test paper	**1 roll**
Heavy duty polyethylene bag	**2**
Waste label	**1**
5 Gal Bucket + lid	**1**

EHLS recommends the following helpful hints when using this kit:

HF is a unique inorganic acid and does not completely dissociate. Therefore, researchers should allow sufficient time for the neutralizing agents to neutralize the acid. Properly dispose of waste from HF cleanup work using polyethylene containers.

A spill containing HF should be neutralized with calcium hydroxide, calcium carbonate, or other magnesium salts.

- Spill kits containing silica such as sand, vermiculite, Floor-Dri or kitty litter must NOT be used because HF reacts with silica to produce a toxic silicon tetrafluoride (SiF_4) gas.
- Commercially available HF specific spill kits include spill absorbent materials such as 3M universal adsorbent, HF Acid-Eater (NPS Corp) or HF Spill Tamer (JT Baker/Mallinckrodt), Kolor-Safe® Kolor-Lock powder, and PIG® HF neutralizer. Silver shield gloves with inner double Nitrile gloves can be used for spill cleanup work.
- The HF spill kit should also include thick chemical resistant gloves (2 pairs, 14 mil or higher thickness), chemical splash goggles (at least 1), polyethylene bags (2 bags, 4 mil thickness). Commercially available spill kits may also include: HF spill adsorbent/neutralizer materials, 2 aprons, 2 pairs of gloves, hazmat boot covers, 2 pairs of goggles, MSDS and cleanup instructions.
- Calcium based neutralizers convert HF to an insoluble calcium fluoride salt.
- Small amounts of HF spill in the fume hood (<2 ml, 40% or less) can be absorbed using calcium carbonate antacid tablets (15 tablets, 500 mg each). Dilute the spilled area with water and then neutralize the acid cautiously using crushed tablets.
- **HF with concentrations greater than 40% will generate fumes in air.** Therefore, the spilled area must be carefully and rapidly diluted to less than 40% concentration with water and then neutralized using calcium hydroxide slurry or other commercial spill materials. The effectiveness of the neutralization should be checked with pH paper.
- HF cleanup waste should be collected separately and EHLS should be contacted for disposal.
- Researchers using boric acid for HF spill cleanup and neutralization should collect the resulting solution for disposal by EHS.
- **Any HF spill greater than 250 ml outside of a fume hood should be treated as a large spill.**
- Call 911 for any large spills (if the spill is greater than 250 ml HF outside of a fume hood).

Common Types Spill Responses

The following section is presented by the EHLS as reference material for the most common types of spills that occur around the campus. However, each spill is unique and you should only perform spill response actions to the level of your training. Call the EHLS or UH Police if conditions change or you need assistance.

Flammable liquids/organic solvents

There are many different organic solvents, most of which are flammable to some extent, used throughout the campus. If the spill is a flammable liquid or organic solvent:

- Use material in the spill kit marked Vermiculite. (Brown absorbent)
- Dike the spill and pour contents of the bag on the chemical spill.
- Completely cover the chemical, and allow the vermiculite to soak up the chemical completely.

If flammable, protect spill from spark and other sources of ignition. Vermiculite can be used to contain (dike) a chemical spill and used to soak up flammable liquids.

Acid/Base Spills

Typically, acid and caustic spills can be neutralized. Simple neutralization will reduce a large portion of the hazardous materials incident into a non-hazardous state. This is the simple element of neutralization. There may be a significant amount of heat generated and gases released (e.g. carbon dioxide). The ideal process is to accomplish this in a relatively controlled and anticipated environment. The *adaptable* concept described below is for a small to medium size spill of one to five gallons. The format may be enlarged to embrace larger spills by adding additional supplies, equipment and personnel.

Your unique situation may demand that you pre-plan how your department will react to small chemical spills. We recommend that you try to keep the plan and process as simple as you can. However, please note strong bases (e.g., sodium hydroxide and potassium hydroxide) should not be used in the neutralization process of strong acid. Likewise, strong acids (i.e. hydrochloric acid and sulfuric acid) should not be used in the neutralization process of strong bases.

The first step is to determine the pH of the spilled substance. This can be done by using the pH paper in the chemical spill kit.

Using the pH paper

- Tear off a strip (3 to 4 inches long)

- Dip the pH paper into the liquid that has spilled
- Check the color chart that is located on the pH paper tape dispenser

If pH paper is **RED**

- Use material in the bag marked Sodium Sesquicarbonate
- Dike the spill and pour contents of the bag on the spill
- Cover the chemical completely
- Leave the immediate area and wait 10-15 minutes to allow complete neutralization

Recheck the pH to see if neutralization has been reached. If not, repeat steps until neutralization is complete. You want a pH level between 6 and 8.

If pH paper is **BLUE**

- Use material in the bag marked Citric acid.
- Dike the spill and pour contents of the bag on the spill.
- Cover the chemical completely
- Leave the immediate area and wait 10-15 minutes to allow complete neutralization.

Recheck the pH to see if neutralization has been reached. If not, repeat steps until neutralization is complete. You want a pH level between 6 and 8.

Common Neutralization Reactions

Here are some common neutralization reactions that the responder may utilize during a spill response:

- *For acidic solutions*
  Add (sodium sesquicarbonate) to solutions whose pH is between 0 and 6.

$$HCl + SodiumSesquicarbonate = Heat + CO_2 + Salt + H_2O$$

- *For caustic or alkaline solutions*
  Add (citric acid) to solutions whose pH is between 8 and 14.

$$SodiumHydroxide + CitricAcid = Heat + Salt + H_2O$$

<u>Disposal</u>

After the immediate spill response effort has brought the situation back under control it is time to clean up the area and consolidate the spilled materials into a container. The container should be labeled and dated. Used gloves and other contaminated material should also be placed in a container (i.e. bag, pail etc.) and labeled with the contents and date.

Arrange EHLS Hazardous Waste Pickup by requesting on EHLS's website. These procedures are outlined in the University of Houston Hazardous Waste Manual.

Appendix B – Compressed Gas Cylinder Policy

Compressed Gas Cylinder Safety

The following must be followed for the transporting, storing, and handling and use of compressed gas cylinders.

Compressed Gas Cylinders Identification

1. The contents of any compressed gas cylinder should be identified clearly so as to be easily, quickly, and completely determined by any Laboratory Personnel.

2. A durable label should be provided that cannot be removed from the compressed gas cylinder.

3. No compressed gas cylinder should be accepted for use that does not identify its contents legibly by name.

4. Color-coding is not a reliable means of identification; cylinder colors vary from supplier to supplier, and labels on caps have no value because many caps are interchangeable.

5. Tags should be attached to the gas cylinders on which the names of the users and dates of use can be entered.

6. If the labeling on the gas cylinder becomes unclear or defaced so that the contents cannot be identified, the cylinder should be marked "contents unknown" and the manufacturer contacted regarding appropriate procedures.

Gas Cylinders Transportation

1. Cylinders transported by truck must be fastened securely in an upright position so that they will not fall or strike each other.

2. Cylinders should not be transported without safety caps. A cylinder's cap should be screwed all the way down on the cylinder's neck ring and should fit securely. Do not lift cylinders by the cap. The cap is for valve protection only.

3. Cylinders should not be transported with the regulator attached to the cylinder.

Compressed Gas Cylinders Storage

All compressed gas cylinders must be properly stored in compliance with OSHA, and NFPA code requirements. Cylinders internal pressure can reach over 2,000 psi. In the event of a container breach, the cylinder becomes a projectile hazard.

The following precautions must be taken for the storage of compressed gas cylinders.

1. Cylinders must be stored in a dry, cool, well-ventilated, secure area.
2. Cylinders shall not be allowed to drop nor be struck violently.
3. Cylinders shall be properly secured at all times whether attached to a wall, cylinder truck, cylinder rack, or post.
4. Liquefied flammable gas cylinders shall be stored in an upright position or such that the pressure relief valve is in direct communication with the vapor space of the cylinder.
5. Caps used for valve protection shall be kept on the cylinders at all times except when the cylinder is actually being used or charged.
6. Cylinders shall not be used for rolling, supports, or any purpose other than the transportation and supply of gas.
7. Cylinders shall be stored in a well-ventilated area away from flames, sparks or any source of heat or ignition. Keep cylinders away from electrical circuits.
8. Cylinders shall not be exposed to an open flame or to any temperature above 125 degrees F.
9. Oxygen cylinders (empty or full) in storage shall be separated from fuel-gas cylinders or combustible materials (especially oil or grease), a minimum distance of 20 feet (6.1 m) or by a noncombustible barrier at least 5 feet (1.5 m) high having a fire-resistance rating of at least one-half hour.
10. Flammable gas cylinders shall not be stored with oxygen or nitrous oxide cylinders or adjacent to oxygen charging facilities.
11. Full and empty cylinders of all gases shall be stored separately and identified by signs to prevent confusion.
12. Cylinders may be stored outdoors but should be protected from the ground to prevent bottom corrosion. Where extreme temperatures prevail, cylinders shall be stored so they are protected from the direct rays of the sun.
13. Cylinders shall not be exposed to continuous dampness, stored near salt or other corrosive chemicals or fumes. Corrosion may damage cylinders and cause their valve protection caps to stick.

Proper Handling of Compressed Gas Cylinders

Compressed gas cylinders should be handled only by those familiar with the hazards and who can demonstrate safety precautions working with cylinders. Cylinders are heavy and awkward to move and improper handling can result in sprain, strain, falls, bruised, or broken bones. Other hazards such as fire, explosion, chemical burns, poison, and cold burns could occur due to mishandling. Eye protection and substantial footwear should always be used when transporting compressed gas cylinders. Always push cylinder carts, never pull.

The following precautions must be taken when handling compressed gas cylinders.

1. Wear the appropriate personal protective equipment when handling cylinders.
2. Cylinders must always be transported on wheeled cylinder carts with retaining straps or chains.
3. Do not roll or drag a cylinder over a few feet necessary to position the cylinder.
4. Compressed gas cylinders must be transported with protective caps in place. Do not lift the cylinder by the protective cap.
5. Avoid dropping the cylinder; do not tamper with pressure-relief devices or remove any product label or shipping hazard labels.
6. Don't try to catch a falling cylinder.
7. Do not allow grease or oil to come in contact with oxygen cylinder valves, regulators, gauges or fittings; an explosion or fire can result. Oxygen cylinders and apparatus must be handled with clean hands and tools.
8. Open cylinder valve slowly, directed away from your face.
9. Do not attempt to refill compressed gas cylinders; this is only to be done by qualified manufacturer of compressed gases.

Proper Usage of Compressed Gas Cylinders Usage

1. Know and understand the gases associated with the equipment being used.

2. Always use the proper regulator for the gas in the cylinder. Always check the regulator before attaching it to a cylinder. If the connections do not fit together readily, the wrong regulator is being used.

3. Before attaching cylinders to a connection, be sure that the threads on the cylinder and the connection mate are of a type intended for the gas service.

4. Do not permit oil or grease to come in contact with cylinders or their valves.

5. Wipe the outlet with a clean, dry, lint-free cloth before attaching connections or regulators. The threads and mating surfaces of the regulator and hose connections should be cleaned before the regulator is attached.

6. Attach the regulator securely before opening the valve wide. Always use a cylinder wrench or another tightly fitting wrench to tighten the regulator nut and hose connections.

7. Use non-sparking tools (brass) when working with flammable/explosive materials. Prevent sparks and flames from contacting cylinders.

8. Open cylinder valves SLOWLY. Do not use a wrench to open or close a hand wheel type cylinder valve. If it cannot be operated by hand, the cylinder shall be returned to the vendor. Do not attempt to repair cylinders or cylinder valves or to force stuck or frozen cylinder valves.

9. Stand to the side of the regulator when opening the cylinder valve.

10. Close the cylinder valve and release all pressure from the downstream equipment. Disconnect the cylinder anytime there an extended non-use period is expected. Cap the cylinder when not in use.

11. Follow storage and handling requirements in Safety Data Sheet.

12. Never use a compressed gas in any confined space.

13. Never work alone when using compressed gas.

14. Never use compressed gas to dust off clothing. This could cause injury to the eyes or body and create a fire hazard. Clothing can become chemically saturated and burst into flames if touched by an ignition source such as a spark or cigarette.

Compressed Gas Cylinder Cabinets

Cylinders containing the compressed gases listed in this section must be kept in a continuously, mechanically ventilated enclosure.

All compressed gas cylinders having a NFPA Health Hazard Rating of 3 or 4 (e.g. ammonia, chlorine, phosgene) and those with a Health Hazard Rating of 2 but no physiological warning properties (e.g. carbon monoxide) must be kept in a gas cylinder cabinet. EHLS can help you determine the Health Hazard Rating of compressed gases.

Full size cylinders must be stored in a gas cylinder cabinet while smaller cylinders, e.g., lecture bottles, can be stored in a chemical fume hood, a storage cabinet under the fume hood (if ventilated), or some other ventilated enclosure. No more than two small cylinders should be stored in single cabinet. When stored in a cabinet or hood, small cylinders must be positioned and secured so that they will not fall out and be fixed to a stationary object.

Compressed gas cylinder cabinets must meet NFPA 55 and the following requirements: negative pressure in relation to the surrounding area with the exhaust from the cabinet going to the outside of the building, self-closing doors, and internally sprinklered or installed in a sprinklered area.

Cylinders stored in gas cylinder cabinets or other ventilated enclosures must be secured at all times. Cylinders should be firmly secured at their center of gravity, not near the top or bottom.

Hazardous gases include:

Acetylene	Fluorine
Ammonia	Formaldehyde
Arsenic Pentafluoride	Germane

Arsine	Hydrogen Chloride, anhydrous
Boron Trifluoride	Hydrogen Cyanide
1,3 - Butadiene	Hydrogen Fluoride
Carbon Monoxide	Hydrogen Selenide
Carbon Oxysulfide	Hydrogen Sulfide
Chlorine	Methylamine
Chlorine Monoxide	Methyl Bromide
Chlorine Trifluoride	Methyl Chloride
Chloroethane	Methyl Mercaptan
Cyanogen	Nitrogen Oxides
Diborane	Phosgene
Dichloroborane	Phosphine
Dichlorosilane	Silane
Dimethylamine	Silicon Tetrafluoride
Ethane	Stibine
Ethylamine	Trimethylamine
Ethylene Oxide	Vinyl Chloride

Compressed Gas Cylinder Policy

Principal Investigators and Department Chairs must not allow the purchase of non-returnable gas cylinders. In addition, corrosive and reactive gas cylinders must be returned to the manufacturer one year after their date of delivery. All other cylinders must be returned to the manufacturer three years after their date of delivery.

Cryogenic Liquid Safety

Contact of liquid nitrogen or any very cold gas with the skin or eyes may cause serious freezing (frostbite) injury. Protect hands at all times when working with liquid nitrogen.

Handle Liquid Nitrogen Carefully

The extremely low temperature can freeze human flesh very rapidly. When spilled on a surface the liquid tends to cover it completely and intimately, cooling a large area. The gas issuing from the liquid is also extremely cold. Delicate tissue, such as that of the eyes, can be damaged by an exposure to the cold gas which would be too brief to affect the skin of the hands or face.

Never allow any unprotected skin to touch objects cooled by liquid nitrogen. Such objects may stick fast to the skin and tear the flesh when you attempt to free yourself. Use tongs, preferable with insulated handles, to withdraw objects immersed in the liquid, and handle the object carefully.

Protective Clothing

Protect your eyes with face shield or safety goggles (safety glasses without side shields do not give adequate protection). Always wear cryogenic gloves when handling anything that is, or may have been, in immediate contact with liquid nitrogen. The gloves should fit loosely, so that they can be thrown off quickly if liquid should splash into them. When handling liquid in open containers, it is advisable to wear high-top shoes. Trousers (which should be cuffless if possible) should be worn outside the shoes.

Any kind of canvas shoes should be avoided because a liquid nitrogen spill can be taken up by the canvas resulting in a far more severe burn.

Approved Containers for Low-Temperature Liquids

Cryogenic containers are specifically designed and made of materials that can withstand the rapid changes and extreme temperature differences encountered in working with liquid nitrogen. Even these special containers should be filled slowly to minimize the internal stresses that occur when any material is cooled. Excessive internal stresses can damage the container.

Do not ever cover or plug the entrance opening of any liquid nitrogen dewar. Do not use any stopper or other device that would interfere with venting of gas.

These cryogenic liquid containers are generally designed to operate with little or no internal pressure. Inadequate venting can result in excessive gas pressure which could damage or burst the container. Use only the loose-fitting necktube core supplied or one of the approved accessories for closing the necktube. Check the unit periodically to be sure that venting is not restricted by accumulated ice or frost.

Proper Transfer Equipment

Use a phase separator or special filling funnel to prevent splashing and spilling when transferring liquid nitrogen into or from a dewar. The top of the funnel should be partly covered to reduce splashing. Use only small, easily handled dewars for pouring liquid. For the larger, heavier containers, use a cryogenic liquid withdrawal device to transfer liquid from one container to another. Be sure to follow instructions supplied with the withdrawal device. When liquid cylinders or other large storage containers are used for filling, follow the instructions supplied with those units and their accessories.

Avoid Overfilling Containers

Filling above the bottom of the necktube (or specified maximum level) can result in overflow and spillage of liquid when the necktube core or cover is placed in the opening.

Never use hollow rods or tubes as dipsticks

When a warm tube is inserted into liquid nitrogen, liquid will spout from the bottom of the tube due to gasification and rapid expansion of liquid inside the tube. Wooden or solid metal dipsticks are recommended; avoid using plastics that may become very brittle at cryogenic temperatures which then become prone to shatter like a fragile piece of glass.

Nitrogen gas can cause suffocation without warning. Store and use liquid nitrogen only in a well ventilated place.

- As the liquid evaporates, the resulting gas tends to displace the normal air from the area. In closed areas, excessive amounts of nitrogen gas reduces the concentration of oxygen and can result in asphyxiation. Because nitrogen gas is colorless, odorless and tasteless, it cannot be detected by the human senses and will be breathed as if it were air. Breathing an atmosphere that contains less than 18 percent oxygen can cause dizziness and quickly result in unconsciousness and death.

Note:
The cloudy vapor that appears when liquid nitrogen is exposed to the air is condensed moisture, not the gas itself. The gas actually causing the condensation and freezing is completely invisible.

Never dispose of liquid nitrogen in confined areas or places where others may enter.

First Aid

If a person seems to become dizzy or loses consciousness while working with liquid nitrogen, move to a well-ventilated area immediately. If breathing has stopped, apply artificial respiration. If breathing is difficult, give oxygen. Call in for an emergency. Keep warm and at rest.

If exposed to liquid or cold gas, restore tissue to normal body temperature 98.6 °F (37 °C) as rapidly as possible, followed by protection of the injured tissue from further damage and infection. Remove or loosen clothing that may constrict blood circulation to the frozen area. Call a physician. Rapid warming of the affected part is best achieved by using water at 108 °F/42 °C). Under no circumstances should the water be over 112 °F/44 °C, nor should the frozen part be rubbed either before or after rewarming. The patient should neither smoke, nor drink alcohol.

Most liquid nitrogen burns are really bad cases of frostbite. This is not to belittle the harm that can come from frostbite, but at the same time, it’s important to keep the dangers associated with liquid nitrogen burns in perspective. Indeed, liquid nitrogen burns could be treated as frostbite.

Handling Liquid Nitrogen Dewars Keep unit upright at all times except when pouring liquid from Dewars specifically designed for that purpose.

Tipping the container or laying it on its side can cause spillage of liquid nitrogen. It may also damage the container and any materials stored in it.

Rough handling can cause serious damage to dewars and refrigerators.

Dropping the container, allowing it to fall over on its side, or subjecting it to sharp impact or severe vibration can result in partial or complete loss of vacuum. To protect the vacuum insulation system, handle containers carefully. Do not "walk", roll or drag these units across a floor. Use a dolly or handcart when moving containers, especially the larger portable refrigerators. Large units are heavy enough to cause personal injury or damage to equipment if proper lifting and handling techniques are not used.

When transporting contents from a liquid nitrogen dewar, maintain adequate ventilation and protect the unit from damage.

Do not place these units in closed vehicles where the nitrogen gas that is continuously vented from unit can accumulate. Prevent spillage of liquids and damage to unit by securing it in the upright position so that it cannot be tipped over. Protect the unit from severe jolting and impact that could cause damage, especially to the vacuum seal.

Keep the unit clean and dry
Do not store it in wet, dirty areas. Moisture, animal waste, chemicals, strong cleaning agents, and other substances which could promote corrosion should be removed promptly. Use water or mild detergent for cleaning and dry the surface thoroughly. Do not use strong alkaline or acid cleaners that could damage the finish and corrode the metal shell.

Appendix C – Glove Selection Guide

Use chart to choose the appropriate type of protective glove for your job. The Glove Selection Chart provides advantages and disadvantages for specific glove types. This guidance was prepared for lab researchers but is helpful for all people working with hazardous materials. Always read the Safety Data Sheets (SDSs) for each chemical involved.

1. **Identify the hazards of the materials you will be working with.**

   Base selection of glove type and material on the type of exposure and nature of hazard. Factors, such as Chemical type, temperature extremes (cryogenic properties), physical hazards (sharps, piercing objects), PH, Toxicity and Infectious potential of biological hazards, should be considered. Read the Safety Data Sheets (SDSs) for each chemical involved.

2. **Determine if you will have incidental or extended contact with the hazardous materials.**

   Incidental contact (little or no direct contact with the hazardous material) includes these situations:

   - Accidental spills or splashes
   - Accidental overspray from a dispensing device
   - Handling infectious agents that require barrier protection
   - To prevent contamination of materials during handling

   Extended contact includes these situations:

   - Handling highly contaminated materials
   - Submerging hands in a chemical or other hazardous substance
   - Need for physical protection from temperature extremes or sharp/piercing objects

3. **For incidental contact, disposable, surgical-type gloves are appropriate.** Nitrile gloves are preferred over latex because of their chemical resistance, their tendency to visibly rip when punctured, and prevent possible latex allergies.
   - See the Glove Selection Chart for pros and cons of commonly used surgical-type gloves.
   - Disposable glove usage: check for rips of punctures before use. Remove and replace gloves immediately with new ones when a chemical spills or splashes on them. Never wash or reuse disposable gloves. Always remove gloves before touching common objects such as doorknobs, phones, or elevator buttons.

4. **For extended contact, more substantial gloves are required.** Norfoil gloves are recommended for highly toxic materials and materials that are absorbed through the skin.
    - See the Glove Selection Chart for pros and cons of commonly used for extended contact.
    - Reused glove usage: many gloves intended for extended contact are reusable. Check the gloves for rips or punctures before and after each use; prior contamination; signs of degradation (change in color or texture). Replace gloves as soon as signs of degradation appear. Wash after removal and air dry in the laboratory. Consider wearing inner surgical gloves for extra protection.
5. **Dispose of used and damaged gloves according to whether or not they're contaminated with a hazardous material.**
    - Place in regular lab trash if no contamination
    - Radioactive materials
    - Chemical contamination
    - Biohazardous materials
6. **ALWAYS wash your hands after removing gloves.**
7. **Once selected, glove use requirements for your lab should be announced and added in the Standard Operating Procedures (SOPs).**

How to select the Appropriate Glve Material

Glove Selection Chart
Consult this chart for an overview of commonly used glove types for laboratory use and their general advantages and disadvantages. Please note, this information is provided as a guide to proper glove material selection. Glove performance varies between manufactures, so always consult the manufacturer to make sure you will have the right glove for your application.

Gloves	Usage	Pros and Cons
Latex (natural rubber)	Incidental contact	▪ Good for biological and water-based materials ▪ Poor for organic solvents ▪ Little chemical protection ▪ Hard to detect puncture holes ▪ Can cause or trigger latex allergies
Nitrile (Synthetic Rubber)	Incidental contact	▪ Excellent general use glove. ▪ Good for solvents, oils, greases and some acids and bases. ▪ Clear indication of tears and breaks. ▪ Good alternative for those with latex allergies

Butyl (Synthetic Rubber)	Extended contact	▪ Good for ketones and esters ▪ Poor for gasoline and aliphatic, aromatic and halogenated hydrocarbons
Neoprene (Synthetic Rubber)	Extended contact	▪ Good for acids, bases, alcohols, fuels, peroxides, hydrocarbons, and phenols. ▪ Good for most hazardous chemicals ▪ Poor for halogenated and aromatic hydrocarbons
Norfoil	Extended contact	▪ Good for most hazardous chemicals. ▪ Poor fit (Note: Dexterity can be partially regained by using a heavier weight Nitrile glove over the Norfoil/Silver Shield glove.
Viton (Fluoroela-stimer)	Extended use	▪ Good for chlorinated and aromatic solvents ▪ Good resistance to cuts and abrasions ▪ Poor for ketones ▪ Expensive
PVA (Ployvinyl Alcohol)	Specific use	▪ Good for aromatic and chlorinated solvents ▪ Poor for water-based solutions
PVC (Polyvinyl chloride)	Specific use	▪ Good for acids, bases, oils, fats, peroxides, and amines ▪ Good resistance to abrasions ▪ Poor for most organic solvents
Stainless steel Kevlar Leather	Specific use	▪ Cut-resistant gloves. ▪ Sleeves are also available to provide protection to wrists and forearms. ▪ (If potential for biological or chemical contamination: wear appropriate disposable gloves on top of your cutresistant gloves and discard after use).
Cryogenic Resistant Material Leather	Specific use	▪ For use with cryogenic materials. ▪ Designed to prevent frostbite. Note: Never dip gloves directly into liquid nitrogen.
Nomex	Specific use	▪ For use with pyrophoric materials. ▪ Consider wearing a flame-resistant glove such as a Nomex 'flight' glove with a thin nitrile exam glove underneath.