DESERT RESEARCH INSTITUTE
CHEMICAL HYGIENE PLAN

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1.0 INTRODUCTION

In 1990, the Occupational Safety and Health Administration (OSHA) issued a safety and health standard entitled "Occupational Exposure to Hazardous Chemicals in Laboratories" (29CFR 1910.1450). The basis for this standard was a determination by OSHA that laboratories are different from industry with respect to the usage and handling of hazardous chemicals in response to industry consensus that special considerations are needed to protect laboratory workers.

The OSHA Lab Standard was promulgated to ensure that the hazards of all chemicals handled and used in laboratories at DRI are evaluated, addressed, and conveyed to laboratory workers (i.e., principal investigators, laboratory staff and graduate assistants). This standard requires the development of a Chemical Hygiene Plan (CHP) that addresses a specific set of program elements (see section 1.2).

The DRI CHP was developed to meet the requirements of the OSHA Lab Standard (29 CFR 1910.1450) and to establish DRI policies and procedures that when implemented will minimize risks to personnel, facilities and the environment. The policies and procedures are based on currently accepted laboratory safety practices established at academic, government and industrial research laboratories. It is designed for alerting laboratory workers to potential workplace hazards, providing guidance to lab employees for avoidance of exposure to chemicals through their adherence to safe work practices and procedures and protecting all DRI personnel and property.

1.1 Applicability of the Laboratory Standard

The Laboratory Standard applies to all DRI research divisions that use hazardous chemicals in laboratories where:

- Chemical operations are carried out on a laboratory scale as opposed to operations whose objective is to produce commercial quantities of materials.
- Operations are designed to be easily and safely operated by one person.
- Multiple chemicals or processes are used
- Procedures involved are not part of a product process nor simulate production process.
- Standard laboratory procedures and equipment are commonly used to minimize potential employee exposure.

1.2 Chemical Hygiene Plan – Overview

The DRI Chemical Hygiene Plan provides general information on the following areas:

- Designation of responsibilities
- Employee information and training
- Control measures (administrative, engineering and PPE)
- Standard operating procedures for certain chemical classifications (e.g. carcinogens, cryogenics, corrosives, etc)
- Laboratory safety equipment operation
- Medical consultations and examinations
- Required recordkeeping (i.e., medical records, training records, etc.)

2.0 CHEMICAL HYGIENE PLAN RESPONSIBILITIES

In fulfilling the Desert Research Institute's mission to become the world leader in environmental research hazardous chemicals and substances will be used occasionally. However, DRI is committed to ensuring the safety of all personnel working at DRI and to complying with federal, state and local regulatory requirements. To achieve this goal the following responsibilities are designated to implement the Chemical Hygiene Plan.

2.1 Environmental Health & Safety Department

The EH&S Department reports to the VP for Research and has responsibility for the development and implementation of all institution programs concerning occupational safety and environmental quality. The Lab/Occupational Safety Specialist is designated as the Chemical Hygiene Officer (CHO) for DRI. Responsibilities of the CHO include:

- Administering and implementing the DRI Chemical Hygiene Plan (CHP)
- Assisting Principal Investigators (PI) and Laboratory Supervisors in development and implementation of lab specific procedures and work practices
- Performing laboratory assessments
- Reviewing CHP annually
- Determining if exposure monitoring is necessary
- Determining if medical surveillance is necessary

2.2 Division Executive Directors

The Division Executive Director has ultimate responsibility for environmental health and safety issues within her/his division and associated facilities. It is the director's responsibility to ensure that PIs and lab supervisors understand their responsibilities and are committed to the implementation of the CHP in DRI laboratories.

2.3 Principal Investigators/Lab Supervisors

Principal Investigators and/or Laboratory Supervisors are responsible for the health and safety of all personnel working in their laboratories. The DRI CHP is the guide for improving lab safety and PIs are responsible for implementing the plan in their lab(s); however, specific duties may be delegated. Responsibilities include:

- Approving planned laboratory activities and the hazardous chemicals involved
- Developing SOPs specific to their lab operations
- Ensuring all lab personnel receive appropriate training as specified by the CHP
- Ensuring that appropriate engineering controls and PPE are available and in working order, and that employees have been trained in the proper use of such equipment
- Handling and disposing of hazardous waste in accordance with DRI policies and regulatory guidelines
- Performing periodic lab safety assessments and initiating any corrective action
- Maintaining a current chemical inventory of hazardous chemicals in their lab
- Ensuring that MSDSs and other sources of chemical hazard information are available to lab personnel, and that workers know how to access this information

2.4 Laboratory Workers (employees and students)

All laboratory workers (employees and graduate assistants) are directly responsible for their own safety, as well as the safety of other laboratory workers and persons on DRI premises. Specific responsibilities include:

- Conducting laboratory activities in accordance with the DRI CHP and lab specific standard operating procedures.
- Participate in required training
- Utilizing engineering controls, safety equipment, and PPE in an appropriate manner
- Informing the laboratory supervisor of any accidents or unsafe conditions

2.5 Laboratory & Field Safety Committee

The Lab Safety Committee acts as an advisory body to the CHO on specific laboratory health and safety issues that come to the attention of the EH&S Office and Committee members. In that regard the Committee is responsible for:

- Providing input to EH&S concerning deficiencies in DRI labs and/or CHP
- Assisting in annual review of CHP
- Facilitating the dissemination of information to personnel in their division.

3.0 EMPLOYEE INFORMATION AND TRAINING

The OSHA Laboratory Standard requires that individuals who will be working with chemicals in the laboratory be provided with sufficient training to enable them to conduct their work safely. Training must be provided prior to the time when individuals begin their duties involving chemicals and whenever there is a significant change in the types or quantities of chemicals used. Division Executive Directors and, ultimately, principal investigators (or laboratory supervisors) are responsible for ensuring that all individuals working in their laboratories have been adequately trained.

3.1 General Chemical Hygiene Training

The Environmental Health & Safety Department provides a number of types and formats of safety training to DRI employees. Among the training offered is the Chemical Hygiene Plan Orientation that is designed to cover, in a general way, many of the topics covered by the OSHA Lab Standard. This Orientation, however, is not intended to be the sole means of training laboratory workers but must be supplemented by additional safety instruction from the principal investigator (or laboratory supervisor) on the potential hazards associated with an individual's specific duties.

The general training topics required by the OSHA Lab Standard are the:

- Content of the Lab Standard.
- Location and availability of the Chemical Hygiene Plan.
- Permissible exposure limits (PELs) for OSHA regulated substances.
- Signs and symptoms associated with chemical exposure.
- Location and availability of known reference material on the hazards, safe handling, storage, and disposal of chemicals. This includes, but is not limited to, Material Safety Data Sheets (MSDSs).
- Methods to detect the presence or release of chemicals.

- Physical and health hazards of chemicals.
- Measures that laboratory workers can take to protect themselves from chemical hazards, including control measures, personal protective equipment, SOPs, and emergency procedures.

3.2 Lab Specific Training

The general training provided by EH&S covers regulatory requirements, and general laboratory safety topics; however, this training is not designed to provide adequate training on all specific hazards that may be encountered in the laboratory. Therefore, each PI or laboratory supervisor is responsible for providing supplemental training on hazards specific to their laboratory. This lab specific training is necessary before personnel are exposed to such hazards, and whenever a new hazard is introduced into the laboratory. Laboratory specific training should include the following information:

- Hazards of specific laboratory chemicals and procedures
- Location of laboratory SOPs
- Procedures requiring prior approval from the PI or Laboratory Supervisor
- Chemical storage and inventory practices
- Specific use of laboratory hoods and other engineering controls
- Availability, selection, and use of PPE (e.g., gloves, safety glasses, etc.)
- Location and availability of MSDSs and other chemical hazard reference material
- Emergency procedures, such as spill response and fires

3.3 Training Documentation

Principal investigators and/or laboratory supervisors are responsible for documenting the safety training provided to individuals working within their laboratories. A training documentation form has been developed for laboratory specific training (see Appendix A). For each individual, a record should be maintained not only for formal training sessions attended, but also for informal safety instruction provided in the laboratory and for each person's tenure at DRI.

4.0 CONTROL MEASURES

The OSHA Lab Standard requires that laboratory personnel implement appropriate control measures to ensure that chemical exposures are maintained below regulatory limits and as low as reasonably achievable. In general, control measures can be categorized as administrative controls, engineering controls, procedural controls (i.e., standard operating procedures), or personal protective equipment.

4.1 Administrative Controls

Administrative controls consist of various policies and requirements that are established at an administrative level (e.g., by the principal investigator, laboratory supervisor, Division Executive Director, Lab and Field Safety Committee, or the Environmental Health & Safety Department) to promote safety in the laboratory. They may include:

- Ensuring all laboratory personnel have been provided with adequate training to enable them to perform their duties safely (see Section 3.0 Employee Information and Training).

- Requiring prior approval and additional control measures for procedures involving highly hazardous chemicals or operations (see Section 5.7 Highly Hazardous Chemicals Procedures).
- Restricting access to areas in which highly hazardous chemicals are used.
- Posting appropriate signs to identify specific hazards within an area.
- Requiring standard practices for chemical safety and good housekeeping are observed at all times in the laboratory.

4.1.1 Procedural Controls

Procedural controls (or work practice controls) are typically in the format of standard operating procedures (SOPs) that define the manner in which certain types of chemicals are handled, or the manner in which specific operations involving chemicals are conducted, in order to minimize hazards. Section 5.0 of this Plan contains a number of SOPs that are generally applicable to all laboratories. It is the responsibility of personnel in each laboratory, however to develop (and incorporate into the CHP) specific SOPs that reflect the operations and experimental protocols performed in their laboratory.

4.1.2 Laboratory Entrance Signs

The entrance to each laboratory in which chemicals are used or stored shall be posted with an NFPA fire diamond indicating by number 0-4 overall health, fire, reactivity hazards present in the laboratory; the names and phone numbers of the principal investigator, laboratory supervisor and any other designated personnel who can be contacted in the event of an emergency; and a current copy of the chemicals inventory. In addition, laboratory entrance postings shall indicate the presence of certain specific hazards such as OSHA regulated carcinogens, acutely toxic substances, radioactive materials, etc.

4.2 Engineering Controls

Engineering controls consist of various measures for reducing a hazard at its source or for separating personnel from the hazard. In the laboratory, examples of engineering controls include the substitution of less hazardous chemicals in an operation, isolating a particular chemical operation, enclosing a potentially explosive reaction, or utilizing local exhaust such as a laboratory hood for an operation which produces airborne chemicals (see Section 6.1 Chemical Hoods). Because engineering controls function to reduce or eliminate a hazard at its source before it is created, they should be fully considered and utilized whenever possible as the first step in chemical hazard control within the laboratory.

4.4 Personal Protective Equipment

For many laboratory operations, the risk of chemical exposure cannot be totally eliminated through the use of engineering and procedural control measures. For this reason, it is necessary to supplement such measures with the use of personal protective equipment (PPE) and apparel. Because PPE functions as a barrier between the laboratory worker and the chemical hazard, rather than by actually reducing or eliminating the hazard, its use should always be in addition to (and never as a substitute for) appropriate engineering and procedural controls. It is the responsibility of the principal investigator/lab supervisor of the lab to ensure that appropriate PPE is provided to, and used by, all laboratory personnel. PPE assessments have been completed for all laboratory areas at DRI and a record is retained with EH&S. Such equipment should be adequate to ensure personnel are

protected from chemical exposure to the eyes, skin, and respiratory tract. Contact the CHO if you have any questions at 702-862-5358.

4.4.1 Eye Protection

Appropriate PPE for the eyes is required whenever there is a reasonable probability that the eyes could be exposed to flying particles (including dusts), molten liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation. Vented safety goggles are the preferred eye protection to be worn when chemicals are handled in the laboratory. These should be worn over prescription glasses. Historically the wearing of contact lenses has not been allowed in the laboratory since it was believed that contact lenses would exacerbate damage to the eye caused by chemical contact. This policy has been visited and most experts now agree that contact lenses do not increase the risk of eye damage when handling chemicals. All protective equipment for the eyes must bear the stamp Z87, which indicates that it meets the performance guidelines established by the American National Standards Institute in ANSI Z87.1 “Practice for Occupational and Educational Eye and Face protection.”

4.4.2 Face Protection

A face shield is required whenever there is a potential for severe chemical exposure from splashes, fumes, or explosions. Because a face shield alone does not adequately protect the eyes, it must be worn over safety goggles. In general, any operation that requires a face shield should be conducted inside a hood with the sash lowered as an additional barrier.

4.4.3 Hand Protection

Because the hands are typically the part of the body in closest contact with chemicals in the laboratory, they are particularly vulnerable to chemical exposures. For this reason it is essential that laboratory personnel select appropriate protective gloves and wear them whenever handling chemicals. Because different glove materials resist different chemicals, no one glove is suited for all chemical exposures. Glove selection guides are available from most manufacturers and should be consulted before choosing a glove. Below is a general guideline for glove selection.

Glove Material	Generally Recommended For	Not Recommended For
Nitrile	Many acids, caustics, alcohols, and hydrocarbons	Ketones, halogenated hydrocarbons, and strong acids
Neoprene	Organic acids, caustics, alcohols, ketones, and petroleum hydrocarbons	Aromatic and halogenated
Latex	Alcohols, caustics, ketones, and many acids	Aromatics and hydrocarbons (especially halogenated or aromatic)
Butyl Rubber	Acids, bases, ketones, esters, alcohols, aldehydes	Aliphatic, aromatic, and halogenated hydrocarbons
Polyvinyl	Most organic solvents, including aromatic, halogenated, and petroleum solvents	Inorganic acids, caustics, alcohols, and other aqueous or polar liquids
Viton	Halogenated and aromatic organic solvents	Ketones, ethers, amines, and aldehydes
4H/Silver Shield	Good resistance to many chemicals, including chlorinated solvents, hydrocarbons, and ketones	No specific guidance; consult North Safety Products (www.northsafety.com)

4.4.4 Foot Protection

Safety shoes or other specialized foot protection are generally not required for most laboratory operations. However, footwear that completely covers the skin of the feet must be worn whenever chemicals are being used (sandals and open-toed shoes are prohibited in the labs).

4.4.5 Body Protection

By virtue of its large surface area, the skin is at considerable risk or exposure to chemicals in the laboratory. To lessen this risk, it is essential that laboratory personnel wear clothing that, to the extent possible, covers all skin surfaces. A fully buttoned lab coat should be worn when handling chemicals. Clothing and lab coats should be regarded, not as a means of preventing exposure, but as a means of lessening or delaying exposure. The effectiveness of clothing as a protective barrier for the skin depends upon its prompt removal in the event that it becomes contaminated.

4.4.6 Respiratory Protection

The implementation of appropriate engineering and procedural controls should always be the preferred strategy for ensuring that any airborne levels of chemicals within the laboratory are well below regulatory limits. However, in rare circumstances where such control measures are not sufficient, laboratory personnel may need to utilize respirators for a particular operation. In such instances, personnel must participate fully in Desert Research Institute's Respiratory Protection Program that requires a medical exam, respirator fit-testing, and training prior to respirator use. Contact the Environmental Health & Safety Department for more information.

5.0 STANDARD OPERATING PROCEDURES

5.1 General Laboratory Safety Procedures

Know the potential hazards of the materials used in the laboratory. Review the Material Safety Data Sheets (MSDS) and container label prior to using a chemical. All employees shall remain vigilant to unsafe practices and conditions in the laboratory and shall immediately report such practices and/or conditions to the laboratory supervisor. The supervisor must correct these unsafe practices and or conditions promptly, or halt the operation until corrected.

- Know the location of safety equipment such as emergency showers, eyewashes, fire extinguishers, fire alarms, spill kits, first aid kits, and telephones.
- Seek information and advice from knowledgeable persons, lab standards and reference material about the hazards present in the laboratory.
- Review emergency procedures to ensure that necessary supplies and equipment for spill response and other accidents are available.
- Outside visitors who wish to enter the laboratory are to receive authorization from an employee in that laboratory and use appropriate PPE.
- Use engineering controls and laboratory safety equipment in accordance with Section 6.0.
- Practice good housekeeping to minimize unsafe work conditions such as obstructed exits and safety equipment, cluttered benches and hoods, and accumulated chemical waste.
- Inspect personal protective equipment prior to use, and wear appropriate PPE as procedures dictate and when necessary to avoid exposure. This includes eye protection, lab coat, gloves, and appropriate foot protection (no sandals). Gloves should be made of a material known to be resistant to permeation by the chemical in use (see Section 4.4.3).
- Refrain from horseplay, practical jokes, or other behavior that might confuse, startle, or distract another employee or cause an accident.
- Long hair and loose-fitting clothing must be confined close to the body to avoid being caught in moving machine/equipment parts.
- Wash skin promptly if contacted by any chemical, regardless of corrosiveness or toxicity. Wash hands and arms thoroughly after working in laboratories.
- Label all new chemical containers with the “date received” and “date opened.”
- Do not release hazardous chemicals in cold rooms, warm rooms, or other rooms with re-circulating atmospheres.
- Unless equipped with automatic door closures, laboratory doors leading to corridors or other laboratories shall remain closed.
- Label and store chemicals properly. All chemical containers should be labeled to identify the container contents (no abbreviations or formulas) and hazard information. Chemicals must be stored by hazard groups and chemical compatibilities.
- Use break-resistant bottle carriers when transporting chemicals in glass containers that are greater than 500 milliliters.

- Use chemical hoods when processes or experiments may result in the release of toxic or flammable vapors, fumes, or dusts. Use only those chemicals appropriate for the ventilation system.
- Avoid unnecessary exposure to all chemicals by any route. Eating, drinking, smoking, applying cosmetics, or chewing gum in the laboratory is prohibited as is storing food in laboratory refrigerators, ice chests, or cold rooms, or cooking in laboratory ovens and microwaves. Do not use laboratory glassware to prepare or consume food.
- Do not smell or taste chemicals.
- Do not pour hazardous chemicals or bio-hazardous materials down a sink or floor drain.
- Use equipment only for its designed purpose. All laboratory equipment shall be inspected on a periodic basis and replaced or repaired as necessary. Documentation shall be maintained as needed.
- Do not pipette by mouth.
- Quantities of combustible materials (e.g., paper, cardboard) stored in laboratories should be kept to a minimum.
- A clearance of 18 inches must be maintained from the ceiling and storage materials.
- Heavy objects must not be stored overhead or on shelves that are not adequately reinforced.
- Receive prior approval from lab supervisor before working alone in the laboratory and leaving potentially hazardous experiments or operations unattended. In such instances, the lights in the laboratory should be left on and emergency phone numbers posted at the laboratory entrance.

5.2 Procedures for Proper Labeling and Safe Storage of Chemicals

Proper chemical labeling and storage is essential for a safe laboratory work environment. Inappropriate storage of incompatible or unknown chemicals can lead to spontaneous fire and explosions with the associated release of toxic gases. To minimize these hazards, chemicals in the laboratory must be segregated properly. The storage procedures listed below are not intended to be all-inclusive but should serve instead, to supplement more specific procedures and recommendations obtained from container labels, MSDSs, and other chemical reference material. For more information about chemical storage contact the Chemical Hygiene Officer at 702-862-5358.

5.2.1 Labeling

- Manufacturer chemical labels should never be removed or defaced until the chemical is completely used.
- All chemical and waste containers must be clearly labeled with the full chemical name (no abbreviations or formulas) and appropriate hazard warning information. Small containers that are difficult to label such as 1-10mL vials and test tubes can be labeled as a group and stored together. Unattended beakers, flasks, and other laboratory equipment containing chemicals used during an experiment must be labeled with hazard warning and the full chemical name.
- Label all chemicals with the “date received” and “date opened.”
- All hazardous waste containers must be labeled with the words “HAZARDOUS WASTE”, the accumulation start date (represents the date the container becomes 90% full), composition of the container contents, hazardous properties of the waste (i.e., flammable, corrosive, toxic) see MSDS for more information, and the physical state (gas, liquid, solid) of the material.
- All full waste containers must be disposed of promptly, refer to the DRI Hazardous Waste Generation Satellite Accumulation SOP located at http://safety.dri.edu/Programs/hwsat.pdf or contact EH&S at 775-673-7329.
- All chemical storage areas such as cabinets, shelves and refrigerators must be labeled to identify the hazardous nature of the chemicals stored within the area (e.g., flammables, corrosives, oxidizers, water-reactives, toxics, carcinogens, and reproductive toxins). All signs must be legible and conspicuously placed.
- MSDSs that are received with incoming shipments of hazardous chemicals shall be maintained and readily accessible to laboratory employees.

5.2.2 Storage

To minimize hazards associated with incompatible storage, chemicals in the laboratory must be segregated properly. The storage procedures listed below are not intended to be all-inclusive but should serve instead to supplement more specific procedures and recommendations obtained from container labels, MSDSs, and other chemical reference material. For more information about chemical storage contact the Chemical Hygiene Officer at 702-862-5358. The following list is a general, separation guideline for storage of hazardous substances:

Flammables
Oxidizers
Corrosives (4 subgroups)
1. inorganic acids
2. organic acids
3. caustic alkalis (bases)
4. perchloric acid

Highly reactives (shock sensitive, peroxides, water-reactives)
Highly toxic, carcinogens, reproductive toxins
Compressed gases and cryogenic liquids
Low hazard (sucrose, sodium carbonate)

- A designated storage place should be provided for each chemical and the chemical should be returned to that location after each use.
- Chemical containers must be in good condition before they are stored. Containers should be managed to prevent leaks.
- Chemicals (including waste) must be separated and stored according to their hazard group and specific chemical incompatibilities. Chemicals within the same hazard group can be incompatible and therefore it is important to review the chemical label and MSDS to determine the specific storage requirements and possible incompatibilities. Appendix F contains a partial list of incompatible chemicals.
- Special attention shall be given to the storage of chemicals that can be classified into multiple hazard groups (acetic acid is both a flammable and corrosive). Refer to the MSDS or contact the CHO for further information.
- Chemicals should be separated by distance or barriers. Physical barriers such as storage cabinets and secondary containers can be used to prohibit contact of incompatible chemicals in the event that they are accidentally released or spilled.
- Secondary containers are highly recommended for the storage of liquid chemicals. Secondary container must be made of a material that is compatible with the chemical(s) it will hold and be large enough to contain the contents of the largest container.
- Liquid chemicals must not be stored above dry chemicals unless they are stored in secondary containers.
- Storage of chemicals within hoods and on bench tops and near sinks must be avoided.
- Stored chemicals must not be exposed to heat or direct sunlight.

- Storage shelves and cabinets shall be secure to prevent tipping. Shelving should contain a front-edge lip or doors to prevent containers from falling.
- Flammable and corrosive storage cabinets should be used when possible.
- Flammable liquids in quantities exceeding a total of 10 gallons in each laboratory must be stored in an approved flammable storage cabinet.
- Only laboratory-safe (UL approved for flammable liquid storage with no internal source of ignition) refrigerators and freezers may be used to store flammable liquids. If refrigerated storage is required, as in flammable liquid dispensing and storage rooms, refrigerators and freezers shall be explosion proof.
- Liquid chemicals shall be stored below eye level to avoid accidental spills.
- Chemicals should not be stored in areas where they can be accidentally broken and spilled such as on the floor, above or next to sinks or on the edge of a bench top.
- Chemicals must not be stored in areas where they obstruct aisles, exits, and emergency equipment.

5.3 Corrosive Substances-Procedures for Safe Handling and Storage

Corrosive substances cause destruction of living tissue by chemical action at the site of contact and can be solids, liquids, or gases. Corrosive effects can occur not only to the skin and eyes, but also to the respiratory tract through inhalation and to the gastrointestinal tract through ingestion. In order to minimize these potential hazards, precautionary procedures must be observed when handling corrosives.

Handling

- Safety goggles, protective gloves, and a laboratory coat shall always be worn when working with corrosive chemicals. A face shield, rubber apron, and rubber booties may also be appropriate depending on the work being performed and concentration of the corrosive.
- Appropriate protective gloves which are resistant to permeation or penetration from corrosive chemicals must be selected and tested for the absence of pin holes prior to use (see Section 4.4.3 for glove selection guidelines).
- Eyewashes and safety showers should be readily available in areas where corrosive chemicals are used and stored. In the event of skin and eye contact with a corrosive chemical, the affected area should be immediately flushed with water for 15 minutes. Contaminated clothing shall be removed and medical attention sought.
- Corrosive chemicals should be handled in a chemical hood to ensure that any possible hazardous or noxious fumes generated are adequately vented. Lab hoods must be utilized when handling concentrated acids (≥ 6M).
- When mixing concentrated acids with water, add the acid slowly to the water. Allow the acid to run down the side of a container and mix slowly to avoid violent reactions and splattering. Never add water to acid.
- When performing exothermic reactions, inspect glass for cracks prior to use as heat can shatter glass.
- Appropriate spill material should be available in areas where corrosive chemicals are used and stored.
- Protective carriers must be used when transporting corrosive chemicals.
- Hydrofluoric acid is highly corrosive to body tissue, even in dilute solutions. Personnel using hydrofluoric acid must be specifically trained prior to use, and special work practices must be implemented to prevent exposure to HF. Hydrofluoric acid users should consult the DRI guidelines for using HF at (http://safety.dri.edu/Hazards/HydrofluoricAcidGuidelines.pdf).
- Perchloric acid must not be heated in a regular chemical hood. A specially designed lab hood is needed, refer to safety webpage at (http://safety.dri.edu/Hazards/perchloric.doc).

Storage

- Containers and equipment used for storage and processing of corrosive materials must be corrosive resistant.
- Corrosive chemicals shall be stored below eye level, preferably near the floor to minimize the danger of their falling from cabinets or shelves.
- Acids and bases must be stored separately from each other. Secondary containers can be used to help with separation within a corrosive cabinet.

- Inorganic acids must be separated from flammable/combustible material as they are particularly reactive to each other.
- Acids must be segregated from active metals (e.g., sodium, potassium, and magnesium) and from chemicals that can generate toxic gases (e.g., sodium cyanide and iron sulfide).

5.4 Flammable and Combustible Liquids-Procedures for Safe Handling and Storage

Chemicals which exist, at ambient temperatures, in a liquid form with sufficient vapor pressure to ignite in the presence of an ignition source are called flammable or combustible liquids (note that the flammable/combustible liquid itself does not burn; it is the vapor from the liquid that burns). Flammables generate sufficient vapor at temperatures below 100º F (37.8º C), whereas combustibles generate sufficient vapor at temperatures at or above 100º F. Invisible vapor trails from these liquids can reach remote ignition sources causing flashback fires. In addition, these liquids become increasingly hazardous at elevated temperatures due to more rapid vaporization. For these reasons, precautionary measures must be observed when handling and storing flammables and combustibles. Common examples of flammable materials include: toluene, benzene, acetone, ethers, cyclohexane, and alcohols.

Flammable Liquids

Class IA – Liquids having a flashpoint <73º F, and a boiling point <100º F.
Class IB – Liquids having a flashpoint <73º F, and a boiling point ≥100º F.
Class IC _ Liquids having a flashpoint ≥73º F, and <100º F.

Combustible Liquids

Class II – Liquids having a flashpoint ≥100º F, but <140º F.
Class IIIA – Liquids having a flashpoint ≥140º F, but < 200º F.

Handling

- Appropriate PPE (gloves, lab coat, and safety goggles) must be worn when working with flammable/combustible liquids.
- Do not heat flammable chemicals with an open flame.
- Flammable chemicals should be used only in lab hoods (or other well ventilated areas) and away from sources of ignition. Similarly, combustibles should not be used near ignition sources, and it is recommended that they be used in lab hoods whenever possible.
- For highly flammable chemicals, static electricity or hot surfaces can serve as ignition sources. Do not use electrical devices with cracked or frayed electrical wiring.
- Transfer flammable liquids from containers of 5 gallon capacity or less inside a laboratory hood (or other area with similar ventilation) to prevent accumulation of a flammable concentration of vapors.
- Transfer flammable liquids from containers greater than 5 gallons in a well-ventilated area outside the laboratory building, or in an approved flammable storage room.
- When transferring flammable liquid from a bulk container (generally greater than 5 gallons), the containers must be electrically bonded and grounded. The friction of flowing liquid may be sufficient to generate static electricity, which in turn may discharge, causing a spark and ignition.
- Fire extinguishers appropriate for the fire hazards present must be available in all laboratories and storage areas.

Storage

The Nevada State Fire Marshall, through incorporation of the International Fire Code, mandates maximum storage quantities for flammable and combustible liquids. The National Fire Protection Association provides additional recommendations for management of flammable and combustible liquids. The maximum allowable storage quantities of flammable and combustible liquids (including waste material) in laboratories are summarized below:

- The maximum allowable quantity of flammable liquid (Class I) per laboratory that can be used in operations in a open environment is as follows:
  Class IA: 10 gallons
  Class IB: 15 gallons
  Class IC: 20 gallons
  Class IA, IB, IC combined: 30 gallons (containing less than the allowable quantity of each individual class)

Note: The maximum allowable quantities can be doubled in laboratories protected by an approved automatic sprinkler system.

- Containers larger than 5 gallons shall not be stored in the lab.
- Flammable/combustible liquid stored in glass containers shall not exceed 4 liters.
- Flammable/combustible liquids (if required) must only be stored in laboratory-safe refrigeration equipment (no spark source in the interior) never in household refrigerators.
- Flammables and combustibles must not be stored near oxidizers, corrosives, combustible material, or near heat sources. Make sure all chemicals stored near flammable and combustibles are compatible.

Flammable Liquid Storage Cabinets

- Maximum storage quantities per individual flammable liquid storage cabinet are:
  - 60 gallons of flammable or combustible liquid.
  - 120 gallons of flammable and combustible liquid combined.
- Flammable cabinets do not have to be vented for fire protection purposes.
- Do not remove vent bungs from flammable cabinets unless the cabinets are properly ventilated.
- Storage cabinets must be labeled “Flammable-Keep Fire Away.”

5.5 Oxidizing Agents – Procedures for Safe Handling and Storage

Oxidizing agents are chemicals that spontaneously evolve oxygen at room temperature or with slight heating and promote combustion. The oxidizing agent may 1) provide oxygen to the substance being oxidized (in which case the agent has to be oxygen or contain oxygen) or 2) receive electrons being transferred from the substance undergoing oxidation (chlorine is a good oxidizing agent for electron-transfer purposes, even though it does not contain oxygen). The intensity of the oxidation reaction depends on the oxidizing-reducing potential of the material involved. Fire or explosion is possible when strong oxidizing agents come into contact with easily oxidized compounds, such as metals, metal hybrids or organics. Because oxidizing agents possess varying degrees of instability, they can be explosively unpredictable.

Examples of Oxidizing Agents

Gases:	fluorine, chlorine, ozone, nitrous oxide, oxygen
Liquids:	hydrogen peroxide, nitric acid, perchloric acid, sulfuric acid
Solids:	nitrites, nitrates, perchlorates, peroxides, chromates, picrates, bromates, chlorites, chlorates, permanganates

Handling

- Appropriate PPE (safety goggles, gloves, lab coat, etc.) should be worn when working with oxidizers.
- If a reaction is potentially explosive, or if the reaction is unknown, use a lab hood (with the sash down as a protective barrier), safety shield, or other methods for isolating the material or the process.
- Oxidizers can react violently when in contact with incompatible materials. For this reason, know the reactivity of the material involved in an experimental process. Assure that no extraneous material is in the area where it can become involved in a reaction.
- The quantity of oxidizer used should be the minimum necessary for the procedure. Do not leave excessive amounts of an oxidizer in the vicinity of the process.
- Perchloric acid must not be heated in a regular chemical fume hood. A specially designed perchloric acid hood must be utilized for this purpose and there are no perchloric acid fume hoods currently at DRI. For more information refer to http://safety.dri.edu/Hazards/perchloric.doc on the safety webpage.

Storage

- Oxidizers should be stored in a cool, dry place.
- Oxidizers must be segregated from organic material, flammables, combustibles and strong reducing agents such as zinc, alkaline metals, and formic acid.
- Oxidizing acids such as perchloric acid and nitric acid must be stored separately in compatible secondary containers away from other acids. Different spill containment devices in a single cabinet will suffice.

5.6 Highly Reactive Chemicals – Procedures for Safe Handling and Storage

Highly reactive chemicals are those that have the potential to vigorously polymerize, condense, or become self-reactive due to shock, pressure, temperature, light, or contact with another material. Examples of highly reactive chemicals are explosives, peroxides, water-reactives, and pyrophorics. All work involving highly reactive chemicals must be approved by the PI before initiation of the work.

- Reactive chemicals must be handled with caution; this includes segregation in storage and prohibiting the mixing of even small quantities with other chemicals without consideration of appropriate procedures, and use of PPE.
- Chemical reactions conducted at temperatures or pressures above or below ambient conditions must be performed in a manner that minimizes hazards such as explosion or vigorous reaction. Provide a mechanism for adequate temperature control and heat dissipation.
- Minimize the quantity of reactive chemicals used or synthesized to the smallest amount needed.
- Utilize shields and barricades, and PPE (such as face shields with throat protectors and heavy gloves) whenever there is a possibility of explosion or vigorous chemical reaction.
- Glass equipment operated under vacuum or pressure must be shielded, wrapped with tape, or otherwise protected from shattering.

5.6.1 Shock/Heat Sensitive Materials

Compounds containing the functional groups azide, acetylide, diazo, nitroso, haloamine, peroxide and ozonide are sensitive to shock and heat and can explode violently, causing sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden adverse conditions. Heat, light, mechanical shock, detonation, and certain catalysts can initiate explosive reactions. Appropriate personal protective (face shield, safety goggles, leather outer gloves, chemical resistant gloves, lab coat, etc.) must be worn when working with explosives.

- Before working with explosives, understand their chemical properties, know the products of side reactions, the incompatibility of certain chemicals, and monitor environmental catalysts such as temperature changes.
- Containers shall be dated upon receipt and when opened. Expired explosives should be discarded promptly.
- Explosives should be kept at the minimum necessary for the procedure.
- If there is a chance of explosion, use protective barriers (e.g., fume hood sash and safety shield) or other methods for isolating the material or process.
- Explosives should be stored in a cool, dry, and protected area. Segregate from other material that could create a serious risk to life or property should an accident occur.

5.6.2 Organic Peroxides

Organic Peroxides are one of the most hazardous chemicals commonly used in laboratories. Most organic peroxides are sensitive to heat, impact, friction, light and readily react with oxidizing and reducing compounds, and are highly flammable. Since
the sensitivity and instability of these compounds vary, always review the properties of specific compounds prior to their use. Common peroxidizable chemicals include; 2-butanol,

benzyl alcohol, cyclohexane, 2-propanol, styrene, hydrogen peroxide, and other secondary alcohols. Appropriate personal protective equipment (safety goggles, gloves, lab coat, etc.) must be worn when working with organic peroxides or peroxide-forming compounds.

- Containers must be airtight and stored in a cool, dry place away from direct sunlight. Segregate from incompatible chemicals.
- Peroxide formers, liquid peroxides, or solutions must not be refrigerated below the temperature at which the peroxide freezes or precipitates. Peroxides in these forms are extra sensitive to shock (never store diethyl ether in a refrigerator or freezer).
- Unused peroxides must never be returned to the stock container.
- Metal spatulas must not be used with peroxide formers. Only ceramic or plastic spatulas can be used. Contamination by metal can cause explosive decomposition.
- Friction, grinding, and all forms of impact, especially with solid organic peroxides should be avoided. Never use glass containers with screw cap lids or glass stoppers. Instead, use plastic bottles and sealers.
- Testing for the presence of peroxides shall be performed periodically as needed.
- Containers with obvious crystal formation around the lid or viscous liquid at the bottom of the container must not be opened or moved.
- Refer to http://safety.dri.edu/Hazards/peroxide.doc for the complete DRI policy on peroxide formers and more information regarding safe handling and storage.

5.6.3 Water-reactives

Water reactives react with water or moisture in the air releasing heat or flammable, toxic gas. Examples include alkali metals, alkaline earth metals, carbides, hydrides, inorganic chlorides, nitrides, peroxides, and phosphides.

- Appropriate PPE should be worn when working with water-reactives.
- Water-reactives should be stored under mineral oil in a cool, dry place. Isolate from other chemicals.
- Water-reactives must not be stored near water, alcohols, and other compounds containing acidic OH.
- In case of fire, keep water away. Appropriate fire extinguishers should be available in areas where water-reactives are used (Type “D” used for metal fires).

5.6.4 Pyrophorics

Pyrophorics ignite spontaneously in air below 130º F (54º C). Often the flame is invisible. Examples of pyrophoric materials include silane, silicon tetrachloride, white and yellow phosphorus, sodium, tetraethyl lead, potassium, nickel carbonyl, and cesium.

- Appropriate PPE must be worn when working with pyrophorics.
- Pyrophorics must be used and stored in inert environments.
- Appropriate fire extinguishers should be available in areas where pyrophorics are used.

5.7 Carcinogens, Reproductive Toxins, and Acutely Toxic Chemical – Procedures for Safe Handling and Storage

The OSHA Laboratory Standard requires that special handling procedures be employed for certain chemicals identified as "particularly hazardous substances." Particularly hazardous substances include chemicals that are "select" carcinogens, reproductive toxins, and chemicals that have a high degree of acute toxicity, a partial list is located in Appendix C. In addition, many chemicals used (including synthesized) in research laboratories have not been tested explicitly for carcinogenic or toxic properties and should therefore be handled as "particularly hazardous substance" since the hazards are unknown.

Carcinogens - are substances that are either known to cause cancer in humans or animals, or are suspected of being capable of causing cancer in humans. These materials include substances that:

- OSHA regulates as a carcinogen.
- The National Toxicology Program (NTP) lists as "known to be a carcinogen" or "reasonably anticipated to be a carcinogen" in their Annual Report on Carcinogens.
- The International Agency for Research on Cancer (IARC) lists under Group 1 "carcinogenic to humans", Group 2A "probably carcinogenic to humans", or Group 2B "possibly carcinogenic to humans".

Reproductive/Developmental Toxins - are substances that cause chromosomal damage or genetic alterations (mutagens) or substances with lethal or teratogenic (malformations or physical defects) in a developing fetus or embryo. Reproductive toxins also include chemicals that affect the fertility of males and/or females.

Acutely Toxic Chemicals – acute toxicity is the ability of a chemical to cause a harmful effect after a single exposure. Acutely toxic chemicals can cause local toxic effects, systemic effects, or both. In general, acutely toxic chemicals have an oral LD50 of <50 mg (rats, per kg), skin contact LD50 <200 mg (rabbits, per kg), inhalation LC50 of <200 (rats, ppm for 1 hr) or, <2000 (rats, mg/m^3 for 1 hr).

Prior Approval

As a matter of good practice, and to satisfy regulatory requirements, particularly hazardous substances require additional planning and considerations. Because of the high risk associated with these substances, laboratory workers planning to use a particularly hazardous substance must first receive explicit written approval from their Division Director, Principal Investigator and the DRI Chemical Hygiene Officer. All OSHA and National Toxicology Program listed carcinogens must formally be registered with the CHO by using the form found in Appendix B. A specific SOP shall be developed for the substance in question.

Information to be included on the request include:

- Identity, physical characteristics, and health hazards of the substance involved
- Consideration for exposure control methods
- Plans for storage and secondary containment

- Plans for safe removal of contaminated waste
- Decontamination and spill procedures
- Designated area

The designated area shall be marked with the following sign:

DANGER
DESIGNATED AREA
for select carcinogens, reproductive toxins and
high acute toxicity chemicals

AUTHORIZED PERSONNEL ONLY

The signage can be posted at the actual use area or if the entire lab will be designated, on each entry door.

Handling

- Designated areas (e.g., chemical hoods, glove boxes, lab benches, outside rooms, etc.) for material use must be established and the areas identified by signs or postings.
- Containment devices such as fume hoods (if necessary) and personal protective equipment (gloves, lab coat, eye protection) must be used when handling these hazardous substances.
- Procedures for the safe use of the material and waste removal must be established prior to use.
- Decontamination procedures must be developed in advance and strictly followed.
- Only laboratory personnel trained to work with these substances shall perform the work, and always within the designated area. Prior approval is required by the principal investigator or supervisor (see above).
- Only the minimum quantity of the particularly hazardous substance necessary to conduct the research should be ordered and to the extent possible, the experimental design should be done on a micro-scale.

Storage

- These materials must be stored in areas designated for “particularly hazardous substances.”
- Storage areas must be clearly marked with the appropriate hazard warning signs.
- All containers of these materials (even if the material is in very small quantities such as 0.1%) must be clearly labeled with the chemical name or mixture components and the appropriate hazard warning information.
- Chemical storage areas must be secure to avoid spills or broken containers (e.g., cabinets closed, adequate earthquake bracing).
- Storage areas or laboratory rooms must be locked when laboratory personnel are absent.

5.8 Compressed Gases – Procedures for Safe Handling and Storage

In general, a compressed gas is any material contained under pressure that is dissolved or liquefied by compression or refrigeration. Compressed gas cylinders should be handled as high energy sources and therefore as potential explosives and projectiles. Prudent safety practices should be followed when handling compressed gases since they expose workers to both chemical and physical hazards. For more detailed information, refer to the DRI "Use, Handling & Storage of Compressed Gases & Cryogenic Liquids" procedure located at http://safety.dri.edu/Programs/Compressed.pdf.

Handling

- Safety glasses with side shields (or safety goggles) and other appropriate PPE must be worn when working with compressed gases.
- Cylinders must be marked with a label that easily visible and clearly identifies the contents.
- All cylinders must be checked for damage prior to use. Do not repair damaged cylinders or valves. Damaged or defective cylinders, valves, etc., must be taken out of use immediately and returned to the manufacturer/distributor for repair.
- All gas cylinders (full or empty) must be rigidly secured to a substantial structure at 2/3 height. Double chaining is preferred and only link chains or belts with buckles are acceptable. Cylinder stands are also acceptable but not preferred.
- Gas cylinder hand carts (3 or 4 wheeled models are preferred) shall be used when moving gas cylinders. Cylinders must be chained to the carts.
- Plan the route of transport. The best practice is to avoid using an elevator. If an elevator cannot be avoided, send the cylinder to the required floor in an empty elevator, with a warning sign posted. A co-worker should be waiting on the other level to receive the cylinder.
- All cylinders must be fitted with safety valve covers before they are moved.
- Only three-wheeled or four-wheeled carts should be used to move cylinders.
- A pressure-regulating device shall be used at all times to control the flow of gas from the cylinder.
- The main cylinder valve shall be the only means by which gas flow is to be shut off. The correct position for the main valve is all the way on or all the way off.
- Cylinder valves should never be lubricated, modified, forced, or tampered.
- Regulators and valves should be tightened firmly with the proper size wrench. Do not use adjustable wrenches or pliers because they may damage the nuts.
- After connecting a cylinder, check for leaks at connections. Periodically check for leaks while the cylinder is in use.
- Cylinders must not be placed near heat or where they can become part of an electrical circuit.
- Cylinders must not be exposed to temperatures above 122º F (50º C). Some rupture devices on cylinders will release at about 149º F (65º C). Some small cylinders, such as lecture bottles, are not fitted with rupture devices and may explode if exposed to high temperatures.
- Rapid release of a compressed gas shall be avoided because it will cause an unsecured gas hose to whip dangerously and also may build up enough static charge to ignite a flammable gas.

- Appropriate regulators must be used on each gas cylinder. Threads and the configuration of valve outlets are different for each family of gases to avoid improper use. Adaptors and homemade modifications are prohibited.
- Cylinders must never be bled completely empty. Leave a slight pressure to keep contaminants out.

Storage

- When not in use, cylinders shall be stored with their main valve closed and the valve safety cap in place.
- Segregate and clearly mark full and empty cylinders.
- Toxic gases (NFPA health hazard rating of 3 or 4) should be stored and used in a ventilated hood or gas cabinet. An area monitor with alarm should be used if a ventilated enclosure is not used, and when the toxic gas has poor warning properties (such as carbon monoxide). Contact the CHO for specific guidance
- Cylinders must be stored upright and not on their side. All cylinders must be secured.
- Cylinders awaiting use must be stored according to their hazard classes.
- Cylinders should not be located where objects may strike or fall on them.
- Cylinders must not be stored in damp areas or near salt, corrosive chemicals, chemical vapors, heat, or direct sunlight. Cylinders stored outside should be protected from the weather.

Maximum Number of Gas Cylinders:
The maximum amount of compressed gas or liquefied gas cylinders per control area (generally an area enclosed by exterior and/or corridor walls) are:

Flammable Gas	2000 ft^3
Oxidizing Gas (including oxygen)	3000 ft^3
Corrosive Gas	1620 ft^3
Toxic Gas	1620 ft^3
Highly Toxic Gas*	20 ft^3

*Allowed only when stored in approved exhausted gas cabinets or exhausted enclosures.

Note[1]: Above limits are based on the International Fire Code with additional allowance given for DRI buildings being equipped with sprinklers. For areas without sprinklers, the maximum is 50% of the amounts listed above.

Note[2]: Contact the CHO (702) 862-5358 if there is a need to have more than 500 ft^3 of any of the above groups in individual labs. This is to ensure that storage limits are not exceeded.

Special Precautions
Flammable Gases:

- Low melt point piping must not be used with flammable gases.

- Manifolded systems shall be designed and constructed by competent personnel who are thoroughly familiar with the requirements for piping of flammable gases. Manifolds shall comply with the standards of a recognized safety authority (i.e., Underwriters Laboratories, Compressed Gas Association). Consultation with the gas supplier before installation of manifolds is recommended.
- Valves on flammable gas cylinders must be shut off when the laboratory is unattended and no experimental process is in progress.
- Flames involving a highly flammable gas must not be extinguished until the source of the gas has been safely shut off; otherwise it can reignite causing an explosion.
- Heat generated by flames associated with the use of flammable gases in laboratories must be vented.

Acetylene Gas Cylinders:

- Acetylene cylinders must always be stored upright. They contain acetone, which can discharge instead of or along with acetylene. Do not use an acetylene cylinder that has been stored or handled in a non-upright position until it has remained in an upright position for at least 30 minutes.
- A flame arrestor must protect the outlet line of an acetylene cylinder.
- Compatible tubing must be used to transport gaseous acetylene. Some tubing like copper forms explosive acetylides.

Lecture Bottles:

- All lecture bottles must be marked with a label that clearly identifies the contents.
- Lecture bottles shall be stored according to their hazard classes.
- Lecture bottles that contain toxic gases shall be stored in a ventilated cabinet.
- Lecture bottles must be stored in a secure place to eliminate them from rolling or falling.
- Lecture bottles shall not be stored near corrosives, heat, direct sunlight, or in damp areas.
- To avoid costly disposal fees, lecture bottles must only be purchased from suppliers that will accept returned bottles (full or empty). Contact the supplier before purchasing to ensure that they have a return policy.
- Lecture bottles must be dated upon initial use. It is advised that bottles be sent back to the supplier after one year to avoid accumulation of old bottles.

5.9 Cryogenic Liquids – Procedures for Safe Handling and Storage

Cryogenic liquids are liquefied gases having boiling points of less than 100º F (73.3º C). The primary hazards of cryogenic liquids include both physical hazards such as fire, explosion, and pressure buildup and health hazards such as severe frostbite and asphyxiation. Potential fire or explosion hazards exist because cryogenic liquids are capable, under the right conditions, of condensing oxygen from the atmosphere. This creates a oxygen-rich environment which is potentially hazardous and can lead to a fire or explosion. Pressure is also a hazard because of the large volume expansion ratio from liquid to gas that a cryogen exhibits as it warms and the liquid evaporates. This expansion ratio also makes cryogenic liquids more prone to splash and therefore skin and eye contact is more likely to occur. Contact with living tissue can cause frostbite or thermal burns, and prolonged contact can cause blood clots and have very serious consequences. All laboratory personnel who handle cryogenic materials should follow prudent safety practices and refer to the DRI guidance document "Using Cryogenic Liquids" located on the web at http://safety.dri.edu/Hazards/CryogenicLiquidGuidelines.pdf.

Handling

- Appropriate PPE shall be worn when handling cryogenic liquids. This includes at a minimum special cryogen gloves, safety glasses or goggles plus a face shield, lab coat, long pants, and high topped shoes. Gloves should be impervious and sufficiently large to be readily removed should a cryogen be spilled. Watches, rings, and other jewelry must not be worn.
- Unprotected body parts should not come in contact with vessels or pipes that contain cryogenic liquids because extremely cold material may bond firmly to the skin and tear flesh if separation is attempted.
- Objects that are in contact with cryogenic liquid must be handled with tongs or proper gloves.
- All precautions must be taken to keep liquid oxygen from organic materials; spills on oxidizable surfaces can be hazardous.
- All equipment should be kept clean, especially when working with liquid or gaseous oxygen.
- Work areas should be well ventilated.
- Transfers or pouring of cryogenic material must be done very slowly to minimize boiling and splashing.
- Cryogenic liquids and dry ice used as refrigerant baths must be open to the atmosphere. They should never be in a closed system where they may develop uncontrolled or dangerously high pressure.
- Dewar flasks should be shielded with tape or wire mesh to minimize flying glass and fragments should an implosion occur. Plastic mesh will not stop small glass fragments.
- Liquid hydrogen must not be transferred in an air atmosphere because oxygen from the air can condense in the liquid hydrogen presenting a possible explosion risk.

Storage

- Cryogenic liquids must be handled and stored in containers that are designed for the pressure and temperature to which they may be subjected. The most common

container for cryogenic liquids is a double-walled, evacuated container (dewar flask).

- Containers and systems containing cryogenic liquids must have pressure relief mechanisms.
- Cylinders and other pressure vessels such as dewar flasks used for the storage of cryogenic liquids should not be filled more than 80% of capacity, to protect against possible thermal expansion of the contents and bursting of the vessel by hydrostatic pressure. If the possibility exists that the temperature of the cylinder may increase to above 86º F (30º C), a lower percentage (e.g., 60% capacity) should be the limit.
- Dewar flasks must be labeled with the full cryogenic liquid name and hazard warning.

5.10 Hazardous Material Spills – Procedures

If an immediate fire hazard exists or medical assistance is required call 911. Evacuate the area. While awaiting emergency response, notify EH&S using an emergency ONLY number (775-742-6330). For spills involving radioactive materials or radiation hazards, immediately contact the UNR Radiation Safety Office at (775-784-4540) then call the DRI EH&S using the above emergency ONLY number.

Toxic or hazardous materials are any substances which endanger the health and safety of employees (or the environment should they escape the building). Release of such material is defined as liquid spills, venting and/or re-entry into the air intake of gases, fumes, vapors or mists, or hazardous solids outside of their normal containers. Also included are the releases of pathogens or radioactive material. Depending on the quantity as well as the inherent hazard of the released materials, hazardous materials spills can be broadly classified as **"Incidental"** or **"Non-incidental"** spills as follows:

An **incidental spill** is one that does not cause a health or safety hazard to employees and does not need to be cleaned up immediately to prevent death or serious injury to employees or damage to the environment. Responses to incidental releases of hazardous substance where the substance can be absorbed, neutralized, or otherwise controlled at the time of the release by employees in the immediate release area are not considered to be an emergency response. Hazardous substance releases with no immediate danger to life personnel safety or environment are not considered to be emergency responses and cleanup using proper PPE as follows.

- Verbally notify everyone within hearing distance that a spill has occurred.
- Ensure ventilation is adequate to prevent accumulation of flammable or toxic vapors.
- Confine the spill. If liquid, dike the spill with absorbent pillows or pigs, or surround with powder absorbent, then place absorbent over the contamination. If dry, carefully collect the material, being very careful to prevent it from becoming airborne.
- If the spill is on skin or in the eyes, flush thoroughly with running water for a minimum of 15 minutes, then seek medical attention. If the spill is on clothing, you must discard all outer layers and deluge area using an emergency shower. Enlist the help of other persons to conduct the spill clean up.
- Use plastic tongs to pick up broken glass and other sharps; dispose of all sharps in a hard-sided container to prevent sticks.
- Use absorbent to soak up the liquid. Start at the perimeter of the spill and work toward the center.
- Place contaminated absorbent in a plastic bag for disposal. Use dust pan to handle contaminated absorbent in order to minimize contact with the chemical.
- Carefully wipe with water all contaminated surfaces until chemical residue is removed (soapy water may be required). Place used wiping material in a plastic bag for disposal.
- Inspect the area. Carefully check the entire affected area for spill residue, hidden contamination, or unsafe conditions.
- Place all used absorbent material and contaminated PPE in a plastic bag; seal the bag, label as chemical waste, and submit a request for waste disposal.

- Dispose of any broken glass collected as non-hazardous waste (regular trash) – assuming only trace chemical contamination is present.
- Restock the chemical spill cleanup kit.

A non-incidental spill is a spill that requires a response effort from outside the immediate release area by other designated responders (i.e., the fire department) because the incident will result, or is likely to result, in an uncontrolled release which may cause high levels of exposure to toxic substances, or which poses danger to employees or the environment requiring immediate attention. Responding to non-incidental spill is called an **"Emergency Response" and requires persons who have had the 40 hr. initial hazardous waste operations training and subsequent 8 hr. refreshers to conduct the response.**

Refer to http://www.dri.edu/Admin/Policies/safetyandsecurity.htm for additional information.

5.11 Electrical Safety Procedures

Serious injury or death by electrocution is possible when appropriate attention is not given to the engineering and maintenance of electrical equipment and personal work practices around such equipment. In addition, equipment malfunctions can lead to electrical fires. By taking reasonable precautions, electrical hazards in the laboratory can be dramatically minimized.

- Laboratory personnel should know the location of electrical shut-off switches and/or circuit breakers in or near the laboratory so that power can be quickly terminated in the event of a fire or accident.
- Electrical panels and switches must never be obstructed and be clearly labeled to indicate what equipment or power source they control.
- All electrical equipment should be periodically inspected to ensure that cords and plugs are in good condition. Corrosive chemicals and organic solvents can easily erode insulation on wires frayed wires and wires with eroded or cracked insulation must be repaired immediately or tagged out of service until repairs can be made.
- All electrical outlets should have a grounding connection requiring a three-pronged plug.
- Electrical equipment should have three-pronged, grounded connectors (low-power devices may have UL approved two-pronged connectors).
- Three-pronged connectors must not be modified into two-pronged devices.
- Faceplates should be in good condition (not cracked or broken) and must not be removed from electrical outlets.
- Electrical wires must not be used as supports.
- Extension cords should be avoided and never used in place of fixed wiring for permanently installed equipment . If used, they should have three-pronged, grounded connectors and positioned or secured as not to create a tripping hazard.
- All shocks must be reported to the principal investigator or lab supervisor. All faulty electrical equipment must be immediately removed from service until repaired.
- Electrical outlets, wiring, and equipment within a laboratory or building must only be repaired by DRI Facilities staff or other professional electricians.
- Proper grounding and bonding of larger flammable liquid containers (≥ 5 gallons) must be practiced to avoid the build-up of excess static electricity. A Spark generated from static electricity is a good ignition source.

5.12 Glassware and Sharps – Procedures for Safe Handling and Disposal

Handling

- Glassware must be handled and stored carefully to avoid damage.
- Chipped, broken, or star-cracked glassware must be discarded or repaired. Damaged glassware should never be used.
- Only thick-walled, pressure resistant glassware should be utilized under a vacuum.
- Appropriate hand protection must be used when picking up broken glass or other sharp objects. Small pieces should be swept up using a brush and dustpan.
- Appropriate hand protection should be used when inserting glass tubing into a rubber stopper or when placing tubing on glass hose connections. Use of plastic or metal connectors should be considered.

<u>Disposal</u>

Uncontaminated glass, including broken glassware, destined for disposal should be placed in a sturdy, bag lined cardboard box. The box should be labeled “BROKEN GLASS” and when full, taped shut and loaded into a dumpster.

Contaminated glass should be rinsed with a small amount of acetone, methanol or other solvent that will remove the contamination. The rinsate must be collected for chemical waste disposal. The rinsed glass is then packaged for solid waste disposal as above.

If the glass is heavily contaminated or is broken and would pose a laceration hazard to the worker when rinsing it, package as above, but label it as a hazardous solid waste. Complete a “Request for Waste Disposal Form” and contact EH&S to schedule a pick up.

- All broken glassware must be collected in a hard plastic receptacle labeled “Broken Glassware.” The custodial staff will discard the contents of these containers.
- All other sharps (needles, razor blades, scalpels, etc.), regardless of contamination, must be placed in heavy cardboard boxes or other puncture-proof containers and marked as “Sharps”. Uncontaminated sharp containers may then been placed in the normal trash.
- Sharps and glassware that are contaminated with hazardous materials must be collected in puncture-proof containers, marked as “Sharps” and placed in double bags with other lab generated solid wastes (i.e., contaminated gloves or bench paper) and held for waste disposal. Contact EH&S to schedule pick up.
- For sharps and glassware contaminated with hazardous biological materials (e.g., blood, pathogenic microbes) place in a sharps container labeled with the biohazard symbol. Autoclave or steam sterilize prior to disposal or contact EH&S for other disposal options.
- All sharps and glassware contaminated with radioactive materials must be discarded according to procedures outlined in University of Nevada – Reno’s Radiation Safety Manual.

6.0 LABORATORY SAFETY EQUIPMENT

6.1 Chemical Hoods

Chemical hoods are one of the most important items of safety equipment present within the laboratory. Chemical hoods serve to control the accumulation of toxic, flammable, and offensive vapors by preventing their escape into the laboratory atmosphere. In addition, chemical hoods provide physical isolation and containment of chemicals and their and their reactions and thus serve as a protective barrier (with the sash closed) between laboratory personnel and the chemical or chemical processes within the hood. For more detailed information refer to DRI's chemical hood procedure at http://safety.dri.edu/Programs/DRIHOOD.pdf.

A chemical hood should be used for any chemical procedures which have the potential of creating:

- Airborne chemical concentrations that might approach PELs for an OSHA regulated substance. These substances include carcinogens, mutagens, teratogens, and other toxics.
- Flammable/combustible vapors approaching one tenth the lower explosion limit (LEL). The LEL is the minimum concentration (percent by volume) of the fuel (vapor) in air at which a flame is propagated when an ignition source is present.
- Explosion or fire hazards.
- Odors that are annoying to personnel within the laboratory or adjacent lab/office units.

Usage Guidelines

- The hood sash opening should be kept to a minimum while the hood is used. When working with hazardous chemicals, the hood sash should be positioned so that it acts as a protective barrier between laboratory personnel and the chemicals.
- Chemicals and equipment should be placed at least 6 inches from the front edge of the hood.
- Chemical hoods should be kept clean and free from unnecessary items and debris at all times. Solid material (paper, tissue, aluminum foil, etc.) should be kept from obstructing the rear baffles and from entering the exhaust ducts of the hood.
- Equipment should be placed as far back in the hood as practical without blocking the baffles. Separate and elevate equipment by using blocks to ensure that air can flow easily around and under the equipment.
- Minimize the amount of bottles, beakers and equipment used and stored inside the hood because these items interfere with the air flow across the work surface of the hood.
- Laboratory personnel should not extend their head inside the hood when operations are in progress.
- The hood must not be used for hazardous waste disposal (evaporation).
- Heated perchloric acid must not be used in a regular chemical fume hood. Specially designed perchloric acid chemical hoods must be used.
- Chemical hoods are calibrated yearly. If your air flow indicator is showing low flow, contact Facilities to arrange repairs.

6.2 Safety Showers

Safety showers are required to be within 100 feet of areas where hazardous chemicals are used (no more than 10 seconds travel time). Safety showers provide an effective means of initial treatment in the event of chemical contamination of the skin or clothing. The shower area should be readily accessible, clear of obstructions, and clearly labeled. Every laboratory worker should know where the safety showers are located and how to use them. To ensure proper operation, safety showers are inspected on a monthly basis by Facilities. In the event of chemical contamination of an individual's body, immediately flush the body for 15 minutes under the shower, removing all clothing, and seek medical attention.

6.3 Eyewash Stations

Eyewash stations are required in areas where hazardous chemicals are used. Eyewashes should be easily accessible, unobstructed, and clearly labeled. The use of hands should not be required to activate and maintain the water flow. Eyewashes are inspected monthly by Facilities to ensure proper operation and lab personnel should perform a weekly flushing to remove contamination build-up. In the event of chemical contamination of the eyes or face, immediately flush the eyes/flash for 15 minutes and seek medical attention.

6.4 Fire Extinguishers

Fires are one of the most common types of laboratory accidents. Laboratory personnel should know the locations of all fire extinguishers in the laboratory, the type of fires for which they are appropriate, and how to operate them correctly. You must be trained to use a fire extinguisher. Training is scheduled at DRI annually, all laboratory personnel are encouraged to attend. Fire extinguishers in the laboratory should be the appropriate type for the expected fire emergency. Extinguishers are classified according to a particular fire type. Type A are used on combustible (wood, paper, rubber, plastic) fires, Type B are used on flammable liquid fires, Type C are used on energized electrical equipment fires, and Type D are used on combustible metal (lithium, sodium, magnesium, potassium) fires. Multipurpose (Type ABC) fire extinguishers are the type most commonly found at DRI. Fire extinguishers should be easily accessible, mounted properly on a wall, and unobstructed. Facilities inspect fire extinguishers monthly. Used fire extinguishers should be immediately serviced.

6.5 Flammable Liquid Storage Cabinets

Flammable liquids in quantities exceeding 10 gallons in a laboratory must be stored in an approved flammable liquid storage cabinet. Flammable storage cabinets shall be designed to meet NFPA (National Fire Protection Agency) guidelines. For quantity limitations refer to Section 5.4. Approved cabinets should be marked in conspicuous lettering "FLAMMABLE-KEEP FIRE AWAY." Fire cabinets are not required to be vented (cabinets are generally vented only if the flammable liquids generate noxious fumes), but if venting is needed it shall be done according to NFPA and the Nevada State Fire Marshal's guidelines. Only flammable and combustible material should be stored in flammable storage cabinets.

6.6 Explosion-Proof, Laboratory-Safe and Commercial Refrigeration Equipment

The use of household refrigerators or commercial cold boxes for the storage of flammable liquids presents a significant hazard to the laboratory work area. Refrigeration temperatures are commonly higher than the flash points of the flammable liquids stored

inside. In addition, they contain readily available and exposed ignition sources such as thermostats, lights, and heater strips. Flammable liquids should only be stored in two types of laboratory refrigerators; explosion-proof and laboratory-safe models.

Explosion-proof refrigeration equipment is designed to protect against ignition of flammable vapors both inside and outside the refrigerated storage compartment and is only required in areas designated for storage or dispensing of flammable chemicals (i.e., flammable liquid dispensing room). Laboratory-safe equipment (also called explosion-safe) is designed to eliminate ignition of vapors on only the inside of the storage compartment, although other safety design features like self-closing doors, magnetic door gaskets, and compressors and circuits located at the top of the refrigeration unit have been incorporated.

All flammable liquids that need to be stored in a cool environment should be stored in these types of approved refrigerators. Containers should be tightly closed to minimize the amount of vapor released. Every laboratory refrigerator, controlled temperature room and freezer should be clearly marked to indicate whether or not it is safe for the storage of flammable liquids.

6.7 Portable Safety Shields

Portable safety shields can provide limited protection against explosions, fires, and chemical splash hazards. When a hood sash cannot provide proper shielding, portable safety shields should be used. It should be noted that portable safety shields do not provide protection on the sides and back of equipment and therefore work best if used in conjunction with a fume hood. Laboratory equipment/chemical apparatus should be shielded on all sides so that there is no line-of-sight exposure to laboratory personnel.

6.8 First Aid Kits

First aid kits should be easily accessible to all laboratory personnel. First aid kits should be regularly inspected and restocked as necessary. First aid kits can be purchased through any laboratory safety supply vendor. As a general guideline, first aid kits should contain the following:

Quantity	Item
1	Absorbent compress (32 sq. in., no less than 4 inches)
16	Adhesive bandages (1” x 3”)
1	Adhesive tape (5 yards total)
10	Antiseptic applications (moist wipes)
6	Burn treatment applications
2	Pair medical exam gloves
4	Sterile pads (3” x 3”)
1	Triangular Bandage (40” x 40” x 56”)
1	CPR mask
1	Eye dressing

Calcium gluconate gel must be available if hydrofluoric acid is used in lab.

6.9 Chemical Spill Kits (for incidental spills only)

Every laboratory that uses hazardous chemicals should have access to a spill control kit. Refer to Section 5.10 for further information in spill clean-up procedures. The keys to an effective spill kit are location and content. DRI has strategically located spill kits around laboratory areas so they are easily accessible by multiple lab groups. These spill kits (marked 5 gallon buckets) contain absorbent material for acids, bases, and solvents. Laboratories that use mercury or mercury filled thermometers and manometers should also have a mercury spill kit available. Once a spill kit has been used it should be immediately restocked. Spill kits can be purchased through most vendors that sell chemicals or safety supplies. The following is a list of recommended items that should be used in a chemical spill clean-up. However, it is important that spill kits be tailored to meet the specific spill control needs of each laboratory.

Personal Protective Equipment

The minimum PPE required for spill cleanup is:

- Splash goggles not just safety glasses
- Lab coat with sleeves rolled down
- Nitrile or neoprene gloves in good condition (other gloves may be required for specific chemicals, check with EH&S if you are unsure).

Spill Cleanup Materials

The following is a minimum recommended list of supplies:

- Absorbent material
- Plastic trash bags (30 gallon, 3 mil thick)
- 3-5 gallon plastic bucket with lid
- 1 pair of plastic tongs for picking up broken glass
- 1 plastic dust pan for scooping up solidified material

7.0 MEDICAL CONSULTATIONS AND EXAMINATIONS

In accordance with the requirements of the OSHA Lab Standard, DRI provides all employees who work with chemicals the opportunity to receive medical attention without cost to the employee and loss of pay provided one or more of the criteria listed in 7.1 is met.

All occupational injuries or illnesses should be reported to the DRI Workers Compensation Coordinator at (775) 673-7325, as soon as possible, but no longer than 24 hours after the injury/illness has occurred along with notifying his/her supervisor.
The coordinator will need a C-1 Form (Employer's Notice of Injury or Occupational Disease Incident Report) to be completed by the employee and supervisor and returned within seven days after the incident. You can access the C-1 form online at http://safety.dri.edu/EmergInfo/C-1-D-2.doc. In addition, all laboratory incidents resulting in personal injury, illness, and/or property or equipment damage, should be reported to the CHO.

7.1 Examination/Consultation Criteria

- Employee develops signs or symptoms that are associated with a hazardous chemical to which they have been exposed.
- Air monitoring indicates a routine exposure level above the PEL (if no OSHA PEL level exists, ½ the ACGIH TLV or other exposure limit will be used).
- A spill, leak, explosion, or other events occur in the laboratory resulting in the likelihood of chemical exposure.

7.2 Medical Surveillance

When toxicologically significant quantities of carcinogens, reproductive toxins, or chemicals with high chronic toxicity are used on a regular basis (i.e., multiple times per week) implementation of a medical surveillance program should be considered. Since the specific circumstances determine the need for medical surveillance, consult the CHO in these instances.

As a general guideline, a toxicologically significant quantity of a chronic toxin is an amount that exceeds one-half of the acute dose that is expected to be lethal to 50% of exposed test animals (LD_{50}). The following equation is based on exposure to a 50 kilogram person (a conservative assumption):

Toxicologically Significant Quantity (g):≥ [LD_{50} (mg/kg) x 50 kg x 1/1000] / 2

7.3 Principal Investigator/Lab Supervisor's Responsibility

Provide the following to the physician:

- Identity of any chemicals involved in exposure (include MSDS or other hazard information).
- A description on the conditions under which the exposure occurred.
- A description of the employee's symptoms.

7.4 Physician's Written Opinion

After completion of the employee's examination, the lab supervisor must obtain a written opinion from the examining physician that includes the following:

- Any recommendation for medical follow-up.
- The results of the medical examination and any associated tests.
- Any medical condition identified during the examination that may place the affected person at increased risk as a result of exposure to hazardous chemicals found in the workplace.
- A statement that the affected person has been informed by the physician of the results of the examination, and of any medical condition that may require further examination or treatment.

NOTE: This report must not include specific findings of diagnoses unrelated to occupational exposure.

7.5 Medical Facilities

Employees who are injured or exposed to chemicals, and require medical attention, should go to one of the following medical facilities that participate in the Worker's Compensation Program. For all life threatening injuries call **911**.

7.5.1 **Reno** (non-life threatening injuries)

Specialty Health Clinic (preferred)
350 W. Sixth Street, Suite 2-D
Reno, NV
(775) 322-2122
Hours: 8:00 a.m. to 7:00 p.m. M-F

St. Mary's Hospital
235 W. Sixth Street
Reno, NV
(775) 770-3000
Hours: 24 hours, 7 days a week

Northern Nevada Medical Center
2375 E. Prater Way
Sparks, NV
(775) 331-7000
Hours: 24 hours, 7 days a week

7.6.1 **Las Vegas** (non-life threatening injuries)

Harmon Medical Center
150 E Harmon Av, 2nd floor #206
Las Vegas, NV
(702) 796-1116
Hours: 24 hours, 7 days a week
After Hours: Go to 1st floor clinic

Any Rainbow Medical Center Clinic

8.0 RECORDKEEPING

8.1 Training Records

Training records for each laboratory worker shall be maintained for the worker's entire tenure at DRI. EH&S maintains training records of general laboratory safety training and other training sessions conducted by EH&S. Laboratory-specific training records should be maintained by individual laboratories or departments and include documentation of content provided (see Appendix A).

8.2 Exposure Monitoring Records

Records of exposure monitoring results and exposure assessments performed or oversaw by EH&S are maintained by EH&S. These records are available to personnel or their designated representatives upon request.

8.3 Medical, Injury and Illness Records

The Business Center North Worker's Compensation Office maintains records of reported accidents and illnesses, and associated medical consultations and examinations in accordance with UCCSN policy. These records are confidential and must be maintained as such. Access to medical records must be limited to those persons with legitimate needs.

LAB SPECIFIC TRAINING DOCUMENTATION

Lab specific training is necessary to augment the Chemical Hygiene Plan Orientation for specific hazards and procedures unique to each lab. This training includes the following information:

- Hazards of specific laboratory chemicals and procedures
- Location of laboratory SOPs
- Procedures requiring prior approval
- Chemical storage and inventory practices
- Specific use of laboratory hoods and other engineering controls
- Availability, selection and use of PPE (e.g., gloves, safety glasses, etc.)
- Location and availability of MSDSs and other chemical hazard reference material
- Emergency procedures and equipment (i.e., eyewash stations, spill and fire response)

NOTE: <u>All</u> lab personnel must also complete the CHP Orientation training.

TRAINER	LAB PERSONNEL	DATE

PARTICULARLY HAZARDOUS SUBSTANCE USE APPROVAL FORM

Before using any particularly hazardous substance, complete this form and have it approved by the Principal Investigator, Chemical Hygiene Officer and Division Director. To simplify the approval process a list of more commonly used PHS is located in Appendix C, however the list is not all inclusive. For help in determining whether a substance meets the PHS criteria, contact the CHO at x5358.

Date _____ Authorization # _____

Division _____ Bldg./Room # _____

Applicant _____ Phone _____

Substance Information

Chemical Name _____ CAS # _____ Physical Form _____

☐ Carcinogen ☐ Reproductive Toxin ☐ High Acute Toxicity Max Quantity _____

Stability (decomposes, polymerizes, short shelf life) ☐ Stable ☐ Unstable Physical Hazard (flam, cor) _____

Duration of Project _____ Known Incompatibilities _____

Experiment purpose and material use description (attach additional sheet if needed)

_____

_____

_____

_____

Exposure Controls/Personal Protective Equipment

☐ Chemical Hood ☐ Glove Box ☐ Safety Glasses ☐ Splash Goggles

☐ Face Shield ☐ Gloves (type_____) ☐ Lab Coat ☐ Apron

☐ Respirator ☐ Other, please describe _____

Spills, Decontamination and Disposal

Spill control materials readily available ☐ Yes ☐ No

Decontamination method _____

In-lab neutralization ☐ Yes ☐ No

Deactivation ☐ Yes ☐ No

Dispose as hazardous waste ☐ Yes ☐ No

All use of chemical carcinogens listed in this application will be in conformance with the requirements listed in the DRI Chemical Hygiene Plan and Carcinogen SOP. All personnel listed below will be specifically trained to use chemical carcinogens safely.

Medical surveillance for project personnel may be required. Notification will be issued if it is required and project account will cover the cost.

A written SOP is required with this application. Contact the CHO for assistance in establishing a specific standard operating procedure.

Additional personnel participating in this project

_____ _____ _____

_____ _____ _____

_____ _____ _____ _____

Applicant Signature **Date** **Division/Center Director** **Date**

_____ _____

Environmental Health & Safety **Date**

PARTICULARLY HAZARDOUS SUBSTANCES

(not all inclusive, DRI examples in bold)

Carcinogens – OSHA, IARC Group 1 and NTP Type 1

2- Acetylaminofluorene
Acrylonitrile
Aflatoxins
4-Aminobiphenyl
Arsenic (and As compounds)
Asbestos
Azathioprine
Benzene
Benzidine
Beryllium (and Be compounds)
Bis-chloromethyl ether
1,3-Butadiene
1,4-Butanediol dimethylsulfonate
Cadmium
Chlorambucil
N,N-bis(2-Chloroethyl)-2-naphthylamine
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea
Chromium (VI) compounds
Chloromethyl ether
Coal tars (and volatiles and extracts)
Ciclosporin
1,2-Dibromo-3-chloropropane
Cyclophosphamide
Diethylstilbestrol
3,3-Dichlorobensidine (and its salts)
N,N-Dimethylnitrosamine
4-Dimethylaminoazo-benzene
Estrogens (conjugated)
Erionite
Ethyleneimine
Ethylene oxide
Formaldehyde
Melphalan
Methyl chloromethyl ether
Methylene Chloride
8-Methoxypsoralen plus UV radiation
4,4-Methylenedianiline
Mineral Oils (untreated and mildly treated)
Mustard gas (bis(2-chloroethyl)sulfide)
α-Naphthylamine
ß-Naphthylamine
Nickel (and Ni compounds)
4-Nitrobiphenyl
N-Nitrosodimethylamine
Oestrogens (steroidal and non-steroidal)
Oral contraceptives (combined & sequential)
Phenacetin contained in analgesic mixtures
ß-Propiolactone
Radon
Shale oils
Silica (crystalline)
Soots (containing PAHs)
Tamoxifen
2,3,7,8-Tetrachlorodibenzo-*p*-dioxin
Thiotepa
Thorium dioxide
Tobacco smoke (and smokeless tobacco)
Treosulfan
Vinyl Chloride
Wood dust (certain hard woods)

Examples of Reproductive Toxins (not all inclusive)

Arsenic (and certain As compounds)
Benzene
Cadmium (and certain Cd compounds)
Carbon disulfide
Ethylene glycol monomethyl and ethyl ethers
Ethylene oxide
Lead compounds
Mercury compounds
Vinyl Chloride
Xylene

Examples of Chemicals with High Acute Toxicity (not all inclusive)

Acrolein
Arsine
Carbon tetrachloride
Chlorine
Cycloheximide
Diazomethane
Diborane (gas)
Furan
Hydrogen cyanide
Hydrogen fluoride
Hydrazine
Methyl fluorosulfonate
Nickel carbonyl
Nitrogen dioxide
Osium tetroxide
Ozone
Phosgene
Sodium azide
Sodium cyanide (and cyanide salts)
Thioglycolic acid

LABORATORY SAFETY INSPECTION CHECKLIST

Date:_____ Area:_____ Inspected by:_____
PI:_____ Phone:_____ Email:_____

General Safety/Emergency Procedures

	SAT	UNSAT	N/A		
1.	☐	☐	☐		Chemical Hygiene Plan and Material Safety Data Sheets available
2.	☐	☐	☐		Emergency information and contact list posted
3.	☐	☐	☐		All personnel have completed required training
4.	☐	☐	☐		Housekeeping adequate, egress lanes clear
5.	☐	☐	☐		Floors and ceiling in good condition
6.	☐	☐	☐		Lighting fixtures intact, no bulbs burned out
7.	☐	☐	☐		First Aid kit stocked and available
8.	☐	☐	☐		Fire extinguisher unobstructed and maintained
9.	☐	☐	☐		Exit lights illuminated
10.	☐	☐	☐		Fire alarm pull stations unobstructed
11.	☐	☐	☐		Sprinkler head clearance adequate (18 inches)
12.	☐	☐	☐		Eyewash and safety shower unobstructed and maintained
13.	☐	☐	☐		Spill kit available
14.	☐	☐	☐		No exposed wiring or damaged cords
15	☐	☐	☐		All equipment grounded via 3-prong plugs, if applicable
16.	☐	☐	☐		Outlets not overloaded
17.	☐	☐	☐		No permanent use of extension cords, no piggybacked power strips
18.	☐	☐	☐		GFCI outlets used within 6 ft of sinks
19.	☐	☐	☐		No food or drink in the lab area
20.	☐	☐	☐		Refrigerators properly labeled
21.	☐	☐	☐		All machine and equipment safeguards in place and working correctly

Chemical/Lab Safety

	SAT	UNSAT	N/A		
20.	☐	☐	☐		PPE Provided is appropriate for hazards present
21.	☐	☐	☐		Personnel working with chemicals wearing correct PPE
22.	☐	☐	☐		Lids tightly closed when not in use
					Incompatible chemicals are segregated
24.	☐	☐	☐		Flammables & Inorganic acids are segregated
25.	☐	☐	☐		Oxidizers & Flammables are segregated
26.	☐	☐	☐		If acids are stored in a cabinet, it is clearly labeled “acid”
27.	☐	☐	☐		If bases are stored in a cabinet, it is clearly labeled “caustics”
28.	☐	☐	☐		Acids and bases (caustics) are segregated
29.	☐	☐	☐		Highly toxic or odorous chemicals are stored in a vented cabinet
30.	☐	☐	☐		Water reactives are isolated in an enclosed labeled cabinet
31.	☐	☐	☐		Perchloric acid is stored according to safe handling guidelines
32.	☐	☐	☐		Fume hoods working correctly and not being used for long term storage
33.	☐	☐	☐		Fume hoods have been calibrated within the last year
34.	☐	☐	☐		All containers are correctly labeled with name and hazard warning
35.	☐	☐	☐		Chemicals stored below eye level
36.	☐	☐	☐		Flammables stored in flammable storage cabinet (>10 gallons)
37.	☐	☐	☐		Peroxide forming chemicals (ether) have date when opened
38.	☐	☐	☐		Gas cylinders are properly secured and capped
39.	☐	☐	☐		Gas cylinders stored away from heat sources
40.	☐	☐	☐		Chemicals not stored in or around sinks and floor drains
41.	☐	☐	☐		Chemicals near sinks and floor drains have secondary containment
42.	☐	☐	☐		Acids, bases, solvents and chemical waste have secondary containment
43.	☐	☐	☐		Hazardous waste containers closed and not over 90% full
44.	☐	☐	☐		Hazardous waste containers are labeled per waste procedure
45.	☐	☐	☐		Glassware in good repair and no broken edges

PEROXIDIZABLE CHEMICAL GUIDELINE

LIST A:
These chemicals form explosive levels of peroxides without concentration. Discard or test for peroxides every 3 months after open date.

Butadiene (liquid monomer)
Chloroprene (liquid monomer)
Divinylacetylene
Di-isopropyl Ether
Potassium Amide
Potassium Metal
Sodium Amide
Tetrafluorethylene
Vinylidene Chloride

LIST B:
These chemicals produce some peroxides when stored; there is an increased hazard when concentrated. Do not distill or evaporate without first testing for the presence of peroxides. Discard or test for peroxides at least every 12 months after open date.

Acetal
Acetaldehyde
Benzyl alcohol
2-Butanol
Cumene
Cyclohexanol
2-Cyclohexen-1-ol
Cyclohexene
Cyclooctene
Cyclopentene
Decahydronaphthalene
Diacetylene
Dicyclopentadiene
Diethly ether
Dioxanes
Diethylene glycol dimethyl ether
Ethylene glycol dimethyl ether
Furan
4-Heptanol
2-Hexanol
Methylacetylene
3-Methyl-1-butanol
Methycyclopentane
Methyl isobutyl ketone
4-Methyl-2-pentanol
2-Pentanol
4-Penten-1-ol
1-Phenylethanol
2-Phenylethanol
2-Propanol
Tetrahydrofuran
Tetrahydronaphthalene
Vinyl ethers
Other secondary alcohols

LIST C:
These chemicals form peroxides which initiate rapid polymerization. Uninhibited chemicals are **not** to be stored longer than **24 hours**.

Normally liquids – discard or test for peroxides within 12 months after open date.
Chlorotrifluoroethylene
Acrylic Acid
Acrylonitrile
Methyl Methacrylate
Styrene
Vinyl acetate
Vinyladiene chloride
Vinyl pyridine

Normally gases – discard after 12 months from transfer date to secondary container.
Butadiene
Chloroprene
Tetrafluoroethylene
Vinyl acetylene
Vinyl chloride

Document http://safety.dri.edu/Hazards/PeroxideFormingCompounds.pdf Table D lists chemicals that may form peroxides but cannot clearly be placed in Tables A-C.

References:

1. Kelly, R.J. *Chem. Health Saf*. 1996, 3(5), 28-36.
2. Jackson, H.L.; McCormack, W.B.; Rondestvedt, C.S.; Smeltz, K.C.; Veile, I.E. *Chem. Educ*. 1970, 47(3), A175-188.

PARTIAL LIST OF CHEMICAL INCOMPATIBILITIES

Chemical	Incompatible With
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetone	Chlorine, bromine, copper, fluorine, silver, mercury
Acetylene	Chlorine, bromine, copper, silver, fluorine, mercury
Alkali and alkaline earth metals (such as powdered aluminum or magnesium, calcium, lithium, sodium, potassium)	Water, carbon tetrachloride or other halogenated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury (e.g., in manometers), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorate, nitrates, sulfur, finely divided organic combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenic compounds	Any reducing agent
Azides	Acids
Bromine	See chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorine	Ammonia, acetylene, butadiene, butane, other petroleum gases, hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic, combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	All other chemicals
Hydrocarbons (i.e., butane, propane)	Fluorine, chlorine, bromine, chromic acid
Hydrocyanic acid	Nitric acid, alkali
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, combustible materials
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous)
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Acids

Chemical	Incompatible With
Nitric acid	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids and gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen, flammable liquids, solids and gases
Perchloric acid	Acetic anhydride bismuth and its alcohol, paper, wood, grease, oils
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalies, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate – see also chlorates	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrate	Ammonium nitrate and other salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals, such as sodium lithium)
Tellurides	Reducing agents