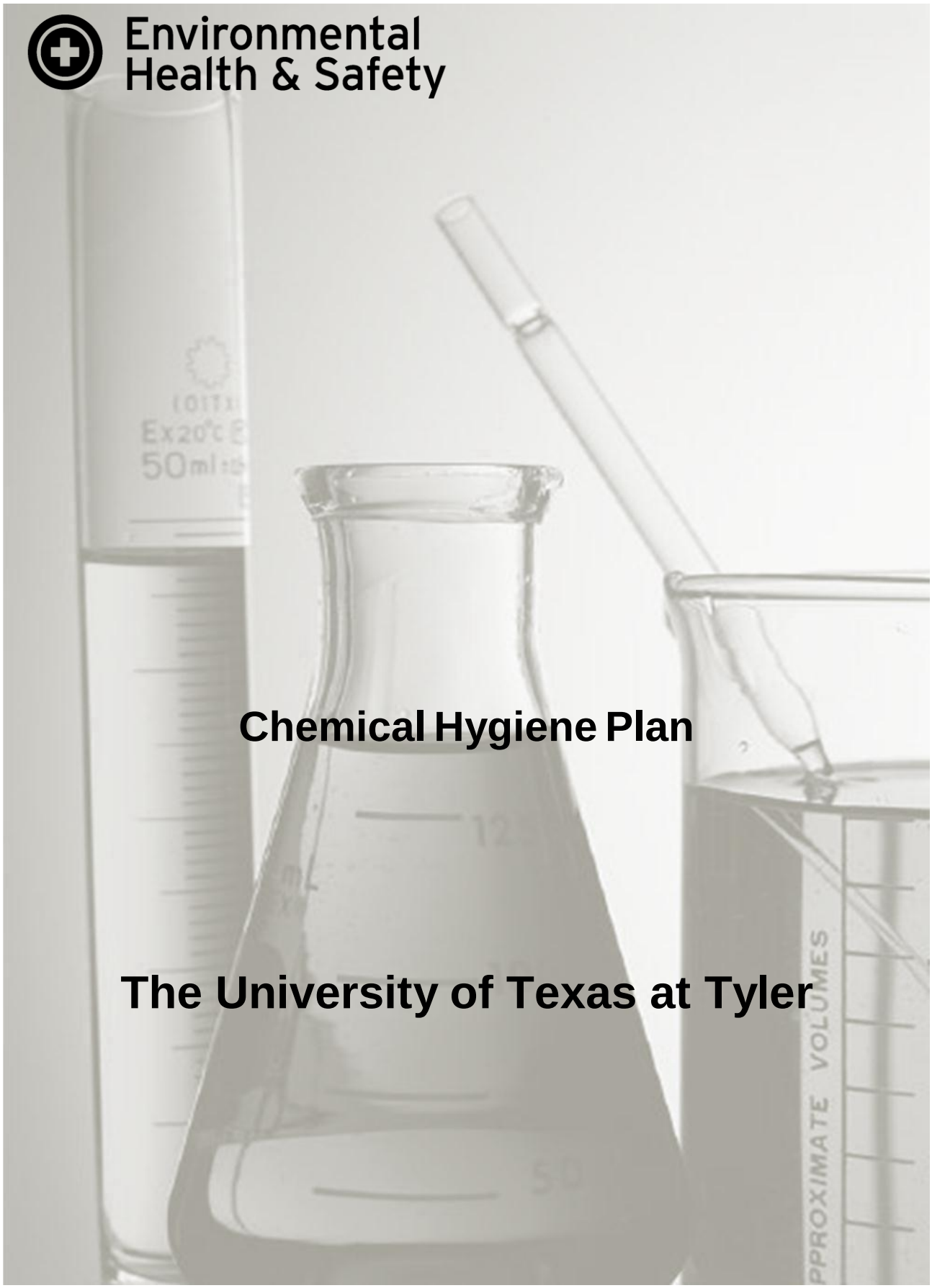
Environmental
Health & Safety
Chemical Hygiene Plan
The University of Texas at Tyler

THE UNIVERSITY OF TEXAS AT TYLER

Laboratory Safety Manual

ENVIRONMENTAL HEALTH AND SAFETY

Jan 2020

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THE UNIVERSITY OF TEXAS AT TYLER

Laboratory Safety Manual

Introduction

The University of Texas at Tyler (UT Tyler) is committed to maintaining the safest possible laboratories. Faculty and researchers must take all reasonable precautions to protect the health and safety of everyone - staff, students, visitors and the general public. In other words, keep you and those around you safe. This document is a guide to help you stay safe inside laboratories but is by no means all encompassing. Consult your instructor about specific safety hazards that pertain to your lab.

Laboratory operations can be dangerous whether you are working with hazardous materials or equipment or just performing common laboratory procedures. Every day there are incidents in teaching and research laboratories on university campuses across the U.S. Although many accidents are minor, there are also serious cases, including fatalities. Every year, UT Tyler has multiple incidents in our laboratories. Our goal is to reduce that number and reduce accidental injuries.

This Laboratory Safety Manual has been prepared specifically for UT Tyler by the Department of Environmental Health and Safety in collaboration with The University of Texas Laboratory Safety Manual. This manual promotes safe and practical laboratory procedures. We have included information on the use of personal protective equipment (PPE), the use and storage of chemicals, hazard communication and the proper methods of using equipment and waste disposal. This manual also covers emergency procedures and incident response in the event of an emergency.

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 UT Tyler. Faculty and researchers know the most about the unique hazards in their laboratory. It is expected that the instructor/Principal Investigator will append any supplementary safety information to this manual pertinent to their specific laboratory.

RESPONSIBILITIES

University-wide Laboratory Safety Responsibilities

Lab workers conducting chemical reactions, using chemicals, or performing laboratory procedures are required to have proper training in the safe handling and disposal of all materials they use. Each individual is responsible for conducting activities in a safe manner that complies with the applicable requirements of state and federal law as well as with university policies and procedures described in this manual. Oversight responsibility for ensuring that laboratory activities conform to prescribed standards is assigned as follows:

The President of the University

The President has ultimate responsibility for laboratory safety within the institution.

Environmental Health and Safety

The Department of Environmental Health and Safety (EH&S) is responsible for the overall facilitation of the UT Tyler laboratory safety program which includes the following.

- Provides training to laboratory personnel.
- Conducts periodic and unannounced laboratory inspections.
- Provides hazardous waste disposal services.
- Provides hazardous material spill response services.
- Reviews laboratory construction and renovation plans for safety design.
- Conducts fume hood surveys, testing and certification.
- Performs exposure monitoring upon request.
- Provides guidance for maintaining compliance with federal, state, and local regulations, as well as the procedures stated in this manual.
- Provides recommendations and assistance in obtaining personal protective equipment (PPE).
- Provides recommendations and assessments for engineering controls.
- Investigates laboratory incidents and conducts follow-up activities to prevent future incidents.
- Undertakes enforcement actions to ensure full compliance with all institutional safety policies, up to and including authority to shut down laboratories for violations of policies.

University Personnel

Personnel are responsible for following the procedures and faithfully executing the policies and responsibilities prescribed by this manual. Failure to do so is a serious breach of university policy and subject to disciplinary action that may include termination of employment at the university. If a lab is not in compliance with the safe operating procedures as outlined in this manual, EH&S has the authority to close the lab until violations are corrected. Approval of the Dean is not required.

Facilities Management

The Department of Facilities Management maintains facilities and facility-related safety systems and equipment to assure the continuous operation of laboratories.

College Laboratory Safety Responsibilities

Dean

- Ensures instructors/Principle Investigators maintain safe operation of all laboratories where hazardous materials are used or laboratory procedures are conducted.
- Ensures compliance with all UT System and UT Tyler university policies and procedures pertaining to laboratory safety.
- Has independent enforcement authority to close a laboratory for safety violations.

Department Chairs and Directors

- Appoints at least one Laboratory Safety Coordinator (LSC) for each department.
- Serves as the LSC to the local department.
- Oversees laboratory safety within departmental laboratories.
- Ensures adequate engineering controls, administrative controls, and PPE are provided for each department.
- Ensures laboratories complete and update annual inventories of hazardous chemicals as required by the university's Hazard Communication Program.
- Ensures all employees and students complete Laboratory Safety training prior to working in a laboratory or handling hazardous chemicals or materials.
- Approves all first time chemical and hazardous material orders within their respective departments.

Laboratory Safety Coordinators

- Ensures laboratories develop and implement site-specific safety policies.
- Monitors procurement, safe practices and disposal of hazardous materials with EH&S.
- Ensures laboratories complete self-evaluation forms once an academic year.
- Acts as a liaison with EH&S to ensure inspection issues are corrected.
- Notifies EH&S if specialized training is needed.
- Provides researchers technical guidance regarding lab safety issues.
- Advises college administration on laboratory safety issues. Notifies EH&S if issues require immediate action.
- Provides technical and administrative support for local safety committees.
- Notifies EH&S of incidents and near misses.
- Notifies EH&S of laboratories that will be decommissioned.

Principal Investigators and Laboratory Supervisors

- Designs and conducts laboratory processes and operations to assure that personnel exposure to risk is minimized according to university policy.
- Monitors the procurement, safe use, and proper disposal of hazardous materials.
- Provides EH&S access to Standard Operating Procedures (SOPs) relevant to lab processes in their specific areas.

- Instructs personnel on the contents of this manual and the location of the manual within the workplace.
- Takes all reasonable precautions to protect the health and safety of laboratory workers and the environment.
- Ensures personnel properly utilize engineering and administrative controls.
- Provides and ensures personnel properly utilize appropriate PPE.
- Schedules hazardous waste disposal and oversees the handling of hazardous waste pending proper disposal.
- Aids EH&S in conducting laboratory safety evaluations every year (Fall semester).
- Completes and updates annual laboratory chemical inventories in accordance with the instructions and schedule provided by EH&S.
- Informs lab personnel of where to find permissible exposure limit (PEL) for the hazardous chemicals listed on inventories and the signs and symptoms associated with exposures to these chemicals.
- Provides training and documentation on laboratory hazards as described in the university's Hazard Communication Program.
- Provides training and documentation for special procedures, activities, or operations.
- Works with EH&S to ensure that all required safety equipment (fire extinguishers, fume hoods, flammable liquid storage cabinets, eye washes, safety showers, and spill cleanup kits) is available, in working order and that appropriate training for all safety equipment has been provided.
- Ensures all students complete Laboratory Safety training prior to working in a laboratory or handling hazardous chemicals or materials.
- Maintains access to a current copy of a Safety Data Sheet (SDS) for all hazardous chemicals in the laboratory.
- Maintains emergency information signage in accordance with this plan.
- Reports to EH&S if there is reason to believe that exposure levels for a hazardous chemical exceed the action level or the PEL and document the incident.
- Forwards documentation on laboratory accidents and exposures to EH&S and Department Chair.
- Provides for the safety of visitors.

Personnel/Lab Participants

- Maintains a thorough understanding of and follows the laboratory policies and procedures.
- Uses and maintains engineering controls and required PPE.
- Effectively uses flammable liquid storage cabinets, acid storage cabinets, biosafety cabinets, fume hoods, glove boxes, and other laboratory safety equipment provided.
- Informs supervisor immediately of any laboratory safety equipment that is needed but not available or that is not in good working order.
- Informs supervisor immediately of any exposure symptoms, accidents, or releases and documents the incident.
- Completes all applicable EH&S and departmental laboratory safety training sessions.
- Participates in the Occupational Health Program if required as a condition of employment or by specific protocol.

EMERGENCY PROCEDURES

Prevention measures

The key to keeping laboratories safe for lab personnel and other patrons of UT Tyler is prevention. The following are mandatory safety and security guidelines in order to ensure a safe working environment:

- Doors of laboratories are to remain closed at all times while not entering or exiting a laboratory.
- PPE, as required by the Standard Operating Procedure (see fundamentals of laboratory safety section), must be worn at all times
- Lab personnel must not transport lab material through hallways/corridors with gloves worn. Appropriate equipment must be utilized to keep hands free of chemicals or microorganisms.

Departments should ensure their personnel are properly trained and equipped to implement appropriate actions to mitigate emergencies occurring in laboratories and chemical storage areas.

All accidents, hazardous materials spills, or other dangerous incidents must be reported to EH&S. A list of telephone numbers must be included on lab signs posted on the exterior of the door or near the laboratory entrance.

Telephone numbers should include:

- Department Chair
- Principal Investigator or Laboratory Supervisor
- UT Tyler Police Department//Tyler Fire Department/Emergency Medical Services: 903-566-7300
- Environmental Health and Safety (EH&S): 903-566-7011
- Poison Control Center: 1-800-222-1222

Primary Emergency Procedures for Fires, Spills, or Accidents

- In the event of a fire, activate the nearest manual fire alarm pull station. If you are unable to control or extinguish a fire, follow the building evacuation procedures and take instructions from the lab coordinator.
- Attend to persons who may have been exposed and/or injured if it is safe to reach them. Use emergency showers and eyewash stations as appropriate. In the case of eye contact, promptly flush eyes with water for a minimum of 15 minutes and seek medical attention immediately.
- In cases of ingestion, contact the Poison Control Center: 1-800-222-1222.
- In cases of skin contact, promptly flush the affected area with water and remove any contaminated clothing or jewelry. If symptoms persist after washing, seek medical attention.
- Notify persons in the immediate area about the spill; evacuate all personnel from the spill area and adjoining areas that may be impacted by vapors or a potential fire.
- If the spilled material is flammable, turn off all potential ignition sources. Avoid breathing vapors of the spilled materials. Be aware that some materials either have no odors or induce olfactory fatigue (i.e. the odor is detectable only briefly).

- Leave on or establish exhaust ventilation if it is safe to do so. Close doors to slow down the spread of vapors/smoke.
- Notify EH&S. Essential personnel familiar with the incident need to stay in communication with EH&S and emergency responders.

If there is an immediate threat to life or health or a major release of chemicals:

- Call 911 or UTT PD for assistance at (903) 566-7300.
- Given the nature and the extent of the emergency, be as specific and detailed as possible.

If the spill is minor (1 liter or less):

- If you have been trained to respond, use a spill control kit to control material spilled. If you have not been trained, notify your supervisor.
- Determine the cleaning method by referring to the SDS, sections 4, 6 and 8.
- If the spill is minor (1 liter or less) and of known limited danger, clean up immediately.
- Wear personal protective equipment during cleanup. The protective equipment required will depend upon the material spilled, the amount, and the airborne concentration. At a minimum a lab coat, chemical resistant gloves and goggles should be worn.

- Cover liquid spills with compatible absorbent material such as spill pillows.
- Powdered materials should be covered with wet paper towels (if compatible) to avoid dispersal. Corrosives should be neutralized prior to absorption. Clean spills from the outer areas first, cleaning towards the center.
- Place the spilled material into a waste container, seal it, attach waste tag and contact EH&S for disposal.
- If appropriate, wash the affected surface with soap and water. Mop up the residues and place in container for disposal.
- Call EH&S if you have questions or concerns with the cleanup procedures, (903-566-7011).

Special Procedures for Radioactive Hazards

- Personnel of laboratories that utilize radioactive materials (RAM) must consult the UT Tyler Radiation Safety Manual located on the EH&S Laboratory Safety webpage here: https://www.uttyler.edu/safety/laboratory-safety.php
- Do not take any action unless you have been trained to respond, except to summon assistance.
- Notify EH&S to obtain appropriate assistance.
- Notify the UTT Police Department.
- Notify physical plant to shut off ventilation
- If possible, close windows and doors, and turn off hoods. Do not do this if radioactive gas is involved, as release to the environment is preferable in that case.
- Remove all personnel from the immediate spill area to a safe meeting location in or near the lab.
- With the assistance of EH&S, check all personnel for skin and clothing contamination.
- Under the guidance of EH&S personnel, decontaminate personnel and re-survey until radiation levels are at background using the methods outlined in the Radiation Safety Plan.

Building Evacuation Procedures

- Building evacuation may be necessary if there is a chemical release, fire, explosion, natural disaster, or medical emergency.
- Be aware of the marked exits in your area and the building.
- The evacuation alarm may have flashing lights and a loud continuous siren, horn, or voice.
- To activate the building alarm system, pull the handle on one of the red manual pull stations located near building exits. If there is a fire, call UTT PD at 903-566-7300, give your name, and

the building name, room number and size of the fire.

- Whenever the building evacuation alarm is sounded or when you are instructed to leave by UTT Police, EH&S, or emergency response personnel, listen to instructions by the lab coordinator and walk quickly to the nearest marked exit and ask others to do the same.
- Outside, proceed to a clear assembly area that is at least 200 feet from the affected building and off the streets where first responders may need access. Keep walkways also clear for emergency vehicles and personnel.
- To the best of your ability and without reentering the building, be available to assist UTT Police and EH&S in their attempts to determine that everyone has been evacuated safely.
- An Incident Command Post may be set up near the emergency site by the emergency responders. Keep clear of the area unless you have important information to report.
- DO NOT re-enter the building or affected area until you are told it is safe to do so by the UTT Police, EH&S, or the City of Tyler emergency responders.

Refer to the Emergency Information flipchart on the UT Tyler website to obtain specific procedural guidance for campus emergencies.

FUNDAMENTALS OF LABORATORY SAFETY

Risk Assessments

A risk assessment should be done during the planning stage of any new or modified project/experiment/demonstration. The risk assessment reviews the hazards associated with the project. This assessment should review the chemical properties, reactions/byproducts, procedural hazards, equipment used, potential routes of exposure as well as control measures to mitigate the hazards such as substitution using less hazardous chemicals or micro-scaling projects. It is recommended that risk assessment process be documented.

Resources for developing a risk assessment include reviewing Safety Data Sheets (SDSs), consulting published resources, employing the *Laboratory Risk Assessment Template* (Appendix C), and consulting with EH&S.

A risk assessment must also be accomplished anytime an experiment or demonstration is conducted involving a physical reaction. Guidance for conducting the assessment is in the *Laboratory Experiment Hazard Assessment Form* (Appendix D).

Standard Operating Procedures (SOPs)

Once a risk assessment is completed for a project, Standard Operating Procedures (SOPs) can be developed. SOPs should include:

- Engineering controls such as fume hoods or other safety equipment.
- Work practice controls such as designated areas or work restrictions.
- Personal protective equipment to be used.
- Monitoring (as needed).
- Storage, cleanup, and waste disposal.
- Emergency procedures.
- Occupational Health requirements (as needed).
- Training requirements.

SOPs should include the minimum:

- Ensure students and employees know that doors must remain u

Training

The University requires that all personnel that work in a laboratory are adequately informed about the physical and health hazards present in the laboratory, the known risks, and what to do if an accident or emergency situation occurs. Every laboratory worker must complete the appropriate lab safety training courses prior to working in a UT Tyler laboratory.

Hazard Communication Training

All UT Tyler employees that work with or may be exposed to hazardous materials in the workplace are required to complete the *General Hazard Communication* training. This training must be completed before personnel can be assigned to work with or around hazardous materials. HR facilitates this

training upon employment and every two years thereafter.

General Hazard Communication Training comprises the central requirements of the Texas Hazard Communication Act, to include the following training topics.

- Interpreting chemical labels and SDSs.
- Chemical hazard classifications and personal protection measures.
- Chemical handling and storage guidelines.
- Spill clean-up and chemical disposal procedures.
- Emergency equipment and procedures.

Site-Specific Hazard Communication Training is required for all employees who have the potential to be exposed to hazardous materials in the workplace. Any work in a laboratory using hazardous materials meets this definition and these employees are required to complete the training outlined below.

Laboratory Safety Training

EH&S facilitates general laboratory safety training courses. The courses are for faculty, staff, or students who work in or around the laboratory area. These courses shall be completed prior to receiving lab-specific training from the PI in order to provide a foundation for additional information.

Lab-Specific Training must be conducted by the PI or Lab Supervisor and documented in accordance with departmental guidelines. Departments may use the *Site-Specific Hazard Communication Form*, *Appendix D* in the Hazard Communication Program Manual or another similar form and are responsible for maintaining training documentation for five (5) years. The PI/Lab Supervisor is responsible for providing information to their personnel about potential chemical exposure and PPE requirements at the time of a lab person's initial assignment and prior to any assignments involving new situations. The following lists the information that should be provided by the PI/Lab Supervisor:

- Ensure personnel complete *General Hazard Communication* training.
- Lab-specific standard operating procedures (SOPs) for the safe handling and use of hazardous materials (chemical, biological, radioactive).
- Lab-specific engineering controls and safe work practices.
- Procedures for using safety equipment including fume hood, biosafety cabinets, special ventilation, or other equipment.
- PPE requirements for personnel including; selection, maintenance and use.
- How personnel can obtain PPE and how to dispose of PPE after use.
- Procedure for accessing and using Safety Data Sheets and institutional Laboratory Safety Manuals.
- Physical and health hazards (acute and chronic) associated with the materials.
- Signs and symptoms associated with exposures to hazardous materials in the lab.
- Methods and observation techniques to determine the presence or release of hazardous materials.
- Location of signage including hazard signs, emergency numbers, and the Texas Hazard Communication Employee notification poster.
- The lab's housekeeping procedures.
- Procedures for transporting hazardous materials safely across campus.
- Requirements for chemical labeling on primary and secondary containers.

- Storage location of chemicals and their segregation by compatibility.
- Use of hazardous chemicals that warrant exposure monitoring.
- Inform personnel how to request monitoring by EH&S.
- Location of machine guards and their use.
- Use, storage, and handling of gas cylinders and cryogenics.
- How to respond to an emergency including; exposures, first aid, and evacuation routes.
- Procedures for proper waste disposal including waste accumulation sites and process for requesting waste disposal.
- Location of emergency equipment including; spill kits, fire-fighting equipment, alarms, emergency shut-offs, emergency showers and eyewash stations.
- Spill clean-up and chemical disposal procedures specific to the lab.
- Emergency and evacuation procedures specific to the lab.
- How to contact EH&S in the event of an accident/injury.
- Occupational Health requirements such as medical evaluation, respirator fit-testing, or vaccinations.

Personnel must be re-trained when new chemical hazards are introduced into their workplace, or when new hazards are updated on applicable Safety Data Sheets (SDS), as well as upon assignment to different workplaces that involve new chemical hazards or protective measures. This supplemental training shall be conducted by the PI/Lab Supervisor and documented in accordance with departmental guidelines. Departments are responsible for maintaining training documentation.

In addition to the lab-specific training, the following hazardous materials training is offered by EH&S and is required for all lab personnel (faculty, graduate students, staff, and visitors) that engage in laboratory activities:

Fire Extinguisher Training

Fire extinguisher training is provided by EH&S is recommended for all laboratory

workers. Fire extinguisher training includes:

- What to do in the event of a fire
- The behavior of fire and how it spreads
- The classes of fires
- The proper selection and use of a fire extinguisher

This training program will familiarize laboratory workers with the general principles of fire extinguisher use; give them confidence in their ability to operate extinguishers; and remove fears associated with putting out a fire by showing them successful fire extinguishers use.

Bloodborne Pathogens and Biosafety Training

Bloodborne pathogens and biosafety training is required for UT Tyler personnel, including faculty, staff, and graduate students who work in laboratories where infectious agents or human or non-human primate body fluids are present or in use. The OSHA Bloodborne Pathogens Standard training course is available online through the CITI Program, or Canvas for academic students.

Hazardous Waste Management Training

EH&S facilitates hazardous waste management training for all PIs and Lab Supervisors on an as-need basis. Laboratory personnel (faculty, staff, and graduate students) that work in areas where hazardous chemicals or biological materials are used will receive lab-specific hazardous waste management training from the PI/Lab Supervisor. Every teaching lab must have at least one individual that has received this training and is responsible for following the procedures included in the training.

Additional Lab Safety Training

Sponsored Research has additional laboratory safety training for biology worker which are offered online through the CITI Program. Departments may also contact EH&S to facilitate lab safety training.

- Basic Introduction to Biosafety
- Biosafety Officer Training – Basic/Initial
- Initial Biosafety Training
- Biosafety Retraining
- Animal Biosafety
- Emergency Incident Response to Biohazard Spills and Releases

Personal Protective Equipment Policy

The Principal Investigator and/or Lab Supervisor is responsible for providing all necessary personal protective clothing for laboratory workers. The University is responsible for providing basic safety equipment such as fire extinguishers, emergency showers, and eyewash stations.

Personal Clothing and Shoes in Labs

Personal clothing provides an additional layer of protection between PPE and the skin. There have been a number of laboratory injuries where adequate personal clothing would have reduced the extent of an exposure and injury.

EH&S recommends that at a minimum, laboratory personnel who work with hazardous materials or are in the presence of hazardous materials that are in use wear a combination of proper personal clothing and PPE such as lab coats so essentially the skin is covered from the shoulders to the hands and feet.

EH&S requires that closed-toed shoes be worn at all times in the laboratory. All shoes worn in the laboratory must have slip-resistant, non-absorbent soles. Sandals or perforated shoes are not allowed in the laboratory. Proper shoes reduce the potential for exposure to chemicals and injuries from broken glass and dropped items. Personnel who want to wear shorts/sandals should bring a change of clothing to work in a lab.

See the *Basic Hazardous Materials Guidelines* section for specific information regarding PPE.

Ear buds or headphones

The use of ear buds or headphones is discouraged because their use may impede hearing and be a route of exposure. Headphones are not usually tolerated in industry. Therefore, earbuds and headphones are not allowed in labs deemed hazardous by EH&S.

Ergonomic concerns

Ergonomics is the study of healthy musculoskeletal workplace practices including but not limited to: sitting, standing, movement, repetitive motion and lifting. EH&S provides ergonomic assessments for individuals as well as departments. Laboratory personnel must be conscious of how much they lift, improper lifting techniques, any repetitive motion such as pipetting or sitting for long periods of time.

EH&S suggests lab personnel take regular breaks at lead 5 to 10 minutes every hour to stretch or walk. Adequate posture and position are key to deskwork. EH&S provides consultation and equipment to keep you healthy at your desk. Please contact safety at safety@uttyler.edu for further information.

Chemical Procurement, Transport, and Storage

Procurement

Before a chemical is received, information on proper handling, storage, and disposal should be reviewed. Refer to the appropriate Safety Data Sheet (SDS) to obtain this information. No container may be accepted into a laboratory without an appropriate identifying label.

The original label from the manufacturer or supplier must remain attached to the chemical container and must not be removed, defaced, or damaged in any way. Refer to the *Signs and Labels* section below for additional information on labeling requirements.

Transporting/Shipping

Chemical containers are vulnerable to damage when being transported and personnel should take appropriate safeguards and exercise extreme caution to prevent chemical accidents/releases.

- When chemicals are hand carried, place the container in an outside (secondary) container or bucket. Container carriers for breakable containers such as glass can be purchased through a variety of vendors. These secondary containers provide protection to the bottle. They also help to minimize spillage if the bottle breaks.
- Use a cart if transporting more than 4 liters or two bottles of a chemical. When transporting chemicals on a cart, use a box or other secondary container to prevent containers from breaking or falling off the cart.
- Freight-only elevators (when available) should be used when transporting chemicals. Avoid using stairs.

- Personnel transporting chemicals should have appropriate PPE, be trained in spill procedures, and be aware of the spill kit location.
- Chemicals that are shipped off-campus may need special packaging and may need to be shipped by trained certified personnel. Contact EH&S for assistance with shipping chemicals.
- Hazardous chemicals should be transported to a designated stockroom or storeroom as soon as possible upon receipt to prevent potential exposure. They should be removed from the shipping container, inspected, and placed in the appropriate storage location.

Date chemicals when received and first opened. If a particular chemical can become unsafe while in storage, then an expiration date should also be included. Keep in mind that expiration dates set by the manufacturer do not necessarily imply that the chemical is safe to use up to that date.

Stockrooms/Storerooms

Stockrooms/Storerooms are required to be secured and access should be strictly controlled.

Toxic chemicals must be segregated in a well-identified area with local exhaust ventilation. Chemicals which are highly toxic or chemicals whose containers have been opened must be in unbreakable secondary containers. For example, place containers of concentrated acids or bases into acid cabinets or plastic tubs to help contain any leakage.

Stored chemicals should be examined periodically (at least annually) for expiration dates, replacement, deterioration and container integrity. The labels must be checked to ensure they are still readable. If labels begin to fall off the container, attach new labels.

Laboratory Chemical Storage

- Read the label carefully before storing a chemical. All chemicals must be stored according to their hazard class. Use the *Chemical Storage Segregation Scheme* (Appendix B) to assist you and note that in some instances chemicals of the same category may be incompatible.
- Store all chemicals by their hazard class, and NOT IN ALPHABETICAL ORDER. Storing chemicals by alphabetical order will often result in the placement of incompatible chemicals being next to one another. Only within the segregation groups can chemicals be stored in alphabetical order. If a chemical exhibits more than one hazard, segregate by using the characteristic that exhibits the primary hazard.
- Do not store chemicals or combustible materials near heat sources such as ovens, Bunsen burners, hot plates or steam pipes. Chemicals should **not** be stored in direct sunlight.
- Do not use work surfaces as permanent storage for chemicals. In these locations, the chemicals could easily be knocked over, incompatible chemicals may be alongside one another, and the chemicals will be unprotected in the event of a fire.
- Each chemical must have a proper designated storage location and be returned after use.
- Make sure chemical lids are tightly closed to prevent chemicals from being released into the lab.
- Inspect chemicals routinely for signs of deterioration and for the integrity of the label. All chemicals must be clearly labeled to prevent exposure and to prevent chemicals from becoming "unknowns."
- Avoid storing any chemicals in glass containers on the floor, unless positioned in such a way that they cannot be broken, (i.e., pushed under a table).
- Inspect shelving periodically to ensure that the shelving can support the chemicals.

Proper shelving

Bowed shelving

Shelves with secondary containment

Corroded shelf supports

- Do not use fume hoods as a permanent storage location for chemicals, with the exception of highly odorous chemicals that require ventilation. Some chemical fume hoods have ventilated storage cabinets underneath for storage of frequently used chemicals that require ventilation. Also, avoid placing containers on the edge of the fume hood, as these can easily fall and break.

Proper use of a fume hood

Improper storage in a fume hood

- Chemicals that require refrigeration must be sealed with tight-fitting caps and securely placed within the refrigerator. Lab-safe refrigerators/freezers must be used for cold storage of flammables. Refrigerators not specified as lab-safe can be a potential ignition source.
- Do not store hazardous chemicals above eye level. If the container breaks, the contents can spill onto your face and upper body.

Proper storage of chemicals below eye level

Improper storage of flammable chemicals above eye level

- Do not store excessive amounts of chemicals in the lab. Buying chemicals in large quantities creates a serious fire hazard and limits work space.
- Chemical containers should not extend over the edge of shelves or be packed in too tightly.

Storage Cabinets

Specialized types of storage cabinets must be used in laboratories in order to separate incompatible chemicals from one another and to safely store all chemicals. All chemicals must be stored in a secure container, preferably within enclosed cabinets. Periodically check shelves and supports for corrosion.

Flammable Storage Cabinets should be used for all labs that use flammable chemicals. Flammables not in active use must be stored inside fire resistant storage cabinets. The cabinet design must meet National Fire Protection Association (NFPA) 30.

Proper storage of flammable chemicals

Improper storage of flammable chemicals

Flammable storage cabinets are designed to protect the contents from the heat and flames of external fire rather than to confine burning liquids within. They can perform their protective function only if used and maintained properly

Cabinets are typically designed with double-walled construction and doors which are two inches above the base (the cabinet is liquid-proof up to that point). Keep the doors closed.

Acid Storage Cabinets are specially designed to contain acids and they should be kept stored unless in use. The cabinets are made of plastic or metal coated with epoxy enamel to protect against corrosion. If not provided as part of the cabinet, use polyethylene trays to contain small spills.

Compressed Gas Cylinder Cabinets are used to store gas cylinders that pose a specific health hazard. 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 carbon monoxide) must be kept in a gas cylinder cabinet. EH&S can help you determine the Health Hazard Rating of compressed gases.

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

Hazardous Gases

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

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.

Compressed gas cylinder cabinet

Acceptable method of securing a cylinder

Unacceptable method of securing a cylinder

- 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.
- Valves should be firmly closed when not in operation and the valve protection cap should be on the cylinder when not in use.

Housekeeping

It is important to properly maintain storage areas to prevent accidents or incidents.

- Keep floors dry and free of debris.
- Contain leaks and clean up spills.
- Do not allow boxes or other combustibles to accumulate.
- Routinely monitor chemical storage areas and promptly contact EH&S for the disposal of any old, expired, or unused chemicals.

Signs and Labels

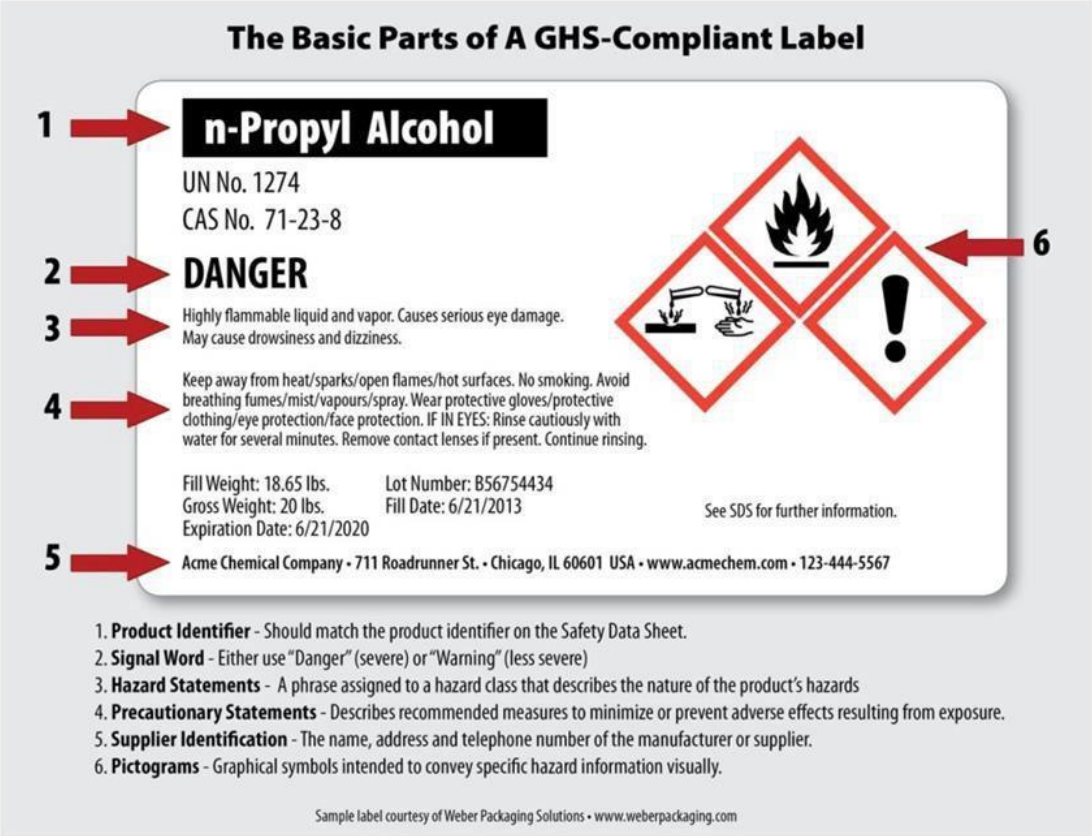
Laboratory Hazard Signs are required to be prominently posted outside of each laboratory, classroom, and designated storage area where hazardous chemicals are present. These signs depict the most severe hazard(s) present and include information for emergencies.

An example of a laboratory hazard sign is shown below.

Warning Signs should be posted outside areas containing specific or unique hazards.

Chemical Labels are required to be on all chemical containers and must depict the container contents and its associated hazards. The original label from the manufacturer or supplier must remain affixed to the chemical container and should not be removed or defaced unless the container is empty and ready for disposal.

OSHA has adopted the Globally Harmonized System (GHS) of classifying and labeling chemicals. Below is an example of a GHS compliant chemical label depicting the six (6) required label elements.



Secondary Containers are other containers that a chemical is transferred into from the original container, e.g. a solvent wash bottle, for other than immediate use.

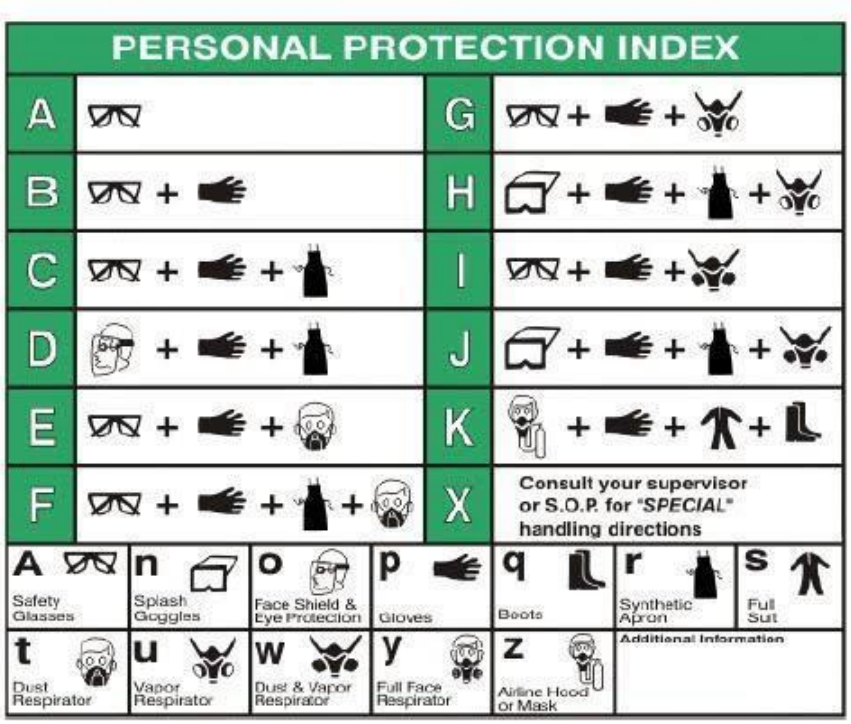
Secondary containers must be relabeled with at least the chemical name as it appears on the SDS and the appropriate hazard warnings. This does not apply to reaction vessels or to bench top research apparatus in active use. The HMIS label should be used to relabel secondary containers.

Hazardous Materials Identification System (HMIS) Labels are designed to be placed on individual containers of hazardous chemicals or chemical products that do not have a manufacturer's label or when the manufacturer label is missing or when chemicals or chemical products are placed in a secondary container.

Secondary containers are not required to be labeled if the transferred chemical is used immediately (within the same day).

HMIS labels are a color coded to reflect the associated hazards and have a numerical rating system representing the level of hazard; 4 severe, 3 serious, 2 moderate, 1 slight, and 0 minimal.

The Personal Protection section is coded with an alphabet and describes the required PPE to be used when working with the substance. The personal protection index is depicted below.



The PI or Lab Supervisor is responsible for compliance with labeling requirements and should be notified immediately if a chemical container is not properly labeled.

Properly labeled primary and secondary chemical containers

Improperly labeled secondary chemical containers

Hazard Communication Standard Pictograms are required on all chemical container labels to alert users of the hazards to which they may be exposed. Each pictogram consists of a symbol on a white background framed within a red border and represents a distinct hazard(s). The pictogram on the label is determined by the chemical hazard classification. See the chart below for specific information regarding the pictograms and the associated hazard classifications.

HCS Pictograms and Hazards

Health Hazard  ▪ Carcinogen ▪ Mutagenicity ▪ Reproductive Toxicity ▪ Respiratory Sensitizer ▪ Target Organ Toxicity ▪ Aspiration Toxicity	**Flame**  ▪ Flammables ▪ Pyrophorics ▪ Self-Heating ▪ Emits Flammable Gas ▪ Self-Reactives ▪ Organic Peroxides	**Exclamation Mark**  ▪ Irritant (skin & eye) ▪ Skin Sensitizer ▪ Acute Toxicity ▪ Narcotic Effects ▪ Respiratory Tract Irritant
Gas Cylinder  ▪ Gases Under Pressure	**Corrosion**  ▪ Skin Corrosion/Burns ▪ Eye Damage ▪ Corrosive to Metals	**Exploding Bomb**  ▪ Explosives ▪ Self-Reactives ▪ Organic Peroxides
Flame Over Circle  ▪ Oxidizers	**Environmental**  ▪ Non-Mandatory ▪ Aquatic Toxicity	**Skull and Crossbones**  ▪ Acute Toxicity (fatal or toxic)

Records

Hazardous Chemical Inventory

Maintaining current records of hazardous chemicals assists in implementing proper storage and safety procedures and is necessary for emergency response pre-planning, both by EH&S and the City of Tyler emergency services. Departments are required to establish and maintain an inventory of all of the hazardous chemicals or chemical products in their respective work areas, regardless of quantity. This inventory is to be updated annually and will be made available to employees upon request.

Lab personnel should also keep usage records of high-risk substances.

Laboratory Incidents

Lab supervisors/PIs should document and report any lab incidents to EH&S as soon as possible. Personnel who are exposed/injured in a laboratory should contact EH&S and complete a First Report of Injury or Illness form. This form is available from Human Resources.

Any medical records associated with a person's exposure to hazardous materials will be maintained by the university in accordance with state and federal regulations. These records are normally maintained by the Occupational Health clinic that treated the employee.

Monitoring

EH&S maintains records whenever monitoring of hazardous materials is performed.

Safety Data Sheets (SDS)

The Safety Data Sheet (SDS) or Material Safety Data Sheet (MSDS) provides information on hazardous chemicals and must be readily available for all hazardous chemicals in the lab. SDSs are available in some labs and can be obtained online on the EH&S website at UT Tyler MSDS database.

Information on the University of Texas at Tyler Hazard Communication Program Manual can be found on the EH&S website at: Hazard Communication Program Manual

Procedures for Authorizing Medical Treatment

- It is the responsibility of every Lab Supervisor to promptly contact EH&S when a suspected exposure to hazardous materials has occurred. The Lab Supervisor will provide details of the exposure, including the identity of the material, a description of the conditions under which the exposure occurred, a description of the signs and symptoms of the exposure, and the SDS.
- In the event of serious adverse symptoms or injury, medical attention should be sought prior to notification of EH&S.
- If known, EH&S will provide details of the exposure (identity of the hazardous material, a description of the conditions under which the exposure occurred, a description of signs and symptoms of exposure, and the applicable SDS, and any other relevant information) to the health care provider.
- Call 9-1-1 to request medical assistance and/or transportation to the nearest hospital. If the injury chemical or biological exposure on main campus, request emergency medical services (EMS).

Chemical Waste Disposal Program

Chemical wastes are regulated by the Environmental Protection Agency (EPA) under the Resource Conservation and Recovery Act (RCRA). Laboratory Supervisors are responsible for advising laboratory workers on how to handle **all** wastes generated in laboratory operations.

Information on hazardous waste disposal procedures can be found on the EH&S website at:
Laboratory Waste Management Guidelines

Chemical Waste Containers

Containers used for hazardous waste must be in good condition, free of leaks, and compatible with the waste being stored in them. A waste container should be opened only when it is necessary to add waste, and should otherwise be closed. Hazardous waste must not be placed in unwashed containers that previously held an incompatible material (see Appendix B for examples of incompatible chemicals).

If a container holding hazardous waste is not in good condition or if it begins to leak, transfer the waste from the container into a container that is in good condition, pack the container in a larger and non-leaking container, or provide other secondary containment to prevent the potential for a release or contamination. Contact EH&S if assistance is required.

A storage container holding a hazardous waste that is incompatible with any waste or other materials stored nearby in other containers must be separated from the other materials or protected from them by means of a partition, wall, or other secondary containment device.

Waste Container Markings

All waste containers must be properly marked to prevent creating “unknowns” and to prevent potential exposure to employees or students. Waste containers should be marked as described below.

- Containers must have a label affixed.
- Containers will be marked with the word “waste” or “spent” and their contents listed on the label.
- List specific chemicals. It is not sufficient to list waste as “halogenated” or “non-halogenated”

Properly defaced/removed container label

Waste container without proper identification

- Remove or deface old/original container labels.
- Containers must be compatible with contents (i.e. acid should not be stored in metal cans).

- Containers should be closed at all times except when actively receiving waste.

Properly closed waste containers

Improperly closed containers / containercaps

- Waste containers should be properly labeled before a pickup is requested.
- Containers must be safe for transport with non-leaking screw-on caps/lids.
- Containers must be filled to a safe level:
  - Fill solids up to their weight and volume capacity
  - Fill jugs/bottles to the container shoulder
  - Leave 2" of headspace in closed head cans less than 5 gallons
- Do not accumulate waste in containers larger than 5 gallons.
- Do not use biological waste or sharps containers for hazardous chemical waste collection.
- Contact EH&S for assistance with contaminated sharps or glassware.

Accumulation of Chemical Waste

- Keep all waste at or near (immediate vicinity) the site of generation and under control of the generator.
- A generator of potentially hazardous waste may not accumulate more than 55 gallons of waste, or one quart of acutely hazardous waste (see Laboratory Waste Management Guidelines for a list of acutely hazardous waste) at or near the point of generation.
- If a process will generate more than this volume at one time, EH&S must be contacted in advance to arrange a special waste pick up. Hazardous waste in excess of 55 gallons cannot be stored at your site for more than three days; therefore EH&S requires advance notice of generation in order to determine if the waste meets the definition of hazardous and to arrange for prompt removal.
- It is essential that the generator keep incompatible hazardous wastes separated. Mixing wastes can make it more difficult and expensive to dispose. In all cases, do not mix incompatible wastes or other materials in the same container or place wastes in an unwashed container that previously held an incompatible waste or material.
- Before chemical waste can be picked up by EH&S, all containers must be properly labeled and a Chemical Waste Accumulation Log legibly, accurately, and completely filled out.
- The label and accumulation log should be filled out by the waste generator and affixed to each container at all times. The information on the label is used to categorize and treat the waste.

Submitting Requests for Disposal of Chemical Waste

When a chemical waste container is ready for disposal and is properly labeled, the laboratory supervisor should contact EH&S.

Laboratory Evaluations

EH&S will inspect all laboratories each semester using the *Laboratory Inspection Checklist* (Appendix F) to conduct and document the results of the inspection.

Self-Evaluations

Lab Supervisors/PIs will conduct laboratory self-evaluations within the first 60 days of the Fall semester. A copy of the *Laboratory Self-Evaluation Form* (Appendix E) will be sent to EH&S upon completion.

Minors in Laboratories

This section of the manual provides guidance to principal investigators and research personnel regarding minors in laboratories or other potentially hazardous facilities. The presence of minors in hazardous areas raises concerns for their safety as well as the safety or workers in the hazardous areas whose attention might be diverted by the presence of minors.

Scope

- This section applies to all university laboratories and animal facilities. It covers all minors whether students, employees, or volunteers. Minors under the age of 15 are NOT PERMITTED inside research/animal laboratories at the university that contain hazardous materials or devices.
- It is intended for all university faculty, staff, students, visiting minors, and their sponsors and includes all persons under 18 years of age; whether students, employees, or volunteers.

Policy

- No person under the age of 15 is allowed in a university laboratory that contains hazardous materials. This age limit applies unless the laboratory activity is specifically designed for children below the age limit or the children are research study participants. In addition, a signed parental/guardian consent may be required for the minor to participate in either activity.
- Laboratories include facilities where there are hazardous chemicals, biological or radiological agents/devices used or stored, where laboratory animals are present or Class 3B and 4 lasers.
- Minors who are on a tour of a laboratory must be escorted at all times. All hazardous materials and equipment must be secured and made safe.

Exceptions

No person under the age of 18 may access a university laboratory with the exception of:

- Minors enrolled in an academic degree program at the university who are participating or observing in laboratories as a part of their course work.
- Minors who are employed at the university and whose employment responsibilities are in the laboratory.
- Minors who are subjects in approved studies.*

- Minors who are volunteers or interns in the laboratory in a formal internship training program approved in writing by the appropriate department chair or head.*
- Minors who are participating in a formal mentoring program with an individual faculty member approved in writing by the appropriate department chair or head.*
- Minors who are participating in a university-sponsored program.*
- Minors whose presence in the laboratory is for a specific educational purpose (i.e.,tours)
- Minors who are accompanied by and under direct, continuous and active supervision of a parent or legal guardian.
- Other exceptions will be reviewed on a case-by-case basis with written approval from EH&S.

A signed parental/guardian consent is required.

Requirements

- Minors of any age who qualify under one or more of the exceptions listed prior may be in a university laboratory or other potentially hazardous area only if:
- The minor has been authorized by the department to be in that specific laboratory or facility.
- A designated faculty member or administrator is assigned primary responsibility for ensuring that the minor is supervised, trained and provided Personal Protective Equipment
- The minor has reviewed and signed the Guidelines for Non-student, Non-employee Visitors in Researcher Laboratories and the required releases.*
- Appropriate hazard-specific safety training is completed and has been documented by the principal investigator/sponsor.*
- The minor is informed of the proper emergency/evacuation policies and procedures specific to the laboratory, department and the university.*
- Personal protective equipment specific to the hazard, is provided to the minor with instructions for use and disposal.*
- The minor is continuously and actively supervised by a knowledgeable and experienced adult University employee (i.e. the faculty member, principal investigator, adult researcher, or designated supervisor) at all times.
- The laboratory/facility is in full compliance with all applicable university safety programs and regulations.
- The faculty member, principal investigator, laboratory manager, or designated supervisor may place additional restrictions on the presence of minors in their specific activity areas.

The minor must also demonstrate an effective understanding of the topic.

High Hazard Areas

All minors (including the exceptions listed above) are not allowed in any of the “high hazard areas” identified below:

- Any laboratory designated as Biosafety Level 3 or follows BSL-3 practices (UT Tyler has no BSL 3).
- Any laboratory where explosives, acute/reproductive toxins or carcinogens are used or stored.
- Any animal housing or procedure area considered high risk.
- Other high hazards areas (radiation, lasers, etc.) as determined by EH&S.

Children of University Personnel

Children are allowed to be in areas adjacent to the laboratory (i.e., an office or break room within the laboratory) if they are supervised.

Compliance

The faculty member, principal investigator, or laboratory supervisor/manager is directly responsible for compliance with this policy and for the safety of all minors who are approved to be in their areas under this policy. Non-compliance must be reported to a supervisor, and failure to comply with the conditions of the policy may result in disciplinary action.

BASIC HAZARDOUS MATERIALS GUIDELINES

General Rules

Laboratory Protocol

- Everyone in the lab is responsible for their own safety and the safety of others.
- Avoid working alone in the lab. If you must work alone, make someone (such as a supervisor) aware of your location.
- Before starting any work in the lab, personnel should be familiar with the procedures and equipment being used. Lab personnel should be aware of the chemical hazards before working with them. Personnel who are unfamiliar with the hazardous material or a new procedure should consult their supervisor.
- SDS information available in the laboratory.

Personal Safety Practices

- Lab coats, gloves, and safety glasses should be worn as appropriate in all laboratories.
- Do not wear shorts, sandals, or open-toed shoes in lab.
- Minors or personal pets are not permitted in laboratories.
- Do not smell or taste chemicals or pipette by mouth.
- Secure any loose jewelry, restrain loose clothing, and tie back long hair before starting work.
- Food and drink must not be consumed in the lab.
- Do not store food and drinks in laboratory refrigerators.
- Wash your hands frequently throughout the day and before leaving the lab.

- Do not wear lab coats, gloves, or other personal protective clothing outside of lab areas. This clothing may have become contaminated and you could spread the contamination.
- Cell phones and use of music headphones should be avoided while working in the lab. They can be distracting and thereby increase the potential for an accident to occur. They can also become contaminated if handled while working with hazardous materials.

Cell phones should not be used while working in the lab

Housekeeping and Decontamination

- Work areas must be kept clean and free of unnecessary chemicals. Clean the work area throughout the day and before leaving the lab for the day.
- If necessary, clean equipment after use to avoid the possibility of exposing the next person who uses it.
- Keep all aisles and walkways in the lab clear to provide a safe walking surface and an unobstructed exit. Do not block doors.
- Do not block access to emergency equipment such as fire extinguishers, eyewashes, emergency shut-offs, and utility controls (i.e. electrical panels, fire panels).

Emergency eyewash obstructed

Blocked fire extinguisher

Accidents and Spills

- See the Emergency Procedures section for detailed procedures. Do not clean up spills unless trained to do so.
- Supplies for cleaning up minor spills should be readily available. In case of release, promptly clean up spills using appropriate personal protective equipment (PPE).

Spill Response Equipment

Supplies for a chemical spill should include:

- An inert absorbent such as kitty litter or vermiculite or a 50/50 mixture of the two or a commercial absorbent
- A plastic (non-sparking) scoop, plastic bags for the spilled material
- Chemical resistant gloves
- Goggles
- Sodium bicarbonate to neutralize acids.

Items that should be included in a spill kit

Note: All spent spill clean-up materials should be disposed of in the same manner as the spilled chemical or biological material. Spill clean-up supplies should be checked and re-stocked as necessary. Contact EH&S to coordinate disposal of spent clean-up materials.

Steps to Prevent Routine Exposure

- Develop and encourage safe work practices/habits.
- Ensure engineering controls are working as designed.
- Avoid unnecessary exposure to chemicals by any route.
- Do not smell or taste chemicals or pipette by mouth.
- Vent any apparatuswhich may discharge toxic chemicals (e.g., vacuum pumps, distillation columns) into local exhaust devices such as fume hoods.
- Inspect gloves and test glove boxes before use.
- Do not allow release of toxic substances in cold rooms or warm rooms, since these have contained, re-circulated air.

Equipment and Glassware

EHS recommends the following guidelines for the use and care of glassware and other laboratory equipment:

Glassware and Glass Bottles

- Inspect all glassware before use. Discard any broken, cracked, or chipped glassware.
- Tape or shield glass vacuum vessels to prevent flying glass in the case of an implosion. Also, tape or shield glass vacuum desiccators.
- Transport all glass chemical containers in rubber or polyethylene bottle carriers when leaving one lab area to enter another. Use a cart if transporting more than two bottles.

Chemical cart

Bottlecarrier

- Fire-polish all cut glass tubing and rods before use.
- Practice the following when inserting glass tubes or rods into stoppers:
  - Be certain that the diameter of the tube is compatible with the diameter of the stopper.
  - Fire-polish the end of the glass tube.
  - Lubricate the glass with water or glycerol.
  - Wear heavy gloves and hold the glass not more than two inches from the end to be inserted.
  - Insert the glass carefully with a twisting motion.
  - Remove stuck tubes by slitting the stopper with a sharp knife.

Assembly of Laboratory Apparatus

- Firmly clamp apparatus and set up away from the edge of the lab bench.
- Only use equipment that is free from cracks, chips, or other defects.
- If possible, place a pan under a reaction vessel or other container to contain liquid if the glassware breaks.
- Do not allow burners or any other ignition sources nearby when working with flammable liquids.
- Lubricate glass stopcocks.
- Properly support and secure condensers and water hoses with clamps and wires.
- Be sure to direct the water hoses so that any drips that come off the hoses do not splash down onto any electrical wires.
- Position apparatus that is attached to a ring stand with the center of gravity over the base and not to one side.
- Assemble the apparatus so that burners or baths can be removed quickly.
- Use an appropriate vapor trap and confine the setup to a fume hood if there is a possibility of hazardous vapors.
- Put the setup in a fume hood whenever conducting a reaction that could result in an implosion or explosion. Keep the sash pulled down. If it is not possible to use a fume hood, use a standing shield that is stabilized and secured.

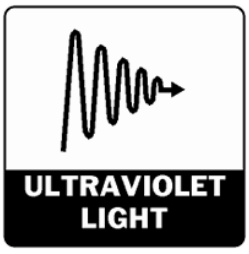
Centrifuges

- Securely anchor tabletop centrifuges and place in a location where the vibration will not cause lab equipment to fall off the bench top.
- Keep the centrifuge lid closed while operating and do not leave the centrifuge until you are certain it is running safely without vibration.
- If the centrifuge starts vibrating, stop and check the load balances.
- Regularly clean rotors and buckets with a non-corrosive cleaning solution.
- Use sealed safety cups while centrifuging hazardous materials.

Sealed safety cups being used in a centrifuge

Ultraviolet Lamps

- Wear ultraviolet absorbing protective safety glasses while working with ultraviolet light.
- Protect your skin from potential burns due to ultraviolet light.
- Shield any project in which ultraviolet light is used to prevent escape of the direct beam or scattered radiation.



Lasers

- Always wear goggles that protect against the specific wavelength of the laser.
- Never look directly at the beam.
- Do not allow any reflective materials in or along the path of the beam.
- Post warning signs in all laser areas. If required, use a flashing light at the lab entrance to indicate when a laser is in use.

Laser warning sign

Laser warning light

Contact EH&S for more information on Laser Safety.

Separatory Funnels

- Use extreme caution if the temperature of the materials is elevated.
- When a volatile solvent is used, swirl the unstoppered separatory funnel first to allow some solvent to vaporize and to release pressure.
- Close the funnel and invert it with the stopper held in place, then immediately open the stopcock to release pressure.
- Do not vent the separatory funnel near a flame or any other ignition source.
- Do not point the funnel at a co-worker. Be aware of nearby co-workers.
- Vent the separatory funnel into a fume hood.
- Close the stopcock, swirl the funnel, then immediately open the stopcock with the funnel in an inverted position to vent the vapors again.

Cryogens, Cooling Baths, and Cold Traps

- Always use caution when working with cryogenic coolants.
- Use temperature resistant gloves and a face shield while slowly immersing an object to be cooled.
- Do not pour cold liquid onto the edge of a glass Dewar flask when filling because the flask may break and implode.
- Never lower your head into a dry ice chest; no oxygen is present.
- Wear temperature resistant gloves while handling dry ice. If no protection is used, severe burns can result.

Vacuum Pumps

Mechanical vacuum pumps used in laboratories pose many hazards. There are mechanical hazards associated with the moving parts. There are chemical hazards of contaminating the pump oil with volatile substances and subsequently releasing them into the lab. There are also fire hazards when pumps malfunction or overheat and ignite nearby flammable or combustible materials.

Follow these guidelines for safe pump operation:

Physical (injuries/fires)

- Ensure that pumps have belt guards in place during operation to prevent hands or loose clothing from getting caught in the belt pulley.
- Ensure that electrical cords and switches are free from defects.
- Do not place pumps in an enclosed, unventilated cabinet allowing heat and exhaust to build up.
- Do not operate pumps near containers of flammable chemicals, flammable chemical wastes, or combustible materials such as paper or cardboard.
- Use correct vacuum tubing (thick walls) not thin Tygon-type hoses.
- Replace old tubing; crumbly tubing can degrade performance.
- Use the shortest length of tubing that reaches where needed.

Chemical

- Do not use solvents which might damage the pump.
- Always close the valve between the vacuum vessel and the pump before shutting off the pump to avoid sucking vacuum oil into the system.
- Place a pan under pumps to catch oil drips.
- Check oil levels and change oil when necessary. Replace and properly dispose of vacuum pump oil that is contaminated with condensate. Used pump oil must be disposed as hazardous waste.
- With oil rotary pumps many vapors condense in the pump oil. Solvents in the oil degrade its performance (and eventually ruin the pump), create a chemical hazard when the oil is changed, and are emitted in an oil mist vented from the system. Other vapors pass directly into the exhaust stream. To avoid these problems:
    - Trap evaporated materials with a cold trap before they reach the pump.
    - Depending on the material that is to be trapped, this can be a filtration flask either at room temperature or placed in an ice bath. For more volatile solvents more sophisticated options exist (e.g. dry ice trap).
    - Vent the pump exhaust properly.

Personnel

- Conduct all vacuum operations behind a table shield or in a fume hood and always wear safety glasses, lab coat, and gloves.
- Keep a record for each pump to record oil change dates and to keep track of the maintenance schedule.

Electrical

- Examine all electrical cords periodically for signs of wear and damage. If damaged electrical cords are discovered, unplug the equipment and have it repaired.
- Properly ground all electrical equipment.
- If sparks are noticed while plugging or unplugging equipment or if the cord feels hot, do not use the equipment until it can be serviced by an electrician.
- Do not run electrical cords along the floor where they will be a tripping hazard and be subject to wear. If a cord must be run along the floor, protect it with a cord cover.
- Do not run electrical cords above the ceiling. The cord must be visible at all times to ensure it is in good condition.

- Do not plug too many items into a single outlet. Cords that enable you to plug more than one item in at a time should not be used.
- Multi-plug strips can be used if they are protected with a circuit breaker. Do not overuse or daisy-chain in a series.

Overused multi-plug strip

Electrical cords daisy-chained

Note: Do not use extension cords for permanent wiring. If you must use extension cords throughout the lab, then it is time to have additional outlets installed.

Operation of Fume Hoods

- Use a fume hood for all procedures that might result in the release of hazardous chemical vapors or dust.
- Confirm that the hood is working before use by holding a Kimwipe®, or other lightweight paper, up to the opening of the hood.
- The paper should be pulled inward.
- Leave the hood "on" when it is not in active use if toxic substances are stored inside or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off."

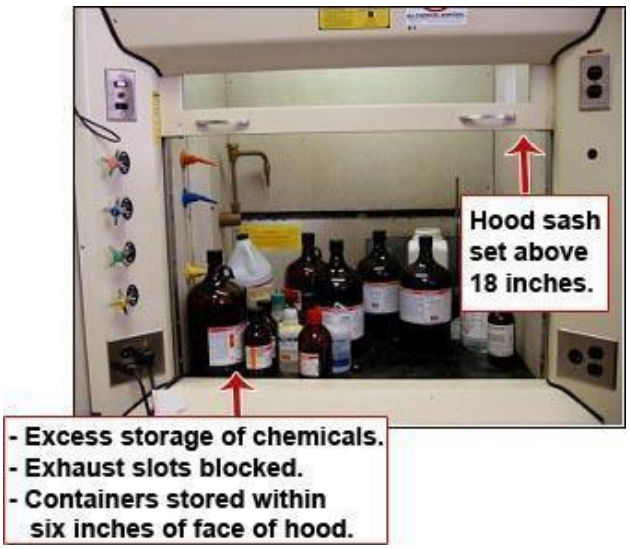
Proper Use of Fume Hoods

- Equipment and other materials should be placed at least six inches behind the sash, preferably in the middle of the hood. This will reduce the exposure of personnel to chemical vapors that may escape into the lab due to air turbulence.
- When the hood is not in use, pull the sash all the way down. While personnel are working at the hood, pull down the sash as far as is practical. The sash is constructed of safety glass to protect users against fire, splashes, and explosions.

Work with the fume hood sash down as far as practical

Improper use of the fume hood

- Fume hood sash should be at or below 18 inches.
- Do not keep loose papers, paper towels, or tissues (e.g., kimwipes® in the hoods.
- These materials can be drawn into the blower and adversely affect the performance of the hood.
- Do not use a fume hood as a storage cabinet for chemicals
- Excessive storage of chemicals and other items will disrupt the designed airflow in the hood. In particular, do not store chemicals against the baffle at the back of the hood, because this will interfere with the laminar airflow across the hood.



- If large equipment must be kept in a fume hood, raise it 1.5 inches off the work surface to allow air to flow underneath. This dramatically reduces the turbulence within the hood and increases its efficiency.
- Do not place objects directly in front of a fume hood (such as refrigerators or lab coats hanging on the manual controls) as this can disrupt the airflow and draw contaminants out of the hood.
- Keep in mind that modifications made to a fume hood system, e.g., adding a snorkel, can render the entire system ineffective. Modifications should not be done without proper authorization.
- Minimize the amount of foot traffic immediately in front of a hood. Walking past hoods causes turbulence that can draw contaminants out of the hood and into the room.

Personal Protective Equipment (PPE)

The lab supervisor must ensure that appropriate personal protective equipment is worn by all persons, including visitors, in areas where chemicals are stored or handled.

- Safety Data Sheets or other references should be consulted for information on the type of protective clothing required for the particular work you are performing.
- In general, when working in an area with hazardous materials, your skin should be covered from shoulders to toes.

Protective Eyewear

- Goggles provide the best protection against chemical splashes, vapors, dusts, and mists.
- Goggles that have indirect vents or are non-vented provide the most protection, and an anti-fog agent can be applied.
- Standard safety glasses provide protection against impact.
- Remember, prescription glasses do not provide adequate protection in a laboratory setting. Prescription safety glasses can be purchased from most opticians.
- Alternatively, safety glasses and goggles designed to fit over prescription glasses are available through commercial vendors.

Face shields

- Face shields can protect against impact, dust, particulates, and splashes to the face, eyes, and throat. However, always wear protective eyewear such as goggles underneath a face shield. Chemical vapors and splashes can still travel under and around a face shield.
- If scratches or cracks are noticed in the face shield, replace the window.

Protective Gloves

- Any glove can be permeated by chemicals. The rate at which this occurs depends on the composition of the glove, the chemicals present and their concentration, and the exposure time to the glove. If you are not certain which type of glove provides you with the protection you need, contact the manufacturer and ask for specifics on that glove.
- Refer to the Chemical Compatibility Guides to select the appropriate gloves for the materials you are working with.
- If direct chemical contact occurs, replace gloves regularly throughout the day.
- Wash hands regularly and remove gloves before answering the telephone or opening doors to prevent the spread of contamination.
- Check gloves for tears, holes and cracks.

- Butyl, neoprene, and nitrile gloves are resistant to most chemicals, e.g., alcohols, aldehydes, ketones, most inorganic acids, and most caustics.
- Disposable latex and vinyl gloves protect against some chemicals, most aqueous solutions, and microorganisms and reduce risk of product contamination.
- Leather and some knit gloves will protect against cuts, abrasions, and scratches, but not against chemicals.
- Temperature-resistant gloves protect against cryogenic liquids, flames, and high temperatures such as autoclaves.

Note: Latex gloves should not be worn if a person has or suspects a latex allergy.

Lab Coats and Aprons

- The primary purpose of a lab coat is to protect against splashes and spills. A lab coat should be nonflammable, where necessary, and should be easily removed. Other types of lab coats such as flame resistant coats are available.
- Lab coats should be buttoned when in use.
- Rubber coated aprons can be worn to protect against chemical splashes and may be worn over a lab coat for additional protection.

Shoes

Shoes that fully cover the feet should always be worn in a lab. If work is going to be performed that includes moving large and heavy objects, steel-toed shoes should be worn.

Respirators

Contact EH&S if you are conducting research that necessitates the need for a respirator. EH&S will evaluate whether there is a need for a respirator and what type of respirator is needed. (Refer to the UT Tyler Respiratory Protection Program to obtain additional information.)

The most important thing to remember about PPE is that it only protects you if you wear it!

Storage of Chemicals in the Lab

Refer to the section on *Laboratory Chemical Storage* on page 16 of this manual.

Unattended Operations

Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation.

Working with Allergens

A wide variety of substances can illicit skin and lung hypersensitivity. Examples include common substances such as; diazomethane, chromium, nickel, bichromates, formaldehyde, isocyanates, and certain phenols. Because of this variety and the varying response of individuals, suitable gloves should be used whenever there is potential for contact with chemicals that may cause skin irritation. Voluntary use of N95 masks are authorized. Consult EH&S for proper fit.

Working with Embryotoxins

Embryotoxins are substances that cause adverse effects on the developing fetus in pregnant women. These effects may include embryolethality (death of the fertilized egg, the embryo, or the fetus), malformations (teratogenic effects), retarded growth, and postnatal function deficits.

- A few substances have been demonstrated to be embryotoxic in humans and include:

Azo dyes	Benzene	Chloroform	Nitrous oxide
Formaldehyde	Heavy Metals	Propylene glycol	Xylene
Toluene	Carbon Tetrachloride		

- Many substances, some as common as sodium chloride, have been shown to be embryotoxic to animals at some exposure level, but usually this is at a considerably higher level than is encountered in the course of normal laboratory work. However, some substances do require special controls due to embryotoxic properties. One common example is formamide: women of childbearing potential should handle this substance only in a hood and should take precautions to avoid skin contact with the liquid because of the ease with which it passes through the skin.

- Because the period of greatest susceptibility to embryotoxins is the first 8-12 weeks of pregnancy, which includes a period when a woman may not know that she is pregnant; women of childbearing potential should take care to avoid skin contact with all chemicals. The following procedures are recommended to be followed routinely by women of childbearing potential in working with chemicals requiring special control because of embryotoxic properties:
    - Each procedure involving embryotoxins should be reviewed for particular hazards by the Principal Investigator or Lab Supervisor, who will decide whether special procedures are warranted or whether warning signs should be posted. Consultation with EH&S is recommended.

- In cases of continued use of a known embryotoxin, the operation should be reviewed annually and/or whenever a change in procedures is made.
- Embryotoxins requiring special control should be stored in an adequately ventilated area. The container should be labeled in a clear manner such as the following: **EMBRYOTOXIN: READ SPECIFIC PROCEDURES FOR USE.** If the storage container is breakable, it should be kept in an impermeable, unbreakable secondary container.
- Women of childbearing potential should take adequate precautions to guard against spills and splashes. Operations should be carried out using impermeable containers and in adequately ventilated areas. Appropriate safety apparel, especially gloves, should be worn. All fume hoods, glove boxes, or other essential engineering controls should be working properly before work is started.
- Supervisors must be notified regarding all incidents of exposure or spills of embryotoxins requiring special control. Occupational Health should be consulted about any exposures of women of childbearing potential above the acceptable level (i.e. any skin contact or inhalation exposures).

Working with Chemicals of Moderate, Chronic, or Acute Toxicity

Before beginning a laboratory operation, each worker is strongly advised to learn about the substances to be used. The precautions and procedures described in this section should be followed if any of the substances used in significant quantities are known to be moderately or highly toxic. ***If any of the substances used are known to be highly toxic, it is recommended that two people be present in the area at all times.***

These procedures should also be followed if the toxicological properties of any of the substances used or prepared are unknown. If any of the substances to be used or prepared are known to have high, chronic toxicity (e.g., compounds of heavy metals and other potent carcinogens), then the directions and procedures described below should be supplemented with additional precautions to aid in containing and ultimately destroying the substances having high chronic toxicity. Some examples of potent carcinogens (substances known to have high chronic toxicity), along with their corresponding chemical class, are:

Alkylating Agents	***Sulfonates***	***Organohalogen Compounds***
Aziridines	Sulfate	1,2-Dibromo-3-Chloropropane
Ethylene Imine	Methanesulfonate	Bis(2-Chloroethyl) Sulfide Ethyl
2-Methylaziridine	Trifluoromethanesulfonate	Vinyl Chloride
Diazo, Azo & Azoxy Compounds	1,3-Propanesultone	Chloroform
4-Dimethylaminoazobenzene	1,4-Butanedioldimethanesulfonate	Methyl Iodide Ethylene Oxide
Electrophilic Alkenes & Alkynes	***Acylating Agents***	2,4,6-Trichlorophenol
Acrylonitrile	*α -Halo*	Carbon Tetrachloride
Acrolein	β –Butyrolactone	Hexachlorobenzene
Acrylate	β -Propiolactone	1,4-Dichlorobenzene Styrene
Epoxides	Dimethylcarbamoyl Chloride	***Natural Products***
Diepoxybutane	***Aromatic Amines***	Adriamycin Diethyl
Epichlorohydrin	4-Aminobiphenyl	Aflatoxins Dimethyl
Propylene Oxide	Aniline	Bleomycin Ethyl
Oxide	o-Anisidine	Progesterone Methyl
Ethers	Benzidine	Reserpine Methyl
Bis(Chloromethyl) Ether	o-Toluidine	Safrole
Methyl Chloromethyl Ether		***Inorganic Compounds***
Propylene Oxide		Cisplatin
Oxide		

The overall objective of the procedures outlined in this section is to minimize exposure of the laboratory worker to toxic substances by taking all reasonable precautions.

- Thus, the general precautions outlined above should normally be followed whenever a toxic substance is being transferred from one container to another or is being subjected to some chemical or physical manipulation. The following precautions should always be followed:
    - Protect the hands and forearms by wearing either gloves and a laboratory coat or suitable long gloves to avoid contact of the toxic material with the skin.
    - Procedures involving volatile toxic substances and those involving solid or liquid toxic substances that may result in the generation of aerosols should be conducted in a fume hood or other suitable containment device.
    - After working with toxic materials, wash the hands and arms immediately. Never eat, drink, chew gum or tobacco, apply cosmetics or contact lenses, take medicine, or store foods in areas where toxic substances are being used.

- These standard precautions will provide laboratory workers with good protection from most toxic substances. In addition, records that include details of material used and names of workers involved should be kept as part of the laboratory notebook record of research projects. To minimize hazards from accidental breakage of apparatus or spills of toxic substances in the fume hood, containers of such substances should be stored in pans or trays made of polyethylene or other chemically resistant material and apparatus should be mounted above trays of the same type of material.

- The general waste disposal procedures described in the EH&S *Laboratory Waste Management Guidelines* must be followed for these types of chemicals. In general, the waste materials and solvents containing toxic substances must be stored in closed, impervious containers so that personnel handling the containers will not be exposed to their contents.

- The laboratory worker must be prepared for potential accidents or spills involving toxic substances. Lab workers must be trained in handling toxic materials and spill clean-up before beginning work with toxic substances.

- If a toxic substance contacts the skin, the area should be washed with water. If there is a major spill outside of the hood, the room or appropriate area should be evacuated and necessary measures should be taken to prevent exposure of other workers. Spills must be cleaned by personnel wearing suitable personal protective apparel. If a spill of a toxic material occurs outside the hood, an air-supplied full-face respirator may be needed. Immediately contact EH&S for assistance.

- In addition to the precautions described in this section, researchers should develop written standard operating procedures intended to establish a concise, step-by-step method for carrying out routine laboratory operations with the substance in question and train lab personnel on these procedures.

Working with Substances of High Chronic Toxicity

All of the procedures and precautions described in the previous section should be followed when working with substances known to have high chronic toxicity. In addition, when such substances are used in quantities exceeding a few milligrams to a few grams, depending on the hazards posed by the particular substance, the additional precautions described in this section should be followed. Each laboratory worker's plan for project work and for disposing of waste materials must be approved by the laboratory supervisor.

Consultation with the departmental Lab Safety Coordinator or EH&S is recommended to ensure that the toxic material is effectively contained during the project and that waste materials are disposed of in a safe manner. Substances in this high chronic toxicity category include certain heavy metal compounds (e.g., dimethylmercury and nickel carbonyl) and compounds normally classified as select carcinogens.

Examples of compounds normally classified as select carcinogens include the following:

2-acetylaminofluorene
benzo[a]pyrene
bis(chloromethyl) ether
dimethylcarbamoyl chloride
7,12-dimethylbenz[a]anthracene
hexamethylphosphoramide

aflatoxin B1
3-methylcholanthrene
2-nitronaphthalene
propane sultone
various N-nitrosamides
various N-nitrosamines

- Record of the amounts of substances of high chronic toxicity being stored and the amounts used, dates of use, and names of users for research purposes. It is appropriate to keep such records as part of the record of project work in the laboratory workers' research notebook.

- Any volatile substances having high chronic toxicity must be stored in a ventilated storage area in a secondary tray or container having sufficient capacity to contain the material should the primary storage container fail. All containers of substances in this category should have labels that identify the contents and include a warning such as: WARNING! HIGHLY TOXIC OR SUSPECTED CARCINOGEN. Storage areas for substances in this category must have limited access, and special signs should be posted if a special toxicity hazard exists. Any area used for storage of substances of high chronic toxicity must be maintained under negative pressure with respect to the surroundings. Contact EH&S if there is a problem with airflow in the storage areas.

- All projects with and transfers of such substances or mixtures containing such substances must be done in a controlled area (i.e., a laboratory, or a portion of a laboratory, or a facility such as an exhaust hood or a glove box that is designated for the use of highly toxic substances. Its use need not be restricted to the handling of highly toxic substances if all personnel who have access to the controlled area are aware of the nature of the substances being used and the precautions that are necessary). When a glove box is used, the ventilation rate in the box should be at least two volume changes per hour, the pressure should be at least 0.5 inches of water lower than that of the surrounding environment, and the exhaust should be passed through a trap, charcoal or High Efficiency Particulate Air (HEPA) filter as appropriate.

- Positive pressure glove boxes are normally used to provide an inert anhydrous atmosphere. If these glove boxes are used with highly toxic compounds, then the box should be thoroughly checked for leaks before use and the exit gases should be passed through a suitable trap or filter. Laboratory vacuum pumps used with substances having high chronic toxicity should be protected by high-efficiency scrubbers or HEPA filters and vented into an exhaust hood. Motor-driven vacuum pumps are recommended because they are easy to decontaminate.

- Proper gloves must be worn when transferring or otherwise handling substances or solutions of substances having high chronic toxicity. In some cases, the laboratory worker or the research supervisor may deem it necessary to use other protective apparel, such as an apron of reduced permeability covered by a disposable coat. Additional precautions such as these might be taken, for example, when handling large amounts of certain heavy metals and their derivatives or known potent carcinogens.

- Surfaces on which high chronic toxicity substances are handled must be protected from contamination by chemically resistant trays or pans that can be decontaminated after the project or by using dry, absorbent plastic-backed paper.

- On leaving a controlled area, laboratory workers must remove any used PPE and thoroughly wash hands, forearms, face, and neck. If disposable apparel or absorbent paper liners have been used, these items must be placed in a closed and impervious container that should then be labeled in some manner such as: CAUTION: CONTENTS CONTAMINATED WITH SUBSTANCES OF HIGH CHRONIC TOXICITY (for waste disposal purposes, chemical names are required). Non-disposable protective apparel should be thoroughly washed, and containers of non-reusable apparel and protective liners must be disposed of through EH&S.

- Wastes and residues must be placed in an impervious container and disposed of through EH&S. In general, liquid wastes containing such compounds must be placed in a glass or polyethylene bottle half filled with vermiculite.

- Normal laboratory work must not be resumed in a space that has been used as a controlled area until it has been adequately decontaminated. Work surfaces must be thoroughly washed and rinsed. If projects have involved the use of finely divided solid materials, dry sweeping should not be done. In such cases, surfaces must be cleaned by wet mopping or by use of a vacuum cleaner equipped with a HEPA filter. All equipment (e.g., glassware, vacuum pumps, and containers) that is known or suspected to have been in contact with substances of high chronic toxicity should be washed and rinsed before removing from the controlled area.

- In the event of continued exposure to a substance of high chronic toxicity (i.e., if a worker regularly uses significant quantities of such a substance at least three times a week),

- EH&S should be consulted to determine whether it is advisable to establish a regular schedule of medical surveillance or biological monitoring.

- In addition to the precautions described in this section, lab supervisors must develop written standard operating procedures intended to establish a concise, step-by-step method for carrying out routine laboratory operations with the substance in question. These procedures should be reviewed by a department laboratory safety coordinator or EH&S.

PROCEDURES FOR SPECIFIC CLASSES OF HAZARDOUS CHEMICALS

This section offers specific guidelines for working with common hazardous materials that, for varying reasons, may pose a significant risk to human life and health if used improperly. Six fundamental classes of laboratory chemicals will be discussed; flammables, corrosives, oxidizers, reactives, compressed gases, and nanomaterials. These classes of chemicals may include chemicals that are also covered in the previous section regarding their property of toxicity.

Note that the hazard characteristics of the classes of hazardous chemicals are generalized. Check the SDS to determine the specific hazard characteristics for the chemical before using it.

Flammable Liquids

Terms and Definitions

Flammable liquids are among the most common chemicals found in a laboratory. The primary hazard associated with flammable liquids is their ability to readily ignite and burn. The vapor of a flammable liquid, not the liquid itself, can ignite and start a fire.

- ***Vapor Pressure*** – The rate at which a liquid vaporizes. In general, liquids with high vapor pressure evaporate at a higher rate compared to liquids of lower vapor pressure. The vapor pressure increases rapidly as the temperature is raised. A low- pressure environment also accelerates the rate of evaporation.
- ***Flash Point*** – The lowest temperature at which a liquid gives off vapor to form an air- vapor mixture that will ignite, but will not sustain ignition. Many commonly used flammable liquids have flashpoints significantly lower than room temperature:

Compound	Flash Point (° C)
Diethyl ether	-45.0
Acetone	-17.8
Isopropyl alcohol	11.7

- ***Limits of Flammability or Explosivity*** – The range of fuel:air mixtures that will sustain combustion. The lower limit of this range is called the *Lower Explosive Limit* (*LEL)*, and the higher limit of this range is called the *Upper Explosive Limit* (*UEL)*. Materials with very broad flammability ranges (e.g., acetylene, LEL = 3%, UEL = 65%) are particularly dangerous due to the fact that virtually any fuel:air combination may form an explosive atmosphere.
- ***Vapor Density*** of a flammable liquid – The density (mass to volume ratio) of the corresponding vapor relative to air under specific temperature and pressure conditions. Flammable vapors with densities greater than 1.0 (and thus “heavier” than air) are hazardous because they can accumulate at floor level and spread. These mobile vapors may eventually reach an ignition source, such as an electrical outlet or a Bunsen burner.
- **Autoignition Temperature** – The minimum temperature at which a substance can ignite without a spark or flame. Some examples: acetone 538°C (1000°F), ethyl ether 180°C (356°F), phenol 715°C (1319°F).

Use and Storage of Flammables

- Flammable liquids that are not in active use should be stored inside fire resistant flammable storage cabinets.
- Minimize the amount of flammable liquids stored in the lab. Do not store more than a gallon outside of flammable storage cabinets.
- Keep flammables away from vacuum pumps and other ignition sources.
- The transfer of material to/from a metal container can result in an accumulation of static charge on the container. When transferring flammable liquids, this static charge could generate a spark, thereby igniting the liquid. To make these transfers safer, flammable liquid dispensing and receiving containers should be bonded together before pouring.
- Large containers such as drums must also be grounded when used as dispensing or receiving vessels. All grounding and bonding connections must be metal to metal.
- Do not heat flammables with an open flame. Instead, use steam baths, water baths, oil baths, hot air baths, sand baths or heating mantles.
- Do not store flammable chemicals in a standard household refrigerator. There are several ignition sources located inside a standard refrigerator that can cause a fire or explosion. Flammables that need to refrigeration should be stored cold in a lab-safe explosion-proof refrigerator.

Health Hazards Associated with Flammables

The vapors of many flammables are irritating to mucous membranes of the respiratory system and eyes. Routes of entry with corresponding symptoms are listed below.

Acute Health Effects

- *Inhalation* – headache, fatigue, dizziness, drowsiness, narcosis (stupor and unresponsiveness).
- *Ingestion* – slight gastrointestinal irritation, dizziness, fatigue.
- *Skin Contact* – dry, cracked, and chapped skin.
- *Eye Contact* – stinging, watering eyes, and inflammation of the eyelids.

Chronic Health Effects

The chronic health effects will vary depending on the specific chemical, the duration of the exposure and the extent of the exposure. However, damage to the lungs, liver, kidneys, heart and/or central nervous system may occur. Cancer and reproductive effects are also possible.

Flammable Groups Exhibiting Similar Health Effects

- *Hydrocarbons* – aliphatic hydrocarbons are narcotic, but their systemic toxicity is relatively low. Aromatic hydrocarbons are potent narcotic agents, and overexposure to the vapors can lead to loss of muscular coordination, collapse and unconsciousness. Benzene is toxic to bone marrow and can cause leukemia.
- *Alcohols* – vapors can be moderately narcotic.
- *Ethers* – exhibit strong narcotic properties and can be moderately toxic.
- *Esters* – vapors may result in irritation to the eyes, nose and upper respiratory tract.
- *Ketones* – systemic toxicity is generally low.

First Aid Procedures

- *Inhalation Exposures* – remove the person from the contaminated area. Get medical attention.
- *Ingestion Exposures* – Get medical attention.
- *Dermal Exposures* – remove the person from the source of contamination. Remove clothing and jewelry from the affected areas. Rinse in a safety shower for at least 15 minutes and obtain medical attention.
- *Eye Contact* – remove the person from the source of contamination. Flush with an eyewash for at least 15 minutes and obtain medical attention.

Engineering Controls and Protective Equipment

Fume hoods should be used when working with flammable liquids. Nitrile and neoprene gloves provide protection against most flammables. Wear a fire-resistant lab coat to provide a barrier to your skin. Safety goggles/glasses should be worn if there is a splash risk.

Explosive-proof Refrigerator

Proper PPE

Oxidizers

General Characteristics

- Oxidizers present fire and explosion hazards on contact with flammable and combustible materials. Depending on the class, an oxidizing material may increase the burning rate of combustibles which it contacts; cause the spontaneous ignition of combustibles which it contacts, or produce an explosive reaction when exposed to heat, shock or friction.
- Oxidizers are generally corrosive.

Examples of Common Oxidizers

Chlorates	Hypochlorites	Perchlorates
Chlorites	Nitrites	Peroxides
Dichromates	Nitrates	

Use and Storage of Oxidizers

- Store oxidizers away from flammables, organic compounds and combustible materials.
- Strong oxidizing agents like chromic acid should be stored in glass or some other inert container. Corks and rubber stoppers should not be used.
- Reaction vessels containing oxidizing material should be heated in a mantle or sand bath. Oil baths should not be used.

Use and Storage of Perchloric Acid

- Perchloric acid is an oxidizing agent of particular concern. The oxidizing power of perchloric acid increases as the concentration and temperature increase. Cold, 70% perchloric acid is a strong, non-oxidizing corrosive. A 72% perchloric acid solution at elevated temperatures is a strong oxidizing agent. An 85% perchloric acid solution is a strong oxidizer at room temperature.
- Do not attempt to heat perchloric acid if you do not have access to a properly functioning perchloric acid fume hood. Perchloric acid can only be heated in a hood specially equipped with a wash-down system to remove any perchloric acid residue. The hood should be washed down after each use, and it is preferred that the hood be restricted to perchloric acid use only.
- Whenever possible, substitute a less hazardous chemical for perchloric acid or use a dilute solution.
- Perchloric acid can be stored in a perchloric acid fume hood. Keep only the minimum amount necessary for your work. Another acceptable storage site for perchloric acid is in an acid cabinet that has secondary containment.
- Do not allow perchloric acid to come in contact with any strong dehydrating agents such as sulfuric acid. The dehydration of perchloric acid is a severe fire and explosion hazard.
- Do not order or use anhydrous perchloric acid. It is unstable at room temperature and can decompose spontaneously with a severe explosion. Anhydrous perchloric acid will explode upon contact with wood.
- Consult with EH&S before working with perchloric acid.

Health Hazards Associated with Oxidizers

Acute Health Effects

Some oxidizers such as nitric and sulfuric acid vapors, chlorine, and hydrogen peroxide act as irritant gases. All irritant gases can cause inflammation in the surface layer of tissues when in direct contact. They can also cause irritation of the upper airways, conjunctiva, and throat.

- Fluorine, can cause severe burns of the skin and mucus membranes.
- Chlorine trifluoride is extremely toxic and can cause severe burns to tissue.
- Nitrogen trioxide is very damaging to tissue, especially the respiratory tract. The symptoms from an exposure to nitrogen trioxide may be delayed for hours, but fatal pulmonary edema may result.
- Osmium tetroxide also dangerous due to its high degree of acute toxicity. It is a severe irritant of the eyes and respiratory tract. Inhalation can cause headache, coughing, dizziness, lung damage, difficulty breathing and death. Osmium tetroxide is regarded by many in the field as having "poor warning properties." This is due to the fact that it is difficult to detect in the atmosphere (by smell or other means). The OSHA Permissible Exposure Limit (PEL) for osmium tetroxide is 0.002 ppm, while its odor threshold is 2 ppm -this means that one could conceivably be exposed to osmium

tetroxide at concentrations 1,000 times the PEL without knowing it. It is recommended that laboratories using osmium tetroxide have necessary safeguards in place before the container is even opened.

Chronic Health Effects

Nitrobenzene and chromium compounds can cause hematological and neurological changes. Compounds of chromium and manganese can cause liver and kidney disease. Chromium (VI) compounds have been associated with lung cancer.

First Aid Procedures

If a person has inhaled, ingested or come into direct contact with these materials, the person should be removed from the immediate area as quickly as possible. Seek medical attention immediately. Rinse with a safety shower for at least 15 minutes if there is direct skin exposure. Flush with an eyewash for at least 15 minutes if there is direct eye exposure.

Engineering Controls and Protective Equipment

- Oxidizers should be used in a chemical fume hood due to the inhalation hazard risk.
- Neoprene, polyvinyl chloride (PVC), or nitrile gloves are acceptable. Consult a glove compatibility chart to ensure the glove material is appropriate for the particular chemical you are using.
- Safety glasses must be worn if the potential for splashing or exposure to vapor/gas exists.

Corrosives (Acids and Bases)

General Characteristics

- Corrosives are most commonly acids and bases, but many other materials can be severely damaging to living tissue.
- Corrosives can damage tissue. Inhalation of the vapor or mist can cause severe bronchial irritation. Corrosives are particularly damaging to the skin and eyes.
- Certain substances considered non-corrosive in their natural dry state are corrosive when they come in contact with moist skin or mucus membranes. Examples include lithium chloride, halogen fluorides, and allyl iodide.
- Sulfuric acid is a very strong dehydrating agent while nitric acid is a strong oxidizing agent. Dehydrating agents can cause severe burns to the eyes due to their affinity for water.

Examples of Corrosives

Ammonium Hydroxide	Chromic Acid
Bromine	Sulfuric Acid

Use and Storage of Corrosives

- Always store acids and bases separately. Store acids in acid storage cabinets or plastic secondary containment away from flammables as many acids are also strong oxidizers.
- Do not work with corrosives unless an emergency shower and eyewash are available within 10 sec travel time. Contact EHS if one is not available.
- Add acid to water, but never add water to acid.

- Do not store liquid acids above eye level. Store on a low shelf or inside a cabinet.
- Store acids in a plastic tray, tub or rubber bucket to contain any leakage.

Acids stored in a plastic tray

Acids stored in acid storage cabinet

- Purchase corrosives in containers which are plastic coated, this will reduce the danger to personnel if the container is dropped.
- Store acids in an acid cabinet or one that has a corrosion-resistant lining. Acids stored in an ordinary metal cabinet will quickly corrode the interior. If an acid cabinet is not available, store the corrosive in a plastic tub inside a wooden cabinet.
- Nitric acid should always be stored away from other acids and organic materials in a separate cabinet or compartment due to its high reactivity.

Use and Storage of Hydrofluoric Acid

- Hydrofluoric acid (CAS: 7664-39-3) can cause severe burns. Inhalation of anhydrous hydrogen fluoride can be fatal. Initial skin contact with hydrofluoric acid may not produce any symptoms. However, hydrofluoric acid can scavenge calcium for the skin and bones, causing severe injuries.
- Always use hydrofluoric acid in a properly functioning fume hood. Wear personal protective clothing. 6mil nitrile gloves, buttoned lab coat with splash shield, safety goggles with face shield, pants and closed shoes must be worn when working with HF.
- If you suspect that you have come in direct contact with hydrofluoric acid; wash the area with water for at least 5 minutes, then apply cream. Remove contaminated clothing and seek medical attention. If hydrogen fluoride vapors are inhaled, move the person immediately to an uncontaminated atmosphere (if safe to do so) and seek prompt medical attention.
- Never store hydrofluoric acid in a glass container as it is incompatible with glass.
- Hydrofluoric acid usually comes in a plastic bottle.
- Store hydrofluoric acid separately in an acid storage cabinet and keep only the amount necessary in the lab.
- Creams for skin exposure such as 2.5% calcium gluconate for treatment of hydrofluoric acid exposure are commercially available and should be stored in the lab. Calcium gluconate reacts with hydrofluoric acid reducing attack of calcium in the body.
- Contact EH&S if you use or store HF in your laboratory.

Health Hazards Associated with Corrosives

- All corrosives possess the property of being severely damaging to living tissues. Acids also react with other materials such as metals.
- Skin contact with alkali metal hydroxides (e.g., sodium hydroxide and potassium hydroxide) is more dangerous than with strong acids. Contact with base metal hydroxides normally causes deeper tissue damage because there is less pain than with an acid exposure. The exposed person may not wash it off thoroughly enough or seek prompt medical attention.
- All hydrogen halides are acids that are serious respiratory irritants and also cause severe burns.

Acute Health Effects

- *Inhalation* – irritation of mucus membranes, difficulty in breathing, fits of coughing, pulmonary edema.
- *Ingestion* – irritation and burning sensation of lips, mouth, and throat; pain in swallowing; swelling of the throat; painful abdominal cramps; vomiting; shock; risk of perforation of the stomach.
- *Skin Contact* – burning, redness and swelling, painful blisters, profound damage to tissues, and with alkalis; a slippery, soapy feeling.
- *Eye Contact* – stinging, watering of eyes, swelling of eyelids, intense pain, ulceration of eyes, loss of eyes or eyesight.

Chronic Health Effects

Symptoms associated with a chronic exposure vary greatly depending on the chemical. For example, the chronic effect of hydrochloric acid is damage to the teeth; the chronic effects of hydrofluoric acid are decreased bone density, fluorosis, and anemia.

First Aid

- *Inhalation* – remove person from source of contamination if safe to do so. Seek medical attention.
- *Ingestion* – remove person from source of contamination. Seek medical attention and inform emergency responders of the name of the chemical swallowed.
- *Skin Contact* – remove person from source of contamination and take immediately to an emergency shower or source of water. Remove clothing, shoes, socks, and jewelry from affected areas as quickly as possible, cutting them off if necessary. Be careful not to get any chemical on your skin or to inhale the vapors. Flush the affected area with water for a minimum of 15 minutes. Get medical attention.
- *Eye Contact* – remove person from source of contamination and take immediately to an eyewash or source of water. Rinse the eyes for a minimum of 15 minutes. Have the person look up and down and from side to side. Get medical attention. Do not let the person rub their eyes or keep them tightly shut.

Personal Protective Equipment

Always wear the proper gloves when working with corrosives. Neoprene and nitrile gloves are effective against most acids and bases. A rubber coated apron and goggles should also be worn. If splashing is likely to occur, wear a face shield over the goggles. Always use corrosives in a chemical fume hood.

Reactives

General Characteristics

Polymerization Reactions

Polymerization is a chemical reaction in which two or more molecules of a substance combine to form repeating structural units of the original molecule. This can result in an extremely high or uncontrolled release of heat. An example of a chemical which can undergo a polymerization reaction is styrene.

Water Reactive Materials

- When water reactive materials come in contact with water, one or more of the following can occur: liberation of heat which may cause ignition of the chemical itself if it is flammable, or ignition of flammables that are stored nearby; release of a flammable, toxic, or strong oxidizing gas; release of metal oxide fumes; and formation of corrosive acids.
- Water reactive chemicals can be particularly hazardous to firefighting personnel responding to a fire in a lab, because water is the most commonly used fire extinguishing medium.
- Examples of water reactive materials:

Alkali Metals: Lithium / Potassium / Sodium	Aluminum
Alkylaluminums	Magnesium
Silanes	Zinc

Pyrophorics

- Pyrophoric materials can ignite spontaneously in the presence of air.
- Examples of pyrophoric materials:

Tert-butyllithium	Triethylaluminum
Diethylzinc	Several organometallic compounds

Peroxide-Forming Materials

- Peroxides are very unstable and some chemicals that can form them are commonly used in laboratories. This makes peroxide-forming materials some of the most hazardous substances found in a lab. Peroxide-forming materials are chemicals that react with air, moisture, or impurities to form peroxides. The tendency to form peroxides by most of these materials is greatly increased by evaporation or distillation.
- Organic peroxides are extremely sensitive to shock, sparks, heat, friction, impact, and light. Many peroxides formed from materials used in laboratories are more shock sensitive than TNT. Just the friction from unscrewing the cap of a container of ether that has peroxides in it can provide enough energy to cause a severe explosion.
- Examples of peroxide-forming materials (the italicized group is the more hazardous):

Acrylonitrile	*Dioxane*	*Sodium*
Amide	Divinylacetylene	Styrene
Butadiene	Inylpyridine	*Tetrahydrofuran*
Diethyl Ether	Potassium Amide	Vinyl Ethers
Diisopropyl Ether		

Peroxide Testing

- For certain classes of compounds (e.g., ethers as peroxide formers), the date the container was opened should be written on the label. Peroxide formers should have the test history and date of discard written on the label as well.
- The following tests can detect most (but not all) peroxy compounds, including all hydroperoxides:
    - Add 1 to 3 milliliters (mL) of the liquid to be tested to an equal volume of acetic acid, add a few drops of 5% aqueous potassium iodide solution, and shake. The appearance of a yellow to brown color indicates the presence of peroxides. Alternatively, addition of 1 mL of a freshly prepared 10% solution of potassium iodide to 10 mL of an organic liquid in a 25-mL glass cylinder should produce a yellow color if peroxides are present.
    - Add 0.5 mL of the liquid to be tested to a mixture of 1 mL of 10% aqueous potassium iodide solution and 0.5 mL of dilute hydrochloric acid to which has been added a few drops of starch solution just prior to the test. The appearance of a blue or blue-black color within a minute indicates the presence of peroxides.
    - Peroxide test strips, which turn to an indicative color in the presence of peroxides, are available commercially. Note that these strips must be air dried until the solvent evaporates and then exposed to moisture for proper operation.

  None of these tests should be applied to materials (such as metallic potassium) that may be contaminated with inorganic peroxides.

Other Shock-Sensitive Materials

- These materials are explosive and sensitive to heat and shock.
- Examples of shock-sensitive materials:

  Compounds containing functional groups: acetylide, azide, diazo, halamine, nitroso, ozonide
  Chemicals containing nitro-functional groups
  Fulminates
  Hydrogen Peroxide (30% +) Ammonium
  Perchlorate
  Benzoyl Peroxide (when dry)
  Blasting caps

- EH&S must be consulted if the use of shock-sensitive materials are used in the laboratory. There are a variety of State and Federal requirements that may apply.

Use and Storage of Reactives

- A good way to reduce the potential risks is to minimize the amount of material used in the project. Use only the amount of material necessary to achieve the desired results.
- Always substitute a less hazardous chemical for a highly reactive chemical whenever possible. If it is necessary to use a highly reactive chemical, order only the amount that is necessary for the work.

Water Reactive Materials

Store water-reactive chemicals in an isolated part of the lab. A cabinet removed from water sources, such as sinks, emergency showers, and chillers, is an appropriate location. Clearly label the cabinet "Water-Reactive Chemicals – No Water".

Water reactive materials include the alkali metals: sodium, potassium, lithium, rubidium, caesium, and Francium. The materials become more exothermic down group 1.

Pyrophorics

Store pyrophorics in an isolated part of the lab and in a clearly marked cabinet. Be sure to routinely check the integrity of the container and have the material disposed of through EH&S if the container is corroded or otherwise damaged.

Peroxide-Forming Materials

- Do not open the chemical container if peroxide formation is suspected. The act of opening the container could be sufficient to cause a severe explosion. Visually inspect liquid peroxide-forming materials for crystals or unusual viscosity before opening. Pay special attention to the area around the cap. Peroxides usually form upon evaporation, so they will most likely be formed on the threads under the cap.
- Date all peroxide forming materials with the date received. Chemicals such as diisopropyl ether, divinyl acetylene, sodium amide, and vinylidene chloride should be discarded after one year. Chemicals such as dioxane, diethyl ether, and tetrahydrofuran should be submitted to EH&S for disposal after one year if opened or expired.
- Store all peroxide-forming materials away from windows, heat, light, and sources of ignition. Light accelerates the formation of peroxides.
- Secure the lids and caps on these containers to discourage the evaporation and concentration of these chemicals.
- Never store peroxide-forming materials in glass containers with screw cap lids or glass stoppers. Friction and grinding must be avoided.
- From *Prudent Practices in the Laboratory – Handling and Disposing of Chemicals – 1995 – Page 100 – Section 5.G.3.1 Peroxide Detection Tests* The following tests can detect most (but not all) peroxy- compounds, including all hydroperoxides:
    - Add 1 to 3 milliliters (mL) of the liquid to be tested to an equal volume of acetic acid, add a few drops of 5% aqueous potassium iodide solution, and shake. The appearance of a yellow to brown color indicates the presence of peroxides. Alternatively, addition of 1 mL of a freshly prepared 10% solution of potassium iodide to 10 mL of an organic liquid in a 25-mL glass cylinder should produce a yellow color if peroxides are present.
    - Add 0.5 mL of the liquid to be tested to a mixture of 1 mL of 10% aqueous potassium iodide solution and 0.5 mL of dilute hydrochloric acid to which has been added a few drops of starch solution just prior to the test. The appearance of a blue or blue-black color within a minute indicates the presence of peroxides.
    - Peroxide test strips, which turn to an indicative color in the presence of peroxides, are available commercially. Note that these strips must be air dried until the solvent evaporates and then exposed to moisture for proper operation.

  None of these tests should be applied to materials (such as metallic potassium) that may be contaminated with inorganic peroxides.
- If you suspect that peroxides may be present contact EH&S. If you notice crystal formation in the container or around the cap, do not attempt to open or move the container. Call EH&S for proper disposal.
- Never distill ether unless it is known to be free of peroxides.

Other Shock Sensitive Materials

- Store these materials separately from other chemicals and in a clearly labeled cabinet.
- Never allow picric acid (Bouin's solution) to dry out, as it is extremely explosive. Always store

picric acid in a moist environment.

Chemical containers in poor condition from corrosion and crystal formation.

Health Hazards Associated with Reactives

Reactive chemicals are grouped as a category primarily because of the safety hazards associated with their use and storage and not because of similar acute or chronic health effects. For health hazard information on specific reactive materials consult the SDS, the manufacturer, or EH&S. However, there are some hazards common to the use of reactive materials. Injuries can occur due to: heat or flames, inhalation of fumes, vapors, reaction products, and flying debris.

First Aid

- If someone is seriously injured, the most important step to take is to contact emergency responders as quickly as possible. Explain the situation and describe the location clearly and accurately.
- If someone is severely bleeding, put on protective gloves and apply a sterile dressing, clean cloth, or handkerchief to the wound. Place the palm of your hand directly over the wound and apply pressure. Keep the person calm. Continue to apply pressure until help arrives.
- If a person's clothes are on fire, he or she should drop immediately to the floor and roll. If a fire blanket is available, put it over the individual. An emergency shower, if one is immediately available, can also be used to douse flames.
- If a person goes into shock, have the individual lie down on their back (if safe to do so) and raise the feet about one foot above the floor.

Engineering Controls and Protective Equipment

- Wear appropriate personal protective clothing while working with highly reactive materials. This might include: impact resistant safety glasses or goggles, a face shield, gloves, a flame-resistant lab coat (to minimize injuries from flying glass or an explosive flash), and a blast shield. Conduct work within a chemical fume hood as much as possible and pull down the sash as far as is practical. While the project does not require you to reach into the fume hood, keep the sash closed.

- Barriers can offer protection of personnel against explosions and should be used. Many safety catalogs offer commercial shields which are commonly polycarbonate and are weighted at the bottom for stability. It may be necessary to secure the shields firmly to the work surface.

Compressed Gas Cylinders

General Characteristics

- Cylinders of compressed gases can pose a chemical as well as a physical hazard.
- If the valve were to break off a cylinder, the amount of force present could propel the cylinder through a brick wall. For example, a cylinder of compressed breathing air used by SCUBA divers has the explosive force of 1.5 pounds of TNT.

Use and Storage

- Whenever possible, use flammable and reactive gases in a fume hood or other ventilated enclosure. As noted previously, concerning storage cabinets, certain categories of toxic gases must always be stored and used in ventilated enclosures. Note specific gases that require ventilated storage.
- Always use the appropriate regulator on a cylinder. If a regulator will not fit a cylinder's valve, replace the cylinder, not the regulator. Do not attempt to adapt or modify a regulator to fit a cylinder for which it was not designed. Regulators are designed to fit only specific cylinder valves to avoid improper use.

Properly attached regulator and safety cap

- Inspect regulators, pressure relief devices, valves, cylinder connections, and hose lines frequently for damage.
- Do not use a cylinder that cannot be positively identified. Color-coding is not a reliable way of identifying a cylinder because the colors can vary from supplier to supplier.
- Do not use oil or grease on any cylinder component because a fire or explosion can result.
- Do not transfer gases from one cylinder to another. The gas may be incompatible with the residual gas remaining in the cylinder or may be incompatible with the cylinder material.
- Never completely empty cylinders during lab operations.
- Leave approximately 25 PSI of pressure. This will prevent any residual gas in the cylinder from becoming contaminated. However, if the cylinder is non-returnable, call EH&S for instructions. If inert, vent the remainder of the gas. If not inert, react the remainder of gas off. In either case, EH&S will be able to discard the cylinder after valve removal. If venting or reacting is unsafe, EH&S can still coordinate disposal of most cylinders.
- Orient cylinders so that the main valve is always accessible and the name of the gas is visible.

- Close the main cylinder valve whenever the cylinder is not in use.
- Remove regulators from unused cylinders and always put the safety cap in place to protect the valve.
- Always secure cylinders, whether empty or full, to prevent them from falling over and damaging the valve (or falling on your foot). Secure cylinders by firmly chaining or strapping them to a wall, lab bench, or other fixed support.
- Oxygen should be stored in an area that is at least 20 feet away from any flammable or combustible materials (including gasses) or separated from combustibles by a non-combustible barrier at least 5 feet high and having a fire-resistance rating of at least 1/2 hour.
- To transport a cylinder, put on the safety cap and strap the cylinder to a hand truck in an upright position. Never roll a cylinder.

Properly restrained gas cylinders

Proper transport of a gas cylinder

- Be careful while handling compressed gas cylinders and never drop or strike a cylinder against anything.
- Always clearly mark empty cylinders and store them separately.
- Use only wrenches or other tools supplied by the cylinder supplier to open a valve.
- Open cylinder valves slowly.
- Only compatible gases should be stored together in a gas cylinder cabinet.
- Do not store compressed gas cylinders in areas where the temperature can exceed 125^{o} F.

Nanomaterials

Contact EH&S for assistance regarding the safe use of nanomaterials. The College of Business and Technology also has courses in nanomaterials and safety.

References

1. CRC Handbook of Laboratory Safety, Fifth Ed. A. K. Furr, Ed. CRC Press. 2000.

2. First Aid Manual for Chemical Accidents. M. Lefevre. 1989.

3. Hazards in the Chemical Laboratory. L. Bretherick, Ed. 1986.

4. Matheson Gas Data Book. C. Yaws. 2001.

5. Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version. National Academy Press. 1995.

6. Safety in Academic Chemistry Laboratories. American Chemical Society. 2003.

7. Sigma-Aldrich Library of Chemical Safety Data, Second Ed. R. E. Lenga, Ed. 2 volumes, 1988.

8. Texas Hazard Communication Act. Texas Department of State Health Services.

APPENDIX A

The University of Texas at Tyler

LABORATORY SAFETY COORDINATOR APPOINTMENT FORM

Each college, department, and organized research unit that has laboratories using hazardous materials should designate a Laboratory Safety Coordinator (LSC) to carry out the duties and responsibilities of the LSC described in the Laboratory Safety Manual.

LSC Name: _____ **EID:** _____

College/Department: _____

Building: _____ **Room:** _____

Phone Number: _____ **Email:** _____

The individual identified above has been appointed as a LSC and has accepted the designated responsibilities and duties associated with this appointment.

_____ _____
LSC Signature *Date*

Dean/Department Chair: _____

_____ _____
Signature *Date*

A copy of this form shall be placed in the appropriate LABORATORY SAFETY MANUAL, retained in the appropriate Dean/Department Chair Office and submitted to Environmental Health and Safety.

APPENDIX B

The University of Texas at Tyler

CHEMICAL STORAGE SEGREGATION SCHEME

Developing safe storage practices for laboratory chemicals is not always easy and often requires a considerable amount of thought and planning. Your ability to develop a safe storage system will depend on your knowledge of chemicals or your ability to find information on the hazards associated with materials you have.

The goal of your storage system should be to separate materials according to chemical compatibility and hazard class. You will need to develop a segregation scheme to fit your specific needs; but, do not store chemicals alphabetically until you have them properly segregated. Use the following broad hazard classes as a guide for segregating your hazardous chemicals. Storing solids above and liquids below is a good practice.

CLASS OF CHEMICALS	RECOMMENDEDSTORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS IN ALL CASES
Compressed Gases – Flammable (includes Combustible)	Store in a cool, dry area, at least ***20 feet away*** from oxidizing gases. Securely strap or chain cylinders to a wall or bench top. Some gases may require a sprinklered and/or ventilated gas storage cabinet.	Methane, Acetylene, Hydrogen	Oxidizing and toxic compressed gases, oxidizing solids
Compressed Gases – Liquefied Flammable	Store in a cool, dry area, at least ***20 feet away*** from oxidizing gases. Securely strap or chain cylinders to a wall or bench top. Some gases may require a sprinklered and/or ventilated gas storage cabinet. Limit storage inside buildings to ***16 oz. containers or less***. Larger cylinders are for day use only inside buildings. Permanent storage should be located outside of the building.	Propane, Butane	Oxidizing and toxic compressed gases, oxidizing solids
Compressed Gases – Reactive (includes Oxidizing)	Store in a cool, dry area, at least ***20 feet away*** from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top. Some gases may require a ventilated gas storage cabinet.	Oxygen, Chlorine, Bromine	Flammable gases

CLASS OF CHEMICALS	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS IN ALL CASES
Compressed Gases – Threat to Human Health (includes Toxic and Corrosive)	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench top. Some gases may require a ventilated gas storage cabinet.	Carbon monoxide, Hydrogen sulfide	Flammable and/or oxidizing gases
Corrosives – Acids INORGANIC	Store in a separate, lined/protected acid storage cabinet or plastic secondary container	**Inorganic (mineral) acids** - Hydrochloric acid, Sulfuric acid, Chromic acid, Nitric acid. *Note: Nitric acid is a strong oxidizer and should be stored by itself. Separate nitric acid from other acids by storing in a secondary container or a separate acid cabinet.*	Flammable liquids, flammable solids, bases, and oxidizers. ***Organic acids***
Corrosives – Acids ORGANIC	Store in a separate, lined/protected acid storage cabinet or plastic secondary container	**Organic acids** - Acetic acid, Trichloroacetic acid, Lactic acid	Flammable liquids, flammable solids, bases, and oxidizers. ***Inorganic acids***
Corrosives - Bases	Store in a separate storage cabinet	Ammonium hydroxide, Potassium hydroxide, Sodium hydroxide	Oxidizers and Acids
Explosives	Store in a secure location away from all other chemicals. Do not store in an area where they can fall.	Ammonium nitrate, Nitro Urea, Sodium azide, Trinitroaniline, Trinitroanisole, Trinitrobenzene, Trinitrophenol/Picric Acid, Trinitrotoluene (TNT).	All other chemicals.
Flammable Liquids	Store in a flammable storage cabinet. *Note: Peroxide forming chemicals must be dated upon opening, e.g., ether, tetrahydrofuran, dioxane*	Acetone, Benzene, Diethyl ether, Methanol, Ethanol, Hexanes, Toluene	Oxidizers and Acids
Flammable Solids	Store in a separate dry cool area away from oxidizers, corrosives	Phosphorus, Carbon, Charcoal	Oxidizers and Acids
Water Reactive Chemicals	Store in a dry, cool location. Protect from water and the fire sprinkler system, if applicable.	Sodium metal, Potassium metal, Lithium metal, Lithium Aluminum hydride	Separate from all aqueous solutions, and oxidizers

CLASS OF CHEMICALS	RECOMMENDEDSTORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS IN ALL CASES
Oxidizers	Store in a spill tray inside a non-combustible cabinet, separate from flammable and combustible materials.	Sodium hypochlorite, Benzoyl peroxide, Potassium permanganate, Potassium chlorate, Potassium dichromate. *Note: The following chemical groups are considered oxidizers: Nitrates, Nitrites, Chromates, Dichromates, Chlorites, Permanganates, Persulfates, Peroxides, Picrates, Bromates, Iodates, Superoxides.*	Separate from reducing agents, flammables, combustibles and organic materials.
Toxins	Store separately in a vented, cool, dry, area in chemically resistant secondary containers	Cyanides, heavy metal compounds, i.e. Cadmium, Mercury, Osmium	See SDS
General Chemicals Non-Reactive	Store on general laboratory benches or shelving. Use upper shelving for non-hazardous chemicals only.	Agar, Sodium chloride, Sodium bicarbonate, and most non-reactive salts	See SDS

The following gases will require ventilated storage: Ammonia, Arsenic pentafluoride, Arsine, Boron trifluoride, 1,3-Butadiene, Carbon monoxide, Chlorine trifluoride, Chloroethane, Cyanogen, Diborane, Dichloroborane, Dichlorosilane, Dimethylamine, Ethylamine, Ethylene, Ethylene oxide, Fluorine, Formaldehyde, Germane, Hydrogen chloride, Hydrogen cyanide, Hydrogen fluoride, Hydrogen selenide, Hydrogen sulfide, Methylamine, Methyl bromide, Methyl chloride, Methyl mercaptan, Nitrogen oxides, Phosgene, Phosphine, Silane, Silicon tetrafluoride, Stibine, Trimethylamine, Vinyl chloride

APPENDIX C

The University of Texas at Tyler

LABORATORY RISK ASSESSMENT TEMPLATE

Standard Operating Procedures for Hazardous Chemicals

Lab Location:_____ Date: _____

Title of Procedure: _____ Principal Investigator: _____

RISK ASSESSMENT

Hazardous Chemicals: (*List chemicals used: include chemical name, common name and abbreviation.)*

Potential Hazard(s): (*Describe the potential hazards associated with the chemicals or the procedure.)*

Examples include:

1) *Chemical hazards such as carcinogenic, irritant, corrosive, acutely toxic*
2) *Reproductive hazards such as teratogens and mutagens*
3) *Allergies or chemical sensitivities that may be associated with the chemical*
4) *Physical hazards such as reactive, pyrophoric, exothermic, use of high energy equipment*

Rules of Exposure: (*As applicable, describe the potential routes of exposure associate with the procedures such as inhalation, absorption, skin/eye contact)*

Exposure Limit: (*As applicable, list the Permissible Exposure Limit (PEL) or Threshold Limit Value (TLV) of the chemical(s), if known)*

Quality/Concentration Hazards: (*As applicable, describe if the quantity/concentration of the chemical(s) used increase the risk of exposure to the chemical.)*

Solution of Less Hazardous Chemicals: (*As applicable, describe the potential use of less hazardous chemicalsubstitutes.)*

CONTROL MEASURES

Engineering Controls: (*As applicable, describe the engineering controls used for the procedure.)*

Examples:

1) *Use of fume hoods or glove boxes*
2) *Specialventilation*
3) *HEPA filtered vacuum lines*
4) *Non-reactivecontainers*
5) *Temperaturecontrol*
6) *Bench paper, pads, chuks, plastic-backed paper*
7) *Specialsignage*
8) *Safe sharp devices*
9) *Other safety devices*

Work Practice Controls: (*As applicable, describe work practice controls used for the procedure.)*

Examples:

1) *Designated areas (for highly toxic chemicals)*
2) *Performing procedures with a least two people present*
3) *Rotating workers*
4) *Restricting access; locks*
5) *Housekeeping*

Personal Protective Equipment (PPE): (*List all applicable, personal protective equipment needed for the procedure.)*

For example, describe use of:

1) *Gloves (type)*
2) *Lab coats, suits, aprons*
3) *Safety glasses, goggles, face shields*
4) *Respirators, hearing protection*
5) *Special equipment (such as blast shields)*
6) *Other PPE*

Monitoring: (*As applicable, describe any monitoring needed for the procedure.)*

Examples:

1) *Personnel exposure monitoring*
2) *Gas/spill release monitoring*

Use in Animals: (*As applicable, describe how the chemical will be safely used in animals.)*

Examples:

1) *Dosing administration*
2) *Animal restraining*
3) *Information on shedding/excretion of chemical*
4) *Aerosol suppression practices*
5) *Handling animals*
6) *Special cage handling/washing instructions*

Cleanup/Decontamination Procedures: *(Describe the process for cleaning the work are during and after the procedure.)*

Storage Procedures: *(Describe how and where the chemical(s) will be safely stored.)*

Example: Reviewing expiration dates on peroxide formers.

Transportation Procedures: *(If the chemical will be transported on campus, describe the procedure.)*

Waste Disposal Procedures: *(Describe how waste will be disposed.)*

Examples:

1) *Animals: include bedding, cages, and carcasses*
2) *Chemicals*
3) *Radioactive*
4) *Sharps*

Emergency Procedures: *(Describe procedures to be followed in the event of an emergency.)*

Spills or Releases: *(Provide specific instruction on what personnel should do in the event of a spill or gas release. Include location of spill kits.)*

Fire: *(Provide specific instruction on what personnel should do in the event of a fire)*

Emergency Shut Offs: *(Describe procedures for shutting down equipment in an emergency.)*

Signs and Symptoms of Exposure: *(Describe the specific signs and symptoms of an exposure to the chemical(s), such as visual cues or odors.)*

Exposures: *(Provide specific instructions on what to do in the event of an exposure.)*

First Aid: *(If first aid for an exposure is available, describe the procedure. If not, describe what steps personnel should take if injured.)*

Occupational Health Requirements: *(Describe and Occupational Health requirements necessary that are associated with the procedure.)*

Examples include medical evaluation, baseline serum samples, and respiratory fit testing.

Safety Data Sheet (SDS): *(Describe how personnel will access the SDS in the lab and include a copy of the SDS with this SOP.)*

Training Requirements: *(Describe what training personnel must complete before using the chemical/procedure. This training should be documented.)*

Review of Procedure: *(Describe the frequency for reviewing the SOP document.)*

PROTOCOL

(Description of how to safely perform the experiment or operation.)

APPENDIX D

The University of Texas at Tyler

LABORATORY EXPERIMENT HAZARD ASSESSMENT FORM

Requester Name:	Event Date: Start/End Times:
Building/Room Location:	
Brief description of the experiment/demonstration:	
Hazard Assessment: *(check all that apply)*	⎦ Experiment/Demonstration is necessary to UT Tyler curriculum ⎦ Substitution of less hazardous material impractical ⎦ The minimum hazardous material(s) will be used ⎦ The safest procedures will be implemented ⎦ Actions will be taken to minimize/neutralize hazardous waste
Type of Reactive: *(check one)*	⎦ Explosive ⎦ Organic Peroxide ⎦ Water-Reactive ⎦ Pyrophoric
Event Procedures: *(check all that apply)*	⎦ Follow SDS Handling & Storage procedures ⎦ Utilize Engineering Controls ⎦ Utilize Administrative Controls ⎦ Utilize Protective Barrier/Safety Shield ⎦ Utilize PPE
Participant Safety:	⎦ Cordon/Safe standoff distance ⎦ Sited upwind of hazard ⎦ PPE provided
Safety Checklist: *(check all that apply)*	⎦ Emergency Action Plan (readily available) ⎦ Emergency Notifications (cell phone readily available) ⎦ Fire Extinguisher (readily available) ⎦ Spill/Containment Materials (readily available)
Fire Alarm System Impact:	⎦ Heat Detector ⎦ Smoke Detector ⎦ N/A – Heat/Smoke will not be generated
Notifications: (Prior to / upon completion)	⎦ Building/Area Occupants ⎦ Environmental Health & Safety (903)-566-7011 ⎦ University Police Department (903)-566-7300

Requester Signature:	Date:
Department Chair Signature:	Date:
Director of EH&S Signature:	Date:

APPENDIX E

The University of Texas at Tyler
LABORATORY SELF-EVALUATION FORM

LS/PI Name:	Evaluation Date:
Department:	Building / Room:

Brief description of lab/material associated hazards:	
Lab Safety: *(check if assessed)*	⎦ Lab-Specific Chemical Hygiene Plan Implemented ⎦ Chemical Inventory Current ⎦ SDS Current ⎦ Chemicals Properly Labeled ⎦ Lab Signage / Emergency Information/Procedures
Risk Assessment: *(check if assessed)*	⎦ Chemical Quantity/Concentration ⎦ Potential Hazards (Chemical/Biological) ⎦ Routes of Exposure ⎦ Chemical PEL/TLV
Control Measures: *(check <u>all</u> that apply)*	⎦ Engineering Controls ⎦ Work Practices / SOPs / Administrative Controls ⎦ PPE / Special Equipment ⎦ Cleanup / Decontamination Procedures ⎦ Transportation Procedures ⎦ Storage Procedures (Container Compatibility / Chemical Segregation)
Emergency Procedures: *(check <u>all</u> that apply)*	⎦ Chemical Spill or Release ⎦ Spill Kit ⎦ Fire ⎦ Emergency Shut-off ⎦ Emergency Shower/Eyewash ⎦ Exposure / First Aid
Waste Disposal: *(check if assessed)*	⎦ Accumulation Storage Area ⎦ Chemical Waste ⎦ Bio-waste ⎦ Sharps ⎦ Broken/Contaminated Glass
Special Hazards *(check <u>all</u> that apply)*	⎦ Lasers ⎦ Radioactive Material ⎦ Special Equipment (Autoclaves, Centrifuges, Machinery, etc.)

LS/PI Signature:	Date:
Director of EH&S Signature:	Date:

APPENDIX F

The University of Texas at Tyler

LABORATORY INSPECTION CHECKLIST

Department _____ **Date** _____

LS/PI _____ **Bldg/Room** _____

Inspector _____ **Inspection Type** _____

GENERAL LAB SAFETY	Y	N	N/A	COMMENTS / NOTES
1 Written SOPs / Work Practices developed *				
2 Written lab-specific training plan developed *				
3 HAZCOM / lab-specific training current & documented *				
4 Appropriate PPE available, functional, & utilized *				
5 Personnel trained / fitted to use required PPE *				
LABELING/SIGNAGE				
6 All containers (hazardous/non-hazardous) labeled				
7 Refrigerators/cooling equipment properly labeled				
8 Signs identifying hazards posted at entrance				
9 Emergency procedures/contact information posted				
10 “Do Not Pour Down Drain” signs posted at sinks				
LABORATORY CHEMICALS				
11 Chemical inventory available *				
12 SDSs current & available *				
13 Chemical containers properly labeled				
14 Chemical containers compatible & in good condition				
15 Chemical containers closed when not in use				
16 Chemicals segregated by hazard class				
17 Chemicals not stored above eye level				
18 Chemical shelves have lips or other type of restraint				
19 Chemicals not stored in alphabetical order				
20 Glass chemical containers are not stored on floor				
21 Oxidizers stored on wooden shelves & segregated				
22 Hazardous chemicals not stored above/below sinks				
23 Lab safe refrigerator used for cold flammable storage				
24 Flammables stored in flammable storage cabinets				
25 Less than 60 gallons of flammables stored in cabinets				
26 Peroxide forming chemicals not expired / testing done				
27 Acids stored in acid cabinet/secondary containment				
28 Expired/legacy chemicals are disposed of as waste				

COMPRESSED GAS CYLINDERS	Y	N	N/A	COMMENTS / NOTES
29 Gas cylinders legibly marked/content identified				
30 Toxic and hazardous gas cylinders properly ventilated				
31 Gas cylinder valves closed when not in use				
32 Gas cylinders properly secured/stored				
33 Cylinder safety caps in place when not connected/in				

RADIOACTIVE MATERIALS				
34 Lab using radioactive materials registered with RSO *				
35 Appropriate warning signs posted				
36 Radioactive material is properly secured from access/removal *				
37 Personnel wear appropriate PPE when handling materials *				

LASER SAFETY				
38 Lab using lasers is registered with RSO *				
39 Appropriate warning signs posted / warning light is installed				
40 Standard Precautions posted at each laser				
41 Personnel have & use appropriate laser eyewear *				
42 Personnel received Laser Safety training *				

ENGINEERING CONTROLS				
43 Fume hood/Biosafety cabinet tested within past year				
44 Fume hood has continuous flow monitor				
45 Fume hood not used as permanent storage/excess clutter				
46 Back ventilation slot is open at least 2 inches				
47 Fume hood sash at or below 18”				
48 Drains are protected from hazardous materials entering				
49 Lab personnel have completed required training *				

RESPIRATORY PROTECTION				
50 Respirator use valid & IAW UTT program *				
51 Personnel fit tested & medical clearance completed *				
52 Respirators inspected monthly				
53 Cartridges in good condition/for appropriate for hazard				

IGNITION SOURCES				
54 Vacuum pumps and other ignition sources segregated from flammables/combustibles				
55 Precautions taken to prevent ignition of flammable vapors				
56 Electrical cords in good condition / not daisy chained				

LABORATORY WASTES	Y	N	N/A	COMMENTS / NOTES
57 Waste accumulation area is near point of generation and under the supervision of the person generating it				
58 Waste accumulation area signage posted				
59 Hazardous Waste Storage Area Weekly Inspection Checklist is posted and area being monitored weekly				
60 Less than a total of 55 gallons of wastes are present				
61 Less than one liter of acutely hazardous waste present				
62 Waste containers do not exceed 5 gallons				
63 Flammable liquid waste outside a storage cabinet is less than 10 gallons				
64 Waste containers are not over filled				
65 Waste containers marked with "Waste" / "Spent"				
66 Chemical Waste Accumulation Log is maintained for each container and depicts all the contents & their %				
67 All waste containers are compatible with their contents				
68 Waste containers have non-leaking screw-on caps/lids				
69 All containers closed unless actively receiving waste				
70 All hazardous waste is secondary contained				
71 Wastes are not being stored more than 90 days				
72 Incompatible wastes are properly segregated				
73 Glass waste disposal box properly used				
74 Hazardous waste is not drain disposed or evaporated *				
75 Hazardous waste handling training is documented *				

SPECIAL WASTES

76 Microbiological waste is either treated in lab (autoclaved) or placed into biohazard bags for pick up				
77 Pathological waste, blood or blood products are either treated in lab (autoclaved) / placed in biohazard bags				
78 Sharps deposited into labeled sharps containers				
79 Needles are not bent, re-capped or clipped				
80 Biohazard wastes are stored in leak-proof containers				
81 Biohazardous liquid treated/disinfected or autoclaved *				
82 Bio-waste Collection Form is used for waste pickup *				
83 All bedding from animal intentionally exposed to pathogens is treated in lab (autoclaved) or bagged as biohazard for pick up and disposal				
84 All animals/animal parts are kept frozen and doubled-bagged until picked up for disposal				
85 Bloodborne Pathogens training current & documented *				

EMERGENCY PROCEDURES & EGRESS	Y	N	N/A	COMMENTS / NOTES
86 Emergency procedures prominently posted				
87 Exits and aisles clear of obstruction				
88 Doors not propped open				
89 Electrical panels/disconnects have 36” clear space				
90 Electrical panel/disconnect doors closed				
91 Personnel know emergency shutdown procedures *				

EMERGENCY EQUIPMENT				
92 Eyewash available & unobstructed				
93 Emergency shower available & unobstructed				
94 Eyewash tested in the past month				
95 Emergency shower tested in the past month				
96 Spill kit stocked & inventory current / no expired items				
97 18” clearance maintained beneath fire sprinkler heads				
98 Fire extinguisher available & unobstructed				
99 Fire extinguisher charged/pinned & inspection current				
100 Fire blanket labeled & unobstructed				
101 First aid kit is available & no expired items				

HOUSEKEEPING				
102 Unused tools/equipment items properly stored				
103 Trash emptied / floors clean & clear of debris				
104 Spilled materials/liquids not present				
105 Work surfaces clear of clutter & excess chemicals				
106 Food/drinks not stored or consumed in the lab				

*** Lab personnel must be present to answer questions.**

APPENDIX G

LABORATORY AND RESEARCH AREAS CHECKLIST
PREPARATION FOR HAZARDOUS WEATHER

Departments and Principal Investigators are responsible for taking protective actions for their own laboratories. This checklist is designed to identify suggested tasks and facilitate assignment of responsibilities for preparing laboratory areas. Not all items are appropriate for all areas. Departments and researchers should add actions specific to their individual laboratories if needed.

When impacts from hazardous weather are possible, consider necessary preparations to suspend ongoing experiments involving biological materials, radioactive agents and hazardous chemicals. In the event that the University announces the suspension of normal operations, researchers should postpone operations in the laboratory, secure their equipment and complete the checklist. **Note, personnel should not stay in the laboratory during a storm if the University has suspended normal operations.**

When returning to the laboratory after a hazardous weather event, check the lab for any of the following:

- Leaking or broken chemical containers
- Non-functioning safety equipment such as fume hoods or biosafety cabinets
- Displaced waste products
- Missing inventory
- Malfunctioning equipment/instrumentation/facilities

Contact EH&S for assistance (safety@uttyler.edu or 903-566-7011).

Additional mitigation steps can be taken year-round to reduce impacts from hazardous weather and other incidents, including:

- Keep chemical, radiological and biohazardous materials in your inventory to a minimum.
- Dispose of hazardous wastes and old chemicals routinely to minimize accumulation of hazardous materials in your facility.
- Laboratories with exterior windows should identify a secure area for storage of water reactive chemicals, radioactive materials and biohazardous agents. Ideally, materials with significant, potential hazard should be moved to interior rooms. (e.g. – solvents containing reactive metals, glove boxes containing air reactives)
- If dry ice will be needed pre- or post-incident, document vendor information, payment method and delivery or pick-up options. Note, dry ice should not be transported in a closed vehicle for safety of the occupants.
- Maintain a supply of plastic, waterproof containers to store reactive chemicals, lab notes, research documentation, electronic data and other important materials.
- Plan in advance how to ensure the protection of valuable research equipment,

samples and data.

- Maintain a stock of critical supplies to prevent delivery disruptions.
- Update and distribute emergency and contact information to laboratory personnel.

☑	Action/Task	Location	Staff Responsible		Notes
			Primary	Alternate	
	Turn down refrigerators and freezers to the lowest practical settings and plug into emergency power where available.				
	Place recording maximum/minimum thermometers in refrigerators and freezers containing temperature critical supplies and samples.				
	Plug incubators into emergency power outlets if available.				
	Cover and secure or seal vulnerable equipment.				
	Remove or secure equipment from outdoor locations.				
	Ensure arrangements have been made for the care and feeding of laboratory animals. Follow recommended actions of the Animal Resources Center.				
	In areas subject to flooding, relocate or elevate equipment, chemicals, wastes and other important items from the floor to prevent damage.				
	Secure radioactive isotopes, biohazardous agents, recombinant materials and hazardous chemicals to prevent breakage and release.				
	Fill dewars and cryogen reservoirs for sample storage and/or critical equipment.				
	Over-pack reactive chemicals in plastic, waterproof containers.				
	Remove regulators and cap gas cylinders, except for CO2 needed to maintain cell cultures. Ensure all cylinders are secure.				

☑	Action/Task	Location	Staff Responsible		Notes
			Primary	Alternate	
	Autoclave or inactivate infectious or rDNA waste.				
	Due to the possibility of power outages, store volatile, toxic materials in tightly sealed, break-resistant containers rather than fume hoods or open room.				
	Protect computers, valuable files, research samples and notebooks in place or move to a safer location.				
	Protect notebooks and secure samples/data as necessary for colleagues unable to reach the lab.				
	Update emergency contact information. Add and expand temporary contact information if staying at a different location during storm.				
	Close and latch (or secure with tape if needed) filing cabinets and cupboards.				
	Back-up electronic data and store in multiple locations.				
	Follow IT provider instructions for computer equipment preparations.				
	Close and lock all doors and windows before leaving.				