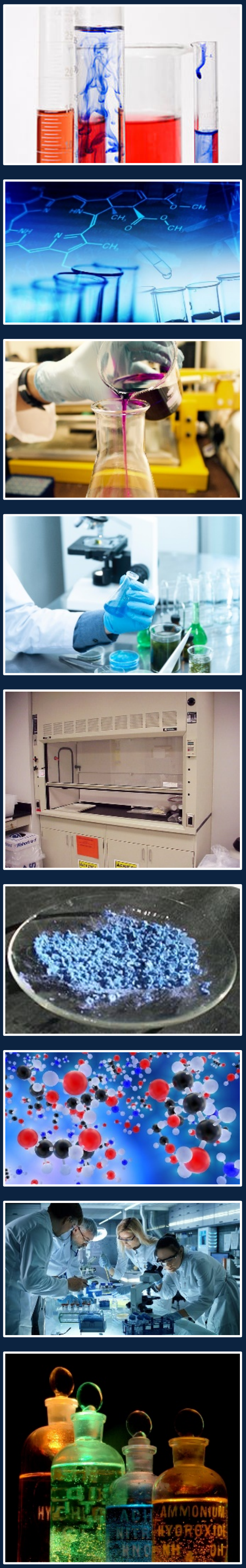

UTSA

Laboratory Safety

CHEMICAL SAFETY AND HAZARD COMMUNICATION PLAN

Laboratory Safety Division

UTSA
Office of the Vice President for
Research, Economic Development,
and Knowledge Enterprise

2021

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REVIEW PAGE

This version of the manual has been reviewed for regulatory compliance and best management practices by the listed individuals and committees and is hereby adopted for use and compliance by all employees at the University of Texas at San Antonio owned or operated facilities.

NAME	TITLE	DATE
Natalie Metzger	Chemical Hygiene Officer	10-27-2021
Oleg Larionov	Chair, Chemical Safety Committee	10-27-2021
Amanda Haley	Sr. Director of Laboratory Safety and Compliance	10-27-2021
Michelle Stevenson	Associate Vice President for Research Integrity	10-27-2021

COMMITTEE

COMMITTEE	REVIEW DATE	APPROVAL DATE
Chemical Safety Committee	09-14-2021	10-27-2021

Review:	September 14, 2021
Replaces:	January 14, 2020
Replaces:	January 8, 2019

Updates are highlighted in gray in the plan and summarized below.

SECTION	UPDATE
Training requirements	Confirmation by the P.I. that the review has been conducted is tracked through ISMS by completing the on-line Laboratory Specific Training Acknowledgement – removed ISMS no longer in use
Personal Protective Equipment	Laboratory coats are available free to all laboratory workers from the vending machines located in AET, BSE, MBT and SEB – text added to the plan.
Chemical Hazard Classes	Particularly hazardous substances renamed Health Hazards and Toxicants.
Particularly hazardous and high risk substances with prior approval requirements	Chapter added.

EMERGENCY CONTACTS

ROUTINE OFFICE HOURS (8 am – 5 pm)	
Chemical Hygiene Officer	210-458-6419
Sr. Director of Laboratory Safety and Compliance	210-458-8515
AFTER-HOURS (including weekends)	
Chemical Hygiene Officer	210-336-9509
UTSA Police	210-458-4911 (cell or outside phone) x4911 (from a campus phone)
LIFE-THREATENING EMERGENCIES (any time)	
UTSA Police	210-458-4911 (cell or outside phone) x4911 (from a campus phone)

ROUTINE CONTACTS

In case of incidents involving laser exposure, all personnel are required to notify the Chemical Hygiene Officer immediately at 210-458-6419 or 210-336-9509.

After 5:00 pm and on weekends, UTSA Police will assist in contacting Laboratory Safety Personnel.

INTRODUCTION

OVERVIEW

Research with chemicals in laboratories can pose an increased risk to personnel who work there. The University of Texas at San Antonio (UTSA) is held to state and federal regulations defining the handling, use and disposal of hazardous chemicals. In addition, UTSA develops site specific plans and procedures that support the diverse research at the institution and the unique location of UTSA situated over the Edwards aquifer. This plan, and the safety committees that support research, are part of overall collaborative efforts between administration and faculty who strive to create a positive safety culture at the institution.

PURPOSE

UTSA is committed to providing a safe and healthy working environment for all faculty, staff and students in accordance with http://www.utsa.edu/hop/chapter9/most specifically in HOP 9.05 - Occupational Safety and Health and HOP 9.06 - Compliance with the Texas Hazard Communication Act. This Chemical Hygiene Plan (CHP) establishes the formal written practices for protecting all UTSA personnel and visitors from adverse health and safety hazards associated with the handling of, and potential exposure to, hazardous chemicals. The Chemical Hygiene Plan, in combination the Institutional Biosafety Plan, Radiation Safety Plan, Laser Safety Plan and X-Ray Safety Plan, should be used as a resource in developing a safe culture in research laboratories across campus.

SCOPE

This plan was developed by the Laboratory Safety Division which is part of the Office of Research Integrity located under the Vice President for Research, Economic Development and Knowledge Enterprise and written with reference to pertinent federal, state and local regulatory requirements. Regulatory agencies referenced include the Occupational Health and Safety Administration (OSHA) the Drug Enforcement Administration (DEA), the Environmental Protection Agency (EPA), the Texas Department of State Health Services (TDSHS), the Texas Commission on Environmental Quality (TCEQ), the Edwards Aquifer Authority (EAA), and the San Antonio Water System (SAWS).

The plan applies to all UTSA operated (leased or owned) facilities and equipment (including vehicles). It also applies to any UTSA employee, volunteer or student worker who works directly with chemicals, or is in close proximity to anyone conducting research using chemicals.

The Chemical Hygiene Plan outlines safe practices and procedures for research and educational laboratories. It is not intended to be a fully comprehensive reference but rather a starting reference. There may be chemicals, procedures and other circumstances in each laboratory that present unique or unusual hazards not addressed here. The Principal Investigator or supervisor of the respective laboratory should address unique hazards associated with specific research projects with specific operating procedures developed with the full support of the Laboratory Safety Division. Questions can be addressed to the Chemical Hygiene Officer (CHO) at 210-458 -6149.

REGULATORY REQUIREMENTS

HAZARD COMMUNICATION AND THE TEXAS HAZARD COMMUNICATION ACT

In Texas, the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard applies to private-sector businesses only. To protect public-sector employees, the Texas legislature passed the Texas Hazard Communication Act in 1985. The law, which was revised in 1993, is also known as the Public Employer Community Right-to-Know Act and can be found in the Texas Administrative Code 25 TAC § 295 or the Texas Health & Safety Code Title 6, Chapter 502 – Hazard Communication Act. It requires public employers to provide their employees with information on hazardous chemicals to which they may be exposed in the workplace. Requirements under the act include compiling and maintaining workplace chemical lists, maintaining Safety Data Sheet (SDS) and informing employees of the hazards associated with the chemicals they use. The law is similar to OSHA's Hazard Communication Standard but is enforced by the Texas Department of State Health Services Division of Regulatory Services Enforcement Unit.

The Texas Hazard Communication Act applies to public schools, colleges and universities in Texas. Chemicals in a laboratory under the direct supervision or guidance of a technically qualified individual may be exempt if:

- labels on incoming containers of chemicals are not removed or defaced
- the laboratory supervisor complies with SDS and training requirements
- the laboratory is not used primarily to produce hazardous chemicals in bulk for commercial purposes.

Otherwise, all requirements of the act apply. Consult with the CHO to see if any exemptions may apply to a specific laboratory.

REQUIREMENTS

A. Container Labels

Hazardous chemical containers must have a label that identifies the hazardous chemical and lists the appropriate hazard warnings.

1. Primary or Original Containers: A label on an existing container must not be removed or defaced unless it is illegible or inaccurate or does not conform to labeling requirements.

2. Secondary Containers: When transfers are made from the primary chemical container (stock bottle) to other containers, the secondary containers should be labeled with:

   a. the name of the chemical (as it appears on the SDS) and

   b. the appropriate hazard warnings unless it is used immediately by the individual who made the transfer.

B. Safety Data Sheets

1. The Safety Data Sheets (SDS) are an extensive compilation of chemical hazard and safe-handling information. Each sheet provides most of the information an employee or student needs to work with a chemical safely. Chemical manufacturers or distributors must develop an SDS for each hazardous chemical they produce or distribute and are required to provide an SDS with each initial shipment and with the first shipment after an SDS is updated.

An SDS must include:

1. The specific chemical identity and common names of the hazardous chemical(s) involved;
2. Physical and chemical characteristics of the hazardous chemical;
3. Known acute and chronic health effects and related health information; exposure limits; whether the chemical is considered a carcinogen by the National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC) or OSHA;
4. Precautionary measures;
5. Emergency and first-aid procedures, and the identification (including name, address and telephone number) of the organization responsible for preparing the SDS.

SDS's must be available within the workplace. Laboratories can keep paper copies of SDS's for all chemicals used or can access the SDS database in BioRAFT on at least one computer in the laboratory. A shortcut to the SDS database must be maintained on the computer's desktop.

C. Training

All laboratory personnel who use or handle hazardous chemicals must receive training on the hazards of those chemicals and measures they can take to protect themselves. Available courses are listed in the Training Requirements section of this plan. Training must include information on interpreting container labels and SDS's; the location, acute and chronic effects, and safe handling of hazardous chemicals to which personnel may be exposed; the proper use of protective equipment and first-aid treatment; and general safety instructions on the handling and clean-up procedures and disposal of hazardous chemicals. Training must be provided before the employee or student works with, or in a laboratory containing, any hazardous chemical. Retraining is required when the potential for exposure to hazardous chemicals in the laboratory increases significantly or when the principal investigator receives new and significant information concerning the hazards of a chemical.

The principal investigator/laboratory supervisor is responsible for providing continued training as necessary. All training must be documented, including the date, employee names and signatures, and the subjects covered in the session. Once laboratory specific training is completed, principal investigators must forward a copy of the training record to the Laboratory Safety Division (LSD).

D. References

Further information regarding the Texas Health & Safety Code Title 6, Chapter 502 – Hazard Communication Act can be found at https://statutes.capitol.texas.gov/Docs/HS/htm/HS.502.htm. A copy of the Notice to Employees from the Texas Department of State Health Services is located at https://dshs.texas.gov/hazcom/publications.aspx in both English and Spanish and on the Laboratory Safety Division website.

INSTITUTIONAL SAFETY AND COMPLIANCE COMMITTEES

The following faculty led committees were established to be an institutional oversight of safety and compliance functions of all research activities conducted at UTSA. The committees provide review and guidance to assist researchers in fulfilling federal, state, and institutional requirements for safe and compliant research. In addition, the committees facilitate communication between faculty and institutional divisions responsible for safety and regulatory oversight.

A. Chemical Safety Committee

The CSC is charged with promoting safe research with hazardous chemicals in research and teaching laboratories across campus. The committee reviews risk assessments and protocols for working with high hazard chemicals, reviews and contributes to the Chemical Hygiene Plan, advises in incident investigations. The committee is also empowered to recommend additional general safety rules regarding chemical use and establish standard procedures for handling and working with chemicals.

B. Institutional Animal Care and Use Committee

The IACUC is a research review committee federally mandated by the Animal Welfare Act and the PHS Policy on the Humane Care and Use of Laboratory Animals. Through the expertise of the committee members, which include faculty, compliance professionals, safety professionals and community members, the IACUC ensures a high standard of animal welfare in research and educational settings across UTSA. The IACUC may also, in consultation with the CSC, set standards for the use of certain hazardous chemicals and pharmaceuticals in animal research to protect both animals and animal handlers.

C. Institutional Biosafety Committee

The IBC is mandated to be a review body for oversight of all research activities involving the use of hazardous biological materials and recombinant or synthetic nucleic acids, as required by the NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules and the CDC/NIH

Biosafety in Microbiological and Biomedical Laboratories (BMBL) 6th Edition. The IBC may also, in consultation with the CSC, set standards for the use of certain hazardous chemicals and pharmaceuticals in biological research to protect both researchers.

D. Radiation and Laser Safety Committee

The RLSC reviews all work with radioactive materials, X-Ray devices and lasers in research, engineering and teaching at UTSA. The committee is charged with implementing safety policies, procedures and practices with all systems and provides guidance to the Radiation and Laser Safety Officers in all areas of radiation and laser safety. The RLSC may also, in consultation with the CSC, set standards for the use of certain hazardous chemicals and pharmaceuticals in radiation, laser and x-ray work to protect researchers.

E. Institutional Review Board

The UTSA Institutional Review Board (IRB) is the university committee that reviews and approves human subject research for the purpose of protecting the rights and welfare of those subjects. The Board is charged with the responsibility to formulate and implement procedures to assure UTSA's compliance with federal, state and institutional regulations for the safeguarding of the welfare and well-being (physical, mental, social, legal, etc.) of human subjects involved in research projects in which UTSA is engaged or for which UTSA otherwise exercises oversight.

The UTSA IRB operates under a Federal wide Assurance (FWA) with the Office for Human Research Protections (OHRP) under the Department of Health and Human Services. The IRB advises and educates researchers, staff and students on research with human subjects and promotes best practices for the ethical conduct of research with these individuals. The IRB may also, in consultation with the CSC, set standards for the use of certain hazardous chemicals and pharmaceuticals in human research to protect both researchers and participants.

RIGHTS AND RESPONSIBILITIES

All faculty, staff, and students have the right to be informed about the potential hazards of the chemicals in their work area and receive adequate training to handle, and work with the items, safely. The culture of safety at UTSA is a shared responsibility and as such all personnel have a duty to fulfill their obligations with respect to maintaining a safe workplace. All personnel working with potentially hazardous chemicals must participate in assigned training, be familiar with the CHP, stay informed regarding the specific hazards in their laboratory space or classroom, and wear the specified Personal Protective Equipment.

VPREDKE, DEANS, AND DEPARTMENT CHAIRS

Commitment to a culture of safety and responsible research and training extends to all levels of UTSA's administration.

1. The Vice President for Research, Economic Development and Knowledge Enterprise (VPREDKE) is responsible for appointing faculty members to the Chemical Safety Committee who will advise upper administration of safety related policies and incidents, where necessary.
2. Deans and Department Chairs are responsible for ensuring that all work performed within their departments complies with UTSA safety plans and policies within their areas. Deans and Department Chairs should work with members of the CSC, Laboratory Safety Division, and faculty to maintain programs that promote a safe working environment.
3. In the event of safety incidents within departments, Deans and Department Chairs will provide communication and support to faculty, CSC, and laboratory safety staff to facilitate the prompt resolution of any issues and prevention of reoccurrence.

LABORATORY SAFETY DIVISION

The Laboratory Safety Division is responsible for the development and implementation of the Laboratory Safety Program and CHP. The Chemical Hygiene Officer (CHO) has primary responsibility for implementation of the components of the CHP. In the case of immediate danger to life or health, the Chemical Hygiene Officer, the Senior Director of Laboratory Safety and Compliance and/or the Associate Vice President for Research Integrity has the authority to order the immediate cessation of the activity until the hazard is mitigated. The Laboratory Safety Division is responsible for:

1. Supporting students, staff, and faculty in the development of a safe and productive research and teaching environment.
2. Establishing general procedures, policies, and minimum standards for the use of chemicals and hazards that may be present at UTSA.

3. Developing and maintaining safety plans and training programs relevant to the safe use, storage, and disposal of chemicals agents. These plans should be reviewed on an annual basis and updated as needed.
4. Performing hazard assessments.
5. Reviewing risk assessments for work with chemical agents in conjunction with the Chemical Safety Committee, and providing recommendations for the safe use, storage, and disposal of chemicals per established procedures.
6. Assisting Departments and Principal Investigators in developing SOPs when requested.
7. Approving the purchase and use of hazardous chemicals and toxins that may require institutional approval.
8. Supervising decontamination and clean-up activities following chemical spills.
9. Investigating chemical spill and / or potential exposure incidents. Providing chemical monitoring to determine potential exposure levels where appropriate.
10. Evaluating laboratories periodically, to ensure compliance with institutional, state and federal guidelines and regulations. Evaluations are conducted on a quarterly, semi-annual, or annual schedule in each laboratory based on the laboratory’s established hazard rating.

CHEMICAL SAFETY COMMITTEE

1. Supporting UTSA faculty, staff, and students in the promotion of safe research practices.
2. Reviewing the use of hazardous chemicals in research and teaching labs at UTSA.
3. Review and advise the CHO when deviations from standard campus safety practices, regarding hazardous chemicals, are requested.
4. Reviewing and prescribing special conditions, requirements and restrictions that may be necessary for the safe handling of hazardous chemicals, and nanoparticles for the protection of personnel and property, including, but not limited to:
    a. Requiring students, staff, and researchers to take additional training.
    b. Requiring the use of additional or specialized personal protective equipment.
    c. Requiring environmental monitoring.
    d. Requiring facility upgrades (chemical fume hoods, safety equipment, and storage space).
    e. Requiring posting of additional safety / caution signage.
    f. Requiring specific or specialized chemical waste disposal processes and procedures in the laboratory.

   g. Requiring specialized handling techniques.
   h. Requiring special procedures following incidents or accidents.

5. Reviewing reports of any incidents or accidents associated with hazardous chemicals, nanoparticles, or hazardous laboratory conditions. At the request of higher administration, the CSC will review new or existing risk assessments following an incident or accident.
6. In response to incidents, the CSC may recommend remedial actions, including temporary suspension or termination of approved research for working with hazardous chemicals, and nanoparticles. The CSC may recommend that an approved procedure meets the criteria for remedial action, suspension or termination and the Associate Vice President for Research Integrity will notify the PI that a specific activity has been suspended pending further action.
7. Providing support and guidance, when requested, during incidents involving chemicals not covered by CSC risk assessments.
8. Annually reviewing the CHP and providing advice and guidance.

PRINCIPAL INVESTIGATORS (PI), LABORATORY OR TECHNICAL SUPERVISORS

Principal Investigators (PI), Laboratory or Technical Supervisors will:

1. Enforce all UTSA standard operating procedures (SOP’s) and policies regarding chemicals and other relevant equipment within their laboratory space or work area.
2. Develop lab specific safety procedures or protocols for the safe use, storage and disposal of chemicals in their laboratory.
3. Determine whom within their laboratory needs chemical hygiene and hazard communication training, and ensure laboratory personnel to include staff, students, volunteers and visiting researchers have been properly trained to work safely within their laboratory or work area.
4. Keep a **written** record of pertinent training classes, lectures, hands-on training, hazard communication training with dates, times and appropriate signatures on file.
5. Ensure that new lab personnel attend mandatory Hazard Communication and Laboratory Safety Training and/or Hazardous Waste Generator’s Courses as appropriate to their work prior to direct contact with hazardous chemicals or toxins. For questions on mandatory and relevant training courses please contact Laboratory Safety Division personnel.
6. Advise the Lab Safety Division of any significant protocol changes prior to bringing new hazardous chemical(s) onto campus. Some chemicals, biologicals and equipment require approval prior to ordering. See Appendix I Hazardous Materials Requiring Institutional Approval.

7. Immediately report any exposures, spills, thefts, or other incidents resulting in injury to personnel or damage to property or equipment and involving chemicals to the Laboratory Safety Division for investigation or assistance.
8. Notify the Laboratory Safety Division and any relevant committee (CSC, etc.; see emergency contact list on page 2) of any significant protocol changes and prior to bringing new hazardous materials, chemicals and/or equipment) onto UTSA property. Maintain the laboratory Chemical Inventory as detailed in Chemtracker (BioRAFT). New chemicals should be tagged with a code and the inventory updated. Accordingly, chemicals that have been used must be removed from the inventory
9. Report any plans to remodel or alter UTSA facilities (Refer to HOP 8.3 - Remodeling and/or Alterations to University Facilities) to Facilities, and LSD to obtain permission before proceeding. LSD will provide guidance in safe removal and temporary storage of hazardous materials and chemicals.

LABORATORY PERSONNEL

This group includes all persons present in a laboratory space excluding LSD personnel and Principal Investigators. Laboratory staff includes, but is not limited to, undergraduate/graduate students, UTSA employees, visiting scholars, and volunteers.

Laboratory Staff and workers will:

1. Observe all established guidelines, departmental SOP's and UTSA policies and procedures for chemical safety to include accessing and reviewing SDS's as appropriate to determine hazard characteristics and handling procedures.
2. Maintain a clean and sanitary workplace. Chemicals should not be stored on benchtops or other surfaces outside fume hoods or chemical safety cabinets. All areas (benchtops, sinks, fume hoods, etc.) must be kept free of clutter, excess glassware, and must be well organized to avoid accidents or spills.
3. Attend all necessary or required training – refer to Training Requirements. Only use hazardous chemicals for which they have been properly trained to handle and use.
4. Properly dispose of all laboratory waste in accordance with laboratory standard operating procedures and UTSA waste management policy.
5. Report all spills or incidents to their supervisor and LSD if necessary.
6. Report to the PI/ Laboratory Supervisor and the LSD any perceived unsafe practices or conditions in the laboratory. Reports to the LSD can be made anonymously on the safety committee website at http://research.utsa.edu/research-funding/safety-committees/

TRAINING REQUIREMENTS

LABORATORY SPECIFIC TRAINING

A safe laboratory environment is dependent on all personnel having a good understanding of the risks posed by the chemicals present and the procedures used.

Laboratory Safety provides online general safety training (described below) and will also provide this training in-person to individuals or laboratory groups on request. However, it is the responsibility of each laboratory to develop training appropriate to their specific research needs and Standard Operating Procedures. Laboratory Safety is available to assist PIs with any tools or documentation they may need to develop this training and maintain safety training records. Laboratories are dynamic environments and research practices, and procedures change constantly therefore laboratory specific training should be reviewed by the P.I. every 6 months to ensure no new training is needed.

Listed below are general areas that should be considered when developing training:

1. An overview of this UTSA Chemical Hygiene & Hazard Communication Safety Plan, its location and availability.
2. Hazardous chemicals present in their workplace operations and how to handle these safely.
3. Physical and health hazards of the hazardous chemicals in their work area to include the Occupational Safety and Health Administration (OSHA) permissible exposure limits (PEL) and the American Conference of Governmental Industrial Hygienists (ACGER) Threshold Limit Values (TLV).
4. Methods and observation techniques used to determine the presence or release of hazardous chemicals in their work area.
5. Specific procedures and equipment in the laboratory and the hazards associated with their operation.
6. How to lessen or prevent exposure using personal protective equipment.
7. Steps the University has taken to lessen or prevent exposure to these hazardous chemicals.
8. Symptoms associated with exposure to chemicals found in the area.
9. Emergency procedures to follow if they are exposed to hazardous chemicals.
10. How to obtain appropriate hazard information from an SDS.
11. Location of SDS file and hazardous chemical list for their work area.

Training must be documented with the subject matter covered, date(s) of training and signed by the attendees.

ONLINE SAFETY TRAINING – REQUIRED

A. Hazard Communication and Laboratory Safety

Hazard Communication (HazComm) training is mandated by both the federal and state governments (Texas Health & Safety Code, Title 6, Chapter 502 – Hazard Communication Act, section 502.009). If you will be exposed to hazardous chemicals within your work area, you must complete the Hazard Communications and Laboratory Safety training course in BioRAFT or request in person (classroom) training by contacting the Sr. Director of Laboratory Safety or the Chemical Hygiene Officer. Hazardous chemicals are defined as chemicals which have a physical or health effect. An irritation is a health effect. This training must be completed before the employee or student works with, or is in an area containing, any hazardous chemical.

B. Hazardous Waste Generator Training

Hazardous Waste Generator training covers chemical and biological waste disposal procedures in accordance with federal, state, and local regulations. Generators must understand the requirements for proper bulking, packaging, labeling and disposal of hazardous waste.

GENERAL LABORATORY SAFETY GUIDELINES

Preparation is a vital component of creating a safe environment. This can include providing training on the lab specific hazards, informing personnel where they can locate fire extinguishers appropriate for the hazards present in their environment, knowing the location of safety showers and eyewashes, knowing the location of spill kits, and knowing who to ask for help.

All laboratory personnel have a responsibility for their own safety and the safety of others in their work environment. Prior to starting any work in the laboratory, ensure personnel are familiar with the procedures, equipment and chemicals that will be used and are aware of the general laboratory safety guidelines as well as any other associated hazards. Personnel should be able to easily access SDS for all the chemicals they may be using, know where to locate this CHP and have a plan in place should an incident happen. The Lab Safety Division serves as a point of contact in case of any arising issues and staff, faculty, and students are encouraged to contact the office at any time. Each laboratory is unique in their research and therefore should create a safety plan specific to their facility using the CHP as a foundation. Templates and guidance for creating safety plans can be found on the Laboratory Safety Division website and by contacting the laboratory safety staff directly.

Below are general guidelines for working safely in any laboratory.

GUIDELINES

1. To ensure that help is available if needed, do not work alone if using hazardous materials or performing hazardous procedures. If circumstances arise where overnight or weekend work is required, please contact Laboratory Safety in advance. A buddy system is strongly recommended.

2. To ensure that help is available in case of emergencies, laboratory personnel should not deviate from the assigned work schedule without prior authorization from the laboratory supervisor.

3. Do not perform unauthorized experiments.

4. Do not leave high hazard reactions unattended if possible. Attach an ‘Unattended Chemical Reaction’ sign with general information on reagents hazards and time frames to the outside of your fume hood. Laminated copies are available from the Lab Safety Office.

5. Plan appropriate protective procedures and the positioning of all equipment before beginning any operation. Always follow the appropriate standard operating procedures in the laboratory.

6. Always read the SDS and the label before using a chemical in the laboratory.

7. Wear appropriate PPE, including a laboratory apron or coat, always in the laboratory. Everyone, including visitors, must wear appropriate eye protection in areas where laboratory chemicals are used or stored.

8. Wear appropriate gloves when handling hazardous material. Inspect all gloves for holes and defects before using.

9. Use appropriate ventilation such as laboratory chemical hoods when working with hazardous chemicals.

10. Contact the Chemical Hygiene Officer (CHO) x6419 if you have questions about the adequacy of the safety equipment available or chemical handling procedures. Report dangerous activities or situations to your laboratory supervisors and the CHO.

11. Know the location and proper use of the safety equipment within the laboratory and in surrounding areas (i.e., eyewash station, safety shower, fire extinguisher, first-aid kit, fire blanket, chemical spill kit, emergency telephone, and fire alarm pulls).

12. Always incorporate safety into your experiments and anticipate and account for things that could go wrong. Never compromise safety in the interest of time.

13. Remove gloves before handling items such as the telephone, doorknobs, and computer keyboards.

14. Always remove gloves and wash hands thoroughly before leaving the laboratory.

15. Designate specific break areas outside the laboratory for eating and drinking. Remember, smoking is prohibited on all UTSA campus areas.

16. Store food and drinks in refrigerators designated for consumable items, away from areas containing chemical, biological, or radiological hazards.

17. Be aware of dangling jewelry, loose clothing or long hair that might get caught in equipment. Secure or remove these items to work safely.

18. Do not wear shorts, skirts, sandals, or open-toed shoes in the laboratory. Shoes that completely cover the foot and shed liquids provide the most protection and should be worn in the laboratory.

19. Always wear appropriate personal protective equipment.

20. Keep aisles and walkways clear and close drawers and cabinet doors while you are working.

21. Do not store hazardous chemicals on the floor in high-traffic or open areas.

22. Never pipette by mouth.

23. Do not allow non-matriculating minors (anyone under 18 years of age) into the laboratory without prior approval as outlined in HOP 10.13, *Minors in Laboratories or Similar Facilities*.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) is a device or clothing worn to help protect you from direct exposure to hazardous materials. Examples include safety glasses or goggles, laboratory coats or aprons, gloves, face shields and respirators. **Remember, PPE only protects you if you use it**. Consult SDS's or other references for information on the PPE required for working with a particular chemical.

EYE AND FACE PROTECTION

Appropriate eye and face protection should be selected after a careful risk assessment of all the hazards involved in conducting a specific procedure. Eye protection must meet standards for impact resistance and provide splash protection. Safety glasses with side shields usually provide adequate impact resistance with limited splash protection and, therefore, consideration must be given to the splash risk of the procedure being performed. Chemical splash goggles (with no direct perforations around the goggles) provide adequate impact resistance and splash protection and limited vapor protection and therefore provide the best all-around eye protection. Vapor resistant goggles are available if needed. The Laboratory Safety Division recommends that all personnel wear chemical splash goggles while working with hazardous chemicals and can provide guidance in selecting and sourcing eyewear.

In addition to protective eyewear, face shields or freestanding shields should be used in situations where implosion or explosion may occur. Follow these guidelines for effective eye and face protection.

1. Always wear protective eyewear in the laboratory.
2. Wear chemical splash goggles for maximum protection, especially if you wear corrective lenses (glasses or contacts).
3. Splash and vapor resistant proof goggles are the only accepted eyewear in all teaching laboratories where chemicals can be found. Everyone in the lab must always wear these.

HAND PROTECTION

Gloves protect your skin from the chemicals you work with. Not all gloves, however, are effective in providing protection against chemicals. Disposable latex gloves protect against water, dirt, and microorganisms, but they do not protect against many solvents and must not be used for handling chemicals. There are several varieties of gloves (i.e., butyl, Neoprene, fluorocarbon (Viton), nitrile), each of which protect against different chemicals. There are also insulated gloves appropriate for work with cryogenic materials or hot glassware. Follow these guidelines for effective hand protection.

1. Wear gloves that provide the greatest protection from the chemical(s) with which you are working. Information on chemical-resistant gloves is available from various manufacturers, online or from the Lab Safety Division.

2. Wash your hands promptly after removing protective gloves to avoid exposure due to microscopic holes, tears, solvent penetration, or accidental contact with the outside of the gloves when removing them.

3. Remove gloves when handling laboratory common items (telephones, keyboards, doorknobs, etc.) to prevent their contamination.

GLOVE TYPE	RECOMMENDED USE GUIDELINES
NITRILE	General use
BUTYL RUBBER	Ketones and esters
NEOPRENE	Acids, bases, alcohols, fuels, peroxides, hydrocarbons (not halogenated or aromatic), phenols
NORFOIL	Most hazardous chemicals
VITON	Chlorinated and aromatic solvents
POLYVINYL CHLORIDE (PVC)	Acids, bases, oils, fats, peroxides and amines
POLYVINYL ALCOHOL (PVA)	Aromatic and chlorinated solvents

Table 1. Glove types and recommended usage.

BODY PROTECTION

The most common form of body protection in the laboratory is the laboratory coat. Laboratory coats protect your skin and clothes in the event of a spill or a splash. Chemical-resistant aprons provide extra frontal protection when there is a greater potential for spills or splashes, as when you are transferring chemicals from one container to another. Laboratory coats are available free to all laboratory workers from the vending machines located in AET, BSE, MBT and SEB. Contact the Laboratory Safety Division to obtain a vending machine card. Follow these guidelines for effective body protection.

1. Protective clothing should be easily removable and free from rips or tears.

2. Wear your laboratory coat or apron only in the laboratory to prevent the potential spread of contamination.

3. Always wash laboratory clothes separately from personal laundry.

4. The following are not to be worn in laboratories: high-heeled or open-toed shoes, sandals or woven shoes, shorts, or miniskirts, or excessive or dangling jewelry.

RESPIRATORY PROTECTION

Respiratory protection in the laboratory is normally provided by engineering controls such as the ventilation system and chemical fume hood(s). When a higher level of respiratory protection is required, a half- or full-face respirator can be used. Contact LSD for assistance in selecting the correct respirator and cartridges. Medical assessment, fit testing and training on proper use and storage are necessary prior to using a respirator. Follow these guidelines for effective respiratory protection:

1. To note chemical odors, use a wafting motion of the hand to dilute the fumes before they reach your nose. Never inhale chemical fumes directly.

2. Do not use a respirator unless you have been trained to do so and have undergone a medical evaluation as well as had the respirator fit-tested.

3. If you are wearing a respirator, be sure the appropriate cartridges are used.

4. Properly store a respirator to prevent continued contamination and exhaustion of the cartridges.

ENGINEERING CONTROLS

CHEMICAL FUME HOODS

The laboratory chemical fume hood is a ventilated enclosure designed to capture, contain, and exhaust fumes, gases, vapors, mists and particulate matter generated within the hood interior. The fume hood is one of the most common and important safety devices in a laboratory, so it is important to ensure that fume hoods are achieving maximum containment to provide maximum protection. Several factors decrease fume hood containment and should be avoided: excessive storage of equipment and chemicals inside the hood; high traffic, fans, air-conditioning vents, and doors to hallways being propped open; blockage of baffle slots (exhaust openings in the back of the hood); and a high sash position (open hood face). These factors result in the generation of turbulence inside the hood, cross-drafts that disrupt hood air-flow patterns and decreased face velocity. The optimum flow rate on a fume hood is 100 feet per minute plus or minus 20 percent.

Follow these guidelines for proper hood use:

1. If large equipment must be used or stored inside the fume hood, place the equipment on blocks at least two inches off the work surface so the baffle slots are not blocked. This allows air to flow beneath the equipment.

2. Do not use the fume hood interior for a chemical storage cabinet. However, if some chemical storage inside the hood is necessary, place the containers on shelving against the side walls (not the back wall) of the hood so the baffle slots are minimally blocked.

3. Do not keep loose paper, towels or Kim wipes inside the hood. These materials can get caught in the exhaust fan and result in fume hood downtime.

4. Equipment and other materials should be kept at least six inches behind the sash (hood opening) during experiments. This will reduce the exposure of personnel to chemical fumes that may escape into the laboratory due to small cross-drafts.

5. When the hood is not in use, keep the sash all the way down. When the hood is in use, keep the sash as low as possible to protect yourself against explosions or chemical splashes.

6. The fume hood is not a substitute for personal protective equipment. Wear your safety goggles, gloves and laboratory coat while working in a fume hood.

7. Ensure the exhaust fan is on and operating before you use a fume hood.

8. Newer models of fume hoods have audible alarms that sound when the face velocity in the hood falls below a certain level. Discontinue all work if the alarm sounds and ensure that the problem has been corrected before you continue.

9. Examinations and maintenance of all laboratory fume hoods are performed by Facilities personnel, contact Facilities at x4262 to report a problem with fume hoods. Ensure that the system is tested at least every six months and that a visual inspection sticker is placed on the system.

10. Place a visual indicator that shows air movement at the face of the hood. A strip of tissue paper works well. If the indicator is being pulled into the fume hood, the hood is functioning. If the indicator is hanging straight down stationary, the hood is not functioning. If the indicator is blowing out into the laboratory, the hood is not functioning and any contaminants in the hood are flowing into the laboratory. If the hood is not functioning, contact Facilities Work Control immediately to have the hood repaired.

PERCHLORIC ACID HOOD

Perchloric acid is a highly reactive chemical. Its use inside a fume hood results in the deposition of perchloric acid precipitates that are potentially explosive. All work involving perchloric acid more than 3mL of 70% solution must be performed in an appropriate perchloric acid fume hood equipped with a wash-down system in the duct work to avoid precipitate buildup. Since perchloric acid reacts violently with other chemicals—such as organic materials or dehydrating agents—the perchloric acid hood must be washed down after each use and dedicated only to work involving perchloric acid. These hoods should be marked “perchloric acid hood.” Contact the Laboratory Safety Division for the location of the perchloric acid fume hoods on campus.

RADIOISOTOPE FUME HOOD

A radioisotope hood is designed to minimize the risk of exposure by making it easier to maintain the hood in an uncontaminated condition. This hood is constructed of stainless steel and sealed to eliminate hard-to-clean areas that would allow the accumulation of radioactive materials. In situations where relatively high levels of radioactive materials are used or where the levels of radioactive fumes generated are substantial, a two stage, in-line high-efficiency particulate air (HEPA) filter may be necessary. Hoods for radioisotope use should be marked with the radioactive material symbol and “radioisotope hood.”

BIOSAFETY CABINETS

Biological safety cabinets are typically designed to provide both worker and product protection from infectious organisms, not hazardous chemicals. They are equipped with high efficiency particulate air (HEPA) filters and may or may not exhaust air out of the laboratory. Therefore, most classes and types of Biosafety cabinet are not suitable for use of hazardous chemicals and open flames. All units must be tested and certified at a minimum annually to ANSI/NSF-49 standards by licensed workers. A Biosafety Cabinet must never be used as a substitute for a fume hood.

GLOVE BOXES

A glove box is a laboratory device that creates an environment sealed from the atmosphere. Glove boxes are commonly used in chemistry laboratories to protect workers from hazardous and toxic materials or to protect chemicals and materials that may produce adverse or violent reaction when brought in contact with atmospheric contaminates such as water vapor or air.

Glove boxes may be used under either positive or negative pressure. Glove boxes that utilize a positive pressure system are usually connected to pressurized cylinders containing an inert gas that will protect any chemicals or material from encountering the atmosphere. Negative pressure glove boxes are used to protect workers and are used for hazardous materials such as toxic gases or biological pathogens. Not all reagents and solvents are acceptable for use in the glovebox; the "box atmosphere" is usually continuously deoxygenated over a copper catalyst. Certain volatile chemicals such as halogenated compounds and especially strongly coordinating species such as phosphines and thiols can be problematic because they may poison the oxygen-scrubbing catalyst. The catalyst must be closed during handling of these compounds, and the glovebox atmosphere be thoroughly purged prior to reopening the catalyst.

A. Daily Inspections

When using glove boxes, perform daily inspections prior to use. As part of your daily checklist, the following items should be inspected:

1. Check the condition of the gloves. Look for holes, areas of discoloration representing a compromised integrity, and the connection to the exterior.

2. Inspect the condition of the window, paying special attention to the area where the window is connected to the rest of the box.

3. Perform a vacuum pump inspection and ensure that all lines are in good condition and that the oil (if applicable) has been changed recently.

4. Inspect vacuum pump exhaust oil-mist filter and ensure it is still within operating parameters.

5. If your box is equipped with a solvent scrubber and solvent delivery system, ensure that the scrubber cartridges are within operating parameters.

6. All pressure gauges and indicators are functioning and are within acceptable ranges.

B. Other Considerations

1. Perform routine maintenance on the system.

2. Avoid abruptly extending gloves into the box, this can severely stress the system and cause an over pressurization.

3. Use nitrile gloves on the glove box gloves. This extends the life of the glove box gloves and helps to avoid cross contamination and makes cleanup easier

4. Train all individuals working in the box. Document this training in a laboratory specific training file.

5. Ensure proper backup measures are in place for a loss of power or loss of facility nitrogen (if applicable).

SCHLENK LINE (VACUUM GAS MANIFOLD)

Vacuum/inert gas manifold systems, or Schlenk lines, are a common alternative to glove boxes when working with air or moisture sensitive materials in research laboratories. Hydrogenations, Grignard reactions, pyrophoric manipulations, air and/or moisture sensitive chemicals are easily handled using Schlenk Line techniques. The design is based on modular setups of specialized glassware and tubing to create an inert environment.

The main body of a Schlenk line apparatus consists of a dual manifold with several ports.

The gas manifold is connected to a source of purified inert gas and is vented by means of an oil or mercury bubbler. The vacuum manifold is connected to a vacuum pump; solvent vapors and gaseous reaction products are prevented from contaminating the vacuum pump by a liquid-nitrogen or dry-ice/acetone cold trap. The vacuum lines from the house vacuum system will not be sufficient to support the requirements of a Schlenk line and vacuum pump must always be used.

A. Safety Considerations

Schlenk lines pose several potential hazards and personnel must always be trained on safe handling and practices. The main risks associate with Schlenk Lines are explosion, implosion and of accidental condensing of gases (particularly liquid oxygen)

Schlenk Line Cold Trap Safety (Liquid Oxygen Condensation)

Extreme care should be taken if liquid nitrogen is used in the cold trap of the Schlenk Line setup. The use of liquid nitrogen in the cold trap can lead to liquid oxygen condensation due to oxygen's higher boiling point (-183°C) when compared to Nitrogen (-196°C). Liquid oxygen presents a significant explosion hazard especially in the presence of organic solvents and other organic materials including vacuum grease and Teflon tape.

A light blue color in the trap indicates the presence of liquid oxygen. Experienced lab personnel should be informed immediately if this is observed. To avoid condensing liquid oxygen, never open the vacuum line to the air when the cold trap is in place.

Other condensed gases

Some gases, such as carbon monoxide and ethylene, are also easily condensed in a liquid nitrogen-based cold trap. Once the liquid nitrogen is removed, either by choice or through evaporation, the condensed liquid will convert back to a gas with an accompanying increase in pressure. Without suitable pressure release, this build up may create an explosion hazard. A suitable pressure release system, such as an oil or mercury bubbler must remain attached to the line and the trap should be vented as soon as the liquid nitrogen Dewar is removed.

Common Causes of Explosions and Implosions

The most common cause for an explosion in a Schlenk Line apparatus is the buildup of excessive pressure within the system. This may occur due to pressure build up because of the use of inert gases, the heating of a closed system, or out-of-control reactions. To ensure adequate pressure relief, the system must be attached to a bubbler and the lines to reaction vessels must remain open.

Implosion hazards are mainly caused by cracked, unsuitable, or otherwise damaged glass. Structurally defective or improper (non-laboratory) glassware must never be used in a Schlenk Line apparatus.

B. Safe Handling and Use

1. All transfers of pyrophoric materials must be conducted using a cannula under positive pressure.
2. Positive pressure must always be maintained when using Schlenk Line apparatus.
3. All reaction vessels should be voided of atmospheric gases and moisture via the vacuum/fill cycle. This process should be repeated a minimum of three times.
4. De-gas and dry all solvents before use with reactive chemicals or materials.
5. Never heat a closed system; always ensure adequate pressure release of the system.
6. Inspect all glassware and tubing before use to ensure structural integrity.
7. Potentially reactive waste must be treated dropwise with isopropanol before submitting it to Hazardous Waste Management.

VACUUM PUMPS AND SYSTEMS

Most chemical fume hoods and biosafety cabinets are equipped with a connection to the “house-vacuum” system. This system creates suction via a large vacuum pump in a mechanical room whose piping extends to laboratories throughout the building. These house vacuum pumps are maintained by campus Facilities staff, and it is important the systems are not contaminated with hazardous materials or organisms.

Laboratories that are not connected to a house vacuum system, or that need a stronger vacuum, commonly employ stand-alone vacuum pumps such as rotary vane pumps, turbo pumps, diffusion pumps, and/or cryogenic vacuum pumps. These vacuum pumps are maintained by the personnel in each laboratory and can present serval hazards if not properly handled. It is of the utmost importance to be familiar with the pump-model specific requirements and limitations when using this equipment. If in doubt, laboratory personnel should contact the supplier for additional information and clarification. Generally, the hazards associated with stand-alone vacuum pumps can be classified into two separate categories; chemical sources and physical sources.

A. Chemical Hazards

Chemical reactions involving gases or vapors which under normal conditions pose little risk but are subject to increased reaction rates or other unexpected reactions when exposed to low, or high, pressure systems. Unexpected chemical reactions can occur when chemicals encounter gases or materials that were not originally taken into account when planning the experiment.

Leaks within the system that allow atmospheric gases to enter or flammable and toxic gases to leave the system is the greatest source of unintended violent reactions.

Additionally, gases and vapors which do not normally encounter each other during the process cycle may be mixed in the pumping system and exhaust pipelines.

Whenever solvents are used to remove deposits from the vacuum system, it is important to ensure that the selected solvent is compatible with all chemicals and materials encountered during the experimental process.

1. Explosion Hazards

The source of explosion hazards generally falls into one of the following categories:

1. Oxidants are often pumped in vacuum systems. Oxidants such as oxygen (O2), ozone (O3), fluorine (F2), nitrogen trifluoride (NF3) and tungsten hexafluoride (WF6) react readily with a wide range of substances and materials and the reaction often produces heat and an increased gas volume. It is highly recommended to always use a PFPE (perfluoropolyether) lubricant in pumps which are used to pump oxygen in concentrations above 25% by volume in an inert gas. These lubricants will not oxidize or break down in an oil-sealed rotary vane or piston and greatly reduce the probability of a system failure or explosion.

2. Flammable materials such as hydrogen (H2), acetylene (C2H2) and propane (C3H8) may ignite or become explosive within certain concentration ranges in the presence of an ignition source. Explosion hazards can be reduced by reducing the concentration of flammable gases and vapors via the introduction of an inert gas into the system.

3. Pyrophoric materials and gases, such as silane (SiH4) and phosphine (PH3), are spontaneously ignitable in air at atmospheric pressure. Combustion may occur when these gases are unintentionally exposed to the atmosphere anywhere in the vacuum system due to a leak or exhaust failure. If pyrophoric materials and oxidants are present within the same process the probability of explosion at both

atmospheric and process pressures increases greatly. Additional safety measures such as blast shields and other explosion containments must be taken into when you pump pyrophoric materials.

4. Unstable materials such as sodium azide pose and additional risk of explosion. Sodium azide can produce hydrozoic acid which in vapor form can react with heavy metals to form unstable metal azides. These azides may explode spontaneously. Brass, copper, tin and zinc are commonly used materials for vacuum pumps and accessories and pipes. For any experimental process that uses or produces sodium azide, the researcher must ensure the gas path is free of heavy metal components.

2. Toxic or Corrosive Materials

Health hazards resulting from exposure to toxic materials are generally chemical and material specific. Whenever conducting experiments with toxic materials, the researcher should consult the SDS to eliminate potential exposure risks.

Corrosive substances degrade the material they are in contact with via ion exchange process in the presence of a suitable liquid solvent (such as water). While this mechanism cannot occur with materials in the vapor phase, unplanned phase changes or condensation may lead to corrosive deposits. Special consideration should be given to possible changes in temperature and pressure when planning the experiment to avoid this hazard.

The formation of corrosive or toxic deposits may also result from cross contamination if equipment is used for more than one purpose or has not been suitably cleaned and purged. An inert gas purge of the entire system should be conducted to avoid condensation of such materials.

Note: To capture most hazardous volatile liquids, a cold trap with dry ice and either isopropanol or ethanol is sufficient (to -78 degrees C). A liquid nitrogen cooling bath may be used only with sealed or evacuated equipment. Extreme caution should be taken if the system is opened while the cooling bath is still in contact with the trap, oxygen may condense from the atmosphere and react vigorously with any organic material present.

B. Physical Hazards

1. Over Pressurization

Over pressurization of a component of the system can be a result of several causes. The most common cause of an over-pressurized exhaust is a blockage or restriction in the exhaust system. All high vacuum pumps are compressors, which are specifically designed to operate under high outlet-to-inlet compression ratios and exhaust to atmospheric pressure. Exhaust pressure more than seven bar gauge (8 x 105 Pa) may result from a blocked exhaust system.

The most common cause of over-pressure in a pump's inlet pipeline is the introduction of compressed gases during the purge with the pump not operating. If components in the inlet pipeline are not suitable for the resulting pressures, pipelines and valves may rupture and process gases will leak from the system. A back flow of gases from the system into a process vessel, not capable of withstanding the pressure, may also cause ruptures and leaks pressure. Regulators designed to provide a low-pressure flow or pressure monitor devices may be employed to minimize this hazard.

C. General safety considerations for vacuum systems

1. Consider all possible chemical reactions within your system. Include possible reactions that could occur under faulty conditions or system failure.
2. Refer to Safety Data Sheets when you assess the potential hazards associated with the experimental process (e.g., auto-ignition temperature).
3. Use the correct type of lubricant in your pump when you pump oxidants and pyrophoric materials.
4. Do not use heavy metals in the gas path of your pumping system if your process produces or uses sodium azide.
5. Ensure that safe working pressures for all components in the system are taken into account.
6. Incorporate the correct type of pressure relief devices that are suitably rated for your application.
7. Ensure that exhaust blockages cannot occur.
8. Use PFPE (perfluoropolyether) oil when you pump oxidants.
9. Use an inert gas to dilute flammable and pyrophoric gas to safe levels.
10. You must not allow the maximum pressure of the system to exceed the maximum pressure rating of any single part of the system.
11. Ensure that the system is suitably controlled and regulated.
12. Leak-test systems and equipment before use.

REFRIGERATORS AND FREEZERS

Follow these guidelines for proper laboratory refrigerator use:

1. Flammable liquids must be stored in flammable or explosion-proof refrigerators.
2. Refrigerators must be labeled prominently to indicate whether they are suitable for storage of flammable liquids.
3. Never place food or beverages in a refrigerator where chemicals are stored.
4. Refrigerators containing chemicals must be labeled “No Food or Drink.”

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Dry ice must never be stored in a refrigerator, freezer, or other tightly sealed container

CHEMICAL HAZARD CLASSES

GLOBAL HARMONIZATION SYSTEM

The Globally Harmonized System (GHS) of hazard communication recognizes thirty-one classes of chemical hazards. These classes fall within three categories – physical hazards, health hazards, and environmental hazards. Each hazard statement is designated a code, starting with the letter **H** and followed by three digits. Statements that correspond to related hazards are grouped together by code number:

- H-2xx: Physical Hazard
- H-3xx: Health Hazard
- H-4xx: Environmental Hazard

Additionally, Precautionary Statements or P-statements are used to communicate safe handling, storage, and disposal requirements.

- P-2xx: Precautionary statements in relation to prevention.
- P-3xx: Precautionary statements based on accidental exposure and spill response.
- P-4xx: Precautionary statements concerning storage and safe handling.
- P-5xx: Precautionary statements in relation to disposal.

Any single chemical or compound may exhibit more than one hazard. The hazard class(es) of a particular material will determine how it should be stored, handled, and disposed of, and what special equipment, engineering controls, and procedures are needed to use it safely. Each chemical container, whether supplied by a vendor or reallocated in the laboratory, must include a GHS label that clearly identify the hazards associated with that chemical or mixture.

Be aware that many chemicals exhibit multiple hazards, in which case, the more prevalent hazard must be considered.

GHS PICTOGRAMS AND SIGNAL WORDS

The nine GHS pictograms and corresponding signal word make up the GHS symbol vocabulary for defining specific types of chemical-related hazards. The use of each pictogram is determined by the predefined hazard classification of the chemical of concern. These pictograms may be accompanied by a signal word (*Warning* or *Danger*) are used on chemical labels appearing on chemical products and on their accompanying safety data sheet (SDS). An example of the GHS pictograms can be found in Figure 1.

Figure 1. GHS Pictograms.

CHEMICAL HAZARD CLASSES

A. Explosive and potentially explosive chemicals

Explosive substances are materials that decompose under conditions of mechanical shock, elevated temperature, or chemical action, and release large volumes of gases and heat. These substances pose an immediate potential hazard and procedures that use or produce them must be carefully reviewed by researchers, the Chemical Hygiene Officer, and Chemical Safety Committee. These materials must be stored in a separate flame-resistant storage cabinet or, in many cases, in a laboratory grade refrigerator or freezer that is designed for storing flammable and reactive chemicals.

Class includes:

- Unstable explosives
- Explosives: Divisions 1.1 – 1.6
- Self-Reactive Substances and Mixtures (types A and B)
- Organic Peroxides (types A and B)

B. Oxidizing chemicals

Oxidizers (e.g., hydrogen peroxide [H_2O_2], potassium dichromate, sodium nitrate) are substances that cause or contribute to combustion of organic materials. They often do so by giving up oxygen atoms. Oxidizers should be stored in a cool, dry place and kept away from flammable and combustible materials, such as wood, paper, Styrofoam, plastics, flammable organic chemicals, and away from reducing agents, such as zinc, alkaline metals, and formic acid

Class includes:

- Oxidizing gases – category 1
- Oxidizing liquids – categories 1, 2, 3
- Oxidizing solids – categories 1, 2, 3

C. Flammable, combustible, and self-reactive chemicals

Flammable liquids include those chemicals that have a flashpoint of less than 100°F. These materials must be stored in flammable storage cabinets if aggregate quantities of 50 gallons/room or more are stored in the lab and/or the size of any individual container is greater than 5 gallons (20 L). Flame-resistant laboratory coats and splash proof googles must be worn when working with large quantities of flammable materials and/or with procedures where a significant fire risk is present. Particular attention should be given to preventing static electricity and sparks when handling flammable liquids

Class includes:

- Flammable gases, category 1
- Flammable aerosols, categories 1, 2
- Flammable liquids, categories 1, 2, 3
- Flammable solids, categories 1, 2
- Self-reactive substances and mixtures, types B, C, D, E, F
- Pyrophoric liquids, category 1*
- Pyrophoric solids, category 1*
- Combustible solids, category 3
- Combustible liquids, category 3

- Self-heating substances and mixtures categories 1, 2
- Substances and mixtures, which in contact with water, emit flammable gases, categories 1, 2, 3
- Organic peroxides, types B, C, D, E, F

1. Pyrophoric Chemicals

Pyrophoric chemicals are a special classification of flammable materials that have auto-ignition temperatures below 130°F, and thus may spontaneously combust in contact with air. The use of pyrophoric chemicals requires laboratory-specific training in addition to a general protocol. This class of chemicals should be handled within a glove box whenever possible. Flame-resistant laboratory coats must always be worn when working with pyrophoric chemicals. Never use nitrile gloves because they do not self-extinguish upon combustion. Chloroprene gloves, coupled with flame resistant glove liners, should be worn when handling highly pyrophoric chemicals outside of a glove box. Refer to the guidelines and regulatory requirements *in Safe Handling of Pyrophoric and Water Reactive chemicals at UTSA* for regulatory and safety requirements when handling or working with pyrophoric chemicals.

Note: Please refer to Special Storage Handling Requirements for additional Information on safe handling of pyrophoric chemicals.

D. Water reactive chemicals

Water-reactive chemicals when in contact with aqueous solutions or atmospheric moisture can develop toxic and/or flammable gases that will produce enough heat to readily ignite. Water-reactive substances must be stored a cool, dry place away from any potential water sources. Water reactive chemicals should always be stored in tightly sealed container to avoid accidental release. They must never be stored in close proximity to acidic materials that could act as a source of protons and cause the evolution of hazardous gases. Water-reactive materials are indicated under GHS by varying pictograms based on the product of their reaction with moisture or water. Common examples include the flame pictogram, skull-and-crossbones pictogram, and corrosion pictograms. Water reactive substances are indicated under the National Fire Protection Association’s Standard System for the Identification of the Hazards of Materials for Emergency Response (NFPA 704) by a strikethrough “~~W~~”.

BEST PRACTICE

It is recommended that whenever working with pyrophorics, peroxides, or water reactive chemicals a container of dry sand is kept close to the work area to immediately extinguish fires.

E. Corrosive, Irritant and Sensitizing Chemicals

As a health hazard, corrosive substances cause irreversible destruction of living tissue by chemical action at the site of contact. Major classes of corrosive substances include:

- Strong acids – e.g., sulfuric, nitric, hydrochloric and hydrofluoric acids
- Strong bases – e.g., sodium hydroxide, potassium hydroxide and ammonium hydroxide
- Dehydrating agents – e.g., sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide
- Oxidizing agents – e.g., hydrogen peroxide, chlorine and bromine.

1. Corrosives

Materials that are corrosive to tissue should always be stored below eye level. The physical hazard presented by corrosive substances may degrade materials they contact, especially metals, and may be violently reactive with other substances. Always consult the SDS regarding the materials they may corrode, and their reactivity with other substances, as well as information on potential health effects. Chemicals in this hazard class should be stored in chemically compatible secondary containers and should be segregated from other classes of materials (e.g., store acids separately from bases or water-reactive materials).

2. Irritants

Irritants are defined as chemicals that cause reversible inflammatory effects. A wide array of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are considered irritants. Symptoms of exposure can include reddening, burning, discoloration or discomfort of the exposed skin and irritation to respiratory systems and eyes.

3. Sensitizers

A sensitizer (allergen) is a substance or chemical that can prompt an exposed individual to suffer an allergic reaction after continuous or prolonged exposure to the substance. Common examples of sensitizing chemicals include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, as well as several phenol derivatives. Sensitizer exposure may lead to all the symptoms associated with allergic reactions or can exasperate an individual’s already existing allergies.

F. Compressed Gases

A compressed gas is defined as a material in a container with an absolute pressure greater than 276 kPa, or 40 psi at 21 °C or an absolute pressure greater than 717 kPa (104 psi) at 54 °C, or both. Compressed gases expose laboratory personnel to both chemical and physical hazards. Compressed gases can be toxic, flammable, pyrophoric, oxidizing, corrosive, inert, or some combination of these hazards. Flammable compressed gasses with flash points significantly lower than ambient temperature present the danger of fire or explosion. Additional hazards may be caused by the reactivity and toxicity of the gas. Asphyxiation can be caused by high concentrations of even inert gases such as nitrogen. If Oxygen levels remain too low to sustain life over an extended period of time death may occur. Lastly, the large amount of potential energy resulting from the compression of gasses makes a compressed gas cylinder a potential rocket or fragmentation bomb.

The following are general recommendations for the safe handling of compressed gasses.

Note: The use of compressed gas cylinders in any laboratory requires prior risk assessment approval by the Chemical Safety Committee.

1. Be familiar with the gasses or gas-mixture's properties, safety precautions and hazards. Consult Safety Data Sheets (SDSs) for safety information.

2. Check Equipment for proper setup and leaks. Always use appropriately designed pressure equipment and ensure all materials are compatible with the specific gas or mixture

3. Develop emergency plans and procedures in case of equipment failure or leak.

4. Note: NEVER attempt to fix a leaking cylinder containing a non-inert gas yourself.

5. Never tighten a leaking regulator with a wrench, this will increase the chances of catastrophic equipment failure.

6. Follow all federal, state, and local regulations pertaining to the storage and use of compressed gas cylinders. Detailed regulatory requirements can be found in the National Fire Protection Association code NFPA-55, Chapter 7 (Compressed Gas)

7. If doubt arises over the correct handling, use or storage of any compressed gasses, or you feel you are unfamiliar with the hazards associated with a particular gas contact Laboratory Safety at (x8515) for additional guidance.

Hazard Identification and Labeling Requirements

All gas cylinders must be clearly labeled with contents, hazard class, hazard class symbol. These labels are usually affixed to the cylinder by the manufacturer and must be always visible.

Compressed gas cylinders potentially fall under two separate labeling systems since the primary holding container also serves as the transport vessel. The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) and the UN Recommendations on the Transport of Dangerous Goods Model Regulations (TDG) are the two main universally adopted hazard communication models. Labels may be based solely on either system or contain elements of both. The pictograms and hazard symbols differ slightly, and a correspondence table can be found below.

Hazard Class	GHS	UN Model
Gas Under Pressure • Compressed Gas • Liquefied Gas • Refrigerated, Liquefied Gas • Dissolved Gas		 
Flammable Gas (1A &1B)		 
Pyrophoric Gas		
Chemically Unstable Gas (A &B)		
Oxidizing Gas		  **Haz. class 2- used for Oxygen only**
Corrosive Gas		
Acutely Toxic		
Severe Health Hazard • Carcinogen • Mutagen • Respiratory Sensitizer • Target Organ Toxicity		**None required**
Health Hazard **Irritant (skin/eye)** **Narcotic effect** **Respiratory Tract Irritant**		**None Required**
Hazardous to the Ozone Layer		**None Required**

Table 2. Gas Cylinder Labeling

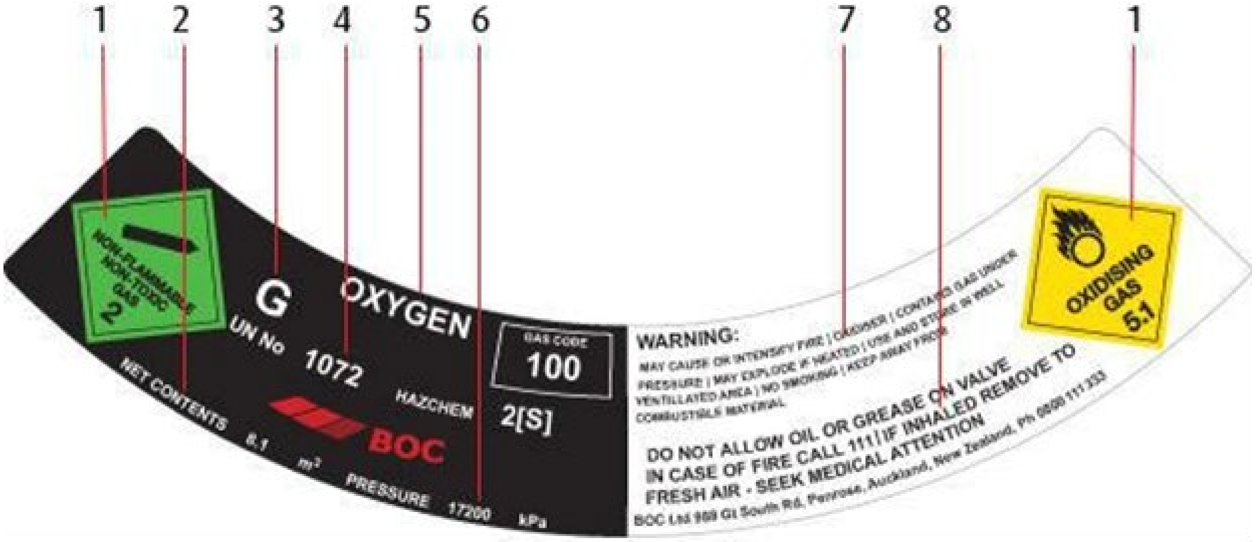


Figure 2. Example of a cylinder label. 1). Dangerous Goods Classification (Hazard Class), 2). Contents of cylinder at standard temperature and pressure (15°C @ 101.3 kPa), 3). Cylinder size, 4). United Nations (UN Model) numbering system for safe handling, transport, and storage, 5). Gas name and grade, 6). Nominal filling pressure at standard conditions (for permanent gas), 7). Caution - indicated major hazards, 8). General safety information.

Storage and Safe Handling

Several precautions should be taken during storage of compressed gas cylinders to minimize hazards.

1. All cylinders must always be stored in an upright position and securely fastened to an appropriate wall bracket, floor stand, or foot clamp. Contact LSD for guidance on appropriate fasteners.
2. Note: gas cylinders must never be clamped to a movable lab bench or to one another for support.
3. Full and empty cylinders should be stored separately and appropriately labeled with a tear-off tag as full, in use, or empty
4. Gas cylinders secured with a chain or strap must have the chain or strap attached 2/3 of the way up on the cylinder.
5. Cylinders should never be stored near heat sources or high voltage electrical equipment.
6. Gases should be used and stored only in a well-ventilated area.
7. Gas cylinders (in storage or empty) should have the gas cap in place. This is especially important for toxic, corrosive, and highly flammable gases. Never store compressed gases for longer than one year without use.

8. Compressed gas cylinders should not be subjected to any mechanical shock that could cause damage to their valves or pressure relief devices. Cylinders should not be dropped, dragged, slid, or used as rollers for moving material or other equipment.

9. Never move a gas cylinder with a regulator or without the gas cap securely in place.

10. Oxidizers and flammable gases should have a minimum distance of 20 ft. from combustible materials and/or incompatible gases or substances.

11. Toxic/poisonous gases must be stored in a chemical fume hood or in a properly ventilated gas cabinet. Appropriate warning signs should be posted in the immediate area of the toxic or poisonous gas, outlining emergency procedures in case of exposure.

12. Inert gases are compatible with all other gases and may be stored together.

Further information on the correct segregation and storage amounts can be found in Appendix II.

Regulator selection

Regulators should be thoroughly inspected before attaching them to a gas cylinder. Regulators and pressure control devices must be selected based on the specific gas and must never be forced or otherwise altered to fit a connection. Tubing, piping, and all fittings must be inert towards the specific gas. Information on appropriate regulators, tubing, and fittings is available from the manufacturer or on the SDS.

Standard cylinder-valve outlet connections have been devised by the Compressed Gas Association (CGA) to prevent the mixing of incompatible gases due to an interchange of connections. Outlet threads used vary in diameter; some are male, and some are female, some are right-handed and some are left-handed. In general, right-handed threads are used for nonfuel and water-pumped gases, and left-handed threads are used for fuel and oil-pumped gases. Information on the standard equipment assemblies for use with specific compressed gases is available from the supplier. To minimize undesirable connections that may result in a hazard, use only CGA standard combinations of valves and fittings in compressed gas installations.

G. Cryogens

A cryogenic liquid is defined as a liquid with a normal boiling point below –130°F (–90°C). Many of the safety precautions observed for compressed gases also apply to cryogenic liquids. Two additional hazards are created from the unique properties of cryogenic liquids:

1. **Extremely Low Temperatures** -The cold boil-off vapor of cryogenic liquids rapidly freezes human tissue; exposure can result in extensive tissue damage. Materials such as carbon steel, plastics and rubber become brittle and may fracture under stress.

2. **Vaporization** - All cryogenic liquids produce large volumes of gas (~1:1000) when they vaporize. Vaporization of cryogenic liquids in an enclosed area can cause asphyxiation and may result in death within minutes when oxygen levels are below 5%. Vaporization of liquid oxygen can produce an oxygen-rich atmosphere, which will support and accelerate the combustion of other materials. Vaporization of liquid hydrogen can form an extremely flammable mixture with air.

Common cryogens and their properties are summarized in Table 2.

Cryogen	Boiling point (1 atm) °C (°F)	Critical pressure psig	Liquid density, g/L	Gas density (27°C), g/L	Expansion ratio (liq → gas)	Type of gas
Argon	-186 (-303)	710	1,402	1.63	860	Inert
Helium	-269 (-452)	34	125	0.16	780	Inert
Hydrogen	-253 (-423)	188	71	0.082	865	Flammable
Nitrogen	-196 (-321)	492	808	2.25	710	Inert
Oxygen	-183 (-297)	736	1,410	1.4	875	Oxidizer

Table 3. Common Cryogens.

1. Cryogenic Liquid PPE

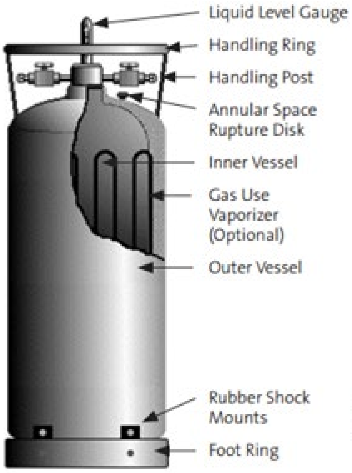
The following PPE is recommended when handling cryogenic liquids:

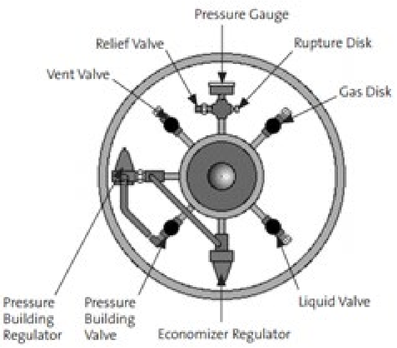
- safety glasses or goggles
- cryogenically rated, loose-fitting gloves
    - gloves should be loose fitting so that they can be quickly removed
    - cryogenic gloves are not rated for immersion into cryogenic liquids or for prolonged handling of cryogenically chilled materials
- long-sleeved shirt or lab coat, pants without cuffs, and closed shoes
- safety shoes are recommended for people involved in the handling of containers.

2. Cryogenic Liquid Storage

Cryogenic liquids can be transported, stored, and handled in a variety of containers depending on cryogen, quantity, and intended use. Not all containers are engineered for all available cryogens. Special care must be taken to ensure the container is suited to safely store and dispense the specific cryogen. Improper use of storage containers can lead to catastrophic failure of the system. If a sufficient amount of liquid is vaporized within a closed container, resulting pressure could rupture the vessel. All cryogenic liquid storage containers are protected with multiple pressure relief devices. Cryogens must never be stored in unapproved or unsuitable containers.

Storage Containers





Dewars are non-pressurized, double walled containers used to contain cryogenic liquids. The area between the walls is kept under high vacuum for maximum thermal insulation. Dewars are usually equipped with a loose fitting, insulated cap that will allow small amounts of gases to escape while preventing moisture buildup at the neck. The Cryogen may be withdrawn as a liquid or a gas depending on engineered flow rate and pressure. A vacuum-jacketed (VJ) transfer line should be used to remove cryogenic gas in a liquid state. In many cases these dewars are used as "satellite" containers for liquid nitrogen within a laboratory, and are periodically refilled from a central storage tank.

Dewar flasks are smaller, double-walled cryogenic storage containers that usually only maintain the liquid for a few hours. They usually have a metal outer wall and a glass inner wall, with the void space under high vacuum. Special care should be taken when handling as these flasks can implode. Always inspect the walls for cracks and other weak points. Do not use a Dewar that has been dropped or subjected to other types of shock; not all stress points are visible to the naked eye.

Cryogenic Storage Tanks are filled by vendors on a set schedule and are used to refill dewars and cryogenic flasks on site.

Cryogenic tubes are typically used for storage, movement, or shipment of samples. There is no pressure-relief device on a cryogenic tube other than the lid. Consequently, cryogenic tubes may explode without warning. Explosions are likely caused by trapped nitrogen expanding inside of the tube during the thawing process and may result in serious injuries. Because of this risk, all recommended PPE should be worn when directly handling a sealed cryogenic tube.

3. Handling Cryogenic Liquids

Most cryogenic liquids are odorless, colorless, and tasteless when vaporized. When cryogenic liquids are exposed to the atmosphere, the cold boil-off gases condense the moisture in the air, creating a highly visible fog.

- Always wear proper PPE.
- Label all containers with content and appropriate warning signs.
- Always use proper containers designed for the transport and use of cryogenic liquids.

- Never tamper with or attempt to repair pressure valves, gauges, and pressure relief devices.
- Examine containers and pressure relief valves for signs of defect. Never use a container with observable defects, or one which has not been designed to hold cryogenic liquids.
- Relief devices must not be removed or modified.
- Always handle these liquids carefully to avoid skin burns and frostbite. Exposure that may be too brief to affect the skin of the face or hands may damage delicate tissues, such as the eyes.
- Never touch uninsulated pipes or vessels containing cryogenic liquids. Flesh will stick to extremely cold materials. If this happens, do not pull away and instead use warm water to release. Even nonmetallic materials are dangerous to touch at low temperatures.
- Use wooden or rubber tongs to remove small items from cryogenic liquid baths. Cryogenic gloves are for indirect or splash protection only; they are not designed to protect against immersion into cryogenic liquids.
- Containers should be handled and stored in an upright position. Do not drop, tip, or roll containers on their sides.
- Do not remove or interchange connections. Contact the vendor if you experience any difficulty operating the container valve or with the container connections. Discontinue use. Use the proper connection. DO NOT USE ADAPTERS!

4. Special considerations based on each cryogen

Argon and Helium: Liquid helium and liquid argon are both inert, colorless, odorless, non-corrosive, extremely cold, and nonflammable. They will not react with other elements or compounds under ordinary conditions and possess no warning properties that will allow humans to detect their presence. Although these gases are nontoxic and inert, they can act as a simple asphyxiant by displacing the oxygen in air to levels below that required to support life. Inhalation of helium or argon in excessive amounts can cause dizziness, nausea, vomiting, loss of consciousness and death. Death may result from errors in judgment, confusion, or loss of consciousness that prevents self-rescue. At low oxygen concentrations, unconsciousness and death may occur within minutes and without warning. Personnel, including rescue workers, should not enter areas where the oxygen concentration is below 19.5%, unless provided with a self-contained breathing apparatus or air-line respirator.

Hydrogen: Hydrogen is colorless as a liquid. Its vapors are colorless, odorless, tasteless, and highly flammable. Liquid hydrogen is non-corrosive. Hydrogen gas may produce suffocation by diluting the concentration of oxygen in air below levels necessary to support life. The amount of hydrogen gas necessary to produce an oxygen-deficient atmosphere is well within the flammable range, making fire and explosion the primary hazards. Hydrogen has a broad flammability range (4% to 74% in air) and only requires a small amount energy to ignite and will burn with a pale blue, almost invisible flame. Extreme care should be taken to avoid accidental release and to eliminate all sources of ignition, such as sparks from electrical equipment, static electricity sparks, open flames, or any extremely hot objects. Gaseous and liquid hydrogen systems must be purged of air, oxygen, or other oxidizers prior to admitting hydrogen to the systems, and purged of hydrogen before opening the system to the atmosphere.

Nitrogen: Liquid nitrogen is inert, colorless, odorless, non-corrosive, nonflammable, and extremely cold. Nitrogen makes up the major portion of the atmosphere (78.03% by volume, 75.5% by weight). Nitrogen is inert and will not support combustion; however, it is not life supporting. When heated to very high temperatures, nitrogen will react with metals such as lithium and magnesium to form nitrides. When combined with hydrogen in the presence of catalysts, nitrogen will form ammonia. Nitrogen acts as a simple asphyxiant by displacing the oxygen in air and may cause dizziness, nausea, vomiting, loss of consciousness, and death.

Oxygen: Oxygen is the second largest component of the atmosphere, comprising 20.8% by volume. Liquid oxygen is pale blue in color and will react with nearly all organic materials. Although oxygen itself is nonflammable, it is a strong oxidizer. Any material or substance capable of burning in air will burn more vigorously in oxygen. Equipment used in oxygen service must meet stringent cleaning to eliminate any incompatible contaminants. Vessels containing oxygen must be stored away from flammable and combustible materials by a minimum of 20 feet or a half-hour fire wall. “No Open Flames” signs should be posted in the immediate storage area.

When pure oxygen is inhaled at pressures greater than 2 or 3 atmospheres, characteristic neurological syndromes can be observed which include nausea, dizziness, vomiting, tiredness, light-headedness, mood changes, euphoria, confusion, incoordination, muscular twitching and epileptic-like convulsions, and loss of consciousness. These effects are reversible after reduction of oxygen pressure.

H. Health Hazards and Toxicants

Hazardous chemicals belonging to certain classes are considered "Particularly Hazardous Substances" (PHSs). Special safety precautions must be established and communicated to prevent the harmful exposure of laboratory personnel to PHSs. In addition to several engineering controls, it is advisable to establish clearly labeled designated areas of use and storage, the use of containment devices, waste disposal, and decontamination procedures. Particularly hazardous substances and approval requirements are addressed in detain in chapter IX of this Chemical Hygiene Plan. In general, health hazard substances can be grouped into 3 categories:

1. Carcinogens
2. Reproductive Toxicants
3. Acute Toxicants

1. Carcinogens

Carcinogens are chemical or physical agents that may cause cancer. Most carcinogens are considered chronically toxic substances that will cause damage after repeated or long-period exposure. Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects, and harmful effect may only become apparent long after discontinuation of exposure.

Carcinogens are separated into three different classes:

- Select Carcinogens
- Regulated Carcinogens
- Listed Carcinogens

Select Carcinogens

Materials which have met certain criteria established by the National Toxicology Program or the International Agency for Research on Cancer regarding the risk of cancer via certain exposure routes. It is important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity.

Regulated Carcinogens

The materials fall into a higher hazard class and have extensive additional requirements associated with their use. The use of these agents may require personal exposure sampling based on usage and Institutional approval via the Chemical Safety Committee (CSC). Spills and exposures must be immediately reported to the Laboratory Safety Division.

Listed Carcinogens

Listed Carcinogens is a term referring to a list of thirteen specific chemicals contained in that are considered to pose the highest cancer hazard. They have further requirements for their use in addition to those of regulated carcinogens. Given these strict regulations for Listed Carcinogen use, handling, and/or storage, the Chemical Hygiene Officer (CHO) must be contacted before any work with these agents begins. OSHA regulation 1910.1200(d)(5)(ii) requires that a mixture, "shall be assumed to present a carcinogenic hazard if it contains a component in concentrations of 0.1 percent or greater, which is considered to be a carcinogenic under this regulation".

2. Acute Toxicants

Acute toxicants are substances that may be fatal as the result of a single exposure or exposures of short duration via one or more of three routes, which is defined as any of the following:

- A chemical with a median lethal dose (LD50) of 50 mg or less (oral) per kg of body weight.
- A chemical with a median lethal dose (LD50) of 200 mg or less (dermal) per kg of body weight.
- A chemical that has a median lethal concentration (LC50) in air of 500 ppm by volume or less of gas, 2.0 mg per liter or less of vapor, or 0.5 mg per liter or less of mist or dust, when administered by continuous inhalation for 4 hours (or less if death occurs within 4 hours).

Class includes:

- Category 1 acute toxic chemicals
- Category 2 acute toxic chemicals

3. Toxic Substances

Substances which may cause toxicity as the result of a single exposure, but are typically not fatal in small doses, are considered toxic.

Class includes:

- Category 3 acute toxic chemicals
- Category 4 acute toxic chemicals

Substances that cause damage to target organs are also considered to be toxic and include:

- **Hepatotoxins** – substances that damage the liver (e.g., nitrosamines, carbon tetrachloride)
- **Nephrotoxins** – substances that damage the kidneys (e.g., certain halogenated hydrocarbons)
- **Neurotoxins** – substances that damage the nervous system (e.g., mercury, acrylamide, carbon disulfide)
- **Hematopoietic agents** – substances that decrease hemoglobin function and deprive the body tissues of oxygen (e.g., carbon monoxide, cyanides)
- **Respiratory Toxicants** – Substances that damage lung tissue (e.g., asbestos, silica)

4. Chemicals Hazardous to the Environment

Materials with demonstrated toxicity to aquatic organisms are classified as toxic to the environment. The unique geographical location of UTSA above the Edwards Aquifer Recharge Zone warrants additional storage precautions for this class of chemicals. The greatest care should be taken to avoid any of these substances to be allowed to enter the drain and subsequently the ground water. As is the case for all other chemical items displaying this label, they must be stored in a secondary, unbreakable container able to contain 150% of the volume and be disposed as hazardous waste.

5. Peroxide forming chemicals

Chemicals that may form potentially explosive organic peroxides (PFC) have not received an independent classification under GHS but are rather categorized under flammable liquids or solids. However, these chemicals pose a significant concern in research laboratories. Many of these chemicals are common solvents and care should be taken for solutions containing them. A common practice is the addition of stabilizers (e.g., hydroquinone and BHT) that inhibit the chain reaction of peroxide formation whenever possible stabilized chemicals should be given priory during purchase from vendors. Peroxide forming chemicals should be stored in airtight containers in a dark, cool, and dry place. The containers should be labeled with the date received, the date opened, and the test dates. This information, along with the chemical identity, should face forward to minimize container handling during inspection.

Note: Please refer to Appendix H and I *for additional Information on safe handling, storage and testing of peroxide forming chemicals.*

PARTICULARLY HAZARDOUS AND HIGH-RISK SUBSTANCES WITH PRIOR APPROVAL REQUIREMENTS

The U.S. Occupational Safety and Health Administration's (OSHA) standard for Occupational Exposures to Hazardous Chemicals requires that a laboratory's Chemical Hygiene Plan include provisions for additional employee protection for work with particularly hazardous substances. OSHA classifies Particularly Hazardous Substances (PHS) as substances that pose a significant threat to human health and are divided into four primary types:

Acute Toxicants

Reproductive Toxicants

Carcinogens

Highly Corrosive Substances (Irreversible Tissue Damage)

Refer to the Toxicological Information and Hazard Identification of the Safety Data Sheet (SDS) to identify if a chemical or mixture is designated one or more of the above risk factors.

UTSA also considers chemicals as ‘high risk’ if they pose a significant reactivity hazard, either as a pure substance, in combination with other chemicals, or via peroxide formation over time. The main types of high-reactivity risk are:

- Highly Corrosive Substances (Corrosive to Metal)
- Pyrophoric and Water Reactive Substances
- Explosives and Peroxide Forming Chemicals
- Extremely Flammable Liquid or Vapor
- Oxidizing Substances

Depending on the severity of each chemicals’ hazard, institutional approval, documented training, specific engineering controls, additional PPE, or purchasing restrictions may apply, as determined during the review and approval process.

PARTICULARLY HAZARDOUS SUBSTANCES – HEALTH HAZARD

A. Acute Toxicants

Acute Toxicants are substances that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration.

-Acute toxicants are identified by referring to the lethal dose (LD50) or lethal concentration (LC50) value, or, if LD50/LC50 is unknown, the GHS hazard designations located in the SDS. Substances which pose an extremely high risk at a very low dose or short duration of exposure require additional institutional. Chemicals that have a toxicity range within category 1 and 2 of the of the below table require a task-specific, CSC approved protocol and a laboratory-specific Hazard Control Plan (HCP) before purchase or beginning work.

Note: Any Substance or chemical with an LD50 of ≤ 50mg/kg (oral/ dermal) or an LC50 of ≤ 500ppm (inhalation) is considered a highly toxic chemical that must have written approval from the CSC prior to purchase and beginning of work.

Example of some chemicals with a High Degree of Acute Toxicity

acrolein
arsine
chlorine
diazomethane
diborane (gas)
hydrogen cyanide
hydrogen fluoride
methyl fluorosulfonate
nickel carbonyl
nitrogen dioxide
osmium tetroxide
ozone
phosgene
sodium azide
sodium cyanide

Routes of exposure		Toxicity Range			Toxicity Range	
		Category 1	Category 2	Hazard Phrase (Hazard Code)	Category 3	Hazard Phrase (Hazard Code)
Oral (mg/kg)		LD50 ≤ 5	LD50 > 5 and ≤ 50	Fatal if swallowed (H300)	LD50 50> and ≤ 300	Toxic if swallowed (H301)
Dermal (mg/kg)		LD50 ≤ 50	LD50 > 50 and ≤ 200	Fatal in contact with skin (H310)	LD50 200> and ≤ 1000	Toxic in contact with skin (H311)
Inhalation	Gases (ppm)	LC50 ≤ 100	LC50 > 100 and ≤ 500	Fatal if inhaled (H330)	LC50 500> and ≤2500	Toxic if inhaled (H331)
	Vapors (mg/L)	LC50 ≤ 0.5	LC50 > 0.5 and ≤ 2.0		LC50 > 2.0 and ≤ 10.0	
	Dust/ (mg/L)	LC50 ≤ 0.05	LC50 >0.05 and ≤ 0.5		LC50 > 0.5 and ≤ 1.0	
Required Action		Task Specific, CSC approved protocol, documented hands-on training by Senior Researcher or PI			Pre-approved protocol and Hands on Training by Senior Lab Member or PI	

Table 4. Guide to acutely toxic substance requiring CSC approval.

1. Organ damage hazard codes and phrases

- **H370:** – Causes damage to organs
- **H371**: May cause damage to organs
- **H372**: Causes damage to organs through prolonged or repeated exposure
- **H373**: May cause damage to organs through prolonged or repeated exposure

B. Reproductive and/or developmental toxicants

Reproductive and Developmental Toxicants are chemicals that may adversely affect reproductive capabilities in adults, including decreased fertility or chromosomal damage (mutations), and developmental effects on fetuses (teratogenesis).

Substances and mixtures with reproductive and/or developmental effects are assigned to one of two hazard categories, 'known or presumed' and 'suspected'.

Reproductive toxicants are identified by the health hazard GHS pictogram on the chemical label or the following GHS hazard designations:

H340: May cause genetic defects
H341: Suspected of causing genetic defects
H360: May damage fertility or the unborn child
H361: Suspected of damaging fertility or the unborn child
H361d: Suspected of damaging the unborn child
H362: May cause harm to breast-fed children

No complete, recognized list of known human reproductive toxins exists. The following list of potential reproductive hazards is a combination of substances extracted from the National Institute of Occupational Safety and Health (NIOSH), the Annual Report on Carcinogens published by the National Toxicology Program (NTP), publications by the International Agency for Research on Cancer (IARC) and the U.S. Air Force.

Refer to the Safety Data Sheet (SDS) or TOXNET (http://toxnet.nlm.nih.gov) to determine if the chemical is considered a reproductive toxin.

Metals	**Pesticides**	**Solvents**
Antimony	Aldrin	Benzene
Arsenic Boron	Carbaryl	Carbon Disulfie
Cadmium	Chlordane DDT	Chloroform
Lead	Dieldrin	Hexane
Lithium	Hexachlorobenzene	Methylene Chloride
Manganese	Kepone (Chlordecone)	Perchloroethylene
Mercury	Lindane	Toluene
Selenium	Methoxychlor	Trichloroethylene
	Mirex	Xylene
Glycol Ethers		
Ethylene Glycol Monomethyl Ether (also called Methyl Cellosolve or Methoxyethanol) Ethylene Glycol Monoethyl Ether (also called Ethyl Cellosolve or Ethoxyethanol) Other Glycol Ethers (many varieties)		
Other Organic Chemicals		
Aminopterin	Dimethyl Formamide	Hydrochloride
1,3-Butadiene	Dinitrotoluene	Isoretinoin
Chlorambucil	Dinoseb	Mechlorethamine
Chlorcyclizine	Diphenylhydantoin	Methotrexate
Chloroprene	Epichlorohydrin	Methyl Mercury
Cycloheximide	Ethylene Dibromide	PCB (Polychlorinated Biphenyl)
Cyclophosphamide	Ethylene Oxide	Thalidomide

Cyhexatin Cytarabine DBCP (Dibromochloropropane) Diethylstilbestrol	Ethylene Thiourea Etretinate Fluorouracil	Valproate Vinyl Chloride Warfarin

Table 5. Substances known to be reproductive or developmental toxicants.

1. General safe handling and use of reproductive and developmental toxicants

1. Whenever possible a less hazardous substitute should be used
2. All areas where these toxins are stored or handled must be prominently labeled, including experiments that could cause exposure.
3. All work (including weighing and transfer) should be conducted within a functioning fume hood
4. A chemical resistant lab coat and long pants/ clothing and closed toed shoes must be worn when handing these chemicals
5. Designated areas for handling and manipulation should be established
6. Women who are pregnant or plan to become pregnant should not handle or work with these chemicals, including storage areas where contamination might be present
7. It is recommended that double gloves are worn when working with these substances

C. Carcinogens

Carcinogens are chemicals or physical agents that increase the likelihood of developing cancer by exposure to a large concentration over a short period or smaller exposures over a long period of time. The biggest concern about carcinogens is that the effects may only become evident after a long latency period. Carcinogens are identified by the health hazard GHS pictogram on the chemical label, and the following GHS hazard designations in Section 2.2 of the SDS.

- H350: May cause cancer
- H351: Suspected of causing cancer

Carcinogens are separated into 3 classifications:

1. Select Carcinogens

Select Carcinogens are materials which meet criteria defined by National Toxicology Program (NTP) or the International Agency for Research on Cancer (IARC) regarding the risk of cancer via certain exposure routes, but may also include compounds that have not yet been subjected to testing for carcinogenicity.

The Annual Report on Carcinogens, published by NTP, includes all substances listed as “known to be carcinogens” and “reasonably anticipated to be carcinogens”.

IARC identifies carcinogenicity based on groups

- Group 1 – Carcinogen to Humans
- Group 2A – Probably Carcinogenic to Humans
- Group 2B – Possibly Carcinogenic to Humans

2. Regulated Carcinogens

Regulated Carcinogens fall into a higher hazard class of carcinogens and have extensive additional requirements associated with them.

- Permissible Exposure Limits (PEL) are defined as either an 8-hour Time Weighted Average (TWA) or a 15-minute Short-Term Exposure Limit (STEL)
- Utilize administrative and engineering controls
- Personal exposure sampling may be required based on the usage or storage amount.

3. Listed Carcinogens

Listed Carcinogens are the highest hazard class of carcinogens and have additional safety requirements.
There are 13 chemicals defined as Listed Carcinogens.
New users should contact the Chemical Hygiene Officer to verify adequate safe handling procedures and training prior to use.

CHEMICAL NAME	CHEMICAL ABSTRACT SERVICE REGISTRY NUMBER
4-Nitrobiphenyl	CAS No. 92-93-3
alpha-Naphthylamine	CAS No. 134-32-7
methyl chloromethyl ether	CAS No. 107-30-2
3,3'-Dichlorobenzidine (and its salts)	CAS No. 91-94-1
bis-Chloromethyl ether	CAS No. 542-88-1
beta-Naphthylamine	CAS No. 91-59-8
Benzidine	CAS No. 92-87-5
4-Aminobiphenyl	CAS No. 92-67-1
Ethyleneimine (Aziridine)	CAS No. 151-56-4
beta-Propiolactone	CAS No. 57-57-8
2-Acetylaminofluorene	CAS No. 53-96-3
4-Dimethylaminoazo-benzene (Methyl yellow)	CAS No. 60-11-7
N-Nitrosodimethylamine	CAS No. 62-75-9.

Table 6. OSHA Listed Carcinogens Standard 1910.1003

All personnel working with Listed Carcinogens must adhere to the strict regulations of storage/handling, complete hazard specific training on PPE selection, and complete procedures for exposure control and disposal.

D. Special requirements for highly toxic compressed gases

Compressed gas cylinders shall be within gas cabinets, exhausted enclosures, or gas rooms. Gas cabinets and gas enclosures shall be in accordance with NFPA standards (8003.3.1.3.2 and 8003.3.1.3.3, respectively).

1. Requirements for gas cabinets and gas enclosures

Gas cabinets and enclosures must:

- be internally sprinklered.
- operate at negative pressure with respect to surrounding area
- be provided with self-closing limited access pots or noncombustible windows to give access to equipment controls, average velocity at windows/port must be at least 200 fpm
- be connected to an exhaust system
- be provided with self-closing doors

Note: Low concentration mixtures of poison gas in inert gas are often not subject to the requirement for a fire-protected ventilated cabinet. All toxic gases require prior CSC approval and review of safety measures and engineering controls regardless of concentration.

E. High risk substances – physical hazards

1. Pyrophoric and water reactive substances

Pyrophoric chemicals are a special classification of reactive materials that spontaneously combust when in contact with air and require laboratory specific training. Due to the hazardous nature of the chemical, Pyrophorics must be handled under an inert atmosphere or in such a way that rigorously excludes air.

1. Flame resistant lab coats must be worn when handling pyrophoric materials

2. Pyrophorics may only be stored/handled in buildings equipped with emergency sprinkler systems

3. Personnel should be trained prior to handling Pyrophorics

Water reactive chemicals will react with water to produce a toxic or flammable gas. Depending on the chemical, some water reactive chemicals are sensitive enough to react with moisture in the air. These chemicals should always be stored away from water sources and aqueous solutions.

2. Peroxide forming chemicals (PFC)

Peroxide formers are chemicals that may form potentially explosive organic peroxides via exposure to oxygen or light and even through distillation of the PFC. There are 4 classes of PFCs, but we are primarily focused on Class 1, 2 and 3 PFCs.

1. Label the bottle with the date received and date opened
2. Use or dispose of the chemical within 12 months of opening or by the expiration date, whichever date is earliest
3. Labs may test the chemical for peroxide formation to keep the chemical beyond 1 year of the opening date
4. If the ppm level for peroxides is below the limit, the lab may keep the PFC as long as it is continuing to be tested for peroxides
5. If the ppm level for peroxides is too high, a vendor will need to be called in to dispose of it and the cost of the vendor will be billed to the lab/department

3. Flammables

Flammable liquids are defined as having a flash point below 100°F and designated as either Category 1 or 2 in Section 2: Hazards Identification of the Safety Data Sheet (SDS). Be aware that the vapor emitted from the flammable liquid also poses a risk and could be ignited with a simple spark.

1. Store flammables in approved flammable cabinets when not in-use
2. Keep them stored away from oxidizers and combustible materials utilizing secondary containment or separate storage cabinets to prevent the possibility of fueling a possible fire outbreak
3. No more than 10 gallons of flammables may be stored outside of an approved flammable cabinet
4. Flammable containers larger than 1 gallon (4L) must be kept inside an approved flammable cabinet
5. Do not store flammables in refrigerators or freezers unless it has been approved for storage by the manufacturer

F. Prior approval requirements

Substances that are classified as “acutely toxic” or “highly reactive” substances require approval by the Chemical Safety Committee prior to acquisition. Approval by the CSC is predicated by submission of a detailed substance-specific SOP outlining the protocol of intended use and training schedule.

1. Established SOPs

To minimize administrative burden, and to implement universal best practices across laboratories at UTSA, the CSC has provided a list of preapproved SOPs and protocols for Potentially Hazardous Substances (PHS).

These documents are intended to serve a dual purpose, to provide:

An application for the purchase/use of PHS submitted to the CSC, and
A foundation for training of new users.

Any deviation from the established regulatory requirements outlined in these SOPs must be noted and addressed in detail before seeking CSC approval.

A list of established SOPs can be found in Appendix X.

2. Training requirements

All laboratory personnel using a PHS/High-Risk Substance must undergo a lab-specific training for use of the specified substance. The training must include:

1. Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by UTSA and the PI, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.).
2. The physical and health hazards of chemicals in the work area.
3. Personnel new to working with the specific PHS/High-Risk substance must obtain and document hands-on training from lab personnel experienced with this substance prior to handling.
4. In addition to hands-on training, personnel must be familiar with safe handling requirements, emergency exposure/spill procedures, and storage requirements delineated in the substance-specific SOP. Personnel must demonstrate and document competence and understanding of the SOP.

3. Handling

1. Designated areas (e.g., fume hoods, glove boxes, lab benches, outside rooms) for material use must be established and the areas identified by signs or postings.
2. Containment devices, engineering controls (e.g., fume hoods) and personal protective equipment (e.g., gloves, lab coat, and eye protection) MUST be used when handling these hazardous substances.
3. Safe handling/waste containment procedures must either be:
    a. in accordance with UTSA's SOP for PHS/High-Risk Substances or

   b. especially highly hazardous materials must be addressed in a specific SOP and MUST be approved by the CSC prior to purchase. Decontamination procedures and first-aid measures MUST be described in the SOP and strictly followed.

4. Only laboratory personnel trained to work with these substances may perform the work, and always within the designated area. Prior approval is required by the Principal Investigator, Lab Manager or Lab Supervisor.
5. Only the minimum feasible quantity of the material should be used.

4. Storage

These materials must be stored in areas designated for PHS/High-Risk Substances. These areas should be clearly marked with the appropriate hazard warning signs.

All material containers (even if the material is in very small quantities such as 0.1%) must be clearly labeled with the chemical name or mixture components. Containers must be labeled with the appropriate GHS hazard warning information.

Chemical storage areas must be secured to avoid spills or broken containers.

For chemicals requiring prior CSC approval, storage areas or laboratory rooms must be locked when laboratory personnel are not present.

5. Recognition of potential exposure

Personnel working with PHS/High-Risk chemicals should be familiar with the signs and symptoms of potential exposure, which shall be documented in their training.

Signs for exposure to PHS/High-Risk substances can include:

1. **Skin Absorption:** itching, redness, burns, blisters, rash/hives
2. **Ingestion:** abdominal pain, nausea, vomiting, diarrhea, a warm sensation in the stomach (halogenated hydrocarbons), dark-colored (black water) urine (arsenic), dehydration
3. **Inhalation**: drowsiness, dizziness/vertigo, headache, confusion/lethargy, clear drainage from nose, cough, dry/scratching/burning, throat, blurred vision, shortness of breath, rapid breathing (tachypnea), rapid heart rate (tachycardia)
4. **Eye Contact:** redness of the eyes, burning sensation in eyes, constant tear production, mucous discharge from tear ducts, blurred vision/blindness (partial or complete)

CHEMICAL STORAGE, SEGREGATION, AND HANDLING

Each laboratory should develop safe chemical storage and segregation procedures based on general and specific hazards presented by the chemical inventory on hand. Consult the specific Safety Data Sheet (SDS) when doubts arise concerning specific chemical properties, safe handling, and associated hazards. All laboratory personnel should receive general lab-specific training before handling hazardous chemicals. All storage and handling procedures must comply with Fire Code, building code regulations (National Fire Protection Association (NFPA) 1, 101, 30, 45, 55, and 400, as applied by the Texas State Fire Marshal's Office, and International Fire Code, as adopted by the city of San Antonio, for the purposes of tactical firefighting only). Additionally, secondary containment is required due to the unique location of UTSA above the Edwards Aquifer recharge zone.

GENERAL RECOMMENDATIONS FOR SAFE STORAGE OF CHEMICALS

Each chemical in the laboratory should have a designated location and should be returned to that location after each use. Acceptable chemical storage locations may include corrosive cabinets, flammable cabinets, laboratory shelving and or wooden cabinets, appropriate refrigerators, or freezers. Freezers should be defrosted periodically so that chemicals do not become trapped in ice formations.

Fume hoods, biosafety cabinets, bench tops, cabinets under sinks, and the floor are not long-term storage locations for chemicals. Hazardous or corrosive liquids should never be stored above eye level. Store chemicals that are highly toxic or extremely corrosive in a secondary unbreakable container. Chemicals must be stored at an appropriate temperature and humidity level, away from heat and electrical sources, and should never be exposed to direct sunlight for long periods of time. Chemical containers that are not in use must be tightly capped to prevent nuisance smells and adverse reactions. Whenever possible, chemicals should be kept in their original container. If a chemical is transferred to a secondary container, it must be labeled based on the Globally Harmonized System (GHS) label requirements. Expired or contaminated chemicals should be submitted to Hazardous Waste for disposal. Unwanted or unused chemicals should be entered in the Chem Swap program at UTSA (for more details regarding the Chem Swap program please contact the CHO at x6149).

Hazard Class of Chemical	Recommended Storage Method	Incompatibilities
Compressed Gas cylinders 	Store in a cool, dry area. Securely strap or chain cylinders to a wall or secure within cylinder floor stand. Lab benches must be rendered immobile before clamping cylinder to it.	Refer to the section on compressed gas cylinders for more detail on storage and handling requirements.

Corrosives – Acids 	Store separately in acid storage cabinet. Segregate oxidizing acids (i.e., Chromic, nitric*, sulfuric, and perchloric acids) from organic acids.	Flammable liquids, flammable solids, bases, oxidizers
Corrosives – Bases 	Store in separate corrosive storage cabinet. Store solutions of inorganic hydroxides in labeled polyethylene containers.	Flammable liquids, oxidizers, poisons, and acids
Flammable Liquids 	Store in flammable storage cabinet and away from sources of ignition. Store highly volatile flammable liquids in a fire or explosion proof refrigerator.	Acids, bases, oxidizers, toxins, and poisons
Flammable Solids 	Store in a separate dry, cool area away from oxidizers, corrosives, flammable liquids	Acids, bases, oxidizers, toxins, and poisons
General Chemicals - non-reactive 	Store on general laboratory shelving preferably behind glass doors and below eye level if space permits.	See specific SDS.
Oxidizers 	Store in a spill tray inside a chemical storage cabinet. Separate from flammable and combustible materials.	Separate from reducing agents, flammables, and combustibles.
Poisons/Toxic Compounds 	Store separately in vented, cool, dry area, in unbreakable chemically resistant secondary containers and in accordance with the hazardous nature of the chemical.	Flammable liquids, acids, bases, and oxidizers. See specific SDS.
Carcinogens 	Label all containers as "Cancer Suspect Agents". Store according to the hazardous nature of the chemical, using appropriate security when necessary.	See specific SDS.
Peroxide-Forming Chemicals 	Store in air-tight containers in a dark, cool, dry area.	See specific SDS.
Strong Reducing Agents 	Store in cool, dry, well-ventilated location. Water reactive. Segregate from **all** other chemicals.	See specific SDS.

Table 7. General chemical storage guidance.

CHEMICAL SEGREGATION

In addition to chemical storage requirements based on hazard class, certain chemicals and classes of chemicals should never be stored together. Table 4 provides a list of commonly used chemicals in research laboratories and their respective incompatible chemical. Chemical hazardous waste containing these chemicals should also be segregated to avoid adverse and potentially hazardous reactions. Chemicals in column A should not be stored, packaged, or handled in the same area as chemicals in Column B. Refer to the SDS for specific hazards upon contact.

CHEMICAL (COLUMN A)	KEEP OUT OF CONTACT WITH (COLUMN B):
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetic anhydride	Hydroxyl-containing compounds such as ethylene glycol, perchloric acid
Acetone	Concentrated nitric and sulfuric acid mixtures, hydrogen peroxide
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali and alkaline earth metals such as powdered magnesium, sodium, potassium	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury, halogens, calcium hypochlorite, hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids, heavy metals and their salts, oxidizing agents
Calcium oxide	Water
Carbon, activated	All oxidizing agents, calcium hypochlorite
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible material
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Chromic acid and chromium trioxide	Acetic acid, alcohol, camphor, glycerol, naphthalene, flammable liquids in general
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids

Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens, other oxidizing agents
Fluorine	All other chemicals
Hydrides	Water
Hydrocarbons (e.g., butane, propane, benzene)	Fluorine, chlorine, bromine, chromic acid, peroxides
Hydrocyanic acid	Nitric acid, alkalis
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, any flammable liquid (i.e., alcohols, acetone), combustible materials, aniline, nitromethane
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Metal hydrides	Acids, water
Nitrates	Acids
Nitric acid (concentrated)	Acetic acid, acetone, alcohol, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Mercury and silver and their salts
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, alcohol, bismuth, paper, wood, grease, oils
Permanganates	Concentrated sulfuric acid, glycerol, ethylene glycol, benzaldehyde
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus, white	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids, ammonium salts, metal powders, sulfur, finely divided organics, combustibles
Potassium perchlorate (see also chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid

Silver and silver salts	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, other chlorinated hydrocarbons, water
Sodium nitrate	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids

Table 8. Incompatible chemicals (*Adapted from Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, National Research Council, 1995, with additions from OHSA*)

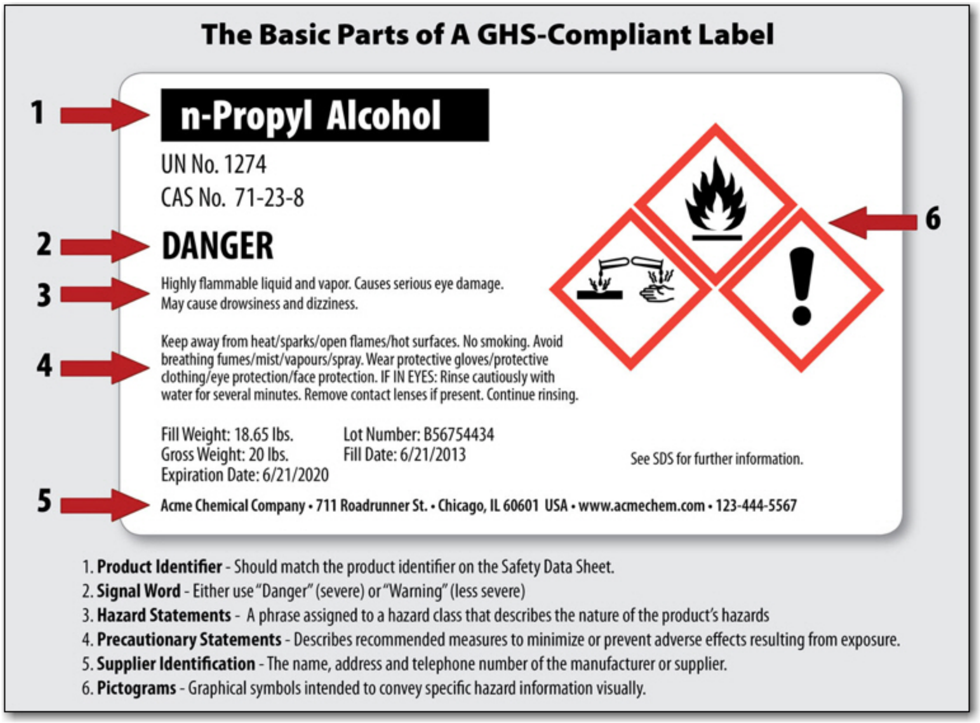
CHEMICAL LABELING REQUIREMENTS

With few exceptions, chemical containers and secondary media bottles used and stored in research laboratories at UTSA must be properly labeled based on GHS and OSHA standards to identify their contents and associated hazards. Proper chemical labeling and storage is essential for a safe laboratory work environment and is a requirement under the Texas Hazard Communication Plan. Inappropriate storage of incompatible or unknown chemicals can lead to spontaneous fire and explosions with the associated release of toxic gases. Proper labeling facilitates quick decision-making and action in the event of an emergency (i.e., spillage, exposure, etc.), especially in the absence of laboratory personnel. Proper labeling also avoids the expense associated with handling, management, testing and subsequent disposal of unknown chemicals. With a few exceptions, labels can be directly printed from the chemical inventory in ChemTracker by selecting the chemical name or CAS Number.

GENERAL GUIDELINES

Manufacturer chemical labels must never be removed or defaced until the chemical is completely used. If an original manufacturer's bottle is to be repurposed, the original label must be completely defaced or removed, and a new label should be put in its place identifying the chemical or mixture within. Small containers and vials that are difficult to label may be numbered, lettered, or coded if an associated log is available that identifies the chemical constituents. Groups of small containers vials and Eppendorf tubes maybe labeled as a group and stored together. Original chemical containers should be labeled with the "date received" and "date opened". All chemical and waste containers must be clearly labeled with the full chemical name(s) (no abbreviations or formulas) and must contain appropriate hazard warning information. Storage areas for hazardous materials like refrigerators, and cabinets should be labeled to identify the hazardous nature of the chemicals stored within the area (e.g., flammables, corrosives, oxidizers, water reactive, toxics and carcinogens).

GHS COMPLIANT LABELING



The Basic Parts of A GHS-Compliant Label

n-Propyl Alcohol

UN No. 1274

CAS No. 71-23-8

DANGER

Highly flammable liquid and vapor. Causes serious eye damage. May cause drowsiness and dizziness.

Keep away from heat/sparks/open flames/hot surfaces. No smoking. Avoid breathing fumes/mist/vapours/spray. Wear protective gloves/protective clothing/eye protection/face protection. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present. Continue rinsing.

Fill Weight: 18.65 lbs.
Gross Weight: 20 lbs.
Expiration Date: 6/21/2020

Lot Number: B56754434
Fill Date: 6/21/2013

See SDS for further information.

Acme Chemical Company • 711 Roadrunner St. • Chicago, IL 60601 USA • www.acmechem.com • 123-444-5567

1. **Product Identifier** - Should match the product identifier on the Safety Data Sheet.
2. **Signal Word** - Either use "Danger" (severe) or "Warning" (less severe)
3. **Hazard Statements** - A phrase assigned to a hazard class that describes the nature of the product's hazards
4. **Precautionary Statements** - Describes recommended measures to minimize or prevent adverse effects resulting from exposure.
5. **Supplier Identification** - The name, address and telephone number of the manufacturer or supplier.
6. **Pictograms** - Graphical symbols intended to convey specific hazard information visually.

Figure 3. Elements of a GHS compliant label.

The standardized label elements included are:

1. Product Identifier (ingredient disclosure): Name or number used for a hazardous product on a label or in the SDS. The GHS label for a substance should include the chemical identity of the substance. For mixtures, the label includes the chemical identities of all ingredients that contribute to acute toxicity, skin corrosion or serious eye damage, germ cell mutagenicity, carcinogenicity, reproductive toxicity, skin or respiratory sensitization, or Specific Target Organ Toxicity (STOT).

2. Signal Words: "Danger" or "Warning" emphasizes hazards and indicates the relative level of severity of the hazard assigned to a GHS hazard class and category. Some lower-level hazard categories do not use signal words. Only one signal word corresponding to the class of the most severe hazard is used on a label.

3. GHS Hazard Statement: Standard phrases assigned to a hazard class and category that describe the nature of the hazard. An appropriate statement for each GHS hazard is included on the label for products possessing more than one hazard.

4. GHS Precautionary Statements: Measures to minimize or prevent adverse effects. There are four types of precautionary statements covering prevention, response in cases of accidental spillage or exposure, storage, and disposal. The precautionary statements are linked to each GHS hazard statement and type of hazard.

5. Supplier Identification: The name, address, and telephone number is provided on the label.

6. Pictograms: Convey health, physical, and environmental hazards information assigned to a GHS hazard class and category. All applicable pictograms should appear on the label.

7. Supplemental Information: Non-harmonized information on the container of a hazardous product that is not required or specified under the GHS. Supplemental information provides further detail that does not contradict or cast doubt on the validity of the standardized hazard information.

   Detailed regulations and standards can be found within the following documents of the United States Occupational Safety and Health Administration (OSHA):
   - Hazard Communication (29 CFR 1910.1200)
   - Occupational Exposure to Hazardous Chemicals in Laboratories (29 CFR 1910.1450)

HYDROFLUORIC ACID

Hydrofluoric acid (HF) is an extremely corrosive material. All forms, including vapors and solutions, can cause severe, slow-healing burns to human tissue, including the lungs and eyes. At concentrations greater than 50% the burning is noticeable in a matter of minutes or less, while at concentrations below 50% the burns may not be felt until several hours after exposure. Burns from concentrated acid involving as little as 2.5% of body surface have resulted in death. Because it has a low boiling point and a high vapor pressure, HF must be kept in a non-glass pressure container. HF dissolves glass: therefore, it should never be stored in a glass container.

Follow these guidelines for the proper use of hydrofluoric acid in the laboratory:

1. Have calcium gluconate available prior to acquiring or working with HF. Contact the Laboratory Safety Division x6419 to obtain calcium gluconate.

2. Never work alone with HF.

3. Always use HF in a properly functioning fume hood. Heating of HF, or its solutions, requires an acid digestion fume hood.

4. In work involving HF, be sure to use materials that are compatible with HF. HF attacks a variety of materials, including glass, concrete, cast iron, wood, leather and rubber. Lead, wax, polyethylene, polypropylene and Teflon will resist its corrosive action.

5. In HF exposures, time is crucial. Immediately wash the affected area(s) with copious amounts of water to minimize the extent and the depth of the burn. Never let a HF burn go untreated, as extensive damage could result. Any area that is exposed to HF must be treated immediately with calcium gluconate or another appropriate material to stop its reaction with human tissue. Seek medical attention as quickly as possible. Ensure medical personnel are aware that HF is involved. Mistakes in

treatment can occur if a miscommunication results in treatment for a hydrochloric acid burn instead of a hydrofluoric acid burn.

MERCURY

Mercury and its compounds are very common in laboratories. Elemental mercury is volatile, and its vapors are extremely toxic. Because of the vapors' high toxicity, it is very important to clean up mercury spills promptly and thoroughly. If this is not done, mercury can accumulate and vaporize over time. Inorganic and organic mercury compounds are also highly toxic, more so than elemental mercury, and should be handled with care.

Follow these guidelines for the proper use of mercury in the laboratory:

1. All work with elemental mercury should be performed over trays to capture and contain any spillage.
2. All work involving mercury should be done in a properly functioning chemical fume hood.
3. Clean up all mercury spills immediately. If you do not have the appropriate spill-control equipment, do not clean the spill yourself, as you can make the situation worse by creating small droplets that can end up in inaccessible locations such as cracks and crevices. For assistance, contact Laboratory Safety Division x6419.
4. Be careful not to heat any surfaces that may contain mercury residue, as increased temperature greatly increases the vapor pressure of mercury.
5. Red spirit thermometers are a nontoxic alternative to mercury thermometers and should be used whenever possible.

DRY PICRIC ACID

Picric acid (trinitrophenol) must be stored hydrated as it becomes increasingly unstable when dehydrated. Dry picric acid is not only explosive but also sensitive to shock, heat, and friction. Picric acid is highly reactive with a wide variety of compounds (including many metals) and is extremely susceptible to the formation of picrate salts. Be sure to label all containers that contain picric acid with the date received, and then monitor the water content every 6 months. Add distilled water as needed to maintain a consistent liquid volume. If picric acid is identified and has not previously been accounted for or regularly checked, do not handle the bottle. Perform a visual inspection only and note any crystallization, signs of evaporation, or the formation of solids in the bottle. Do not handle the container and then immediately call Laboratory Safety at x8515. Restrict access to the area where the bottle is located and wait for Laboratory Safety personnel to evaluate the container. <u>Under no circumstances should laboratory personnel attempt to dispose of, or handle, dry picric acid.</u>

CONTROLLED SUBSTANCES

For guidance on the storage and handling requirements for controlled substances please refer to the UTSA Controlled Substances Policy.

PEROXIDE FORMING AND TIME SENSITIVE CHEMICALS

INTRODUCTION

A variety of organic chemicals can react with oxygen in air to form peroxide derivatives. Over time, these peroxides accumulate in the parent solution. A low concentration these solvents are generally safe to handle; but high levels of peroxides pose additional reactivity hazards that are not present in the original solvent. Distillation or rotary evaporation further concentrates the peroxides and significantly increases the dangerous explosion hazards of some solid organic peroxides. If peroxide levels are allowed to increase to the point of crystallization, or if the parent solvent is evaporated to dryness, the resulting peroxide crystals can violently explode when subjected to heat, friction, or mechanical shock.

A much smaller number of chemicals can peroxidize and explode without evaporation of the parent material. These compounds can potentially spontaneously explode 'on the shelf' but are more likely to detonate during handling of the chemical container. Diisopropyl ether is most notorious in this regard.

Commercially available solvents with a high propensity for peroxidation often have trace amounts of an inhibitor, such as butylated hydroxy toluene (BHT), added to slow the formation of peroxides.

BHT suppresses an increase in the concentration of peroxides in each solvent. However, BHT (or other inhibitor in the solvent) is consumed in this process, and over time, can become depleted, leaving the solvent vulnerable to peroxide formation.

Researchers who handle peroxidizable compounds must learn to handle these materials safely. Any work involving peroxidizable solvents, especially large-scale experiments, require a laboratory specific SOP and documented training. Safe handling practices and procedures involve consideration of alternative, less hazardous solvents, making effective purchasing decisions, implementing a storage control program, periodic testing for peroxides, labeling and dating of manufacturer containers, and proper remediation and disposal of hazardous containers. The elements of safe practices and procedures are described below.

IDENTIFICATION OF PEROXIDIZABLE SOLVENTS

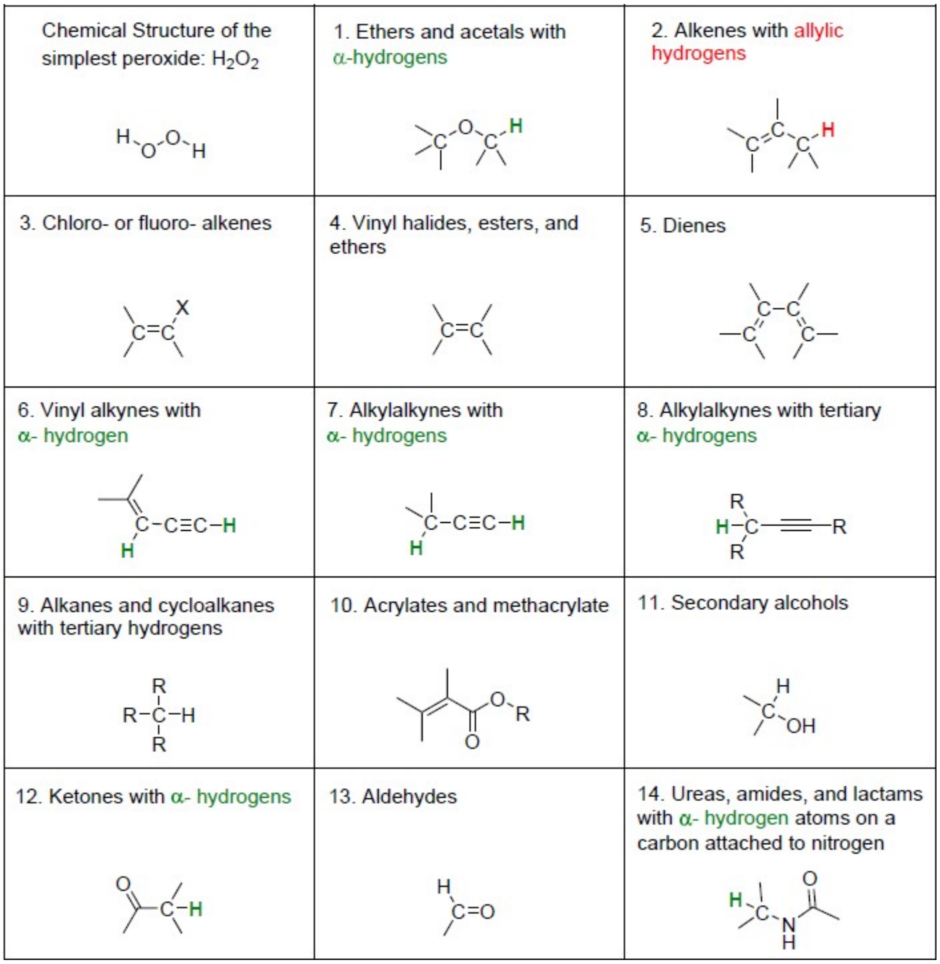
Peroxidation of organic materials is normally attributed only to liquid substances. The risk of peroxide accumulation associated with compressed gases (e.g., butadiene, tetrafluoroethylene, vinylacetylene, and vinyl chloride) is minimal if safe handling practices are observed. The risk of violent decomposition increases if these gases are allowed to condense or encounter oxygen during transfer to the secondary vessel.

The molecular structure of the parent compound is generally considered the determining factor in a solvents auto-oxidation potential.

Peroxide-forming compounds always contain an easily abstracted hydrogen atom that is activated by adjacent structural components.

- Ethers and acetals with an alpha-hydrogen, especially cyclic ethers and those containing primary and secondary alkyl groups
- Compounds containing benzylic hydrogens
- Compounds containing allylic hydrogens, including most alkene; vinyl and vinylidene compounds; and dienes

The below Table shows some common structures that may support peroxidation. in decreasing order of reactivity



Chemical Structure of the simplest peroxide: H_2O_2	1. Ethers and acetals with α-hydrogens	2. Alkenes with allylic hydrogens
3. Chloro- or fluoro- alkenes	4. Vinyl halides, esters, and ethers	5. Dienes
6. Vinyl alkynes with α- hydrogen	7. Alkylalkynes with α- hydrogens	8. Alkylalkynes with tertiary α- hydrogens
9. Alkanes and cycloalkanes with tertiary hydrogens	10. Acrylates and methacrylate	11. Secondary alcohols
12. Ketones with α- hydrogens	13. Aldehydes	14. Ureas, amides, and lactams with α- hydrogen atoms on a carbon attached to nitrogen

Table 9. Chemical moieties prone to peroxide formation (https://safetyservices.ucdavis.edu/safetynet/peroxide-formation-chemicals)

Not all compounds containing these groups will form peroxides. However, the presence of any of these groups in a compound should serve as an indicator that the potential of peroxide formation exists. Chemical structures of low molecular weight that include more than one of these groups are at particular risk of peroxidation. Other factors that affect rate of peroxide formation include exposure to air, light and heat, moisture, and contamination from metals.

CLASSES OF PEROXIDE FORMERS

Different peroxidizable chemicals tend to form dangerous levels of peroxides at varying rates and under different conditions. For some materials the concentration of peroxide reaches dangerous, shock sensitive levels, without concentration. Other compounds do not usually accumulate potentially explosive concentrations of peroxides unless the volatile organic material is reduced in volume--i.e., through incidental evaporation or distillation.

Peroxide forming compounds fall under one of three classes.

CLASS	DESCRIPTION	EXAMPLES
CLASS A	**Chemicals that may form explosive levels of peroxides even if unopened and without concentration.** • Discard 3 months after opening or at expiration date. • Do not test if suspected (e.g., from visual evidence) or known to contain peroxides. • Purchase minimal feasible quantity**.**	Diisopropyl ether Divinyl ether Divinyl acetylene
CLASS B	**Chemicals that form explosive levels of peroxides after concentration**. • Peroxide hazard dependent on concentration; do not distill or evaporate without first testing for the presence of peroxides • Test for peroxide formation annually after opening and prior to concentration. • Test monthly after recommended shelf life has been reached or chemical has expired. • Reduce peroxide levels if > 400ppm • Test and reduce peroxide levels prior to disposal.	Tetrahydrofuran Dioxanes Diethyl ether
CLASS C	**Chemicals that may auto-polymerize because of peroxide formation.** These materials are typically stored with polymerization inhibitors to prevent the polymerization reactions. **For inhibited chemicals:** • Test for peroxide formation every 12 months after opening and reduce peroxides if present or discard. • Test peroxide levels prior to discarding. • Do not store inhibited chemicals under inert atmosphere. The inhibitor often requires small amounts of Oxygen to be effective.	Styrene Methyl methacrylate Vinyl chloride

	Uninhibited chemicals should be used or disposed of promptly.	

Table 10. Classes of peroxide forming chemicals with examples.

Conventionally, peroxide forming chemicals are classified by their susceptibility to peroxide formation, or the potential to violently polymerize and anecdotal evidence of laboratory and industrial accidents.

For example, more than a few incidents involving violent explosions when distilling peroxidized 2-propanol (Isopropyl Alcohol) have been reported and documented over the years. This has led to the addition of most secondary alcohols to the list of peroxide formers in group B (explosive if concentrated)

Another example is the addition of styrene (vinylbenzene,), to the list of dangerous auto-polymerizing substances. Styrene is a water-reactive, aromatic monomer that readily undergoes polymerization when exposed to heat, UV-light, or a peroxide catalyst. Billions of pounds of the monomer are produced each year to manufacture consumer products, polystyrene plastics and resins. Numerous incidents with destructive and deadly outcomes are reported due to peroxide initiated auto-polymerization of industrial storage amounts (cubic meters & metric tons).

In University research laboratories, quantities do generally not exceed 2.5 Liter of Styrene. Violent polymerization is still a possibility, but the destructive force is greatly diminished

It is important to note that this chemical is dangerously reactive, toxic by inhalation and responsible for many deaths and therefore should not be treated carelessly, and all storage, labeling and disposal recommendations must be followed when working with this chemical.

However, in this case, purchase control is the far superior approach to hazard mitigation. The smallest quantity feasible should be purchased, and the container immediately upon opening dated with a disposal date to avoid costly remediation, spill cleanup or testing supplies.

Shelf life (before significant peroxidation occurs), and the resulting products vary widely between compounds and storage conditions. The recommended maximum shelf life for each group is based upon time after opening the container and is conditioned on the premise that the compounds are properly stored, and all manufacturer storage recommendations are followed. Containers of susceptible solvents are normally supplied with an antioxidant or free-radical scavenger. These inhibitors can slow, but not prevent peroxide formation. Therefore, when using these peroxide-forming reagents, it is critical to include procedures to guard against unanticipated result.

PURCHASING

Ideally, purchases of peroxidizable chemicals should be evaluated to ensure that these chemicals are used up completely before peroxides can form. This requires careful experiment planning on behalf of researchers. Researchers should purchase no more material than is needed to complete an experiment within the chemical's safe shelf life. Interestingly, peroxides can form prior to the stipulated expiration or shelf-life of the compound and thus testing should be done routinely to ensure the safety of the researcher(s) using these compounds.

PREVENTING FORMATION OF PEROXIDES

The following practices will help prevent formation of peroxide formers:

- Store Peroxide formers in a cool, dark place. Light (and heat) can accelerate the oxidation reactions responsible for peroxide formation.
- Some solvents especially unstabilized, will accumulate peroxide levels after only a few times of opening the container to the atmosphere. This is especially a concern with unstabilized solvents or solvent that had their inhibiter removed or depleted. It is advisable to flush containers with inert Nitrogen or Argon to remove oxygen present in the headspace of opened containers.
- Important Note: Refrigeration will not reliably stop peroxidation and could even increase the explosion risk if the peroxide crystallizes in the cold solvent.
- Keep containers tightly sealed. Container lids that are either overtightened and uneven or too loose allow oxygen to enter the container and form crystals under the cap that may detonate when cap is unscrewed. Wrap the closed lid and container of solvents in storage with 2-3 layers of ParaFilm
- Keep containers free of common contaminants like dust and NEVER return unused quantities to the original container. Contaminants can contain metals that may facilitate the auto-oxidation process.
- Purchase only chemicals which contain an inhibitor (if feasible) and only quantities that will be used before the expiration date
- Inhibitors will become depleted over time and must not be relied upon to provide indefinite protection.

LABELING PEROXIDE FORMING SOLVENTS

All containers of Peroxide formers should be labeled with the following information (see below for examples):

- The date received
- The dated opened
- The expiration dates
- The presence of inhibitor (if added after opening)
- The date tested and quantity of peroxide (if applicable)

Appendix A provides a printable version of these labels fitted to AVERY 4467 template or available from Lab Safety upon request.

DISTILLING PEROXIDE FORMERS

Distillation of solvents is often performed to remove water, oxygen, and residual impurities.

Due to the hazards posed by distillation in general – and Peroxide formers specifically – this is becoming less common. Column purification systems are replacing stills in many labs. However, if distillation is required, there are methods to increase the safety. When preparing to distill or evaporate compounds identified as peroxide formers.

Always test for peroxides first, using a method as described below (never distill a solvent that shows >50ppm peroxide levels

Never distill to dryness. At least 20% of solvent should remain at the bottom of the still. The addition of mineral oil, or similar non-volatile organic compound, can dilute the peroxides that may be formed in the distillation pot.

Add small pieces of sodium metal to the distillation vessel to reduce peroxides that form.

Use benzophenone as an indicator for the presence of sodium metal. Benzophenone, in the presence of sodium metal, forms a radical with a deep-blue color. When the blue color disappears, add more sodium metal.

⚠

Distillation will remove inhibitors and stabilizers from the solvent

VISUAL INSPECTION

All containers should be carefully examined for their overall condition. Containers that show signs of oxidation (e.g., rusty container or cap) or are stored longer than recommended shelf life should be handled with extreme caution. The first step in determining the presence of unwanted peroxides for any substance is a visual inspection of the container without moving or disturbing its contents.

Use a flashlight to check for any phase changes in amber glass bottles before disturbing the contents.

Visual Inspection:

A. Liquid Chemicals

- Crystallization (around the cap or in the liquid)
- Visible discoloration

- Liquid stratification

Note: Diethyl ether is commonly sold in steel containers which prevents visual inspection of the liquid. Therefore, diethyl ether containers whose age and use history are unknown should be assumed to contain dangerous levels of peroxides and should not be disturbed.

B. Solid Chemicals (potassium metal, potassium and sodium amide)

- Discoloration and/or formation of a thick surface crust (for example, potassium metal forms a yellow or orange superoxide at the surface)

Note: Evaluation of alkali metals and their amides is based on visual criteria only. These substances react strongly with water and oxygen, and standard peroxide tests must never be used.

Materials meeting the above criteria are high risk and will have to be disposed of by special means (limit handling and movement; notify Lab Safety). Only chemicals that pass visual inspection should be evaluated further.

While chemicals that are still within the shelf life are usually safe for normal operations it is still highly recommended that Peroxide formers be tested prior to any procedure that can lead to concentration, such as distillations.

If Levels above 800-1000ppm are suspected the chemical is considered too hazardous to attempt cleaning.

TESTING PEROXIDE-FORMING AGENTS

A. Institutional Requirements

Establishing a testing regime for peroxide forming chemicals is a time consuming but necessary task. All researchers working with or storing quantities of peroxide forming agents **of 1 liter or more** must develop a regular testing protocol and document the results of each test.

- Testing of unexpired Peroxidizable solvents must be conducted at minimum every 12 months after opening and before concentration or distillation.
- Solvents that are stored and unopened for 2+ years after receiving must be discarded, used, or entered into the CHEMSWAP program before additional solvent of this chemical is purchased.
- Any chemicals that have expired or are past the manufactures recommended storage date must be tested for peroxide levels every 3 months or tested once and submitted as Hazardous Waste.

When testing for peroxides, a 100-ppm upper limit is an acceptable level for peroxides in a solvent in storage but may lead to failed experiments if used with sensitive chemicals.

B. Testing Methods

By far the easiest method is using simple dip strips such as Quantofix® Peroxide test sticks available either from lab safety or through numerous vendors. These are inexpensive color-indicating strips which turn different shades of blue depending on the concentration.

1. Peroxide test strips and incubator paper

The presence of organic peroxide in chemicals can be tested with simple starch-iodide indicator paper p. starch iodide paper is sensitive to peroxide concentration below 100 ppm. Low concentration of peroxide present in chemicals turns the paper yellow whereas, high concentration of peroxide turns the paper blue. This test is sensitive to the formation of hydroperoxide which is the principal hazard associated with peroxide-forming solvent

- Immerse the test strip in the chemical for 1 second (Do not use metal tweezers)
- Breathe slowly on the test strip for 15 to 30 seconds or until the color stabilizes (vapor in your breath provides water for the reaction to proceed)
- A yellow color indicates a low concentration of peroxide in the sample while blue color indicates a high concentration.

2. Quantofix® Peroxide Test Strips

(Product Nos. Z249254 and Z101680)
In the presence of hydrogen peroxide the test paper turns blue. Quantofix® Peroxide test sticks can also be used for the determination of peracetic acid and other organic and inorganic hydroperoxides. To test for hydroperoxides in organic solvents, the test zone is wetted with one drop of water after evaporation of the solvent.

- Interferences: In the pH range of 2-9, the accuracy of the determination is independent of the pH of the test solution. Buffer strongly acidic solutions with sodium acetate and adjust alkaline solutions to about pH 5-7 with citric acid. Falsely positive results can only be caused by strong oxidizing agents.
- Storage: Avoid exposing the sticks to sunlight and moisture. Store unopened packs in refrigerator (+2 °C to +8 °C). Opened packs: store container in a cool and dry place. Detailed Instructions can be found in Appendix I

3. Iodine Peroxide Test

Add 0.5–1.0 ml of the liquid to be tested to approximately the same volume of glacial acetic acid to which 0.1 g of sodium iodide (NaI) or potassium iodide (KI) crystals have been added.

- Yellow color indicates a low concentration of peroxides in the sample.
- Brown color indicates a high concentration.

A blank determination should also be performed. Always prepare a fresh new solution of iodide/glacial acetic acid before use, as it will be seen that after a while the blank sample will be brown due to air oxidation.

4. Ferric thiocyanate test for peroxides

One drop of the solution to be tested is mixed with one drop of reagent solution.
A pink or red color indicates the presence of peroxides.

- Reagent solution:9 g of iron (II) sulfate heptahydrate ($FeSO_4 \cdot 7H2O$) in 50ml of 18% hydrochloric acid (HCl). Add 0.5–1.0g of granulated zinc (Zn), followed by 5g of sodium thiocyanate (NaSCN).
- After the transient red color has disappeared, add an additional 12 – 13g of sodium thiocyanate (NaSCN). Decant the solution from the unused zinc (Zn) into a clean bottle.

REMOVING PEROXIDES FROM SOLVENTS

In some cases, it might be desirable to remove peroxides from chemicals rather than dispose of the entire chemical. This can be done safely for relatively low levels of peroxides (less than 800 to 1000 ppm). Scrubbing of concentrations greater than 1000 ppm may pose an unacceptable hazard, depending on the chemical involved. Scrubbing of discolored, crystallized, or layered peroxide formers is almost certainly too hazardous and must not be attempted. These severely peroxidized compounds should be treated as potential bombs.

A. Method 1 – Not reliable for removing alkyl peroxides

Hydroperoxides can be removed by passing the solvent through a column of activated alumina. This method works for water-soluble and water-insoluble chemicals.

The washed solvent should be retested to ensure that it has been cleaned adequately. The alumina catalyzes the degradation of some peroxides, but in some cases the peroxide may remain intact on the alumina, making it potentially shock sensitive. The alumina can be deactivated by flushing with a dilute acid solution of potassium iodide or ferrous sulfate (below) The amount of alumina required depends on the quantity of peroxide.

A column containing 100 g of alumina is sufficient to clean 100 mL of solvent. Additional alumina or passage through a second column may be required to eliminate residual peroxides.

B. Method 2

Peroxides in water-insoluble chemicals can be removed by shaking with a concentrated solution of ferrous salt; 60 g $FeSO_4$, 6 mL concentrated H_2SO_4, and 110-mL water are a standard solution. Another formulation is 100 g $FeSO_4$, 42 mL concentrated HCl, and 85 mL water. The peroxide former is extracted two to three times with an equal volume of the reagent. Drying over sodium sulfate or magnesium sulfate can be used to remove dissolved water. Shaking should be very gentle for the first extraction. This method has been shown repeatedly to be quite effective for most peroxides, but it is not reliable for removing alkyl peroxides.

C. Method 3

Blue-indicating molecular sieve (4–8 mesh, type 4A) is added to containers of peroxidized chemicals and allowed to sit for 1—30 days. An amount equivalent to about 5%—10% (wt/vol) of the peroxidized liquid is used.

Alternatively, the mixture can be refluxed, and the reaction occurs within 4 hours. The peroxide is broken down, and the indicator in the sieve is consumed. When run at room temperature, this process is apparently safe, slow, and controlled. Dialkyl peroxides are not efficiently removed, especially from dioxane. This method may be particularly suited to treatment of THF, diisopropyl ethers, and diethyl ethers, which may be decontaminated at room temperature in a couple of days. Other methods for removing higher peroxides including dialkyl peroxides in one suggested procedure, a 10% molar excess of sodium or potassium iodide is dissolved in 70 mL glacial acetic acid. A small quantity of 36% (wt/vol) HCl is added, followed by 0.01 mol of the dialkyl peroxide. The solution is heated to 90°C—100°C on a steam bath over the course of 30 minutes and held at that temperature for 5 hours. Zinc dissolved in acetic or hydrochloric acid has been recommended. Prolonged treatment with ferrous sulfate in 50% sulfuric acid has also been recommended.

REFERENCES

For additional information about peroxides and peroxide-forming chemicals, refer to NFPA 43B

EMERGENCY RESPONSE

Laboratories can pose several hazards to personnel and each laboratory should be prepared in the event of an emergency such as serious injuries, fires, explosions, spills, and exposure to hazardous material. Procedures should be risk assessed by experienced personnel and any potential emergencies planned for. Before beginning work in any laboratory, personnel should know the location of the nearest spill kit, first aid kit, eyewash station, safety shower, fire extinguisher, and fire alarm pull station. Personnel should also be familiar with how to use all these items. Fire and Life Safety conduct regular training on the use of fire extinguishers and CPR and First Aid; all personnel are strongly encouraged to attend these training classes. Personnel can contact the Laboratory Safety Division at any time for assistance with an incident, including non-serious accidents or spills.

All emergencies requiring immediate response must be reported to UTSA PD (x4911)

Report accidents, exposures, and spills to the Senior Director of Laboratory Safety and Compliance at x8515 and Chemical Hygiene Officer x6419 (use after hours numbers listed in the emergency contacts table after 5pm and on weekends) as this enables the Laboratory Safety Division to ensure personnel receive any necessary assistance and follow up.

ACCIDENTS

In the event of accidents resulting in serious or life-threatening injury or at weekends / after normal working hours call UTSA PD at x4911. Minor injuries can be treated temporarily with First Aid Kit, and personnel should then contact Occupational Health at 210-458-4038 for further treatment and advice. To ensure the safety of all personnel in the laboratory each lab should have the following within easy access:

1. First Aid Kit (checked regularly to ensure it is fully stocked)

2. Posting of all emergency contact numbers (a contact list can be found in Appendix VI and printed for use by labs).

3. SDS readily available in case of accidents involving chemicals.

All accidents must be reported to the Laboratory Safety Division (210-458-8515) and any employee of UTSA who suffers an accidental injury or occupational disease that arises out of, and in the course and scope of, employment should notify his or her supervisor to complete a first report of injury or illness form https://www.utsa.edu/safety/#/workplace within 24 hours. Accurate reporting of accidents and near misses allows Laboratory Safety to develop any recommendations and corrective actions that could prevent future incidents. Near misses can be reported anonymously through a web form at http://research.utsa.edu/research-funding/safety-committees/.

FIRES

In the event of a fire:

If the fire is small (for example a small trash can), and it is safe to do so, an appropriate fire extinguisher or sand can be used. Do not use water to extinguish fires.

Immediately report the fire to Fire Prevention and Life Safety x4420 and the Chemical Hygiene Officer x6419.…

For all other fires

1. Pull the closest fire alarm pull station and immediately evacuate the area.
2. Immediately notify UTSA PD x4911. Have the following information available:
    a. Any injuries
    b. Location of the fire (building name, room number, location within the room)
    c. Potential explosion hazards present (e.g., gas cylinders or liquid nitrogen dewars)
    d. Your name and phone number
    e. The PIs name
3. Remain outside the affected area and notify first responders of the details of the incident.
4. If the fire alarm is sounding, you must evacuate the building. Do not re-enter until you are notified that it is safe to do so by the Fire Department.

1. Fires involving clothing

1. Go to the nearest available emergency shower.
2. If a shower is not available follow: **STOP, DROP** and **ROLL** until flames are extinguished.
3. Fire extinguishers can be used to extinguish fires on a person.
4. Immediately contact UTSA PD x4911 for emergency assistance.

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All fires must be reported to UTSA PD (x4911), the Laboratory Safety Division (x8515) and the UTSA Fire Marshall (x4420)

EXPOSURES AND INJURIES

1. Contact the Lab Safety Division between the hours of 8am and 5pm Monday through Friday to report exposures or injuries. After hours, contact UTSA Police Department x4911. The Lab Safety Division will file an incident report and follow-up documentation needed to continue providing support.

2. Students should seek treatment by the UTSA Student Health Services and will be referred to an external physician if further examination is required.

3. For any work-related exposure reported to a supervisor or in which a supervisor has knowledge, an incident report should be completed and submitted to the Occupational Health and WCI Coordinator (x5304 or x5250). An employer should keep record of the employee's medical surveillance to ensure WCI coverage should the exposure result in an injury or disease.

4. The laboratory supervisor or his/her representative should provide the physician with the identity of the chemicals, description of exposure conditions and symptoms, if any. The physician's opinion must be written and include any need for follow-up, results, any increased risk and a statement that the employee has been notified of the previous items.

5. Contact the Occupational Health & WCI Coordinator at x5304 or x5250 (faculty and staff).

6. UTSA provides medical surveillance under the direction of a licensed physician at no cost to the employee for work related injuries if:

    a. The employee exhibits signs or symptoms associated with exposure to a hazardous chemical used in the laboratory.

    b. A spill, leak, or explosion occurs resulting in the likelihood of a hazardous exposure.

A. Worker's compensation insurance (WCI) and reporting injuries or illness on the job

1. An employee of UTSA who suffers an accidental injury or occupational disease that arises out of, and in the course and scope of, employment should notify his or her supervisor to complete a first report of injury or illness form http://utsa.edu/safety/ within 24 hours. The WCI Coordinator will review the report to determine coverage under the WCI Program. If coverage is available, the employee is entitled to healthcare allowed according to the type of injury.

2. Injuries or chemical exposures that result in the hospitalization of 5 or more employees or the death of any one employee are to be reported to UTSA Police immediately. Police personnel will ensure proper authorities are notified.

3. UTSA will provide the following to injured employees:

    a. Notification of eligibility of coverage under worker's compensation insurance.

b. Arrangements for appropriate treatment in an emergency (Injured employees may select his or her own healthcare provider).

GENERAL CHEMICAL SPILL GUIDANCE

A quick response to spills is vital to mitigate the impact on personnel, property, and the environment. Laboratory personnel should not hesitate to contact the Laboratory Safety Division x6419 to report all spills, regardless of size and manageability. If the spill occurs after normal working hours, or on a weekend, contact UTSA PD x4911 who can then contact the Laboratory Safety Division.

All laboratories are required to have a Chemical Spill Kit readily available in the event of a spill.

Steps to prevent or minimize the risk of a spill:

1. Good housekeeping – maintain a tidy, organized workspace.
2. Perform a procedure review prior to conducting a new experimental procedure.
3. Store liquid chemicals in a secondary containment bin.
4. Keep reagent containers sealed or always closed, except when removing contents.
5. Order reagent chemicals in non-glass or coated glass containers whenever it is practical to do so.
6. Use secondary containment and carts when moving chemicals between locations.

SPILL KITS

All laboratories are required to have a chemical spill kit easily available to laboratory staff. Spill kits should be tailored to the specific hazards within the laboratory, and it is strongly recommended that disposable supplies are used, when possible, as contaminated materials, following a cleanup, will be considered hazardous waste. Spill kit contents should be held in a chemical-resistant container. PPE contained in the spill kit must be selected based on the hazardous materials used. Hazardous materials users should know where to locate the spill kit and how to use the spill response materials contained in the kit.

A. Basic spill kit supplies

1. Container

Obtain a chemical-resistant container to hold the kit contents such as a 5-gallon plastic bucket or Rubbermaid™ tub. It is recommended that an additional 5-gallon container be on hand that has a sealable lid.

2. Personal Protective Equipment

2 pairs chemical splash goggles.
2 pairs chemical-resistant gloves. Silver Shield®/4H® and thick nitrile or neoprene gloves are recommended.
2 pair plastic, vinyl or rubber shoe covers.
2 disposable lab coats, aprons, or coveralls.

3. Absorption Materials

Include universal absorbents such as commercial spill pads, pillows, spill socks, vermiculite, and other loose absorbents. Examples of commercial universal absorbents are MagicSorb™, Wyk® Safety Sorbent, 3M™ Chemical Sorbent, Chemsorb®, Pig® Absorbent Pads, or Hazorb®.

4. Cleanup tools and materials

1. Plastic scoop, dustpan, or shovel. Use plastic (polypropylene) when non-sparking tools are needed.
2. Plastic broom or brush for solids (polypropylene).
3. 3-5 thick, heavy duty waste bags. DO NOT use red biohazard waste bags for non-biohazard spill debris.
4. Cardboard box to hold waste bag containing spill debris.
5. Sealing tape.
6. EHS hazardous waste labels.
7. Forceps or tongs for picking up broken glass or other sharps.
8. Detergent or general cleaner for final cleanup.

5. Additional spill response items as necessary for your work area

1. Additional PPE such as face shields, chemical-resistant clothing, or boots.
2. Neutralizing agents
    a. General neutralizing agents for acids and bases
    b. Chemical-specific neutralizers such as those for formaldehyde
    c. Mercury spill response items
    d. Specialized supplies for air or water-reactive chemicals and hydrofluoric acid.
    e. Bleach, if biological agents are used.

Contact the Laboratory Safety Division x6419 if you would like assistance in building a spill kit appropriate for the hazards in your laboratory.

GENERAL SPILL GUIDANCE

For safe spill management it is important to determine if a spill is manageable by laboratory personnel or is unmanageable and requires assistance. Minor, manageable spills include small amounts of spilled material and non-hazardous substances that are easily contained with the supplies at hand. Major or unmanageable spills are never to be cleaned up by lab personnel.

Spill response plans should be prepared by each laboratory and form a part of the standard training in each laboratory. The Laboratory Safety Division x6419 is available to assist with the development of lab specific plans and any time an individual needs assistance managing an incident.

UNMANAGEABLE SPILLS: CALL 210-458-6419

There are several circumstances in which laboratory personnel should not attempt to handle a spill alone or without the assistance of Laboratory Safety or San Antonio Fire Department HAZMAT team. These include:

1. Any circumstance where the individual does not feel comfortable or sufficiently trained to manage the spill incident.
2. Spills greater than 500ml of any hazardous material (50ml of explosive and highly reactive chemicals).
3. Spills involving multiple or unknown chemicals.
4. Spills that are an immediate threat to lab personnel, students, the public, the environment or building infrastructure.
5. Spills that involve infectious agents, radioactive materials, corrosives, highly toxic or reactive chemicals.
6. Spills that show signs of reactivity (gas evolution, smoke, heat).
7. Leaking Gas Cylinders, venting either toxic, corrosive, oxidizing or flammable gasses
8. Spills that exceed the material or capacity of the in-lab spill kit or require additional PPE (self-contained breathing apparatus, respirator, or Hazmat Suit)
9. A spill that shows signs of unexpected reactivity (gas evolution, smoke, heat)
10. The spill may endanger the environment by reaching drains or outside ground
11. Circumstances where a minor spill was handled incorrectly, and the hazard increased.

A. Response to unmanageable spills

1. Evacuate the affected area and alert all others nearby to evacuate.
2. Remove any injured or contaminated persons if you can do so safely.
3. Contact UTSA PD (or 210 458 4911) and have following information on hand:
    a. Any injuries
    b. Location(s) of the spill (building name and room number(s))
    c. Name of the chemical(s) spilled

   d. Approximate quantity of the chemical(s) spilled

   e. Any fire or explosions hazards present

   f. Your name and phone number

4. Arrange for someone to meet the emergency responders.

5. Secure the area at a safe distance with signs and warning tape, or post staff in safe locations to prevent anyone from entering the affected area before the emergency responders arrive.

B. Emergency contacts for unmanageable spills

UTSA POLICE DEPARTMENT	210-458-4911 (from a cell phone or off campus phone) 4911 (from a university phone)
CHEMICAL HYGIENE OFFICER	210-458-6419(from a cell phone or off campus phone between 8am – 5pm) 6419 (from a university phone between 8am – 5pm) 210-415-5082 (after hours and weekends)
SR. DIRECTOR OF LABORATORY SAFETY	210-458-8515 (from a cell phone or off campus phone between 8am – 5pm) 8515 (from a university phone between 8am – 5pm) 210-294-3342 (after hours and weekends)

It is not recommended that lab personnel attempt cleanup of spills involving chemicals in Table 9 below without the assistance of Laboratory Safety. In the case of a spill with any of the chemicals below, contain the spill with an appropriate absorbent material then immediately alert Lab Safety for further assistance.

CHEMICAL CLASS	EXAMPLES
Strong Acids – Any acid that is concentrated enough to fume or emit acid gases	Fuming Sulfuric Acid Red Nitric Acid Hydrofluoric Acid Perchloric Acid
Strong Bases – Any base that is concentrated enough to emit vapors	Ammonium hydroxide
Poisonous by Inhalation – Any chemical that readily emits vapors / gases at normal temperature and pressure that are extremely toxic by inhalation	White Phosphorous Oxychloride Titanium tetrachloride Formates Isocyanates
Reactive – Any chemical that is sensitive to air, water, shock, friction and/or temperature	Dry Picric Acid Phosphorous metal
Extremely Toxic – Any chemical that is readily absorbed through the skin and is extremely toxic at small concentrations	Sodium cyanide
OSHA Listed Carcinogens	Refer to OSHA list

Table 11. Chemical spills that require assistance from Laboratory Safety

MINOR AND MANAGEABLE SPILLS

Minor spills do not pose an immediate threat to health or environment and should be cleaned up by laboratory personnel immediately. Due to the complexity and nature of minor spills, no single response plan or clean up procedure will work for all circumstances. General steps must be adapted to the hazard introduced by the spill. However, certain immediate steps take precedence over others, and should be followed when cleaning up a minor spill. Never assume that a situation or spill will remain minor if mismanaged or additional factors come into play. If the threat from a minor spill evolves to dangerous levels, immediately evacuate the area call UTSA PD for further assistance with the situation.

A. Response for minor spills

1. Alert others nearby to warn them of the spill.
2. Put on PPE (lab coat, gloves, and safety goggles).
3. Neutralize or absorb liquid spills using appropriate material for the spilled chemical as outlined below under "Spill clean-up procedures for specific spills". Carefully sweep powder spills to avoid contaminating the air with chemical dust.
4. Sweep up spilled material using a broom and dustpan or inert absorbent pads and put the material into a heavy-duty plastic bag or a container with lid.
5. Wash the affected area thoroughly with soap and water and ventilate the area if necessary.
6. Dispose of spilled material as hazardous waste. Questions regarding chemical waste disposal should be addressed to the Lab Safety Division.
7. All spills regardless of size or nature should be reported to Lab Safety for response evaluation and training purposes.

BEST PRACTICE

Apply spill control material over the entire area of the spill, working from the outside inwards. This reduces the chance of splash or further spread of the spilled chemical. Small amounts of color changing indicators may be added to the neutralizing material to indicate when the reaction has finished and can be safely swept up and submitted for disposal.

HAZARD SPECIFIC SPILL GUIDANCE

FLAMMABLE LIQUIDS

Use non-flammable absorbent pillows or pads, or inert absorbent powder:

1. Cover the spill with absorbent material to suppress vapors.

2. Once the liquid is absorbed, place the absorbent material into a sturdy plastic bag or bucket, seal the bag or container, and dispose of as flammable waste through Hazardous Waste Management.

3. The spill area can then be cleaned with soap and water.

Do NOT use paper towels to absorb flammable liquids because they add combustible material to the spill. Do NOT leave absorbent pads or materials under a fume hood to evaporate the solvent before disposal.

CORROSIVE LIQUIDS

Neutralize the corrosive liquid before clean-up because it may break down general purpose spill pads:

Acids: sodium bicarbonate, calcium carbonate, or commercially available acid neutralizer.
Hydrofluoric acid: calcium carbonate or commercially available hydrofluoric acid neutralizer.
Bases: citric acid, sodium bisulfate, or commercially available base neutralizer.

1. Sprinkle the powder at the edges of the spill and work to the center. Be careful because the neutralization process can be vigorous, causing splashes and yielding large amounts of heat.

2. After the initial reaction has taken place move the neutralizer around using a spatula and make sure all the corrosive chemical has reacted. Add more neutralizer as needed.

3. Scoop up the neutralized spill and place it into sturdy plastic bag or container with lid, and dispose of as hazardous waste.

WATER REACTIVE AND PYROPHORIC STRONG BASES

Do not use paper towels, cloth, vermiculite, or other combustible materials, as these can ignite in contact with the reactive material. Never use water when cleaning up a spill of pyrophoric or water reactive material. The exception is a spill on a person or ignited clothing/skin. In these cases, rinsing away unreacted chemical is critical. If you feel uncomfortable or are unsure of the spill situation, do NOT attempt to clean-up of the spill on your own. Call UTSA PD at x4911 and leave the affected area.

1. In the event of a spill, ensure other lab personnel are immediately aware of the incident.

2. Eliminate all nearby ignition sources and locate an appropriate fire extinguisher in case the spill ignites. For water reactive and pyrophoric strong bases use only dry chemical-based extinguishers (class ABC or D). Under no circumstance should a water or CO2 extinguisher be used.

3. If the spill is inside a fume hood cover the spill with excess dry sand or other non-combustible material. Close the fume hood sash and purge the fume hood if a purge button is present. If purge is not possible, immediately call Lab Safety x6419 to assist with disposal of contaminated material.

4. If the spill occurred outside of the fume hood cover with excess dry sand or other non-combustible material (**vermiculite is not appropriate**). Call Lab Safety x6419 for assistance with disposal of contaminated material. If materials are available, the spilled material may be collected with plastic tools and transferred to a plastic container with a loosely fitting lid prior to the arrival of safety personnel. However, if in doubt wait until assistance arrives.

5. If the spill ignites, and only if you are trained and feel comfortable in doing so, a dry chemical fire extinguisher (class ABC or D) may be used to extinguish. If in doubt immediately evacuate the area and pull the fire alarm and notify UTSA PD at x4911 of the situation.

ALKALI METALS (LITHIUM, SODIUM, POTASSIUM)

Due to their reactivity avoid contact with water:

1. Use tweezers to quickly pick-up the metal and put it into a container of mineral oil.

2. Make sure the container holds enough oil so that all metal is fully submerged.

3. Close the container and dispose of as metal waste.

If a fire occurs, smother with sand or extinguish with a Class "D" fire extinguisher. **If the fire cannot be controlled, close the fume hood, evacuate the area, and contact UTSA PD x4911.**

BROMINE

Due to the inhalation hazard of bromine only attempt to clean up spills inside a chemical fume hood. If the spill is outside the hood, the area should be evacuated, and emergency responders should be called.

1. Neutralize spills inside the hood with a 5-10% solution of sodium thiosulfate if safe to do so.

2. Wash the contaminated area several times with the sodium thiosulfate solution to completely decontaminate.

3. Clean up the resulting solution with an absorbent pad.

MERCURY

Elemental mercury has no detectable odor however can create harmful vapors. The vapor generation will increase in the presence of heat.

A. Special materials needed for a mercury spill

Suction device – Pasteur Pipette

Mercury sponge and container

Double Nitrile gloves (recommended)

1. Small spills – for example a broken thermometer

1. Stabilize the spill without contaminating yourself and isolate the area to prevent others from encountering the spill and enlarging the spill area.
2. Keep mercury away from sinks and drains.
3. Do not touch or walk-through spilled material. Do not disturb it until ready to clean it up.
4. Determine if the surface is porous (such as carpet, upholstery, or fabric) or non-porous (sealed wood, vinyl, and linoleum). Observe the area for cracks, crevices, or other places where mercury can collect.
5. Plan and conduct the clean-up.
6. Do not use a broom. The mercury will break up, spread, and generate vapor.
7. Do not use a vacuum! Ordinary vacuums will spread the spilled mercury and generate vapor. The vacuum will also become contaminated and will be considered hazardous waste.

2. Non-porous surfaces

1. Carefully pick up any broken glass. Sharps such as broken thermometers that have contained, or still contain, mercury must be placed in a separate container and labeled as mercury-containing hazardous waste.
2. Working from the edge of the spill inward, use a card or scraper to push the mercury droplets together into a larger drop.
3. Aspirate larger droplets using a suction device such as a Pasteur pipet or syringe with no needle and carefully transfer the droplets directly into a plastic container with a sealable lid (screw-top vial, empty plastic jar, film canister, etc.)
4. Use the suction device to get material out of cracks.
5. Pieces of masking tape or duct tape may be used to pick up tiny droplets.
6. An anti-static spray may help to release tiny droplets.
7. Use a flashlight in reduced-light areas to detect missed mercury. Scan parallel to the floor.
8. A mercury sponge may be used to take up small amounts of material on flat surfaces. Follow directions included with the kit.
9. Commercial mercury-absorbent powder may be used to amalgamate remaining residue. Sprinkle powder over area, spray with water mist or recommended activator, scrape into a paste, and wipe up with damp paper towels.

10. Commercial mercury “wipes” may be used as a final step to remove residue from cleaned surfaces.

11. Place all trash, PPE, etc., into a zip-top bag or a plastic waste bag. Double bag and secure, then place into a box. Seal the box and affix a hazardous waste label identifying the material as “mercury spill debris.”

3. Porous surfaces

1. Contaminated items should be disposed of as hazardous waste.

2. Affected area of a carpet may be cut out and replaced.

3. Seek advice from Laboratory Safety Personnel x6419 if mercury is spilled on other porous surfaces

HAZARD SPECIFIC NEUTRALIZERS

Spilled Substance	Manageable Spills should be treated with:
Acids, organic	Apply sodium bicarbonate. Absorb with spill pillow or vermiculite.
Acids, inorganic	Apply sodium bicarbonate/calcium oxide or sodium carbonate/calcium oxide. Absorb with spill pillow or vermiculite. NOTE: Hydrofluoric acid is an exception to the general practice, see below.
Acids, oxidizing	Apply sodium bicarbonate. Adsorb with vermiculite.
Acid Chlorides	Do not use water. Absorb with sand or sodium bicarbonate.
Bases (caustic alkalis)	Neutralize with citric acid, boric acid or tartaric acid or commercial chemical neutralizers. Absorb with spill pillow or vermiculite.
Cyanides	Cover solids with damp paper towel and push onto dustpan or use a HEPA filter vacuum to collect the solids. Absorb liquids with spill pillow or vermiculite.
Halides, organic or inorganic	Apply sodium bicarbonate.
Halogenated Hydrocarbons	Absorb with spill pillows or vermiculite.
Hydrazine	Avoid organic matter. Apply "slaked lime". Adsorb with spill pillow or vermiculite.
Hydrofluoric Acid	Apply calcium carbonate (limestone) or lime (calcium oxide) rather than sodium bicarbonate. The use of sodium bicarbonate will lead to the formation of sodium fluoride, which is considerably more toxic than calcium fluoride. Be careful in the use of spill pillows used to absorb the acid. Some pillows contain silicates which are incompatible with hydrofluoric acid.
Mercaptans/Organic Sulfides	Neutralize with calcium hypochlorite solution. Absorb with spill pillow or vermiculite.
Nitriles	Sweep up solids. Absorb liquids with spill pillows or vermiculite.
Nitro compounds Organic Nitriles	Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation.
Oxidizing Agents	Apply sodium bisulfite.

Peroxides	Carefully add diatomite, or dry sand to the spill. Then slowly add water to wet the material.
Phosphates, organic and related	Absorb with spill pillow or vermiculite.
Reducing Substances	Apply soda ash or sodium bicarbonate.

Table 12. Hazard Specific Neutralizers.

APPENDIX A – CHEMICALS REQUIRING CSC REVIEW

WHAT IS A PARTICULARLY HAZARDOUS SUBSTANCE?

The Occupational Safety and Health Administration's (OSHA's) Hazardous Chemicals in Laboratories Standard (29 CFR 1910.1450) defines particularly hazardous substances as including select carcinogens, reproductive toxins, and chemicals with high acute toxicity.

The Chemical Safety Committee (CSC) in conjunction with the Lab Safety Division (LSD) has identified certain reactive chemicals or chemical classes to be "high risk" and therefor require additional administrative and safety provisions before beginning work.

HOW CAN I DETERMINE IF MY CHEMICAL INVENTORY CONTAINS PARTICULARLY HAZARDOUS OR HIGH-RISK SUBSTANCES?

Researchers at UTSA have several ways to identify these materials within their inventory or before purchase of new chemicals.

The ChemTRACKER module in BioRAFT is equipped with a search function based on selection of hazards (i.e., carcinogen, pyrophoric, acutely toxic, etc.)

Researchers should always consult the GHS-compliant Safety Data Sheet supplied by the chemical's manufacturer or distributer.

Another useful resource is the GHS Lookup Tool, a current Database of virtually all chemicals listed and classified under GHS. It can be used to quickly generate a list of chemicals that all fall within one or more specific hazard category under GHS (e.g., all oxidizing solids that are also known carcinogens of group 1A)

***NOTE**: Most investigational drugs are treated as particularly hazardous (unless suspected of being high risk) due to typically limited safety information. If there is an SDS for the drug, it can be used to determine if it meets these criteria*

The following list of hazardous chemicals and classes does require CSC approval of the prewritten **SOP ONLY IF**:

- provisions of the provided guidance SOP cannot be met (e.g., fume hood not available in the lab space)
- -the proposed use or storage differs significantly from the regulatory guidelines
- -Any single one substance additionally is Acutely Toxic or falls into another high-risk category requiring approval.

Any single substance is stored within the same lab space in excess of1kg or 5 gallon (20 L)

Select Carcinogens include the following GHS, IARC, NTP and OSHA carcinogens:

- **GHS Carcinogenicity Category 1A or 1B, or**
- **IARC Group 1, or NTP "Known to be Human Carcinogens" or OSHA-listed carcinogens, or**

- **GHS Category 2 AND IARC Group 2 (A or B), AND NTP "Reasonably Anticipated to be Human Carcinogens"**
    - **Reproductive toxins include those listed as GHS Category 1A or 1B for reproductive toxicity.**

The following chemicals will always need CSC approval before new work begins.

The SOPs and guidelines provided by Laboratory Safety may be used by any laboratory but are only considered 'Complete" after approval by the CSC.

Chemicals having high acute toxicity include the following GHS classifications:

- **Acute Toxicity by Inhalation or Dermal exposure — Category 1 or 2**
- **Acute Toxicity by Oral exposure — Category 1**
- **Specific Target Organ Toxicity—Single Exposure — Category 1**

These substances usually have a high toxicity level; exposure to small doses will lead to long lasting, irreversible damage or become fatal.

Highly Reactive & explosive chemicals considered Particularly Hazardous (and High Risk) include the following.

- **Reacts violently with water**
- **Pyrophoric liquid or solid—Category 1, or Pyrophoric Gas**
- **Explosives—Unstable or Divisions 1.1—1.3**
- **Explosive when dry, or Explosive with or without air contact**
- **Self-reactive or Organic peroxides—Type A**
- **Oxidizing liquid or solid, category 1**
- **In contact with water releases flammable gas —Category 1**
- **In contact with acids liberates (very) toxic gas (e.g Sodium Cyanide, Potassium Cyanide)**
- **Self-reactive or Organic peroxides—Type B**

Peroxide formers can be separated into classes (Class A-D) based on their kinetic disposition to form explosive levels of peroxides. and the required time interval to test for the presence of peroxide. Peroxide Forming Chemicals (PFC) are not currently assigned a specific hazard class within the Globally Harmonized System (GHS), the propensity of a chemical to develop explosive levels of peroxides over time is communicated in section 2.3 of the GHS compliant Safety Data Sheet (SDS) under Hazards Not Otherwise Classified (HNOC)- *May form explosive levels of peroxides over time.*

- The table below shows a non-exhaustive list of examples for groups A-C. All Group A PFCs require prior approval by the CSC. Group B and C require CSC approval **ONLY** if
    - **quantities in excess of 5 Gal (20L) are stored within the lab**
    - **quantities in excess of 1 L are concentrated, distilled or heated.**

If <u>any</u> quantities of PFC are stored or used in the lab, they should have a PI approved SOPs that clearly defines the specific use and the lab members that have been trained to use them.

List A **Peroxides from Storage**	**List B** **Peroxides from Concentration**	**List C** **Peroxides from Polymerization**
Butadiene* **Chloroprene*** **Divinyl acetylene** **Isopropyl ether** **Potassium amide** **Potassium metal** **Sodium amide** **Tetrafluoroethylene*** **Vinyldiene chloride *Indicates a peroxide former when stored as a liquid monomer.**	Acetal Acetalaldehyde Benzyl alcohol Chlorofluoroethylene Cumene (isopropylbenzene) Cyclohexene 2-Cyclohexen-1-ol Cyclopentene Decahydronaphthalene (decalin) Diacetylene (butadiyne) Dicyclopentadiene Diethylene glycol dimethyl ethe (diglyme) Dioxane Ethyl ether Furan 4-Heptanol 2-Hexanol Methyl acetylene 3-Methyl-1-butanol Methyl-isobutyl ketone Methylcyclopentane 2-Pentanol 4-Penten-1-ol Phenylethanol Tetrahydrofuran Tetrahydronaphthalene Vinyl ethers Other secondary alcohols	Butadiene** Chlorobutadiene Chloroprene** Chlorotrifluoroethylene Styrene Tetrafluoroethylene** Vinyl acetate Vinyl acetylene Vinyl chloride Vinyl pyridine Vinyldiene chloride **Can form explosive levels of peroxides if stored as a liquid. When stored as gas, peroxide accumulation may cause autopolymerization.

List A chemicals should be tested for peroxide formation before using or discarded after 3 months.
List B chemicals should be tested for peroxides before distillation or evaporation and tested for peroxide formation or discarded after 1 year.
List C chemicals should be tested for peroxide formation or discard liquids after 6 months; and gases after 1 year.

APPENDIX B – COMMON PEROXIDE FORMERS

Listed below are some of the common peroxide formers with recommendations and requirements for testing frequency. Please contact the Laboratory Safety Division x6419 for testing strips and labels and any advice you may need on conducting tests.

Class A: Peroxide Hazard on Storage – Without Concentration

These chemicals can form peroxides that are difficult to detect and eliminate. Label these items with a date of receipt and date of opening and dispose of these items 3 months after opening or 12 months if unopened.

Name	Synonym(s)	CAS Number
Butadiene (liquid monomer)	Alpha-butadiene	106-99-0
Chloroprene (liquid monomer)		126-99-8
Divinyl ether	Vinyl ether; divinyl oxide; vinether; vinidyl; vinydan	109-93-3
Isopropyl ether	Diisopropyl ether	108-20-3
Potassium amide	Aminopotassium; Potassium azanide	17242-52-3
Potassium metal	Kalium	7440-09-7
Sodium amide (sodamide)		7782-92-5
Tetrafluoroethylene (liquid monomer)	Perfluoroethylene; Perfluoroethene; Ethene	116-14-3
Vinylidene chloride	1,1-Dichloroethylene	75-35-4

Class B - Concentration Hazard

Require external energy for spontaneous decomposition.
Form explosive peroxides when distilled, evaporated, or otherwise concentrated.

Name	Synonym(s)	CAS Number:
Acetals	For example: Diethyl Acetal; Acetaldehyde diethyl acetal	105-57-7
Acetaldehyde	Ethanal; Acetic aldehyde; Ethyl aldehyde	75-07-0
Benzyl alcohol	Phenylmethanol; Benzenemethanol; Phenylcarbinol	100-51-6
2-Butanol	Sec-Butanol; Sec-Butyl Alcohol; 2-Hydroxybutane	78-92-2
Cumene	Isopropylbenzene; Cumol;	98-82-8
Cyclohexanol	Cyclohexyl alcohol; Hexahydrophenol; Hydrophenol; Hydroxycyclohexane	108-93-0
Cyclohexene	Tetrahydobenzene; Benzene tetrahydride	110-83-8
2-Cyclohexen-1-ol		822-67-3
Decahydronaphthalene (decalin)	Cis-Decahydronaphthalene; Trans-Decahydronaphthelene	91-17-8
Diacetylene (butadine, gas)		
Dicyclopentadiene	Cyclopentadiene dimer; Bicyclopentadiene; Biscyclopentadienel Dicyklopentadien	77-73-6
Diethylene glycol dimethyl ether (diglyme)		111-96-6
Diethyl ether (ether)	Ethyl ether; Ethoxyethane; Diethyl oxide; Ethyl oxide	60-29-7

Dioxanes	P-Dioxane; Diethylene ether	123-91-1
Ethylene glycol ether acetates (glyme)	Monoglyme; Ethylene glycol dimethyl ether; Dimethyl cellosolve	110-71-4
Furan	Divinylene oxide; Furfuran; Tetrole; Oxacyclopentadiene	110-00-9
4-Heptanol	Heptan-4-ol; Dipropylcarbinol	589-55-9
2-Hexanol	Hexan-2-ol; Sec-Hexyl alcohol	37769-60-1
Methylacetylene (gas)	Propyne; Allylene; 1-Propyne	74-99-7
3-Methyl-1-butanol	Isoamyl alcohol; Isopentyl alcohol; Isopentanol	123-51-3
Methyl cyclopentane	Cyclopentane; Methylpentamethylene	96-37-7
Methyl isobutyl ketone	Isopropylacetone; 4-Methyl-2-pentanone	108-10-1
4-Methyl-2-pentanol	4-Methylpentan-2-ol; Isobutylmethylcarbinol	108-11-2
2-Pentanol	Pentan-2-ol; Sec-Amyl alcohol; Methylpropylcarbinol; Sec-Pentyl alcohol	6032-29-7
4-Penten-1-ol	4-Pentenol; 4-Pentenyl alcohol; 2-Allylethyl alcohol	821-09-0
1-Phenylethanol	Alpha-methylbenzyl alcohol; Methylphenyl carbinol; Styralyl alcohol	98-85-1
2-Phenylethanol	Phenethyl alcohol; benzeneethanol; Phenylethyl alcohol; Benzyl carbinol	60-12-8
Tetrahydrofuran (THF)	Oxolane; Hydrofuran; Furanidine	109-99-9
Tetrahydronaphthalene (tetralin)	Benzocyclohexane; Bacticin	119-64-2
Vinyl ethers	DIVINYL ETHER; Divinyl oxide; Vinether; Vinidyl; Vinydan	109-93-3

Class C - Shock and Heat Sensitive

Highly reactive and can auto-polymerize as a result of internal peroxide accumulation.
The peroxides formed in these reactions are extremely shock- and heat-sensitive.

Name	Synonym(s)	CAS Number
Acrylic acid	Propenoic acid; Vinylformic acid	79-10-7
Acrylonitrile	Propenenitrile; Vinyl cyanide	107-13-1
Butadiene (gas)	Divinyl; Vinylethylene	106-99-0
Chlorobutadiene	Chloroprene	126-99-8
Chloroprene	Chlorobutadiene	126-99-8
Chlorotrifluoroethylene (gas)	Daiflon; Chlorotrifluoroethene; Trifluorochloroethylene	79-83-9
Methyl methacrylate	Methacrylic acid methyl ester	80-62-6
Styrene	Ethenylbenzene; Phenylethylene; Vinylbenzene; Styrol	100-42-5
Tetrafluoroethylene (gas)	Perfluoroethylene; Perfluoroethene; Ethene	116-14-3
Vinyl acetate	Ethenyl acetate; Acetic acid ethenyl ester; Ethenyl ethanoate	108-05-4
Vinylacetylene (gas)	Butenyne; Monovinylacetylene	689-97-4
Vinylidiene chloride		75-35-4

Vinyl chloride (gas)	Chloroethylene; Chloroethene	75-01-4
Vinyl pyridine	2-Vinylpyridine	1337-81-1

Class D - Potential Peroxide Forming Chemicals

May form peroxides but cannot be clearly categorized in Class A, B, or C.

This group is extensive and includes all other ethers, and various other chemicals and substances containing an R-O-O-R’ structure. Some examples are listed below and a more extensive list can be found on the Laboratory Safety Division Website. Always refer to the SDS of the chemical you are using.

Name	Synonym(s)	CAS Number
Benzyl ethyl ether	Benzene ether; Ether benzene; Benzene diethyl ether	103-50-4
Benzyl methyl ether	Methoxymethylbenzene; Methyl Benzyl ether	538--86-3
Diallyl ether	Allyl ether	557-40-4
1,2-Dibenzyloxyethane	Ethylene glycol Dibenzyl ether; Dibenzyl glycol	622-22-0
p-Dibenzyloxybenzene	Hydroquinone dibenzyl ether	621-91-0
1,2-Dichloroethyl ethyl ether		623-46-1
2,4-Dichlorophenetole		5392-86-9
Ethylene glycol monomethyl ether	Methyl Cellosolve; Ethylene glycol monomethyl ether; Methyl oxitol	109-86-4
1-Octene	Caprylne	111-66-0
Tetrahydropyran	Oxane; Oxacyclohexane; Pentamethylene Oxide	142-68-7
1,1,2,3-Tetrachloro-1,3-butadiene	Tetrachlorobutadiene	921-09-5
Vinylene carbonate		872-36-6

APPENDIX C – COMMON POTENTIAL EXPLOSIVES

Use of explosive compounds on campus requires review by the CSC. Contact the Laboratory Safety Division x6419 for an explosives protocol template.

NAME	CAS NUMBER	SYNONYMS
Acetyl peroxide	110-22-5	acetylperoxide; diacetyl peroxide; Peroxide, diacetyl; ethanoyl peroxide; acetyl ethaneperoxoate; ethanoyl ethaneperoxoate; peracetic acid acetyl ester
Acetylene	74-86-2	ethyne
Ammonium nitrate	6484-52-2	
Ammonium perchlorate	7790-98-9	AP
Ammonium picrate	131-74-8	Dunnite; Picratol; 2,4,6-Trinitrophenol ammonium salt; Ammonium picronitrate; Explosive D
Barium azide	18810-58-7	barium dinitride
Benzoyl peroxide	94-36-0	benzoperoxide, dibenzoyl peroxide (DBPO)
Bromopropyne (3-Bromoprop-1-yne)	106-96-7	3-Bromo-1-propyne, Bromopropyne, 1-Brom-2-propin, 1-Bromo-2-propyne, Gamma-bromoallylene, 1-Bromo-2-propyne, 2-Propynyl bromide, Propargyl bromide, Propynyl bromide, gamma-Bromoallylene
Butanone peroxide	1338-23-4	Methyl ethyl ketone peroxide,MEKP, 2-[(2-Hydroperoxybutan-2-yl)peroxy]butane-2-peroxol, 2-Hydroperoxy-2-[(2-hydroperoxybutan-2-yl)peroxy]butane, Ketonox, Mepox, Thermacure
Cumene hydroperoxide	80-15-9	Cumyl Hydroperoxide, CHP
Diazodinitrophenol	4682-03-5	
Dinitrophenol (6 isomers)		
2,3-Dinitrophenol	66-56-8	
2,4-Dinitrophenol	51-28-5	
2,5-Dinitrophenol	329-71-5	
2,6-Dinitrophenol	573-56-8	
3,4-Dinitrophenol	577-71-9	
3,5-Dinitrophenol	586-11-8	
Dinitrophenylhydrazine	119-26-6	2,4-DNPH, 2,4-DNP, Brady's Reagent, Borche's Reagent
Dinitroresorcinol	519-44-8	2,4-Dinitrobenzene-1,3-diol; 1,3-Benzenediol, 2,4-dinitro-;2,4-Diaminotoluene-A,A,A-D3;

Dipicryl amine	131-73-7	Hexanitrodiphenylamine;2,2',4,4',6,6'-Hexanitrodiphenylamine;Benzenamine, 2,4,6-trinitro-N-(2,4,6-trinitrophenyl)-;Bis(2,4,6-trinitrophenyl)amine;Hexyl;Bis(2,4,6-trinitro-phenyl)-amin;Diphenylamine, hexanitro-;Diphenylamine, 2,2',4,4',6,6'-hexanitro-;DPA;Esanitrodifenilamina;Hexamine;Hexamine (potassium reagent); Hexanitrodifenylamine; Hexyl (reagent);2,4,6-Trinitro-N-(2,4,6-trinitrophenyl)benzenamine;2,4,6,2',4',6'-Hexanitrodiphenylamine;Aurantia;
Dipicryl sulphide	2217-06-3	
Dodecanoyl peroxide	105-74-8	Lauroyl peroxide; Dilauroyl peroxide, Peroxide, bis(1-oxododecyl); Dodecanoyl peroxide; Laurydol
Ethylene oxide	75-21-8	Oxirane; ethylene oxide; Epoxyethane; 1,2-Epoxyethane; Oxacyclopropane; EtheneOxide; Dimethylene Oxide;
Heavy metal azides		
Hydrogen peroxide (70%)	7722-84-1	
Lauric peroxide		
Lead azide	13424-46-9	
Lithium azide	19597-69-4	
Mercury azide		
Mercury fulminate	628-86-4	Fulminated Mercury
Methyl ethyl ketone peroxide see butanone peroxide)	1338-23-4	
Nitrocellulose	9004-70-0	
Nitrogen trifluoride	Not an explosive	
Nitrogen trichloride	10025-85-1	Trichloramine, Agene, Nitrogen(III) chloride, Trichloroazan, Trichlorine nitride
Nitrogen tribromide	15162-90-0	
Nitrogen triiodide	13444-85-4	Nitrogen iodide, Ammonia triiodide, Triiodine nitride, Triiodine mononitride, Triiodamine
Nitroglycerine	55-63-0	Propane-1,2,3-triyl trinitrate, 1,2,3-Tris(nitrooxy)propane
Nitroguanidine	556-88-7	Picrite
Nitromethane	75-52-5	Nitrocarbol
Nitrourea	556-89-8	1-Nitrourea, N-Nitrocarbamide
Organic azides		
Picramide	489-98-5	2,4,6-trinitroaniline
Picric acid	88-89-1	Picric acid, Carbazotic acid, Phenol trinitrate, Picronitric acid, Trinitrophenol, 2,4,6-Trinitro-1-phenol, 2-Hydroxy-1,3,5-trinitrobenzene, TNP, Melinite
Picryl chloride, TNCB	88-88-0	2-Chloro-1,3,5-trinitrobenzene, 2,4,6-Trinitrochlorobenzene
Picryl sulphonic acid	2508-19-2	Picrylsulfonic acid; Trinitrobenzene sulfonate; TNBS

Potassium azide	20762-60-1	
Propargyl bromide (neat)	106-96-7	3-Bromo-1-propyne, Bromopropyne, 1-Brom-2-propin, 1-Bromo-2-propyne, Gamma-bromoallylene, 1-Bromo-2-propyne, 2-Propynyl bromide, Propargyl bromide, Propynyl bromide, gamma-Bromoallylen
Silver fulminate	5610-59-3	
Sodium azide	26628-22-8	
Sodium dinitrophenate	824-39-5	Sodium 2-nitrophenolate; Sodium o-nitrophenolate; 2-Nitrophenol Sodium Salt; O-Nitrophenol sodium salt;
Succinic peroxide		
Tetranitroaniline	3698-54-2	2,3,4,6-Tetranitroaniline; Tetranitraniline; Tetranitraniline [French]; Benzenamine, 2,3,4,6-tetranitro-; 3698-54-2; ANILINE,
Trinitroaniline see Picramide	489-98-5	2,4,6-Trinitroanisol; picric acid methyl ether; trisol; trinol; trinitroanisole
Trinitroanisole	606-35-9	
Trinitrobenzene	99-35-4	
Trinitrobenzenesulphonic acid see (Picryl sulphonic acid)	2508-19-2	
Trinitrobenzoic acid	129-66-8	
Trinitrocresol	602-99-3	3-methyl-2,4,6-trinitrophenol
Trinitronaphthalene	87185-24-8	2,3,5-Trinitronaphthalene; CCRIS 5343; 1,6,7-trinitronaphthalene; Naphthalene, 1,6,7-trinitro-; 87185-24-8; NAPHTHALENE,
Trinitrophenol see Picric Acid	88-89-1	Picric Acid
Trinitroresorcinol	82-71-3	syphnic acid;STYPHNIC ACID;Trinitroresorcine
Trinitrotoluene	118-96-7	2,4,6-Trinitromethylbenzene 2,4,6-Trinitrotoluene 2,4,6-Trinitrotoluol TNT Tolite Trilite Trinitrotoluol Trinol Tritolo Tritolol Triton Tritone Trotol Trotyl
Urea Nitrate		

APPENDIX D – CONTROLLED GLASSWARE

The items listed below are considered controlled glassware. Laboratories may own and use the glassware listed below however these items must not be disposed of through surplus. Prior to discarding any of the following glassware items contact the CHO (x6149). Items may be re-distributed within the university.

Controlled Glassware
Condensers
Distilling apparatus
Vacuum dryers
Three-necked flasks
Distilling flasks
Tableting machines
Encapsulating machines
Soxhlet extractors
Transformers
Flask heaters
Heating mantles
Adapter tubes
Erlenmeyer flasks, two-necked flasks, single neck flasks, round-bottom flasks, Florence flasks, thermometer flasks, and filtering flasks
Filter funnels, Buchner funnels, and separatory funnels.

Any institution or site that discovers a readily unacceptable discrepancy, loss, pilferage, or theft of controlled glassware must notify the Laboratory Safety Division x6419 immediately. The CHO will report the incident to the appropriate law enforcement agency no later than 5 business days after the date of discovery of the discrepancy, loss, pilferage, or theft.

APPENDIX E – MATERIAL COMPATIBILITY FOR GAS REGULATORS AND TUBING

The following table is adapted from the mathesongas.com guide for the compatibility of certain gases with commonly used regulator and tubing materials. The compatibility of materials is essential for the safe use of gases. Consult with either the Laboratory Safety Division or your gas supplier if you have any questions.

✓	**Gas is compatible at room temperature in pure form with the material recommended**
X	**Should not be used with this gas**
S	**Suitability depends on the conditions of use**
-	**Insufficient data available, not recommended**

	METALS						**PLASTICS**				**ELASTOMERS**		
	316 Stainless Steel	**Monel**	**Brass**	**Aluminum**	**Zinc**	**Copper**	**Kel-F**	**Teflon**	**Tetzel**	**Kynar**	**Viton**	**Buna-N**	**Neoprene**
Acetylene	✓	✓	✓	✓	X	X	✓	✓	✓	✓	✓	✓	✓
Air	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ammonia	✓	✓	X	✓	X	X	✓	✓	✓	X	X	✓	✓
Argon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arsine	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	✓	✓
Boron Trichloride	✓	✓	S	X	-	✓	✓	✓	✓	-	-	-	-
Boron Trifluoride	✓	✓	S	✓	-	S	✓	✓	✓	-	-	-	-
Bromine Trifluoride	✓	✓	S	S	-	S	S	S	✓	X	X	X	X
1,3-Butadiene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
n-Butane	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1-Butene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
cis-2-Butene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
trans-2-Butene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbon Dioxide	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	S	S
Carbon Monoxide	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbonyl Sulfide	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-
Chlorine	✓	✓	X	X	X	X	✓	✓	✓	✓	✓	X	X
Chlorine Trifluoride	✓	✓	-	X	-	-	S	S	✓	X	X	X	X
Cyanogen	✓	✓	-	-	-	-	-	-	-	-	-	-	-
Cyclopropane	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
Deuterium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dichlorosilane	✓	✓	-	X	-	-	✓	✓	✓	✓	-	-	-
Dimethylamine	✓	✓	X	X	X	X	✓	✓	✓	✓	X	X	-
Dimethyl Ether	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X	X	-
Disilane	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Ethane	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Ethyl Chloride	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Ethylene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Fluorine	✓	✓	S	S	S	S	S	S	S	S	X	X	X
Halocarbon-14	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Halocarbon-23	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Halocarbon-32	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Halocarbon-116	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Halocarbon-218	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Halocarbon-236a	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Halocarbon-1113	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Halocarbon-4110	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Helium	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydrogen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hydrogen Bromide	✓	✓	X	X	X	X	✓	✓	✓	✓	✓	X	X
Hydrogen Chloride	✓	✓	X	X	X	X	✓	✓	✓	✓	✓	X	X
Hydrogen Fluoride	✓	✓	X	X	-	X	✓	✓	✓	✓	X	X	X
Hydrogen Sulfide	✓	✓	X	✓	-	-	✓	✓	✓	✓	X	✓	✓
Isobutane	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Isobutylene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Krypton	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Methane	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Methyl Bromide	✓	-	✓	X	-	✓	-	-	-	-	-	-	-
Methyl Chloride	✓	✓	✓	X	X	✓	✓	✓	✓	✓	✓	X	X
Methyl Fluoride	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	-	-	-
Methyl Mercaptan	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-
Monomethylamine	✓	X	X	X	X	X	-	-	-	-	-	-	-
Neon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nitric Oxide	✓	✓	✓	✓	-	✓	-	-	-	-	-	-	-
Nitrogen	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Nitrogen Dioxide	✓	✓	X	✓	-	X	✓	✓	-	-	X	X	X
Nitrogen Trifluoride	✓	✓	✓	-	-	✓	✓	✓	✓	✓	✓	-	-
Nitrous Oxide	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Octafluorocyclobutane	✓	✓	✓	✓	-	✓	✓	✓	✓	-	-	✓	✓
Octafluoropropane	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Oxygen	S	✓	✓	✓	✓	✓	✓	✓	✓	✓	S	X	X
Phosphine	✓	✓	-	✓	-	-	✓	✓	✓	-	-	-	-
Propane	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Propylene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	X
Silane	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Silicon Tetrachloride	✓	✓	X	X	-	X	✓	✓	✓	✓	X	X	X
Silicon Tetrafluoride	✓	✓	X	X	-	X	✓	✓	✓	✓	X	X	X
Sulfur Dioxide	✓	✓	X	✓	X	✓	✓	✓	✓	✓	✓	X	X
Sulfur Hexafluoride	✓	✓	✓	✓	-	✓	✓	✓	✓	✓	✓	✓	✓
Sulfur Tetrafluoride	✓	✓	X	X	-	X	✓	✓	✓	✓	X	X	X
Trimethylamine	✓	✓	X	X	X	X	-	-	-	-	-	-	-
Tungsten Hexafluoride	✓	✓	X	X	-	✓	✓	✓	✓	✓	X	X	X
Vinyl Methyl Ether	✓	✓	✓	✓	-	X	-	-	-	-	-	-	-
Xenon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

APPENDIX F – CONTACT DETAILS

In the event of any emergency call UTSA PD at x4911 or 210-458-4911

Other contact details are listed below. Please post this information in the laboratory near a telephone.

LABORATORY SAFETY DIVISION STAFF		
NAME	**OFFICE NUMBER**	**EMERGENCY NUMBER**
Amanda Haley	210-458-8515	210-294-3342
Natalie Metzger	210-458-6419	210-415-5082
Dianna Olukotun	210-458-5807	
Quy Fung	210-458-6697	
Cynthia Galindo	210-458-6507	
Alejandro Santillan	210-458-8033	

FACILITIES	
Facilities – Facilities Service Center	210-458-4262
Facilities – Operations and Maintenance	210-458-5347

APPENDIX G – ABBREVIATIONS

ACGER	American Conference of Governmental Industrial Hygienists
BHT	Butylated Hydroxytoluene
BSC	Biosafety Cabinet
CAS Number	Chemical Abstract Service Number
CFR	Code of Federal Regulations
CGA	Compressed Gas Association
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
CSC	Chemical Safety Committee
DEA	Drug Enforcement Administration
EAA	Edwards Aquifer Authority
EPA	Environmental Protection Agency
$FeSO_4$	Ferrous Sulfate
GHS	Globally Harmonized System
H_2SO_4	Sulfuric Acid
HazCom	Hazard Communication
HAZMAT	Hazardous Material
HEPA	High-Efficiency Particulate Air
HF	Hydrofluoric Acid
HOP	Handbook of Operating Procedures
HPLC	High Performance Liquid Chromatography
IACUC	Institutional Animal Care and Use Committee
IARC	International Agency for Research on Cancer
IBC	Institutional Biosafety Committee
IRB	Institutional Review Board
ISMS	Information Security Management System
kPA	Kilo Pascal
LASAC	Laboratory Safety Advisory Committee
LC50	Medial Lethal Concentration
LD50	Median Lethal Dose
LN2	Liquid Nitrogen; N_2
LSD	Laboratory Safety Division
NFPA	National Fire Protection Association
NTP	National Toxicology Program
OSHA	Occupational Health and Safety Administration
P.I.	Principal Investigator
PEL	Permissible Exposure Limit
PFC	Peroxide Forming Chemical
PHSs	Particularly Hazardous Substances
PPE	Personal Protective Equipment
ppm	Part Per Million

RLSC	Radiation and Laser Safety Committee
SAWS	San Antonio Water System SAWS
SDS	Safety Data Sheet (former MSDS)
SOP	Standard Operation Procedure
STOT	Specific Target Organ Toxicity
TAC	Texas Administrative Code
TCEQ	Texas Commission on Environmental Quality
TDG	Transport of Dangerous Goods Model Regulations
TLV	Threshold Limit Values
UN Model	United Nations Model
UTSA PD	University of Texas at San Antonio Police Department
Vac/fil cycle	Evacuate-Refill cycle; the basis of all Schlenk line work
VJ	Vacuum Jacket
VP	Vice President
WCi	Workers Compensation Insurance

APPENDIX H – LABELING AND DISPOSING OF PEROXIDE FORMING CHEMICALS

For your own safety and that of your colleagues, peroxide-forming compounds in your lab must be properly identified, tested, and disposed. Follow these steps:

A. Visual Inspection

Note: Do not open or disturb containers of peroxide-forming compounds showing the following:

- signs of peroxide crystal formation, leakage, or excessive rust formation
- exceedance of shelf life, unknown age, or origin

B. Labeling

Peroxide forming chemicals should be properly identified with labels containing the following information:
date received date opened required testing interval date tested and test results.

Note: Don't cover vendor labels when applying peroxide test labels. Labels can also be requested from Lab Safety

C. Testing

- For peroxide testing procedures, refer to the Quick Guide
- Peroxide testing strips can be requested from Lab Safety

D. Disposal

- If the peroxide concentration is ≥20 ppm, contact Hazardous Materials Management or the CHO for guidance.
- Consult the Waste Management Peroxide-Forming Chemical Test List to determine which peroxide-forming chemicals require testing prior to disposal.

E. Identifying Peroxide-Forming Chemicals in the BioRAFT Inventory

- Inventory Management → Container Search → Click the button for “Advanced Search” → enter Location or Owner and select “Peroxide Formers” from Hazard Category field OR
- Reports → Hazard Report → Enter “Peroxide Formers” in Hazard Category” and Building (+ Room or owner)

⚠

Containers that hold a volume of <u>1 Liter or greater</u> require a written SOP for testing protocols, hazard management, and must have identification label

Contact the CHO (x6419) with any questions.

APPENDIX I – PEROXIDE TESTING QUICK GUIDE

PRE-INSPECTION

Do not open or disturb containers of peroxide-forming compounds showing the following:

- signs of peroxide crystal formation
- signs of leakage
- exceedance of shelf life or unknown age

TESTING

A. Material

The Laboratory Safety Division recommends use of products such as QUANTOFIX® Peroxide test strips with a range of 1–100 ppm, or 400 – 1000 ppm for semi-quantitative determination of peroxides in solution. Test strips are available from Lab Safety upon request (x6419).

B. Procedures

1. Dip the test strip into the test solution for 1 second.

2. Shake off excess liquid. After the solvent has dried and evaporated, **add 1 drop of DI water for organic solvents.**

3. Wait 5 seconds.

4. Compare test field with the color scale. If hydrogen peroxide is present, the test field turns blue.

5. Take the value which matches closest with the colored test field (reading accuracy: ±

6. ½ colored field of the scale). Color changes after 1 minute do not represent a positive reaction.

RESULTS

- If the peroxide concentration is ≤ 100 ppm, the chemical may be used. Concentration or distillation of the chemical may be hazardous and should not be attempted.

- If you would like to dispose of a peroxide-forming chemical with a peroxide concentration

  ≥ 20 ppm, contact Hazardous Materials Management or the CHO for guidance.

STORAGE CONDITIONS OF THE TEST STRIPS

Avoid exposing the test strips to sunlight and moisture. Refrigerate unopened test strip containers. Store opened containers in a cool (but not refrigerated), dark, dry place. Remove only as many strips as are required and close container immediately. Use or dispose by expiration date marked on container/vial. Unused strips can be disposed as normal trash waste.

REFERENCES

1. http://www.airproducts.com/Company/Sustainability/environment-health-and-safety/product-safety-safetygrams.asp

2. http://www.ehs.ufl.edu/programs/lab/cryogens/

3. https://ehs.princeton.edu/book/export/html/184

4. List of peroxide forming chemicals: https://ehs.ucsc.edu/lab-safety-manual/specialty-chemicals/peroxide-formers-list.html

5. National Research Council. 2011. Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version. Washington, DC: The National Academies Press. https://doi.org/10.17226/12654

6. Occupational Safety and Health Standards; Identification, Classification, and Regulation of Carcinogens; Standard Number: 1990.112; Classification of potential carcinogens. https://www.osha.gov/laws-regs/regulations/standardnumber/1990/1990.112

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8. Prudent Practices in the Laboratory Handbook

9. UCLA Chemical Hygiene Plan

10. University of Delaware Chemical Hygiene Plan

11. https://www.acs.org/content/acs/en/about/governance/committees/chemicalsafety/publications/guide-for-chemical-spill-response.html

12. https://www.drs.illinois.edu/AccidentResponse/ChemicalSpill

13. Eastern Washington University, EH&S, Gas Cylinder Standard Operating Procedures

14. Prudent practices in the laboratory handbook

15. https://sites.ewu.edu/ehs/laboratories-and-shops/#gas

16. GHS manual 7th edition

17. NFPA 55 Chapter 7 (Compressed Gas Cylinders in the Workplace)

18. OSHA CFR 1910.101Subpart H (Hazardous Materials); Occupational Safety and Health Standards

19. §1910.101 Compressed gases (general requirements).

20. §1910.102 Acetylene.

21. §1910.103 Hydrogen.

22. §1910.104 Oxygen.

23. §1910.105 Nitrous oxide.