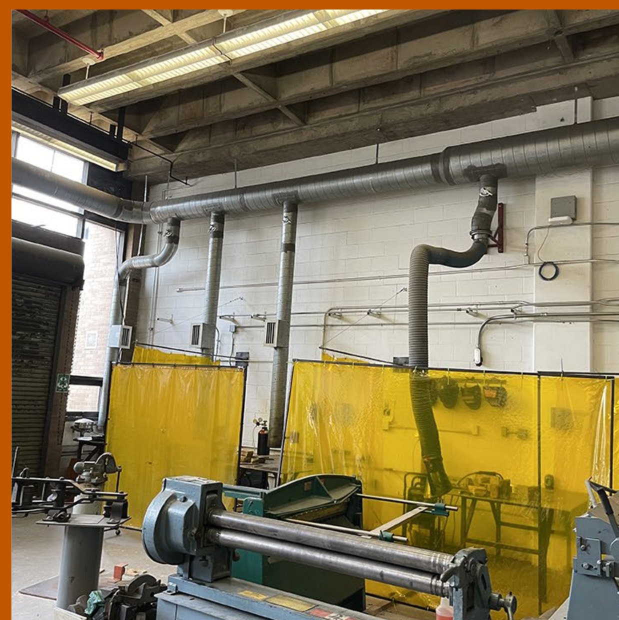
The University of Texas at Austin
Environmental Health & Safety

Research and Academic Laboratory Safety Manual



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I. INTRODUCTION

The University of Texas at Austin (UT Austin) is committed to maintaining the health and safety for the campus community, including the unique risks present in laboratories. Faculty and researchers are required to take all reasonable precautions to protect the health and safety of everyone who enters their lab and those impacted by their research.

Laboratory operations can be dangerous whether 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 Austin has multiple incidents in laboratories. The goal is to eliminate laboratory incidents and injuries. This document provides information to assist with this objective.

A. Purpose

This Laboratory Safety Manual has been prepared specifically for UT Austin by Environmental Health and Safety (EHS) and originally in collaboration with the faculty Research Safety Advisory Committee. The 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 waste disposal. This manual also covers emergency procedures and incident response should something go wrong.

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 Austin. Faculty and researchers know the most about the unique hazards in their laboratory. It is expected that the Principal Investigator will append any pertinent supplementary safety information to their lab specific procedures.

B. Scope

A laboratory at UT Austin is defined as a room or space used for testing, analyzing, researching, teaching, storing, diagnosing, experimenting, or similar activities (but excludes laboratories containing only computers) supporting the academic and/or research mission of the university. This document applies to all laboratories at UT Austin campus locations. This document supplements the Radiation Safety Manual, Biological Safety Manual, or Laser Safety Manual. Laboratory research involving radiation, biological or laser hazards must comply with all applicable regulatory requirements and follow guidance and standard operating procedures and relevant safety manuals. Based on the research risks present, additional oversight may be required.

The information presented in this document represents best practices and provides a broad overview of the information necessary for the safe operation of laboratories that utilize potentially hazardous chemicals and associated equipment that presents physical hazards. This document is not intended to be all inclusive. Researchers engaged in work with potentially hazardous chemicals that have unusual characteristics or are otherwise not sufficiently covered in this document must supplement this document by adding additional information in laboratory specific documents to address the hazards and mitigate risks present. These supplemental documents and information must be approved (prior to commencing research) by the Principal Investigator/Laboratory Manager and UT Austin's EHS. Please contact EHS at 512-471-3511 or labstaff@austin.utexas.edu with questions.

II. REQUIREMENTS AND RESPONSIBILITIES

A. University and Regulatory Requirements

The University of Texas at Austin has compliance obligation within laboratories. The compliance requirements are diverse and is the basis of much of the content of this manual. Source of compliance requirements are provided by the following:

- Occupational Safety and Health Laboratory Safety Standard
- Texas Commission of Environmental Quality (TCEQ) and Environmental Protection Agency (EPA) Waste and Wastewater Regulations
- Texas Hazard Communications Standard
- Department of Transportation (DOT) - Transportation and Shipping Regulations
- Center for Disease Control and Prevention (CDC) - Biosafety in Microbiological and Biomedical Laboratories (BMBL)
- Drug Enforcement Agency (DEA) - Controlled Substances Regulations
- US Department of Agriculture (USDA) Regulations
- UT Austin Handbook of Procedures - Environmental Health and Safety Policy

B. Responsibilities

Lab workers conducting chemical reactions, using chemicals, or performing laboratory procedures are required to understand safe work practices and behaviors for all materials and processes they use in the laboratory. Each individual is responsible for complying with the applicable requirements of state and federal law as well as with university policies, guidelines and procedures. Oversight responsibility for ensuring that laboratory activities conform to prescribed standards is assigned as follows:

1. **President of the University**

   The President has ultimate responsibility for safety on campus and this includes laboratory safety within the institution.

2. **Personnel of the University**

   Personnel are responsible for following the procedures and executing the policies and responsibilities prescribed by this manual and EHS policies, compliance programs, and guidelines. Failure to do so is a 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, EHS has the authority to close the lab until unsafe conditions or behaviors are corrected. Approval of the Dean is not required.

3. **Facility Services**

   Facility Services is responsible for maintaining facilities and facility-related safety systems to assure continuous operation of laboratories.

4. **Environmental Health and Safety (EHS)**

   - Provides specific EHS training to laboratory personnel
   - Conducts periodic 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 survey and testing
   - 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
   - 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 these policies

5. **Deans**

   - Responsible for ensuring the safe operation of all laboratories where hazardous materials, biological materials, and physical hazards are used or laboratory procedures are conducted
   - Ensures compliance with all university's policies and procedures pertaining to

laboratory safety
- Has independent enforcement authority to close a laboratory for safety violations
- Can appoint Lab Safety Coordinators (LSCs) for individual Departments. When implemented, will provide EHS with a list of LSCs who must work cooperatively with EHS.

6. Department Chairs and Directors

- Oversees laboratory safety within departmental laboratories
- Ensures laboratories complete and update (1) annual inventories of hazardous chemicals as required by the university's Hazard Communication Program; (2) annual inventory of control substances; and (3) annual inventory and securing tax-free ethanol
- If authorized by the Dean, may appoint a Laboratory Safety Coordinator.

7. Laboratory Safety Coordinators (if appointed)

- Ensures laboratories develop and implement written site-specific safety policies
- Monitors procurement, safe practices and disposal of hazardous materials with EHS
- Ensures laboratories complete self-evaluation forms
- Acts as a liaison with EHS to ensure inspection issues are corrected
- Notifies EHS if specialized training is needed
- Provides researchers technical guidance regarding lab safety issues
- Advises college administration on laboratory safety issues. Notifies EHS if issues require immediate action.
- Notifies EHS of incidents and near misses

8. Principal Investigators and Laboratory Supervisors/Managers

- Designs and conducts laboratory processes and operations to assure that personnel exposure to risk is eliminated or minimized according to university policy
- Monitors the procurement, safe use, and proper disposal of hazardous materials, biological materials, and controlled substances
- Writes Standard Operating Procedures (SOPs) relevant to lab processes in their specific areas
- Instructs personnel on the contents of this manual and the location of this manual within the workplace
- Takes all reasonable precautions to protect the health and safety of laboratory workers and the environment
- Schedules hazardous waste disposal and oversees the handling of hazardous waste pending proper disposal

- Completes the laboratory safety self-evaluations every semester (fall and spring)
- Completes and updates annual laboratory chemical inventories in accord with the instructions, recording method, and schedule provided by EHS
- Informs personnel of the permissible exposure limits for the hazardous chemicals listed on inventories and the signs and symptoms associated with exposures to these chemicals
- Provides and creates a record of the site-specific training on laboratory hazards as described in the university's Hazard Communication Program
- Assigns a designated Laboratory Safety Coordinator (LSC) who can assist with completing safety requirements. Completes LSC designation form provided in Appendix One and places printed copy in PI's Laboratory Safety Manual.
- Ensures the safety and health of all individuals in assigned or common/shared laboratory spaces and must furnish an environment which is free from recognized hazards that are causing or likely to cause death or serious physical harm.
- Provides training and documentation for special procedures, activities or operations
- Provides appropriate personal protective equipment. When respirators are provided, contact EHS for appropriate selection, fit and medical clearance
- Ensures that all required safety equipment (fire extinguishers, fume hoods, flammable liquid storage cabinets, eyewashes, safety showers, and spill cleanup kits) is available, in working order and that appropriate training for all safety equipment has been provided
- Maintains access to a current copy of a Safety Data Sheet (SDS) for all hazardous chemicals in the laboratory
- Makes emergency telephone numbers available
- Reports to EHS if there is reason to believe that exposure levels for a hazardous chemical exceed the action level or the permissible exposure limits and documents the incident.
- Immediately reports (as soon as practical but at least by the end of the workday) all laboratory incidents (resulting in injury, exposures, potential exposures, or property damage) to EHS and forwards appropriate documentation to EHS
- Leads by example and instills a positive and proactive safety culture within the workplace.

9. Laboratory Personnel

- Maintains a thorough understanding of and follows the laboratory policies and procedures
- Uses and maintains required personal protective equipment (i.e. lab coats,

safety glasses, goggles, face shields, respiratory protection, and gloves)
- Uses flammable liquid storage cabinets, acid storage cabinets, fume hoods, 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, incidents, or releases and documents incident
- Attends all applicable EHS laboratory safety training sessions
- Participates in the Occupational Health Program, if required, as a condition of employment or as required by specific protocol

10. Building Manager of Laboratory Buildings

- Reports any unauthorized electrical, mechanical or plumbing changes that laboratories make to building infrastructure.
- Report (as soon as possible or at least by the end of shift) all incidents (accidents, injuries, near misses or property damage) to EHS.
- Maintains building infrastructure in safe condition. Ensure all repairs that can increase risk to injury are requested to be repaired quickly. If a repair related to safety is not repaired quickly and creates imminent danger, the issue must be immediately escalated to EHS.
- Ensure hazardous waste is not abandoned within the building by submitting a waste pick-up to EHS.
- Maintains all safety signage for the building or requests for its repair.

11. Research Safety Advisory Committee (RSAC)

The RSAC is charged to act in an advisory and consultative capacity regarding the administration, implementation and coordination of policies and procedures for safety and environmental health in university research activities. The functions of this committee complement but do not overlap the responsibilities of the Institutional Biosafety Committee and the Radiation Safety Committee. Areas of consideration include regulatory compliance, training, inspections, hazardous materials management, waste minimization, emergency response, signage, and chemical/biological safety.

12. Institutional Biosafety Committee (IBC) and Protocol Submission Instructions

The IBC is responsible for overseeing and evaluating all aspects of research involving recombinant or synthetic nucleic acid molecules and biohazardous materials, agents and toxins, and is charged with reviewing proposals that involve recombinant or synthetic nucleic acid molecules and biohazardous materials, agents and toxins to ensure that the criteria established in the IBC Policy and the federal regulations and guidelines are implemented. In its review of the proposals, the primary goal of the IBC is to facilitate research personnel compliance with applicable laws, regulations, guidelines and policies consistent with the performance of appropriate and productive scientific endeavors.

IBC protocol submissions, whether they are new IBC protocol submissions, modifications or renewals, must be submitted to RSC by the Principal Investigator for review and IBC approval. No research involving recombinant or synthetic nucleic acid molecules and biohazardous materials, agents and toxins can be initiated until the Principal Investigator has received the approval of the IBC.

Although federal regulations allow exemptions for some types of recombinant or synthetic nucleic acid molecules used, the Principal Investigator must submit an application for all projects using recombinant or synthetic nucleic acid molecules and biohazardous materials, agents and toxins so that the IBC is aware of the activities and can verify that they are exempt. For more information on exemptions, review this document: See Section III F – page 25 at this link: Exemptions_NIH_Guidelines.pdf

No one shall obtain or use recombinant or synthetic nucleic acid molecules and/or biohazardous materials or agents and toxins until the protocol has been approved by the IBC. Modifications to approved protocols shall not be implemented until approved by the IBC.

13. Institutional Animal Care and Use Committee (IACUC)

The responsibility of the Institutional Animal Care and Use Committee (IACUC) is to oversee and provide framework for compliance with federal policies, guidelines and principles related to the care and well-being of animals used for research, teaching, and testing at The University of Texas at Austin. It is federally mandated committee that oversees the institution's animal program, facilities, and procedures. The committee assures compliance with applicable federal and state laws and regulations, as well as intuitional policies (HOP 7-1310). The IACUC is a self-regulating body which is committed to serving the public by ensuring conformance to all legal and ethical standards regarding the use of animals in research. In addition, the IACUC is engaged in assisting animal research investigators with their animal-related needs. New animal researchers or students must complete a series of steps with the IACUC and ARC in order to be able to work with animals.

14. Institutional Review Board (IRB)

The Institutional Review Board (IRB) at the University of Texas at Austin is charged with reviewing all research conducted under the auspices of UT Austin. The purpose of an IRB is to ensure research involving humans (including stem cells) applies ethical principles and complies with federal regulatory requirements for protecting the rights and welfare of human participants. UT Austin has 2 IRBs – a Social Behavioral research IRB and a Health Science research IRB. The principal investigator of a human research study is the individual with ultimate responsibility for the conduct of the activities described in the IRB submission and for protecting the rights and welfare of human participants involved in the research. The principal investigator must be available to devote adequate time and attention the study to ensure its responsible conduct. The Institutional Review Board (IRB) reviews all human subject research. The IRB is composed mainly of UT faculty and meets monthly to review research proposals. The IRB reviews full board research; exempt and expedited research are reviewed "in house" by the Office of Research Support and Compliance.

15. Radiation Safety Committee

The Radiation Safety Committee reports to the President and has the broad responsibility for policies and practices regarding the license, purchase, shipment, use, monitoring, disposal and transfer of radioisotopes or source of ionizing radiation at UT Austin. The Committee will formally approve applications to use radioactive material.

The Committee shall be consulted by EHS concerning any unusual or exceptional action that affects the administration of the Radiation Safety Program.

16. Laser Safety Committee

The Laser Safety Committee reports to the Vice President for Research and is responsible for review and approval of policies and practices regarding the acquisition, manufacture, registration, use, monitoring, transfer, and disposal of lasers or intense pulsed light devices at UT Austin. The Committee reviews applications for laser use, inspection and training activities, any incidents and best safety practices.

The Committee shall consult with EHS regarding regulatory issues and the current standards for safe use of lasers. EHS shall assist the Committee concerning any unusual or exceptional action that affects the administration of the Laser Safety Manual, and provides operational support to implement the program.

III. TRAINING REQUIREMENTS

The university requires that all individuals 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 occurs. The following is a summary of what training is required and training content.

A. Required Classes

Training classes become a requirement as new working conditions with hazards are present. A summary of conditions or hazards present in a laboratory and the required training staff obtain is provided in the following table.

Training Requirements by Condition

Condition Requiring Training	Training Requirement
Working in a **Laboratory**	➢ OH101: General Hazard Communication ➢ OH102: Site-Specific Hazard Communication (provided by the PI or lab manager) ➢ OH201: General Laboratory Safety ➢ OH202: Hazardous Waste Management ➢ OH238: Laboratory Safety Refresher Training (Renewed Every 3 Years) ➢ FF205: Fire Extinguisher Training (in-person or online)
Working with **Radioactive Material/Radiation**	➢ OH301 Basic Radiological Health ➢ OH302 Basic Radiological Health Refresher ➢ OH306: X-Ray Safety ➢ OH311: Radiation Safety Awareness Training
Working with **Lasers**	➢ OH304: Laser Safety
Working with **Human Blood or Tissues**	➢ OH218: Bloodborne Pathogens for Lab Personnel (Annual)
Working with **Biological Materials**	➢ OH207: Biological Safety
Work involving **recombinant DNA** (rDNA):	➢ RC301 NIH Guidelines ➢ CW512 (Online): IBC Training: NIH Guidelines

Condition Requiring Training	Training Requirement
BSL-3 laboratory work	➢ OH206: BSL-3 Laboratory Training (Annual)
Shipping Packages with Dry Ice	➢ OH601: Dry Ice Shipping (every two years)

B. Site Specific Hazard Communication Training (OH 102)

All laboratory personnel must be trained to know the location and proper use of available personal protective clothing and equipment. The PI/laboratory supervisor is responsible for providing information to their personnel about any hazards present in the lab. Document the training on the OH102 form and submit to EHS. This information must be provided at the time of a lab person's initial assignment and prior to any assignments involving new potential chemical exposure situations. The following lists the information that must be provided and content documented by the PI/Lab Supervisor:

- Lab-specific standard operating procedures (SOPs) for the safe handling and use of hazardous materials (chemical, biological, radioactive).
- 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.
- Procedures for using safety equipment including fume hood, biosafety cabinets, special ventilation or other equipment.
- Location of signage including safety signs, emergency numbers and the Texas Hazard-Communication Employee notification poster.
- The lab’s housekeeping procedures.
- Procedures for transporting hazardous materials safely across campus.
- Inform personnel how to register for EHS safety training classes.
- Storage location of chemicals and their segregation by compatibility.
- Requirements for chemical labeling on primary and secondary containers.
- Use, storage, and handling of gas cylinders and cryogenics.
- Use of hazardous chemicals that warrant exposure monitoring.
- Inform personnel how to request monitoring by EHS.
- Location of machine guards and their use.
- PPE requirements for personnel including selection, maintenance and use.
- How personnel can obtain PPE and how to dispose of PPE after use.
- How to respond to an emergency including exposures, first aid and evacuation route.
- Location of emergency equipment including spill kits, fire-fighting equipment, alarms, emergency shut-offs, eyewashes and safety showers.

- Emergency procedures including how to clean up spills.
- How to contact EHS in the event of an accident/injury.
- Procedures for proper waste disposal including waste location and process for requesting waste disposal.
- Procedure for accessing and using Material Safety Data Sheets and institutional Laboratory Safety Manuals (General, Radiation, Biosafety).
- 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. Site-specific training must be conducted by the PI or lab supervisor.

C. Hazard Specific Training

In addition to the site-specific training that is the responsibility of each PI/Lab Supervisor, the following hazardous materials training is offered by EHS and is required for all lab personnel (graduate students, staff, faculty and visitors) that engage in laboratory activities:

1. Hazard Communication Training (OH 101) Online

Hazard Communication training is required for all personnel of UT Austin, including faculty, staff, students and visitors who have the potential for exposure to hazardous materials. Any work in a laboratory using hazardous materials meets the definition of the requirement. EHS offers this training on a regular schedule and it is available online. Training is required before the personnel can be assigned work in or around hazardous materials.

OH 101 training takes approximately 1.5 hours and includes:

- Central requirements of the act, including training, chemical labels, and Safety Data Sheets (SDS)
- Spill clean-up and chemical disposal procedures
- Chemical storage guidelines
- Hazards specific to different chemical groups

2. Laboratory Safety Training (OH 201) Online

Laboratory safety training is required for all personnel of UT Austin, including faculty, staff, and students who may work in a laboratory using hazardous chemicals or biological materials. This training must be received prior to or within 30 days after the beginning of a laboratory assignment. EHS offers this training on a regular schedule and it is available online.

OH 201 training takes approximately two hours and includes:

- Safety equipment and practices
- Emergency procedures
- Emergency equipment
- Waste disposal

3. **Fire Extinguisher Training (FF 205)**

   Provided by Fire Prevention Services, fire extinguisher training, in-person with live fire suppression or the online course, is required for all laboratory workers.

   FF 205 training covers:

   - 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.

4. **Hazardous Waste Management Training (OH 202) Online**

   Hazardous waste management training is required for all laboratory personnel, including faculty, staff, and graduate students where hazardous chemicals or biological materials are in use. Every teaching lab must have one or more individuals that have received this training and are responsible for following the procedures included in the training. EHS only offers this training online.

   The training takes approximately 1 hour and includes:

   - Hazardous waste definitions and regulatory environment
   - Spill clean-up and chemical waste disposal procedures
   - Chemical waste storage and segregation guidelines
   - Waste minimization
   - Drain disposal

5. **Bloodborne Pathogens and Biosafety Training (OH 218, OH 207) Online**

   Bloodborne pathogens and biosafety training is required for personnel of UT Austin, including faculty, staff, and graduate students who work in laboratories where infectious agents or human or non-human primate body fluids are in use. EHS offers this training on a regular schedule and can arrange special sessions with advance notice. This training is also available online.

OH 218 and 207 training takes less than two hours and may include, as appropriate to the attendees:

- Definition of a bloodborne pathogen
- Universal precautions
- Spill clean-up
- Practices and equipment required for work at different biosafety levels

6. Other Hazard Specific Safety Training Classes:

Other laboratory safety classes include:

- Compressed Gases and Cryogens (OH 204)
- Laser Safety (OH 304)
- Radiation Safety (OH 301)
- X-Ray Safety (OH 306)

7. Checking Your Training History Online

You can check your training history online at:
https://utdirect.utexas.edu/txclass/index.WBX

IV. CHEMICAL HAZARDS

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/cryogens, and nanomaterials. These classes of chemicals may include chemicals that are also covered in the other section regarding their property of toxicity.

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

A. Flammable Liquids

1. Terms

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 some types of flammable liquids, not the liquid itself, can ignite and start a fire. The following terms are helpful in understanding the danger and risk associated with flammable liquids.

- ***Vapor pressure*** -The vapor pressure of a liquid is the equilibrium pressure of a vapor above its liquid (or solid); that is, the pressure of the vapor resulting from evaporation of a liquid (or solid) above a sample of the liquid (or solid) in a closed container. 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 to 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 to 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 91319°F).

2. 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 10 gal 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 (i.e., even a thin painted surface can interfere in a bonding connection).
- 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 equipment rated as intrinsically safe. The manufacturer can provide specifications on this type of rating. When a refrigerator in the lab does not have this rating, the sign provided in Figure 1 must be posted on the door:

Refrigerator warning label when not rated as intrinsically safe

3. Health Hazards Associated with Flammables

The vapors of many flammables are irritating to mucous membranes of the respiratory system and eyes but can have significant health risk. For this reason, the SDS must always be consulted. Health effects by exposure routes with corresponding symptoms are listed below.

Acute Health Effects

Below are examples of health effects by exposure route that occur immediately after exposure.

- *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 are injury or illnesses that will last 1 year or longer and can be terminal; the health effect 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.

4. First Aid Procedures for Exposures to Flammable Materials

- *Inhalation Exposures* – remove the person from the contaminated area. Get immediate medical attention. Provide the SDS to the health care provider.
- *Ingestion Exposures* - Get immediate medical attention. Provide the SDS to the health care provider.
- *Dermal Exposures* – remove the person from the source of contamination. Remove clothing and jewelry from the affected areas. Rinse the exposed area for at least 15 minutes and obtain immediate medical attention. Provide the SDS to the health care provider.
- *Eye Contact* – remove the person from the source of contamination. Flush with an eyewash for at least 15 minutes and obtain immediate medical attention. Provide the SDS to the health care provider.

5. Personal Protective Equipment (PPE)

At a minimum, the UT Austin PPE policy must be followed when using chemicals. Although nitrile and neoprene gloves provide protection against most flammables, they will not protect from all flammables. Utilize both the SDS and glove protection charts to ensure the correct glove is selected. Wear a fire-resistant lab coat that will also act as a barrier to your skin. Safety goggles/glasses should be worn if there is a splash risk.

Proper PPE (safety glasses, lab coat, gloves, closed shoes, and pants)

B. Oxidizers

1. 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
  - Peroxides
  - Nitrates
  - Nitrites
  - Perchlorates
  - Chlorates
  - Chlorites
  - Hypochlorites
  - Dichromates

2. 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.

3. Use and Storage of Perchloric Acid

- Depending on the application, use of perchloric acid requires a wash down system in the duct work and fume hood. Contact EHS prior to commencing use of perchloric acid in the laboratory.

- 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 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 washdown 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 when little else is stored in the 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 EHS before working with perchloric acid.

4. Health Hazards Associated with Oxidizers

The below two sections list the acute and chronic health effects 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.

5. First Aid

If a person has inhaled or ingested a hazardous material, the person should be removed from the immediate area as quickly as possible. Seek medical attention immediately. If a person has direct skin contact with a hazardous material, rinse at the closest safety shower for at least 15 minutes (location of a spill/hazard may require a different safety shower to be used). If a person has eye contact with a hazardous material, flush eyes at an emergency eyewash station for at least 15 minutes.

6. Personal Protective Equipment (PPE)

At a minimum, the UT Austin PPE policy must be followed when using chemicals. Neoprene, polyvinyl chloride (PVC), or nitrile gloves are commonly used but it is important to consult a glove compatibility chart to ensure the glove material and thickness is appropriate for the particular chemical being used.

Safety glasses must be worn if the potential for splashing or exposure to vapor/gas exists.

Oxidizers should be used in a chemical fume hood due to the inhalation hazard risk.

C. Corrosives (Acids and Bases)

1. 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 Common Oxidizers
  - Sulfuric Acid
  - Ammonium Hydroxide
  - Chromic Acid
  - Bromine

2. 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.

Acids stored in acid storage cabinet

- 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

- Purchase corrosives in containers that 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.

3. Use and Storage of Hydrofluoric Acid

- Hydrofluoric acid 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.
- 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 minimum amount necessary in the lab.

- Creams such as 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.

4. 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.

5. First Aid

- *Inhalation* - remove person from source of contamination if safe to do so. Immediately seek medical attention.
- *Ingestion* - remove person from source of contamination. Immediately 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 immediate 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 immediate medical attention. Do not let the person rub their eyes or keep them tightly shut.

6. Personal Protective Equipment (PPE)

At a minimum, the UT Austin PPE policy must be followed when using chemicals. Always wear the proper gloves when working with corrosives. Neoprene and nitrile gloves are effective against most acids and bases. Polyvinyl chloride (PVC) is also effective for most acids. Consult the manufacturer's glove compatibility chart prior to use. 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. A link to glove compatibility charts is provided in section VIII, F, 3, pg.69.

D. Reactives

1. 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.

2. 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, Sodium, Potassium
  - Alkylaluminums
  - Magnesium
  - Aluminum
  - Magnesium
  - Zinc

3. Pyrophorics

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

- Tert-butyllithium
- Diethylzinc
- Triethylaluminum
- Several organometallic compounds

4. 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):
  - Diisopropyl Ether
  - Potassium Amide
  - Tetrahydrofuran
  - Vinylpyridine
  - Divinylacetylene
  - Dioxane
  - Vinyl Ethers
  - Acrylonitrile
  - Sodium Amide
  - Diethyl Ether
  - Butadiene
  - Styrene

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[1] can detect most (but not all) peroxy compounds, including all hydroperoxides. None of these tests should be applied to materials (such as metallic potassium) that may be contaminated with inorganic peroxides.

- 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.

[1] From Prudent Practices in the Laboratory – Handling and Disposing of Chemicals – 1995 – Page 100 – Section 5.G.3.1 Peroxide Detection Tests

- 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. Peroxide test strips are available through the chemical storeroom in Welch.

5. Other Shock-Sensitive Materials

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

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

6. 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.

Storage of 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".

Storage of 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 EHS if the container is corroded or otherwise damaged. Additional safety guidance on pyrophorics can be found at: https://ehs.utexas.edu/sites/ehs.utexas.edu/files/Pyrophoric%20Guidance.pdf

Storage of 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 and when opened (the latter being more important). Chemicals such as di-isopropyl ether, divinyl acetylene, sodium amide, and vinylidene chloride should be discarded after three months. Chemicals such as dioxane, diethyl ether, and tetrahydrofuran should be submitted to EHS for disposal after one year if opened or expired.
- Store all peroxide-forming materials away from 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.
- The following tests[2] can detect most (but not all) peroxy compounds, including all hydroperoxides. None of these tests should be applied to materials (such as metallic potassium) that may be contaminated with inorganic peroxides.
    - ✓ 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

[2] From Prudent Practices in the Laboratory – Handling and Disposing of Chemicals – 1995 – Page 100 – Section 5.G.3.1 Peroxide Detection Tests

proper operation.

- If you suspect that peroxides may be present contact EHS. If you notice crystal formation in the container or around the cap, do not attempt to open or move the container. Call EHS for proper disposal.
- Never distill ether unless it is known to be free of peroxides.

Chemical containers in poor condition from corrosion and crystal formation

Storage of 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.

7. 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 EHS. 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 by calling 911. Explain the situation and describe the location clearly and accurately. If other personnel are present and able to help, send them to meeting the emergency responders outside the building to guide them to the injured person.

If someone is severely bleeding, put on protective gloves and apply a sterile dressing, clean cloth, or handkerchief to the wound. Then place the palm of your hand directly over the wound and apply pressure and keep the person calm. Continue to apply pressure until help arrives.

If a person's lab coat or clothes are on fire, he or she should drop immediately to the floor and roll. 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.

8. Personal Protective Equipment (PPE) and Barriers

At a minimum, the UT Austin PPE policy must be followed when using chemicals. 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.

E. Compressed Gas Cylinders

1. 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 destructive explosive force of 1 1/2 pounds of TNT.

2. Purchase Policy

Purchase of gases in non-returnable cylinders is restricted at UT Austin by EHS. EHS requires that all gas cylinders purchased for use on campus must be returnable to the vendor unless a compelling research reason is present. If a non-returnable cylinder is purchased, EHS can bill the PI, or if unavailable the research college, for the cylinder disposal fee

Researchers purchasing cylinders outside the UT Austin purchasing structure will be responsible for cylinder disposable fees.

Based on EHS's discretion, disposal costs of abandoned chemicals, including unknowns, are the responsibility of the PI or associated research department/college.

3. 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, ensure the appropriate regulator is being utilized for the type of gas within the cylinder. Do not attempt to adapt or modify a regulator to fit a cylinder it was not designed for. Regulators are designed to fit only specific cylinder valves to avoid improper use.

Properly attached regulator and safety cap (left) adjacent to operating cylinder with regulator attached

- 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.
- 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. EHS can provide the special tool to remove the safety cap if over tightened.
- 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 them to a wall, lab bench, or other fixed support. Unfixed tables or cabinets (or other unsecured furnishing) cannot be used for securing cylinders. Strapping or webbing used to secure cylinders is not recommended. Chains are the best method for securing cylinders.

Compressed gas cylinders (picture courtesy of Airgas, Inc.)

- 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 (designed for gas cylinders, see Figure 6) in an upright position. Never roll a cylinder.

Proper transport of gas cylinders (picture courtesy of Airgas, Inc)

- Always clearly mark empty cylinders and store them separately.
- Be careful while handling compressed gas cylinders and never drop or strike a cylinder against anything.
- 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 125F.
- Keep minimal quantities of cylinders inside the laboratory. Consider carefully where unused cylinders are stored (example: do not store near emergency exits).
- Tubing or piping used to transfer gases from the cylinder must be constructed of compatible materials. Flammables and oxidizers must never be connected with plastic tubing. Tubing, piping and connectors must be rated for pressures being supplied.
- EHS requires restrictive flow orifices (RFOs) on compressed gas cylinders not to limit normal operations but if a fault or failure occurs causing uncontrolled flow the orifice will present a restriction limiting the flow and potential danger from the gas.

- Only UT Austin employees (paid by UT Austin) can change compressed gas cylinders on campus.
- Contact EHS when needing to change, install or disconnect toxic or corrosive cylinders.

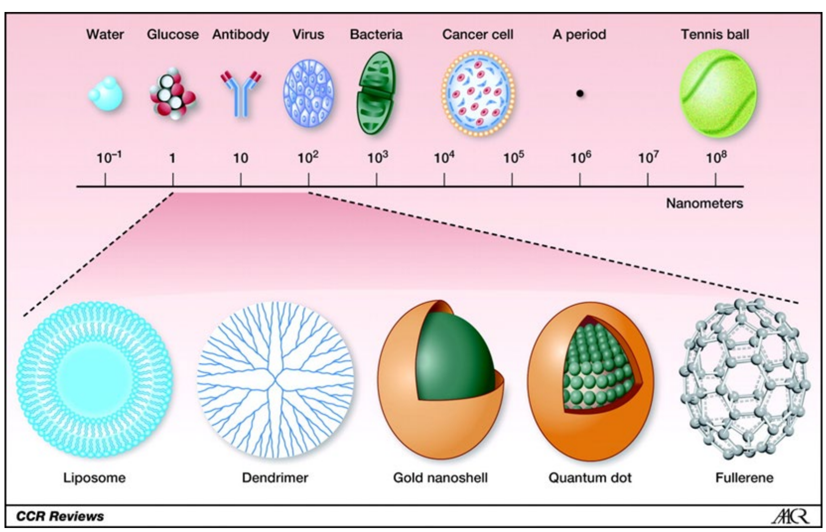
F. Nanomaterials

1. Overview

Nanotechnology involves the manipulation of matter at nanometer scales to produce new materials, structures, and devices. Engineered nanomaterials (NM) are becoming more prevalent in research. One of the concerns of using nanoparticles/nanomaterials is that in some cases, very little is known about the physical toxicity of the nanoparticle/nanomaterial. Variances in size, shape, and surface area can affect toxicity at different levels. Materials that are normally considered non-toxic may be toxic at the nanosize regime. NM can enter the bloodstream via the skin or lungs and be retained in different organs. While there is still great uncertainty about toxicity profiles of engineered nanomaterials, there is enough circumstantial evidence to indicate that precautions should be taken.

For this reason, the safe science of NM use will be regularly monitored by Environmental Health and Safety (EHS). This document will be updated periodically to remain current on NM handling best practices.

Based on current knowledge and practices, NM should be treated as potentially hazardous unless it has been documented that exposure to the specific NM is not hazardous.



The size of nanomaterials (1-100 nm) compared to familiar items.

2. Definitions[3]

Term	Definition
Agglomerate	A group of particles held together by relatively weak forces, including van der Waals forces, electrostatic forces and surface tension.
Aggregate	A heterogeneous particle in which the various components are held together by relatively strong forces, and thus not easily broken apart.
Buckyballs	Spherical fullerenes composed entirely of carbon (C60).
Fullerene	Molecules composed entirely of carbon, usually in the form of a hollow sphere, ellipsoid, or tube.
Graphene	A one-atom thick sheet monolayer of graphite.
Nano-object	According to ISO/TS 27687:2008, a *nano-object* is defined as material with one, two, or three external dimensions in the size range from approximately 1–100 nm. Subcategories of nano-objects are: *(1)* *nanoplate*, a nano-object with one external dimension at the nanoscale; *(2)* *nanofiber*, a nano-object with two external dimensions at the nanoscale with a nanotube defined as a hollow nanofiber and a nanorod as a solid nanofiber; and *(3)* *nanoparticle*, a nano-object with all three external dimensions at the nanoscale. Nano-objects are commonly incorporated in a larger matrix or substrate referred to as a *nanomaterial*. Nano-objects may be suspended in a gas (as a nanoaerosol), suspended in a liquid (as a colloid or nanohydrosol), or embedded in a matrix (as a nanocomposite).
Nanoscience	The study of phenomena and manipulation of materials at atomic, molecular and micromolecular scales, where properties differ significantly from those at a bulk scale.
Nanoaerosol	A collection of nanomaterials suspended in a gas.

[3] UT has adopted the definitions for nanomaterials from the International Organization for Standardization Technical Committee 229 (Nanotechnologies).

Term	Definition
Nanocolloid	A nanomaterial suspended in a gel or other semi-solid substance.
Nanocomposite	A solid material composed of two or more nanomaterials phase having different physical characteristics.
Nanomaterial	A matrix or substrate made up of nano-objects.
Nanoparticle	A substance with dimensions less than 100 nanometers in size.
Nanohydrosol	A nanomaterial suspended in a solution.
Nanotechnology	The understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.
Nanotubes	A sheet of graphene rolled up into a seamless cylinder with diameter on the order of a nanometer.
Nanowires	A wire of dimensions on the order of a nanometer.
Nucleation	The first step in the process by which gases are converted to small liquid droplets.
Physicochemical	The underlying molecular organization of life that is manifested as chemical and energy transformations.
Pyrolysis	Chemical change brought about by the action of heat.
Quantum Dots	A nanomaterial that confines the motion of conduction band electrons, valence band holes, or excitons (pairs of conduction band electrons and valence band holes) in all three spatial directions.
Single-Walled Carbon Nanotube	A single sheet graphene wrapped into a tube approximately 1.5 nanometers in diameter.
Thermites	A mixture of aluminum powder and a metal oxide (as iron oxide) that when ignited evolves a great deal of heat and is used in welding and in incendiary bombs.
Translocation	The act, process, or an instance of changing location or position.
Transmission Electron Microscopy (TEM)	A microscopy technique whereby a beam of electrons is transmitted through an ultra thin specimen, interacting with the specimen as it passes through, and produces an image formed from the interaction of the electrons transmitted through the specimen which is then magnified and focused onto an imaging device.
Ultra-Fine Particles	Airborne particles with an aerodynamic diameter of 0.1 m (100 nm) or less.

3. Regulations

At this time, there are no federal regulations that specifically address the health and safety implications of nanotechnology. There are also no national or international consensus standards on measurement techniques for nanomaterials in the workplace. However, as with conventional chemicals, research with nanomaterials must be conducted in a manner that is safe and responsible. All chemicals, including nanomaterials, must be transported, stored, used, and disposed in accordance with all federal, state, and local requirements.

The Occupational Safety and Health Administration (OSHA) is the minimum safety standard in the United States and adopted by UT Austin. OSHA require employers to maintain a safe and healthful workplace, “free from recognized hazards likely to cause death or serious physical harm” (29 USC 654). According to OSHA, laboratory personnel must be informed of the risks associated with workplace hazards. This is generally accomplished through training programs, safety data sheets (SDS), labeling and signage.

The Resource Conservation and Recovery Act of 1976 (RCRA) regulates the transportation, treatment, disposal, and cleanup of hazardous waste. Nanomaterials that meet the definition of a “hazardous waste” in RCRA are subject to this rule.

Nanomaterials that are defined as “chemical substances” under the Toxic Substances Control Act (TSCA) and which are not on the TSCA Inventory must be reported to U.S. Environmental Protection Agency (EPA). A Pre-manufacture Notice must be submitted to the EPA by anyone intending to manufacture or import a chemical substance that is not on the TSCA Inventory of Chemical Substances.

It should also be noted that the U.S. Food and Drug Administration currently regulates a wide range of products including those that utilize nanotechnology or that contain nanomaterials (e.g., a drug delivery device).

4. Risk Analysis/Assessment

Research with nanomaterials has shown that the physico-chemical characteristics of nanoparticles can influence their effects in biological as well as non- biological systems. Some of these characteristics associated with nanomaterials include:

- Charge;
- Chemical reactivity;
- Degree of agglomeration;
- Shape;

- Size;
- Solubility;
- Surface area; and
- Surface composition.

There are many unknowns as to whether the unique properties of engineered nanomaterials pose health concerns. The potential health risk following exposure to a substance is generally associated with the following (CDC/NIOSH, 2009):

- Magnitude and duration of the exposure;
- Persistence of the material in the body;
- Inherent toxicity of the material; and
- Susceptibility or health status of the person.

Unfortunately, there is limited data regarding the health risks related to nanomaterials. As such, this section of the Lab Safety Manual provides EHS-accepted recommendations for practicing prudent health and safety measures when working with nanomaterials.

If SDS information is available for nanomaterials it should be consulted to determine the material's potential hazardous properties, PPE required, containment needs, handling and disposal. When an SDS is not available, the researcher should conduct a literature review to perform a risk analysis. If no information is available, the researcher should, at a minimum, use standard precautions described below for handling the material as if it were potentially hazardous. Part of the risk analysis/assessment should include:

- Assessment of the potential implications of human exposure to the NM being used recognizing that the characteristics of the NM are different from those of larger particles with the same chemical composition.
- Assessment of any potentially hazardous manipulations that increase the risk of human exposure such as cytotoxicity, aerosolization, injection, excretion, etc.

"The physicochemical characterizations of NM are important steps in toxicological and ecotoxicological studies in order to correctly evaluate and assess their potential exposure routes, toxicity, and related risk." (Nanotoxicity, Monteiro-Riviere and Tran, 2007, p.19). Records of research use will ideally include the size, shape, surface area, chemical composition, lattice structure, surface charge, and aggregation state, as well as the makeup of any associated liquid media if supplied as suspension.

Mass, surface-area and number concentration remain important exposure metrics. Inter-disciplinary collaboration is essential to understanding and managing potential risk.

Researchers should develop their own standard operating procedures (SOP) based on their risk assessment and in consultation with this document and EHS. An SOP, when used in conjunction with completion of hazard communication training, should provide employees and students with an adequate "hazard communication" basis for use of engineered nanomaterials at UT Austin. In addition, the SOP should provide a detailed description of the procedures being conducted including the specific requirements for engineering controls, PPE, dosing, handling, bedding/cage changes, disposal, emergency response and occupational health contacts.

5. Exposure Routes

Nanomaterial exposure can follow the traditional exposure routes of any other material (inhalation, ingestion, injection, and absorption). A summary table of exposure routes is provided in Table 1 below.

The deposition of discrete nanomaterials in the respiratory tract is determined by the particle's aerodynamic or thermodynamic diameter. Particles that are capable of being deposited in the gas exchange region of the lungs are considered respirable particles. Discrete nanomaterials are deposited in the lungs to a greater extent than larger respirable particles. Deposition increases with exertion (due to an increase in breathing rate and change from nasal to mouth breathing). Based on animal studies (Oberdorster), discrete nanomaterials may enter the bloodstream from the lungs and translocate to other organs. Because of their ultra-small size, nanoparticles can penetrate cell membranes and integrate themselves into larger molecules. They can resist cellular defense systems but are large enough to interfere with cell processes.

Ingestion is another route whereby nanomaterials may enter the body. Ingestion can occur from unintentional hand-to-mouth transfer of materials. This can occur with traditional materials and it is scientifically reasonable to assume that it could happen during handling of nanomaterials. This is specifically true while handling very high surface area (>20 m^2/g), porous dry nanomaterials which includes metals, nonmetal oxides, or their mixed forms, and microporous or mesoporous metal organic framework. Some of the examples of commonly used materials of this category are CeO_2, TiO_2, SiO_2, Co_3O_4, Mn_3O_4, Ru_3O_4, ZnO OS_3O_4, V_2O_3, graphene, carbon nanotube and MgO. Ingestion may also accompany inhalation exposure because particles that are cleared from the respiratory tract via the mucociliary escalator may be swallowed.

A few studies (Murray, 2009, Wang et.al, 2011) suggest that nanomaterials may enter the body through the skin during exposure. At this time, little is known if skin penetration of nanomaterials would result in adverse health effects.

There is also little information about the health effects of injecting nanomaterials into living organisms.

Table 3– Potential Sources of Exposure to Nanomaterials through Occupational Activities (Aiken et al. 2004)

Process Synthesis	Particle Formation	Exposure Source or Worker Activity	Primary Exposure Route**
Gas Phase	In Air	Direct leakage from reactor, especially if the reactor is operated at positive pressure	Inhalation
		Product recovery from bag filters in reactors.	Inhalation/Dermal
		Processing and packaging of dry powder.	Inhalation/Dermal
		Equipment cleaning/maintenance (including reactor evacuation and spent filters).	Dermal (and inhalation during reactor evacuation)
Vapor Deposition	On Substrate	Product recovery from reactor/dry contamination of workplace.	Inhalation
		Processing and packaging of dry powder.	Inhalation/Dermal
		Equipment cleaning/maintenance (including reactor evacuation).	Dermal (and inhalation during reactor evacuation)
Colloidal	Liquid Suspension	If liquid suspension is processed into a powder, potential exposure during spray drying to create a powder, and the processing and packaging of the dry powder.	Inhalation/Dermal
		Equipment cleaning/maintenance.	Dermal

Process Synthesis	Particle Formation	Exposure Source or Worker Activity	Primary Exposure Route**
Attrition	Liquid Suspension	If liquid suspension is processed into a powder, potential exposure during spray drying to create a powder, and the processing and packaging of the dry powder.	Dermal
		Equipment cleaning/maintenance.	Dermal

** Note: Ingestion would be a secondary route of exposure from all sources/activities from deposition of nanomaterials on food or subsequently swallowed (primary exposure route inhalation) and from hand-to-mouth contact (primary exposure route dermal).

6. Factors Affecting Exposure

Every attempt should be made to prevent or minimize exposure to nanomaterials. Factors affecting exposure to nanomaterials include the amount of material being used and whether it can be easily dispersed or form airborne sprays or droplets. The degree of containment and duration of use will also influence exposure. In the case of airborne material, particle or droplet size will determine whether the material can enter the respiratory tract and where it is most likely to deposit. Inhaled particles smaller than 10 micrometers in diameter have some probability of penetrating and being deposited in the gas-exchange (i.e., alveolar) region of the lungs, but there is at least a 50% probability that particles smaller than 4 micrometers in diameter will reach the gas-exchange region.

At present there is insufficient information to predict all of the situations and workplace scenarios that are likely to lead to exposure to nanomaterials. However, there are some workplace factors that will increase the potential for exposure, including (CDC/NIOSH, 2009):

- Working with nanomaterials in liquid media without adequate protection (e.g., gloves) will increase the risk of skin exposure.
- Working with nanomaterials in liquid media during pouring or mixing operations, or where a high degree of agitation is involved, will lead to an increased likelihood of inhalable and respirable droplets being formed.
- Generating nanomaterials in the gas phase in non-enclosed systems will increase the chances of airborne release to the workplace.

- Handling nanopowders will lead to the possibility of aerosolization.
- Maintenance on equipment and processes used to produce or fabricate nanomaterials will pose a potential exposure risk to workers performing these tasks.
- Cleaning of dust collection systems used to capture nanomaterials will pose a potential for both skin and inhalation exposure.

7. Containment

The primary routes of exposure to nanomaterials are through the inhalation and dermal exposure; ingestion is a secondary route of exposure. The containment guidelines below are designed to help minimize a potential exposure through these routes.

The preferred method to minimize personnel exposure to liquid or matrix-bound nanomaterial is through engineering controls. Physical containment such as a fume hood, glove box, biological safety cabinet or downdraft table may be necessary to dose/handle animals and for changing bedding/cages. At a minimum, engineering controls should include local exhaust ventilation and localized filtration. Respiratory protection may be required when working with nanomaterials when local exhaust ventilation and filtration is not available.

The following engineering controls are recommended for the safe handling of nanomaterials (CDC/NIOSH, 2009; VCU, 2007):

- Use of containment is recommended for all tasks with potential of aerosolizing nanomaterials in either liquid or powder form.
- A well-designed local exhaust ventilation system with a local high-efficiency particulate air (HEPA) filter should be used to effectively remove nanomaterials.
- When there is heavy usage of aerosolized nanoparticles or process resulting in easy cross contamination, a proper decontamination or buffer area should be utilized to ensure the nanomaterials are not transported outside of the working area.
- Laboratories and other spaces where nanomaterials are used or stored must be equipped with an eyewash station that meets American National Standards Institute (ANSI) and Occupational Safety and Health Administration (OSHA) requirements.

The second level of containment is through administrative controls. Employees are encouraged to use hand-washing facilities after removing PPE and before leaving the laboratory. Inadvertent contamination caused by the transfer of nanomaterials on clothing and skin can be reduced by training personnel to leave lab coats in the work area and provide laundry services for lab coats or implement disposable lab coats. In addition, it is important to incorporate the following administrative controls into all laboratory operations:

- The laboratory's safety plan should be modified to include health and safety considerations of nanomaterials used in the laboratory.
- Principal investigators (PIs) should develop and implement SOPs in the preparation and administration of nanomaterials (with emphasis on minimizing exposure).
- Protocols involving the in vivo use of nanomaterials must be reviewed and approved by the Institutional Animal Care and Use Committee (IACUC).
- Laboratory personnel must receive the appropriate training (prior to working with nanomaterials), including specific nanomaterial-related health and safety risks, SOPs, and steps to be taken in the event of an exposure or unintended release incident.
- Laboratory personnel must be instructed to use extreme caution when performing injections involving nanomaterials since accidental needle stick presents an exposure threat.
- Exposures involving nanomaterials or any other acutely hazardous material must be reported to the Environmental Health and Safety Department as soon as possible.
- Animals should be appropriately restrained and/or sedated prior to administering injections and other dosing methods.
- Frequent hand washing, especially before eating, smoking, applying cosmetics, or leaving the work area should be employed.

If engineering or administrative controls do not eliminate the exposure potential, use of PPE is indicated. The minimum PPE for working with potentially hazardous nanomaterials are gloves, a lab coat, and eye protection. Open–toed shoes, shorts, skirts, and cuffed pants are prohibited. Glove selection is best determined by a risk assessment and the chemicals used for the procedure. Nitrile or rubber gloves, which cover hands and wrists completely through overlapping sleeve of lab coat when working with nanomaterials, may provide adequate protection. Wearing of two sets of gloves "double gloving" is advised whenever performing tasks involving nanomaterials and other hazardous substances. Laboratory personnel should thoroughly wash hands with soap and water immediately upon removal of gloves.

Additional PPE may be necessary as determined by the risk assessment. Safety glasses or goggles are considered to be the appropriate level of eye protection for working with nanomaterials. A respirator may be needed if working with high surface area mesoporous/ microporous powders or aerosols outside of a glove box or fume hood. When working with nanomaterials, if an identified route of exposure includes inhalation for the identified research, contact EHS utilizing this link.

If a respirator is advised, then dust or surgical masks should not be used in place of NIOSH-approved respirators for protection against nanomaterials.

8. Special Methods

i. Using Nanomaterials with Animals

Dosing animals with nanoparticles related processes/procedures:

- Dosage preparation should not be done in animal rooms or in multi-user rooms. Dosage preparation should be done in the PI's lab. After dosing, unused materials should be returned to the PI's lab.
- Only essential personnel should be in the room during dosing. The room should be secured.
- Animals should be chemically or physically restrained during dosing.
- Work areas should be cleaned up and decontaminated after animal dosing is completed.
- Animals should be dosed in containment and absorbent paper used to contain small spills, syringe leakage, etc. Absorbent paper should be changed after each experiment and disposed as nanoparticles waste.
- Luer-lock syringes should be used to prevent needle "blow-off".
- If preparation is being administered via a syringe or other feeding device, a fume hood or BSC must be used. If administration is by food, use of a micro-isolator cage is recommended.

ii. Handling Animals

If nanomaterials is expected to be shed by the animals, PPE should be worn when handling the animals. If the potential exists for the excreted nanomaterials to be aerosolized during handling, then the animals should be manipulated in ventilated containment (fume hood/BSC).

iii. Bedding/Cage Changes

- Use of disposable cages after inoculating mice with nanomaterials is recommended. Cage cards should indicate animals have been inoculated in addition to the estimated washout period. Animals should be kept on a dedicated rack.
- If metabolic cages are used, use ventilated containment (BSC or fume hood)

for handling waste containers and cleaning of cage components.

- Personnel should wear proper PPE (gloves, lab coats, respirator, and eyewear) during cage changes to reduce exposure.
- Once inoculated, nanomaterials may be excreted into the bedding. Waste/bedding/disposable cages should be disposed in appropriate containers by trained staff.
- Cage changes should not be performed for the first 72 hours.
- Animals can typically be transferred to standard micro-isolator cages after 72 hours.
- Cage changes/dumping may need to be conducted in containment (BSC) based on the results of the procedure specific risk assessment.

iv. Transportation

Caution should be taken when transporting animals dosed with nanomaterials. To reduce the potential for exposure to the transporter/driver, dosed animals should typically not be transported until they have been transferred to a clean cage (for at least 72 hours after dosing). Consideration should be given to first transporting the animals to the new location before dosing them.

9. Waste Disposal

Discuss waste to be generated with EHS prior to nanomaterial contaminated waste generation for specific directions for waste collection and disposal methods. Dispose of both the engineered nanomaterial and any materials used for wipe up of work surfaces or wipe down of generation equipment with name of the material preceded by words “nanosized,” such as “nanosize cadmium selenide contaminated waste” unless “nano” is contained in the name, such as “cadmium selenide nanodots”. Concentrated nanomaterials should be disposed as hazardous waste and a clearly written tag of nanowaste with their approximate composition in percent should be presented. Simply writing a bulk name or formula does not properly indicate the nano- waste.

Labs should submit a waste request for disposal form and arrange pick up with EHS to avoid over filling containers. Contact EHS for assistance.

For questions concerning chemical waste and/or biological waste (including the need for waste containers for nanomaterials) disposal contact the Hazardous Materials Program in EHS 512-471-3511.

10. Training and Documentation

Personnel should be trained on the potential hazards of working with NM as part of their site-specific hazard communication training. An SOP should be developed and submitted to EHS for review. Review of SOPs should be documented for all personnel who handle NM. Researchers submitting protocols to the IACUC should note the NM they are planning to use in the toxic/hazardous substance section of the protocol application.

Researchers submitting protocols to the IACUC should note the nanomaterials they are planning to use in the toxic/hazardous substance section of the protocol application.

11. Emergency Spill Response

Report any spills to the PI and EHS.
If a spill is minor and known limited danger, clean up immediately wearing PPE.

Standard approaches for cleaning powder spills include using HEPA-filtered vacuum cleaners, or wiping up the powder using damp cloths, or wetting the powder prior to dry wiping. Damp cleaning methods are preferred. Liquid spills may be cleaned by applying absorbent materials. At a minimum, the following procedures must be followed when managing an accidental spill of nanomaterials (CDC/NIOSH, 2009):

- Small spills (typically involving less than 5 mg of material) of nanomaterials containing powder should be wet-wiped with cloth/gauze that is dampened with soapy water. Affected surfaces should be thoroughly wet-wiped three times over with appropriate cleaning agent and with a clean, damp cloth used for each wipe down. Following completion, all cloth and other spill clean-up materials with a potential for nanomaterial contamination must be disposed of as hazardous waste.
- Small spills (typically involving less 5 ml of material) of nanomaterial-containing solutions should be covered and absorbed with absorbent material. Areas affected by liquid spills should be triple cleaned with soap and water following removal of absorbent paper.

Use of commercially available microfiber cleaning cloths may also be effective in removing NM from surfaces with minimal dispersion into the air. Cleaning cloths should be properly disposed (consult with EHS).

If a spill is major or potentially dangerous, evacuate the area and immediately call EHS 512-471-3511.

12. Exposures

- For dermal exposures to dry material, brush the material off the skin first (in front of a fume hood) with a gloved hand and paper towel or other assistive device, then wash the affected area for a minimum of 15 minutes with soap and water.

- For dermal exposures to liquid material, immediately rinse the affected area for a minimum of 15 minutes with soap and water.
- Remove any contaminated clothing and seal in a bag.
- In the event of inhalation exposure, immediately seek fresh air.
- In the event of eye contact, immediately flush eyes with water for at least 15 minutes.
- In the event of a needlestick, remove needle and wash affected area with soap and water.
- Contact Occupational Health at 512-471-4OHP(4647) for all exposure incidents. If an appointment with Occupational Health is required, bring the SDS (if available) or risk assessment information for the NM being used.

13. Occupational Health

Occupational Health should be consulted whenever a suspected or actual exposure to NM takes place. Personnel who work with NM in animals should notify Occupational Health that they are working with NM on their initial OHP Health Assessment questionnaire and update their NM information on subsequent health monitoring update forms. Personnel who indicate on their Occupational Health Risk Assessment form that they wear respiratory protection (N95 or higher) will be scheduled for annual respiratory medical clearance.

14. References

NIOSH Publication No. 2009-125: Approaches to Safe Nanotechnology Managing the Health and Safety Concerns Associated with Engineered Nanomaterials

NIOSH Publication No. 2009-116: Current Intelligence Bulletin 60: Interim Guidance for Medical Screening and Hazard Surveillance for Workers Potentially Exposed to Engineered Nanoparticles

NIOSH Publication No. 2008-112: Safe Nanotechnology in the Workplace

Interim Best Practices for Working with Nanoparticles Center for High-Rate Nanomanufacturing. M. Ellenbecker Revision 0 – November 2007

Aitken, R.J., Creely, K.S., Tran, C.L. *Nanoparticles: An Occupational Hygiene Review*. Research Report 274. Prepared by the Institute of Occupational Medicine for the Health and Safety Executive, North Riccarton, Edinburgh, England. 2004.

Nanotechnology and Nanoparticles – Safe Working Practices Information.

Virginia Commonwealth University. Office of Environmental Health and Safety. 2007

Occupational Safety and Health Act of 1970 (29 U.S.C. 654). Section 5(a) (1).

Nanoparticles Safety Guide, The University of Texas Health Science Center at Houston, Safety, Health, Environment, and Risk Management

ISO/TS 27687:2008, Nanotechnologies -- Terminology and definitions for nano-objects -- Nanoparticle, nanofibre and nanoplate

Nanotechnology Health and Safety Resources:

- National Institute for Occupational Safety and Health
- NCI Nanotechnology Characterization Laboratory
- The Nano Risk Framework
- Good Nano Guide

G. Toxic Metals

1. General Characteristics

Toxic metals, including "heavy metals," are individual metals and metal compounds that negatively affect people's health. Many of these metals are necessary to support life but only needed in small amounts. However, they become toxic in larger amounts. Metals have the capacity to concentrate in biological systems and become a significant health hazard. Metal toxicity depends on the absorbed dose, the route of exposure, duration of exposure, i.e., acute or chronic, and biological pathway in the body.

There are 35 metals with residential or occupational exposure limits, out of which 23 are heavy metals. These toxic and heavy metals include the following list (not exhaustive) and each of these metals have different health effects, both acute and chronic.

- antimony
- arsenic
- bismuth
- cadmium
- cerium
- chromium
- cobalt
- copper
- gallium
- gold
- iron
- lead
- manganese
- mercury
- nickel
- platinum
- silver
- tellurium
- thallium
- tin
- uranium
- vanadium
- zinc

2. Exposures Routes

Heavy and toxic metals can be present as solid pure materials (solid, liquid, or fine particulate), combined with other compounds (liquid or solid), or be present with different valances. The materials physical characteristic and handling practices can increase or decrease the potential for exposure. The most common exposure routes are airborne and dermal however, ingestion should not be overlooked when cross contaminating of surfaces occurs.

Experiments should be reviewed and assessed, standard operating procedures written, and exposure controls be put in place to prevent exposure to heavy metals. Additional consideration should be given to contamination of work surfaces and equipment. Cross contamination between objects can be a source of exposure.

Some toxic metals exposures can be fatal. A Dartmouth researcher used dimethylmercury to set up a standard against which to measure other mercury involved in her research. A few drops of this compound spilled onto her gloves, passed quickly through the latex and were absorbed through her skin. Five months later her illness was diagnosed and the college had the latex gloves independently tested, and it was determined that the mercury compound could permeate the glove in 15 seconds or much less. The researcher did wash her hands after the initial accident. Ten months after the initial incident, the researcher died.

3. Handling of Heavy and Toxic Metals

- The lab where the material is being handled has an approved / certified emergency eyewash and safety shower.
- Ensure you are wearing the following minimum PPE: tightly fitting safety goggles and face shield, lab coat, full length pants, close-toe rubber or leather shoes, nitrile gloves.
- Lab emergency contact information must be readily posted. Easy access to a cellular phone or land line is readily available.
- Avoid contact with skin, eyes, and clothing.
- Avoid formation of dust.
- Avoid inhalation and ingestion.
- Provide appropriate exhaust ventilation at places where dust is formed.
- All work with toxic and heavy metals is to be done in the “heavy/toxic metal” designated area to keep contamination to a minimum.
- All lab equipment used in the “heavy/toxic metal” designated area is to be labeled as “heavy/toxic metal contaminated” and are not to be removed from the area without first being decontaminated.

- Handle the heavy/toxic metal atom compounds wearing gloves, lab coat, eye protection, long pants and closed-toe shoes.
- Wear gloves even to look at the containers.
- Doorknobs should not be touched while handling heavy metals, take off the gloves, or get somebody to open the doors for you.
- The used gloves, go to solid waste containers, not the trash.
- Do heavy metal work on top of a bench protector sheet, paper side up. The sheet will catch any splatters and drips, same as in radioisotope handling. The bench protector sheet is disposed of as hazardous waste, along with the gloves, pipet tips, etc.
- Dedicated spatulas or glassware must be used for heavy metals because glassware and spatulas used for heavy metal experiments are contaminated forever.
- Do not return them to general circulation and other uses. Clean the heavy metal spatula with a wet Kimwipe®. The contaminated Kimwipe® goes into a solid waste container as solid waste (see disposal section, below). If you must use new glassware, clearly label it, and keep it completely separate from non-heavy metal/ toxic metal glassware.
- MEASUREMENT WEIGHING
  Weigh heavy/toxic metal compounds on weighing paper, or into centrifuge tubes on top of weighing paper. Use the analytical balance (the one with an enclosure), not the top-loader. Many of these compounds are corrosive to the balances, in addition to poisoning all subsequent experiments and users. If spill during weighing, clean up immediately. Heavy metal clean-up materials go into solid waste containers dedicated to toxic and heavy metals.

- Handling and use in: XRD/SEM/TEM/IR/UV-Vis/AAS/ICP-AES
  - Bring Kimwipes®and bag for wiping everything down and disposing of waste temporarily and place the bag in designated solid waste container
  - Bring a few pairs of gloves and face mask for use during sample preparation, and dispose of them in a bag when done

4. Waste Disposal

Label waste

- Attach a completed UT Austin Hazardous Waste tag to all waste containers as soon as the first drop of waste is added to the container.

Store waste

- Store hazardous waste in closed containers, in secondary containment and in a designated storage location.
- Double-bag dry waste using sealable transparent bags.

- Waste must be under the control of the person generating and disposing of it.

Dispose of waste

- Dispose of regularly generated chemical waste within 90 days.
- Use Environmental Management System EMS for disposal request
- Contact EHS (512) 471-3511 with questions.

Mercury and lead compounds need to be segregated and separated. Each compound has to be individually listed on the disposal tag; writing simply "Mercury and lead containing compounds" is not considered accurately label. To minimize disposal costs, segregate the concentrated wastes such as stock solutions from trace contamination wastes such as Kimwipes®.

Weighing paper, paper towels, gloves, and other dry non-sharp wastes contaminated by tiny amounts of heavy/toxic metals should be placed into zip-lock bags (lead and mercury separate) and placed in a heavy/toxic metal solid waste container and accurately label it. Contaminated sharp items such as needles and cover slips should be placed in heavy metal sharps containers.

Toxic metals present different waste segregation requirements. Please reference Section VI.11 and if you have any additional questions, contact HazardousMaterials@austin.utexas.edu .

V. PHYSICAL HAZARDOUS

A. Equipment

- 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.

B. Fire Safety

In addition to other safety requirements, laboratories on campus are subject to the requirements of NFPA 1, Fire Code, and NFPA 101, Life Safety Code, per the Texas

State Fire Marshal's Office. Laboratories where flammable or hazardous chemicals are used or stored shall comply with NFPA 45, Standard on Fire Protection for Laboratories Using Chemicals. For more information, visit UT Austin's Fire Prevention Services website.

C. Noise

The university is committed to protecting the health and safety of lab workers. Review the information below to learn more about hearing protection. Contact EHS if you have questions or concerns about noise levels in your work environment.

Hearing Protection Informational Handout (PDF)

D. Machine Shop Equipment

Many hazards exist for employees working with machine tools. According to the Bureau of Labor Statistics, workers who operate and maintain machinery experience approximately 18,000 amputations, lacerations, crushing injuries, abrasions and over 800 fatalities each year. Additionally, machine shops also contain flammable liquids and other chemicals that may increase the risk of fire.

Department heads, Principal Investigators and supervisors are responsible for ensuring that all employees, students and visitors work safely in machine shops or when working with any machine or tool that can cause injury. Shop managers must ensure all equipment users are trained and training is documented. A shop safety training checklist is provided here. Shop managers must ensure regular inspection (documented) of the space. A machine shop inspection form is provided through this link. The safety requirements are described below and include, but are not limited to, access control, training, and work rules and procedures.

EHS wants to ensure that all employees and students who work in machine shops have the basic training to keep themselves and their colleagues safe. Please keep these rules in mind and take the OH 500 Shop Safety online training if you work in a machine shop. Review the general shops rules below:

- Never work alone. Follow your shop's after-hours policy.
- Never use machinery without the approval of the supervisor and completion of training.
- Never use damaged or malfunctioning equipment.
- Never talk to or touch the machine operator.
- Never allow student use of power machinery without the shop supervisor or a monitor present. Undergraduates must check in with monitor upon arrival.
- Never wear loose clothing in the shop—including ties, scarves, jewelry, and loose sleeves. No open-toed shoes or short pants allowed in the shop.
- Never use a cell phone or personal music player. Store them at the entrance to

the shop prior to working. Loud music is prohibited.
- Never work if you are tired. Take frequent breaks to stay alert.
- Never use compressed air greater than 30 psi pressure for cleaning equipment. Never use compressed air to clean skin or clothing.
- Always complete general and shop-specific training before using facility.
- Always understand your operation before you begin or ask the shop supervisor for help.
- Always wear personal protective equipment (PPE), including glasses or face protection.
- Always remove jewelry before working—including rings, necklaces, bracelets, and watches.
- Always secure long hair including beards.
- Always use all guards and shields. They must be secured prior to operating equipment.
- Always check wood for screws or other embedded metal objects.
- Always clear dust and debris before and after machine use.
- Always keep aisles, exits, and access to emergency equipment clear.
- Always immediately report all problems or concerns to the shop supervisor or monitor.

Follow the guidelines at this link if you work with hand tools such as drills, pliers, and hammers.

E. 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.

Overloaded multi-plug strip

Electrical cords daisy-chained

- 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.
- Building electrical panels may only be modified or wired by a licensed electrician. Electrical panels and/or breakers cannot be used as equipment on-off switches.

F. Robotics Safety

Robotic usage has increased over the years and therefore safety controls and practices need to be implemented. The UT Austin Robotics Safety Program provides users of robotic systems with guidance to enhance operator/personnel safety around industrial robot systems. This can include but is not limited to robots, robot end-effectors, and ancillary equipment. More information can be found on the EHS Robotics Safety website.

The criteria below outlines the basics of what should be implemented into trained user procedures. This can include but is not limited to robots, robot end-effectors, and ancillary equipment.

1. Review the risk assessment created at the design stage, this document should detail the tasks to be performed and the hazards that were mitigated. Ensure the risk assessment with the approved risk reduction measures are up to date and properly documented.
2. Determine what information regarding engineering controls, awareness devices, and personal protective equipment is required to achieve a safe and acceptable risk reduction.
3. Obtain any existing standardized work practices or manufacturer's procedures for each device identified in the task-based risk assessment.
4. Create a standard operating procedure (SOP) based on the task-based risk assessment.
5. Reference any specific additional procedures provided by the manufacturer or integrator as required for clarity of safe operation in the SOP.
6. Divide the SOP into individual procedures not to exceed nine steps. If the SOP is larger than nine steps, break up into smaller SOPs that do not exceed nine steps.

7. Provide training on the SOP to all personnel involved.
8. Determine the location and communication method for workers to access the SOP at the work site.
9. Determine the review frequency for the SOPs and refresher training the personnel involved.

VI. EMERGENCY PROCEDURES

All accidents, hazardous materials spills, or other dangerous incidents must be immediately reported to EHS. A list of telephone numbers and building address must be posted on the "Emergency Instructions" posting required near laboratory entrances.

Emergency telephone numbers must include:

- Principal Investigator (or Laboratory Supervisor)
- UT Police Department (UTPD)/Austin Fire Department/Emergency Medical Services: 911
- Environmental Health and Safety (EHS): (512) 471-3511
- Occupational Health Services – Health Point (OHP): (512) 471-4647
- Building Manager

A. Spill Response Equipment

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. Dispose of clean-up material through the EHS waste disposal program.

B. Primary Emergency Procedures for Fires, Spills and Accidents

Fire alarm pull station

- In the event of a fire, pull the nearest fire alarm. If you are unable to control or extinguish a fire, follow the building evacuation procedures.
- Attend to any person(s) who may have been exposed and/or injured if it is safe to reach them. Use safety showers and eyewashes 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 at (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, evacuating 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 odors.
- Notify EHS. Essential personnel familiar with the incident need to stay in communication with EHS.

C. Immediate threat to life or health

- Call 911 (UTPD) for assistance.
- Give the nature and the extent of the emergency; be as specific and detailed as possible.

D. Minor Spill

- If you have been trained to respond, use the spill control materials located in the laboratory to control material spilled. If you have not been trained, notify your supervisor.
- Determine the cleaning method by referring to the spilled chemical’s SDS.
- If the spill is minor 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 must be worn.

Minor spill

- Cover liquid spills with compatible absorbent material such as spill pillows.
- Powdered materials should be covered with wet paper towels (if compatible with spilled chemical) 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 chemically compatible waste container, seal it, attach waste tag and contact EHS for disposal.
- If appropriate, wash the affected surface with soap and water. Mop up the residues and place in container for disposal.

- Call EHS if you have questions or concerns with the clean-up procedures, (512) 471-3511.

E. Special Procedures for Radioactive Spills

(*In addition to these guidelines, refer to the EHS Radiation Safety website)*

- Do not take any action unless you have been trained to respond, except to summon assistance.
- If it is safe to do so, attend to anyone who may have been contaminated and/or injured. Use safety showers and eyewashes as appropriate. Immediately notify EHS at (512) 471-3511 and obtain appropriate radiation meters and assistance.
- Immediately notify the UT Police Department by calling 911.
- Shut off ventilation, close windows and doors, and turn off/close hoods if possible. Do not do this if radioactive gas is involved; in this case, utilize fume hood exhaust to remove the airborne material from the laboratory.
- Remove all personnel from the immediate spill area to a safe meeting location in or near the lab. Ensure no one else enters spill area.
- With the assistance of EHS, check all personnel for skin and clothing contamination.
- Under the guidance of EHS, decontaminate personnel and re-survey until radiation levels are at background.

F. 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 from your area and building. Ensure marked exits in the laboratory are never blocked.
- The evacuation alarm may have flashing lights and a loud continuous siren, horn or voice.
- To activate the building evacuation alarm system, pull the handle on one of the red boxes located in the hallway. The individual activating the evacuation alarm is responsible to call 911 and report emergency to UTPD and provide your name, nature of the emergency, and location of the event (building name and room number).
- Whenever the building evacuation alarm is sounded or when you are ordered to leave by the UTPD, EHS, or emergency response personnel, walk quickly to the nearest marked exit and ask others to do the same.
- Outside, proceed to a clear reassembly area that is at least 150 feet from the affected building or to your designated assembly area. Keep walkways clear for

emergency vehicles.

- To the best of your ability and without reentering the building, be available to assist UTPD and EHS in their attempts to determine that everyone has been evacuated safely.
- An Emergency Command Post will be set up near the emergency site by the emergency responders. Keep clear of the post unless you have important information to report.
- DO NOT re-enter the building until you are told to do so by the UTPD, EHS, or City of Austin responders.

VII. FUNDAMENTALS OF LABORATORY SAFETY

Everyone in the lab is responsible for their own safety and the safety of others.

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. Laboratory personnel must completely understand the chemicals they are working around. Safety Data Sheets (SDS) must be reviewed with staff and information available here: https://ehs.utexas.edu/programs/labsafety/sds-chemical-information.php

The following guidelines are recommendations for working safely in a lab:

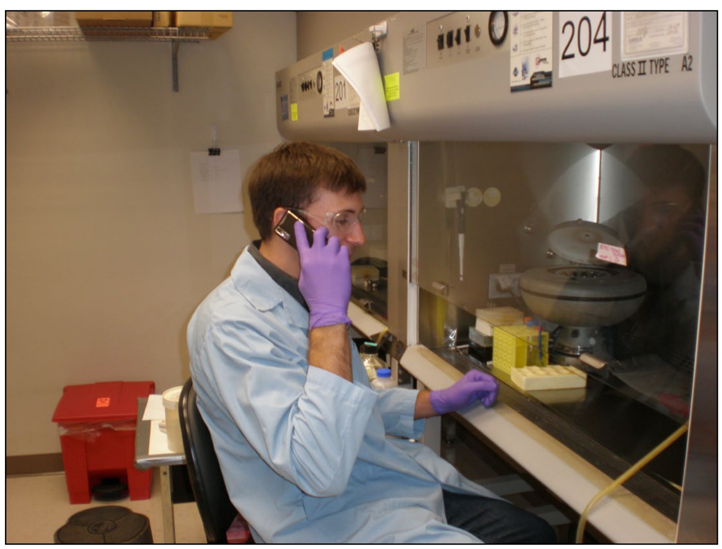
A. Personal Safety Practices

- 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 mouth pipette.
- Secure any dangling jewelry, restrain loose clothing, and tie back long hair that might get caught in equipment before starting work.
- Food and drink should not be consumed in the lab.

- Do not store food and drinks in laboratory refrigerators.

Refrigerator sign

- 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 are prohibited from being used while working in the lab.

B. Risk Assessment

A risk assessment should be done during the planning stage of any new or modified experiment or project. 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. The risk assessment process must be documented.

Resources for developing a risk assessment include reviewing Safety Data Sheets (SDS), consulting published resources, and contacting Environmental Health and Safety (EHS).

Risk assessment guidance can be found at this link.

C. Standard Operating Procedures (SOPs)

Once a risk assessment is completed for a project, Standard Operating Procedures (SOPs) must be developed. SOPs should include but not limited to:

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

A template for SOPs can be found at this link.

D. Minors (Children) 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.

1. 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 age 18, whether students, employees, or volunteers.

2. 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 unit head. *
- Minors who are participating in a formal mentoring program with an individual faculty member approved in writing by the appropriate Department Chair or unit 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 by the Director of Environmental Health and Safety

*A signed parental/guardian consent is required.

3. 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. *http://www.utexas.edu/provost/policies/lab/
- 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.

4. High Hazard Areas

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

- Any laboratory designated as Biosafety Level 3 or follows BSL-3 practices.
- Any laboratory where explosives, acute/reproductive toxins or carcinogens are used or stored.
- Any animal housing or procedure area considered high risk (contact the ARC Director for a case-by-case determination)
- Other high hazards areas (radiation, lasers, etc…) as determined by Environmental Health and Safety

5. 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.

6. **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.

E. Personal Protective Equipment Policy

It is the Principal Investigator and/or Lab Supervisor's responsibility to provide all necessary personal protective clothing for laboratory workers. The university is responsible for providing basic safety equipment such as fire extinguishers, eyewashes and safety showers.

Refer to the SDS for the chemicals in use and Section IV: *Hazard Summary for Hazardous Materials* section of this manual for further information on personal protection requirements.

1. **Personal Clothing and Shoes in Labs**

   All personnel (faculty, staff, and students) in research and teaching laboratories are required to wear the appropriate clothing and PPE. For more information see UT Austin's Laboratory Attire Policy (PDF).

   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. EHS 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.

   EHS 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 and perforated shoes (where holes are present to allow liquid to enter shoe) 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 to campus should bring an additional change of clothing to work in the lab.

SAFE

Proper PPE

UNPREPARED FOR RESEARCH

Improper laboratory attire

2. Chemical Procurement, Transport, and Storage

a. Procurement

Before a chemical is received, information on proper handling, storage, and disposal should be reviewed. Refer to the manufacturer's SDS for further information. No container may be accepted into a laboratory without an appropriate identifying label. This label cannot be removed, defaced or damaged in any way.

b. Stockrooms/Storerooms

Toxic chemicals must be stored in a segregated, well-identified area with local exhaust ventilation. Liquid chemicals which are highly toxic or chemical containers which 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.

Properly labeled secondary storage container

Improperly labeled secondary storage container

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. If a label is becoming unreadable, affix a new label to the container with the identity of the contents, product date, health hazards (including target organs and manufacturer).

EHS may be able to make labels for chemical containers on request.

c. <u>Transporting/Shipping</u>

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.

Chemicals that are shipped off-campus may need special packaging and may need to be shipped by trained certified personnel. Visit the EHS website for further information:
https://ehs.utexas.edu/research-labs-clinical/shipping-research-materials
Contact EHS for assistance with shipping chemicals.

d. Laboratory Chemical Storage (See Chemical Segregation Chart Appendix B)

Read the label carefully before storing a chemical. All chemicals must be stored according to their hazard class. Note that this is a simplified scheme and 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. Also, do not store chemicals in direct sunlight.

Date chemicals when received and first opened. If a particular chemical can become unsafe while in storage, (e.g., diethyl ether) 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.

- 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 to their proper place after use.
- Make sure chemical lids are tightly closed to prevent chemicals from being released into the lab.
- Inspect your chemicals routinely for any signs of deterioration and for the integrity of the label. State law requires that all chemicals must be clearly labeled. Another benefit of labeling is to prevent chemicals from becoming "unknowns." (See Section III.7, Signs and Labels, for more information.)
- 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.

SAFE STORAGE

Proper shelving

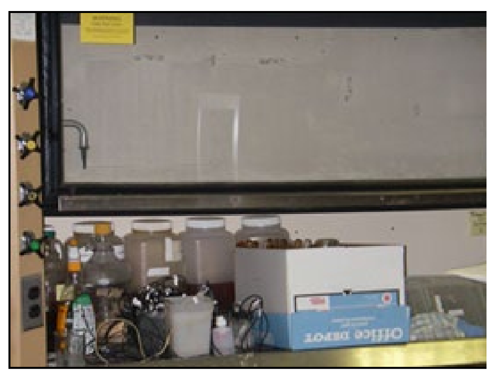
HAZARDOUS STORAGE

Rusted shelf supports

Bowed shelving

- 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 chemical 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

- Promptly contact EHS for the disposal of any old, expired, or unused chemicals. http://www.utexas.edu/safety/ehs/forms/chemrfd2.pdf
- 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 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.

Proper storage of flammable chemicals

Improper storage of flammable chemicals

- Chemical containers should not extend over the edge of shelves or be packed in too tightly.

F. Personnel Protective Equipment (PPE)

The most important thing to remember about protective clothing is that it only protects you if you wear it. 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.

Material 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.

1. 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.

2. Face shields

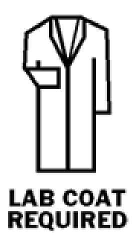
- Face shields can protect against impact, dust, particulates, and splashes to the face, eyes, and throat. However, always wear protective eyewear such as goggles underneath a face shield. Chemical vapors and splashes can still travel under and around a face shield.
- If scratches or cracks are noticed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

3. 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.
- Glove Chemical Compatibility
- 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.

4. 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.

5. 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.

6. Respirators

- Contact EHS if you are conducting research that necessitates the need for a respirator. EHS will evaluate whether there is a need for a respirator and what type of respirator is needed. Occupational Health will conduct fit-testing and a medical respiratory protection evaluation.

G. Working Alone

Working alone in a laboratory is defined as an individual working in a location where assistance is not readily available should injury, illness, or emergency occur. Working alone outside of normal business hours (8 am to 5 pm – Monday to Friday) is risky due to the lack of university support services to assist if an unexpected injury or incident occurs. This applies to all work with hazardous materials or hazardous equipment in laboratories at the University of Texas at Austin.

All undergraduates actively working with hazardous materials in a laboratory must be under supervision of a senior researcher or instructor who is in or near the laboratory. Undergraduate students are prohibited from working in labs alone after 5 pm and before 8 am Monday to Friday and all day Saturday and Sunday because normal campus support is not available.

Although not recommended, laboratory researchers may need to work alone in laboratories and should follow these guidelines to do so safely.

1. Prohibited Materials and Equipment When Working Alone

In general, researchers shall not work alone in a laboratory with hazardous materials of any quantity, including:

- Explosive/Highly Reactive Compounds
- Acutely Toxic Chemicals and Gases
- Large Volumes of Concentrated Corrosive Chemicals
- Pyrophoric Chemicals
- High pressure equipment
- Shop equipment
- Non-human primates

2. General Guidelines on Working Alone

All laboratory researchers who may work alone in a laboratory need to follow these general guidelines:

- **Notify** your PI, manager, or supervisor when you will be working alone and what you will be doing. Prior to working alone, participate in a risk assessment **(which includes a job hazard analysis)** for your work with your PI. A risk assessment process is detailed in Section VII B of this manual.
- Implement a **buddy system.** Check in with someone regularly while working alone in the lab, including at the start of work, key steps of any experiments or equipment use and when you leave.
- **Be alert** and aware of your surroundings. Ear buds or headphones can limit situational awareness and should be avoided.
- **Wear required PPE** in the laboratory, even after hours. This includes long pants, closed shoes, lab coat, and safety glasses but may include additional equipment based on the hazards present (example chemical resistant gloves).
- **Know the location of and how to use emergency equipment** (e.g., safety shower, eye wash, and fire alarm). Program the numbers for **EHS** (512-471-3511) into your cell phone.
- **Avoid walking alone.** Remember that Public Safety offers a 24/7 Walking Escort Service to accompany you from one campus location to another, to your parked vehicle, or to a bus stop. Call **SURE Walk** — 512-471-3166 or utilize the UT Austin LiveSafe App .
- Download the free UT Austin LiveSafe App which allows users to rapidly provide information, such as medical conditions and GPS coordinates, to the UT Austin Police Department dispatch during an emergency.

H. Unattended Operations

Some experiments require operations for extended periods of time. When these experiments require one or more building utility services (such as vacuum, CDA, gas, water (cooling) or electricity) to run safely, the researcher must have controls in place to ensure safe operation when left unattended. Unattended operations are highly discouraged and present an increased risk to others in the building, the laboratory, responding staff (facilities, building managers, etc.) and emergency responders because of the unknown nature of the operation and lack of supervision.

Unattended operations located in areas not normally visited by laboratory staff (small rooms attached to the main laboratory, temperature-controlled rooms, tissue culture rooms, etc.) require more periodic visits than those located in open laboratories where a space may be shared with several laboratories. Spaces with limited access must have periodic visits during unattended operations to ensure that unsafe conditions have not been created.

Unattended operations involving highly hazardous materials **(such as chemicals classified as pyrophorics, toxics, strong corrosives, water reactives, etc.)** require additional consideration and the building manager must be contacted prior to commencing work.

A risk assessment must be completed and documented prior to allowing unattended operations in the laboratory. This risk assessment tool can be found on the EHS website. The Unattended Operations door sign must be completed and posted with the risk assessment on all room entry doors to the unattended operation. The door sign template is provided in Appendix 2.

Examples of risk mitigation can include:

- Use secondary containment such as trays to contain any spills that may occur.
- Use safety shields and keep the chemical hood sash closed to contain chemicals and glass in case an explosion occurs.
- Remove any chemicals or equipment that are not necessary for the experiment or items that could potentially react with the chemicals or other materials being used in the experiment.
- Use automatic shutoff devices to prevent accidents such as loss of cooling water shutoff, over-temperature shut off, etc.
- Use emergency power outlets for those pieces of equipment that could be negatively affected in the event electric service is interrupted.
- Utilize remote monitoring of experiments to identify when city or building utilities are interrupted and will have negative impact to the experiment.

It is the responsibility of PI and lab manager to ensure procedures for unattended operations are developed and followed by personnel working in laboratories under their supervision.

When unattended operations are being conducted, leave building lights on, post the door sign identified above in Appendix 2, and provide physical containment of the experiment’s toxic substances in the event of a utility service failure (such as cooling water).

I. 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 (i.e. fire extinguishers, eyewashes, etc.), emergency shut-offs, and utility controls (i.e. electrical panels).

Cluttered workspace. Emergency eyewash obstructed

Blocked fire extinguisher

J. Steps to Prevent Routine Exposure

- Develop and encourage safe habits
- Avoid unnecessary exposure to chemicals by any route
- Do not smell or taste chemicals
- Vent any apparatus which 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

K. Controlled Substances

Each PI who purchases or works with DEA Controlled Substances must obtain a DEA registration and annually provide EHS with copies of their current registration certificate. Each DEA registrant has the ultimate responsibility for compliance with DEA controlled substance regulations. The University developed the Controlled Substances in Research: Policy (HOP 7-1510), Program, and training course (OH 221) to assist researchers in complying with federal and state regulations.

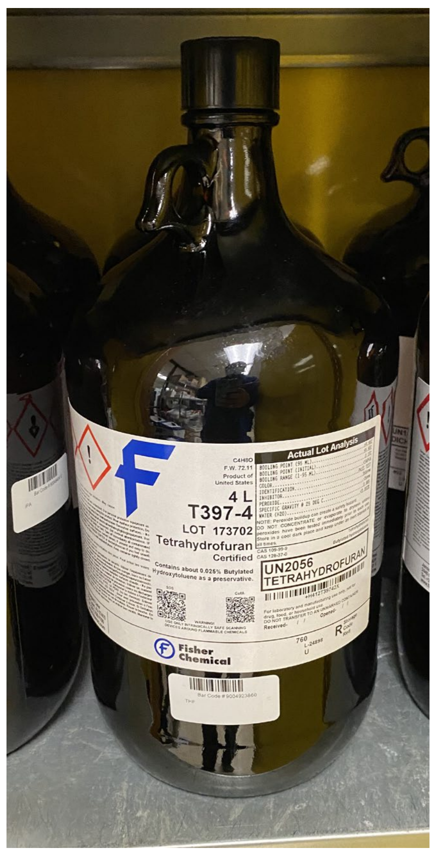
Controlled Items, including chemical precursors and certain laboratory apparatus, do not require a DEA registration, but must be kept secure to prevent unauthorized use. Chemical precursors are disposed of through the University's hazardous waste disposal program.

L. Chemical Labelling

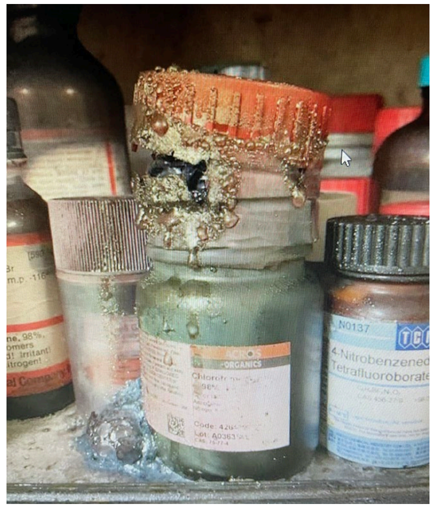
Chemical containers must be labeled, showing container contents and its associated hazards.

1. Primary Containers

Primary containers are chemical containers is defined as the manufacturer's container provided with the manufacturer's chemical label. Ensure manufacturer's chemical labels on incoming primary containers of hazardous chemicals are not removed or defaced either in use or in storage (unless the container is empty and ready for disposal).



Good Chemical Labelling



Poor Chemical labelling and Container Condition

2. Secondary Containers

When a chemical is transferred from the manufacturer's labelled container (primary container) into another container, e.g., a solvent wash bottle, for other than immediate use, it is called a secondary container.

Secondary containers must be labeled with:

- The name of the chemical according to the identity of the chemicals as it appears on the SDS/MSDS (abbreviations or chemical structure CANNOT be used). This does not apply to reaction vessels or to bench top research apparatus in active use.
- The appropriate Globally Harmonized System of Classification and Labelling of Chemicals (GHS) hazard warnings (e.g., poison, flammable, corrosive, carcinogen, etc.)
- The PI or Lab Supervisor is responsible for compliance with labeling chemical containers.
- Labelling requirements for chemical substances developed in the laboratory include:

a. If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the laboratory shall determine if it is a hazardous chemical. If the chemical is determined to be hazardous the follow labelling is required:
   - Chemical name
   - Apply appropriate GHS label to container

Note: Small vials, tubes, or multiple containers with hazardous chemicals can be labeled using the following system labeling system:

i. Place all sample containers into appropriate secondary containment/storage container.
   - Vial Identification -- number or color code
   - Segregate based on hazard compatibilities
   - Apply appropriate GHS label on the outside of secondary containment

ii. Spreadsheet -- Digital and printed copy include:
   - Vial -- identification number/color
   - Constituents
   - Hazards/Possible hazards
   - CAS# if known
   - Name of person who created
   - Special Storage requirements

b. If the chemical produced is a byproduct whose composition is <u>not known</u>, the PI or laboratory manager shall assume that the substance is hazardous and shall develop an SOP that will contain:
   - Chemical Name, Formula
   - Details of process
   - Potential hazards and risks
   - Appropriate PPE selection for handling and use
   - Appropriate engineering controls required for use and handling (i.e. use a fume hood, glove box)
   - Emergency procedures for accidents and spills
   - Storage and handling requirements
   - Proper disposal methods
   - Provide employee training

NOTE: For the unknown samples in small vials, tubes, or multiple containers with hazardous chemicals can be labeled using the following system labeling system:

i. Place all sample containers into appropriate secondary containment/storage container.
   - Vial Identification -- number or color code
   - Segregate based on hazard compatibilities
   - Apply appropriate GHS label on the outside of secondary containment

ii. Spreadsheet -- Digital and printed copy include:
   - Vial -- identification number
   - Constituents
   - Hazards/Possible hazards
   - CAS# if known
   - Name of person who created

- Special Storage requirements

- EHS Waste Disposal Tags must be filled out and affixed to waste containers to identify the container as "Waste”.
- Notification Posters
- Personnel notification posters describing rights under the Texas Hazard Communication Act must be posted in common building areas.
- Posters should be a current version.
- Location signs for safety equipment, first aid equipment, and exits are recommended.
- Warning signs are posted at areas or equipment where special or unusual hazards exist.

M. Chemical Storage Segregation

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	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS
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

CLASS OF CHEMICALS	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS
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
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

CLASS OF CHEMICALS	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS
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	Acetone, Benzene, Diethyl ether, Methanol,	Oxidizers and Acids

CLASS OF CHEMICALS	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS
	dated upon opening, e.g., ether, tetrahydrofuran, dioxane	Ethanol, Hexanes, Toluene	
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. Label location - WATER REACTIVE CHEMICALS -	Sodium metal, Potassium metal, Lithium metal, Lithium Aluminum hydride	Separate from all aqueous solutions, and oxidizers
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.

CLASS OF CHEMICALS	RECOMMENDED STORAGE METHOD	CHEMICAL EXAMPLES	INCOMPATIBLES SEE SDS
Toxics (Poisons)	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

N. 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 the disposal of hazardous waste can be found at: https://ehs.utexas.edu/environment-waste/waste-management

1. 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 chart in Appendix B for examples of incompatible chemicals).

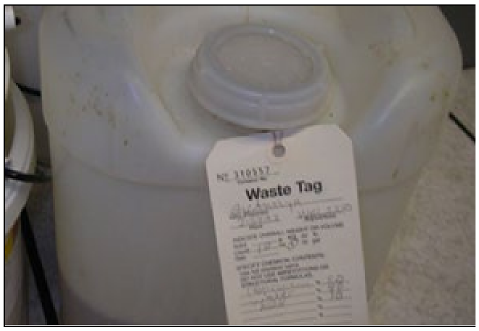
If a container holding hazardous waste is not in good condition or if it begins to leak, transfer the waste from this container into a container that is in good condition, pack the container in a larger and non-leaking container, or provide other secondary containment so the waste prevents the potential for a release or contamination. Contact EHS at (512) 471-3511 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.

All waste containers:

- Must be marked with the word “waste” or “spent” and their contents listed on the waste tag.
- List specific chemicals. It is not sufficient to list waste as “halogenated” or “non-halogenated”.
- Containers should have EHS waste disposal tag attached.

SAFE

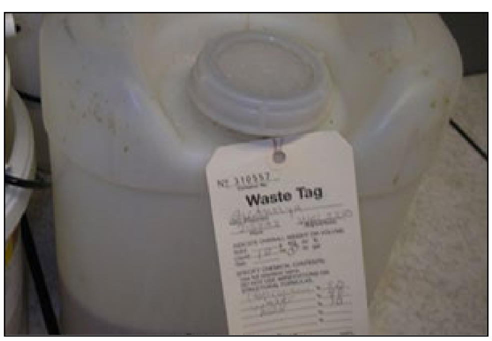


Waste container with EHS waste disposal tag attached

HAZARDOUS

Waste container without proper identification

- No container should be marked with the words “hazardous” or “non-hazardous.”
- Remove or deface old labels.
- Must be kept at or near (immediate vicinity) the site of generation and under control of the generator.
- Must be compatible with contents (i.e. acid should not be stored in metal cans).
- Must be closed at all times except when actively receiving waste.



Properly closed waste container

Open waste container

- Waste tags should be complete before pickup is requested.
- Must be safe for transport with non-leaking screw-on caps.
- Must be filled to a safe level (not beyond the bottom of the neck of the

container or a 2-inch head space for 30 gallon drums).

Note:

- Do not use biological waste containers or sharps containers for hazardous chemical waste collection.
- Do not put broken glassware that is contaminated with chemicals in glass disposal boxes.
- Contact EHS for assistance with contaminated sharps or glassware.

2. Accumulation of Chemical Waste

A generator of potentially hazardous waste may not accumulate more than 55 gallons of waste, or one quart of acutely hazardous waste (see https://ehs.utexas.edu/environment-waste/waste-management/chemical-waste for list of acutely hazardous waste) at or near the point of generation.

If a process will generate more than this volume at one time, EHS 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, EHS 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.

Labeling Containers for Pick-Up by EHS

- Before chemical waste can be picked up by EHS, a waste tag is required
- It should be filled out by the waste generator and attached to each container at all times. The information on the tag is used to categorize and treat the waste.
- Fill out tag legibly, accurately, and completely.

3. Unknown Chemical Compounds

All waste generators and chemical users are responsible for knowing the contents of all containers in their work areas. Researchers and PI's who generate or are wanting to dispose of containers containing an unknown compound must investigate, record, and disclose any known original constituents added and chemical process applied when requesting disposal. Please use this link to obtain more information from EHS about unknown chemical waste.

4. Submitting Requests for Disposal of Chemical Waste to EHS

When a chemical waste container is ready for disposal and is properly tagged, the laboratory supervisor should contact Environmental Health and Safety through Environmental Management Systems (EMS).

5. Laboratory Evaluations

The following describe the two formal evaluations completed on campus:

a. EHS Scheduled (announced and unannounced) Evaluations

EHS inspects all labs at the Main Campus, Dell Pediatric Institute, Pickle Research Campus, the Marine Science Institute, and other outlying locations on an annual basis. Information on the lab inspection program can be found at: http://www.utexas.edu/safety/ehs/lab/labinspection.html

b. Self-Evaluations

Labs are also expected to perform laboratory safety self-evaluations within the first sixty days of each semester. A copy of the self-evaluation must be sent to EHS upon completion.

O. Storage Cabinets

Specialized types of storage cabinets must be used in laboratories 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.

1. Flammable Storage Cabinets

Flammables not in active use must be stored inside fire resistant storage cabinets. Flammable storage cabinets should be used for all labs that use flammable chemicals. The cabinet design must meet National Fire Protection Association (NFPA) 30 & Occupational Safety and Health Administration (OSHA) 1910.106 standards.

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). Cabinet doors should be self-closing. Keep the doors closed.

Examples of flammable storage cabinets

2. Acid Storage Cabinets

Acids should be kept in acid storage cabinets specially designed to hold them. Such 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.

Plastic tubs in a wooden cabinet are considered an acceptable substitute when acid cabinets are not available.

SAFE

SAFE **HAZARDOUS**

Proper acid storage **Proper and improper acid storage methods**

Nitric acid should always be stored in its own acid tray or in a separate acid cabinet compartment.

HAZARDOUS STORAGE METHOD

Improper storage of nitric acid

3. Compressed Gas Cylinder Cabinets

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

Compressed gas cylinder cabinet

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

The following gases will require ventilated storage:

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. 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. Chains are preferred method of securing cylinders.

SAFE

Acceptable method of securing a gas cylinder

HAZARDOUS

Unacceptable method of securing a gas cylinder

P. Laboratory Building Infrastructure

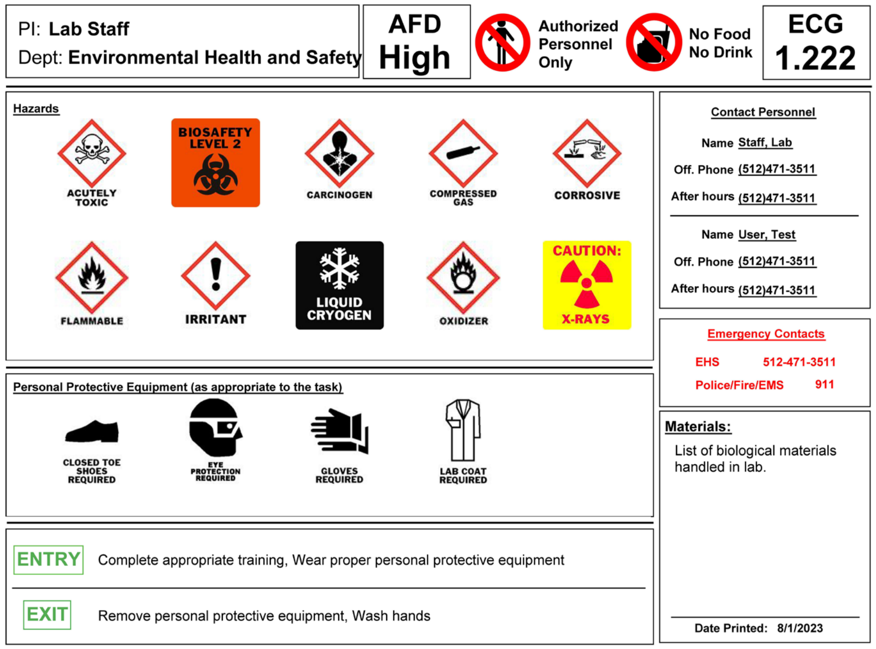
Laboratory personnel are restricted from altering, modifying, or removing building facilities or systems that support the sustainable functionality, underlying foundation, or framework of a campus building without a Facilities Work Order or PMCS project. Electrical, mechanical, plumbing, fire and other systems are designed by the university to meet regulatory and code requirements. These items can include, but not limited to these non-moveable and attached items, fixed furniture (case work, bench tops, etc.) building equipment and mechanical systems such as ventilation systems (ductwork, fume hoods, air handling units, shafts, exhaust fans, etc.), electrical wiring and equipment attached to the building (breaker panels, wiring, conduit, plugs, fixtures, etc.), plumbing (sewer, drain lines, gas lines etc.), voice data or data equipment/wiring/antenna, roofs, elevators, loading docks, soffits, façade, ceiling/ceiling tiles, thermostats, gas meters (attached to building plumbed systems), floor coverings (carpet, vinyl, etc.), and fire protection devices/annunciators.

Unauthorized alteration by licensed or unlicensed personnel to any items attached to the university's buildings (as provided in the list above) compromises compliance to these standards and creates safety concerns. This includes adding/hanging/attaching research equipment on building infrastructure. All building alterations must be approved by the appropriate authority which at a minimum includes your building manager and Facilities Services (FS). Other stakeholders requiring involvement may (but not limited to) Office of Campus Construction, Fire Protection Services (FPS), and Environmental Health and Safety (EHS). It is the responsibility of the PI to ensure the correct departments are notified and involved. Each department, where unauthorized changes occur, will be financially responsible to resolve alterations to ensure code compliance and resulting safety issues. If needed, please send questions on approval process to EHS.

Q. Signs

Prominent signs of the following types should be used:

- Emergency Instruction sign must be prominently posted on the wall inside the lab.
- Hazard communication "Notice to Employees" (English/Spanish) must be posted inside the laboratory.
- Laboratory signs, including emergency contacts and chemical inventory, must be posted outside each work area.



Example of a laboratory sign

R. Records

1. 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 EHS and the City of Austin Emergency Services. It is the Lab Supervisor's responsibility to keep an updated hazardous chemical inventory on file with EHS. This inventory must be updated semi-annually. During the inventory process, the condition of containers must be evaluated and addressed if compromised.

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

2. Laboratory Incidents

Lab supervisors should document and report any lab incidents to EHS as soon as possible. Personnel who are exposed/injured in a laboratory should contact Occupational Health 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. Occupational Health will maintain medical records related to laboratory safety.

3. Exposure Monitoring

EHS maintains records whenever monitoring of hazardous materials is performed.

4. Safety Data Sheets (SDS)

Safety Data Sheets (SDS) provide information on hazardous chemicals and must be readily available for all hazardous chemicals in the lab. SDS are supplied when chemicals are purchased and commonly available online. If a manufacturer does not provide an SDS, it is the responsibility of the Lab Safety Manager or PI to ensure a copy is obtain and retrained. If paper copies are maintained, they should be quickly available.

Information on the university's Hazard Communication plan can be found at: http://www.utexas.edu/safety/ehs/train/hazcom97/hazcom2000.PDF

S. Equipment

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

1. 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 each use by holding a Kimwipe®, or other lightweight paper, up to the opening of the hood. The paper should be pulled inward.
- Check that certification stickers are within a year of last test date.
- Leave the hood "on" if toxic substances are stored inside even when not in active use.

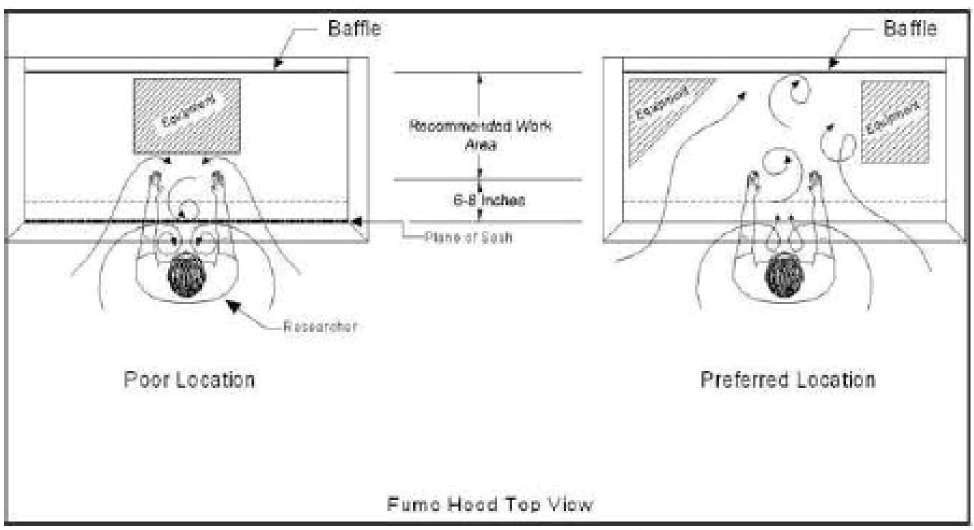
Proper Use of Fume Hoods

When the hood is not in use, keep sash completely closed. While personnel are working in 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. Never put your head inside the hood. Do not slam the sash. Instead, when opening and closing the sash, movement should be slow and consistent as to not create a back draft pulling air out of the fume hood.

Work with the fume hood sash down as far as practical.

Improper use of the fume hood.

- Equipment, chemicals, and other materials should be placed at least <u>six inches</u> behind the sash, elevated 1.5 inches off the work surface, and keep the back baffle clear of obstructions. For example, locate hot plates and baths to the sides of the fume hood to minimize vortices and turbulence zones of which fumes can escape.



Example of how equipment placement can affect airflow inside the fume hood.

- Do not keep loose papers, paper towels, or tissues (e.g., Kimwipes®) in the hood. 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 disrupts 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.

Do not store chemicals or other items in the fume hood.

- 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 shall not be done without proper authorization from EHS.
- 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 someone's breathing zone.

2. 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.

Bottle Carrier

- 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.

3. 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.

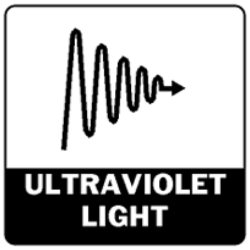
- Assemble the apparatus so that burners or baths can be removed quickly.
- Use an appropriate vapor trap and confine the setup to a fume hood if there is a
  possibility of hazardous vapors.
- Put the setup in a fume hood whenever conducting a reaction that could result in an implosion or explosion. Keep the sash pulled down. If it is not possible to use a fume hood, use a standing shield that is stabilized and secured.

4. 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.

5. 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.

6. 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

Consult the EHS Laser Safety Manual for more information or contact the Laser Safety Officer at EHS.

7. 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.

8. 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.

9. 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.

Vacuum Pump

Follow these guidelines for safe pump operation:

- 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.
- 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.

T. Working Chemicals with Special Health Hazards

1. Sensitizers (also considered allergens)

Allergens are substance that cause recurrent effect after the worker becomes sensitized (allergic) to substance. At first an exposure may cause no reaction, but once the individual becomes sensitized, reaction can occur with additional exposures of even very small quantities for very short periods of time. The physiological reaction almost always presents in the eye, skin, or respiratory tract inflammation but does not affect the nervous system, liver, kidney, heart, or most other organ systems.

Allergens can cause only eye, skin, or respiratory tract response after airborne exposure often occur far below PELs, TLVs, or other occupational exposure guidelines. If a person develops an allergy to a substance, it will persist for years, if not for life.

Some allergens can cause allergic contact dermatitis (from nickel, chromium salts, poison ivy/oak and epoxy constituents), allergic asthma (isocyanates, platinum salts, some wood dusts, animal dander, and organic anhydrides), or allergic pneumonia (some molds, sugar cane residue).

Written SOPs identifying exposure routes and exposure controls is needed for employees handling research selected allergens. Engineering controls, chemical substitution must always be considered first. Personal protective equipment such as gloves and respirators cannot be the first exposure control measures considered or utilized. Suitable respirators and/or gloves should be used whenever there is potential for contact with/exposure to chemicals that may cause allergic reactions.

2. 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. These include:

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

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 appropriate safety personnel (EHS, Occupational Health) 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).

3. Moderate Chronic or High Acute Toxicity Chemicals

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:

α -Halo Ethers

Bis(Chloromethyl) Ether
Methyl Chloromethyl Ether

Aziridines:

Ethylene Imine
2-Methylaziridine

Diazo, Azo, and Azoxy Compounds:

4-Dimethylaminoazobenzene

Electrophilic Alkenes and Alkynes

Acrylonitrile
Acrolein
Ethyl Acrylate

Epoxides

Ethylene Oxide
Diepoxybutane
Epichlorohydrin
Propylene Oxide
Styrene Oxide

Sulfonates

Diethyl Sulfate
Dimethyl Sulfate
Ethyl Methanesulfonate
Methyl Methanesulfonate
Methyl Trifluoromethanesulfonate
1,3-Propanesultone
1,4-Butanedioldimethanesulfonate

Acylating Agents:

β –Butyrolactone
β -Propiolactone
Dimethylcarbamoyl Chloride

Aromatic Amines:

4-Aminobiphenyl
Aniline
o-Anisidine
Benzidine
o-Toluidine

Organohalogen Compounds:

1,2-Dibromo-3-Chloropropane
Bis(2-Chloroethyl) Sulfide
Vinyl Chloride
Chloroform
Methyl Iodide
2,4,6-Trichlorophenol
Carbon Tetrachloride
Hexachlorobenzene
1,4-Dichlorobenzene

Natural Products:

Adriamycin
Aflatoxins
Bleomycin
Progesterone
Reserpine
Safrole

Inorganic Compounds:

Cisplatin

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 in Section D.1 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 need to be followed:

1) 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.
2) 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.

3) 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 amounts of material used and names of workers involved should be kept as part of the laboratory notebook record of the project. 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.

Alternatively, the working surface of the hood can be fitted with a removable liner of adsorbent plastic-backed paper. These materials will contain spilled toxic substances in a pan, tray, or absorbent liner and greatly simplifies subsequent cleanup and disposal. Any material that comes in contact with toxic substances should be disposed of as a toxic substance. Vapors that are discharged from the apparatus should be trapped or condensed to avoid adding substantial amounts of toxic vapor to the hood exhaust air. Areas where toxic substances are being used and stored must have restricted access, and warning signs must be posted if a special toxicity hazard exists.

The general waste disposal procedures described in the EHS Waste Disposal manual 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 EHS 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.

4. High Chronic Toxicity Chemicals

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 EHS 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
- aflatoxin B_1
- benzo[a]pyrene
- bis(chloromethyl) ether
- 7,12-dimethylbenz[a]anthracene
- dimethylcarbamoyl chloride
- hexamethylphosphoramide
- 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. It is appropriate to keep such records as part of the record of project work in the laboratory workers' research notebook, but it must be understood that the research supervisor is responsible for ensuring that accurate records are maintained.

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 EHS 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 EHS.

Wastes and residues must be placed in an impervious container and disposed of through EHS. 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), Occupational Health 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 EHS.

U. Occupational Health Program

1. Medical Treatment

In the event of serious adverse symptoms or injury, medical attention should be sought out immediately. Call 911 and for transport to the nearest hospital. If the injury involves an animal, chemical or biological exposure on main campus, request transport to St. David's Hospital.

It is the responsibility of every Lab Supervisor to promptly contact EHS at 512-471-3511 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.

Following initial phone call notification to EHS, the Lab Supervisor must submit the exposure to the campus Incident Investigation Database.

When medical needs of the exposed employee are not immediate, EHS advises exposed employees to contact HealthPoint Occupational Health Program (OHP) at (512) 471-4OHP (4647) for consultation. Students, not employed by UT Austin, are directed to contact a qualified medical provider for consultation or visit University Health Services (UHS) on campus.

For non-emergency injuries that require treatment outside normal business hours, you may contact any health care provider including your own physician so long as they accept workers' compensation. University Health Services (UHS) does not accept workers' compensation or work-related injuries. Students in a non-employment status may seek urgent care from UHS (see section 3 below).

All medical exams and consultations for work related injuries, described under this Medical Program section, will be performed by or under the over-sight of a licensed physician and will be provided at UT Austin's expense, without loss of pay and at a reasonable time and place. The arrangements for a medical consultation or exam for employees can be made with the assistance of the HealthPoint OHP, unless it is an emergency.

Urgent care clinics that accept workers' compensation include but are not limited to:

- Concentra Medical Centers
- St. David's Occupational Health Services. **Call 512-544-8195** to schedule an appointment.
- Texas MedClinic

2. Physician's Written Opinion

When a work-related incident results in an employee needing a medical consultation or exam, OHP is required to obtain a written opinion from the examining physician which includes the following information:

- Recommendation for further medical follow-up
- Results of the medical examination and any associated tests
- Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace
- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment

The physician's written opinion cannot reveal findings of diagnoses unrelated to occupational exposure. HealthPoint OHP may release the physician's written opinion to EHS or others involved in the incident investigation to further the purpose of providing a safe working environment for employees and/or to meet regulatory reporting requirements.

3. **University Health Services**

When a student that is not employed by the university and is injured in a laboratory, they should be treated at University Health Services. During normal university hours, **University Health Services** (UHS), on main campus, is available for routine care of students who are injured or ill in their student capacity. UHS does not treat work injuries that occur while the student is being paid as an employee. UHS maintains an Urgent Care Clinic open for limited hours in the evenings and on weekends. During these times, a small after-hours fee can be charged.

Hours and advice can be obtained by calling the UHS 24-hour Nurse Advice Line at (512) 475-NURS (512-475-6877). If care is needed that UHS cannot provide or when UHS is closed, students may seek care from local urgent care or emergency rooms that are in close proximity to the university, e.g., St. David's, Dell Seton, etc.

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

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IX. REVISIONS:

Date	Change Made	Author and Reviewer(s)
1996	Laboratory Manual 1st publication	Lab Staff
2017	Nanomaterials chapter was added	Naween Dahal, Dennis Nolan
2023	Fully re-formatted and major changes to each section	Andrea McNair, Rudy Guerrero, Suzanne Kilpatrick

X. APPENDICES

APPENDIX ONE: Designation Form for Laboratory Safety Coordinator

The University of Texas at Austin
Laboratory Safety Coordinator

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

The individual identified below has been appointed LSC and has accepted the responsibilities and duties associated with this appointment.

Rooms/Laboratory(s) Assigned to LSC: ____

Appointing official:	Designated Individual:
______________________________	______________________________
PI (print name)	Laboratory Safety Coordinator (print name)
______________________________	______________________________
PI (signature)	Laboratory Safety Coordinator (signature)
___________________	___________________
Date	Date

A signed copy of this form shall be placed in the appropriate LABORATORY SAFETY MANUALS or accessible from the laboratory.

APPENDIX TWO – Unattended Operations Door Sign Template

NOTICE: UNATTENDED LABORATORY OPERATIONS WITHIN THIS ROOM

<table>
<tr><td colspan="4">UNATTENDED OPERATIONS CAN CREATE A HAZARDOUS CONDITION AFTER EQUIPMENT OR BUILDING UTILITIES FAILURES</td></tr>
<tr><td colspan="4">Experimental process and hazards:</td></tr>
<tr><td>In-process hazardous materials process (e.g. pyrophoric, high pressure, etc.)</td><td>☐</td><td colspan="2">Specific hazardous materials in use, other hazards present (e.g. electrical, heat); listed access restrictions:</td></tr>
<tr><td>Continuous Energized Magnetic or Electric Fields</td><td>☐</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>Continuous running water (cooling water)</td><td>☐</td></tr>
<tr><td colspan="4">Steps to be taken if an incident were to occur (including what not to do (i.e. don’t add water)):</td></tr>
<tr><td>START DATES AND TIMES:</td><td colspan="3"></td></tr>
<tr><td>END DATES AND TIMES:</td><td colspan="3"></td></tr>
<tr><td colspan="4">24-HOUR EMERGENCY CONTACTS:</td></tr>
<tr><td>Primary Contact:</td><td colspan="3">Phone Number:</td></tr>
<tr><td>Secondary Contact:</td><td colspan="3">Phone Number:</td></tr>
<tr><td colspan="4">If a hazardous condition is suspected, call:</td></tr>
<tr><td colspan="3">Monday-Friday 8 am to 5 pm:</td><td>After Hours:</td></tr>
<tr><td colspan="3">EHS @ 512-471-3511</td><td>911 (UTPD will automatically be notified)</td></tr>
</table>