Laboratory Safety and Chemical Hygiene Plan

Revised
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Office of Environmental Health & Safety

940-898-4001

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https://twu.edu/health-safety/

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I. INTRODUCTION

A. General Intent

The general intent of this Chemical Hygiene Plan (CHP) is to protect Texas Woman's University (TWU) laboratory users (both employees and students) from health hazards associated with the use of hazardous materials or processes in the laboratory and to assure that laboratory personnel are not exposed to substances in excess of the permissible exposure limits adopted by the U.S. Occupational Safety and Health Administration (OSHA 29 CFR 1910 subpart Z) or other published exposure limits. A full copy of the OSHA regulation is available from TWU's Office of Risk Management. Additionally to protect lab users from health hazards, the EH&S office also follows University Regulation and Procedure Number 04.430.

In order to satisfy this intent, this CHP addresses the following issues:

1. Standard operating procedures (SOPs) relevant to safety and health considerations to be followed when laboratory work involves the use of chemicals, biological materials, or related processes presenting physical hazards (e.g. vacuum and pressure operations).

2. Criteria that the TWU will use to determine and implement control measures to reduce exposure to hazardous materials including engineering controls (e.g. fume hoods), the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for materials that are known to be extremely hazardous.

3. A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment.

4. Provisions for personnel information and training.

5. The circumstances under which a particular laboratory experiment, operation, procedure or activity shall require prior approval from the appropriate department chairperson before implementation.

6. Provisions for medical consultation and medical examination.

7. Designation of personnel responsible for implementation of the CHP, including the assignment of a Chemical Hygiene Officer.

8. Provisions for additional personnel protection for work with particularly hazardous substances.

This CHP also describes procedures required to protect laboratory users from other hazards not related to hazardous materials (such as cuts from clean glassware).

B. General Principles

There are some general principles which should be followed when implementing the guidelines of this plan, including:

1. Minimize all chemical exposure - Because few laboratory chemicals are without hazard, general precautions for handling all laboratory chemicals should be adopted, in addition to specific guidelines for particular chemicals. Skin contact with chemicals should be avoided as a cardinal rule.

2. Avoid underestimation of risk - Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present specific hazards, special precautions should be taken. One should assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are significantly toxic.

3. Observe exposure limits - The Permissible Exposure Limits (PELs) of OSHA, Recommended Exposure Limits (RELs) of the National Institutes of Occupational Safety & Health (NIOSH), and Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists (ACGIH) should not be exceeded.

This CHP must be available to all laboratory users and their representatives. The CHP is available online at https://twu.edu/health-safety/safety-programs/chemical-hygiene-planlaboratory-safety/. Printed copies are also available from the Office of Risk Management.

This CHP conforms to 29 CFR 1910.1450 (Occupational Exposure to Hazardous Chemicals in Laboratories) as well as the guidelines and recommendations of the National Research Council found in 29 CFR 1910.1450 Appendix A.

It shall be noted that this CHP applies to all laboratory users working in laboratories, including TWU employees and students, as well as visiting scientists and laboratory personnel. All laboratory users are to follow the procedures set forth in this CHP. The employee advising, supervising, or teaching a student's or other subordinate's activities is responsible for ensuring good chemical hygiene practices, both in research and teaching laboratories.

C. Scope/Applicability

At TWU, the Occupational Exposure to Hazardous Chemicals in Laboratories standard, as set forth by OSHA in [29 CFR 1910.1450](), applies to all laboratory users engaged in the "laboratory use" of hazardous chemicals either for teaching or research. It applies to research and teaching laboratories that are carrying out small-scale operations (those which can be handled safely and easily by one person) using multiple chemicals and procedures, where the procedures are neither a part of, nor simulate, a production process. Additional safety procedures would need to be developed if production level processes are carried out in TWU laboratories. This plan does not apply to non-laboratory use of hazardous chemicals, such as in maintenance operations (e.g. painting) or the use of consumer products in consumer quantities (e.g. Occupational Therapy lab exercises).

This CHP applies the following departments: Biology, Chemistry & Biochemistry, Woman's Health, Kinesiology, Nutrition & Food Sciences, and any departments or areas engaged in laboratory use of hazardous chemicals.

Building (or applicable areas of buildings) covered by this Plan: Old Main Building (OMB), Graduate Research Building (GRB), Woodcock Hall (WH), Pioneer Hall, the Ann Stuart Science Complex (ASSC), Scientific Research Commons (SRC), T. Boone Pickens Institute of Health Sciences – Dallas, and Institute of Health Sciences - Houston.

Designation of Chemical Hygiene Officer: **DIRECTOR OF ENVIRONMENTAL, HEALTH & SAFETY– OFFICE OF RISK MANAGEMENT**
Phone: **x3650**

The Chemical Hygiene Officer is referred to as "Risk Management" in the remainder of the Plan for simplicity.

D. Designation of Responsibility

The following designates responsibility for implementation of this CHP at TWU:

1. Laboratory User (lab user) - This term includes all TWU faculty, staff, student assistants, graduate assistants, visiting scientists, laboratory personnel, or volunteers conducting research or otherwise working in a laboratory, and students enrolled in academic laboratories at TWU. However, the responsibilities vary as follows –
    a. Laboratory Users Working in Or Conducting Research in a Lab: Responsible for following safe work practices and attends required training. They must be familiar with this CHP as well as safety plans/procedures unique to their lab. These laboratory users, including students, are responsible for following the CHP, all safety SOPs unique to their lab, and waste disposal procedures while working at TWU.

b. Laboratory Users Solely Enrolled in Academic Laboratories: Must be closely supervised by a "Laboratory Supervisor" at all times while in a laboratory (not allowed to work alone). Responsible for directly following lab protocols, exercises, and safety precautions as written or directed by the Laboratory Supervisor. Not required to take the CHP/Lab Safety Training.

2. Laboratory Supervisor (Faculty or staff given charge of a research, preparatory, or academic laboratory, sometimes known as a Principal Investigator in research laboratories) – Responsible for seeing that all laboratory users in the lab follow this CHP, provides necessary hands-on training, develops and implements additional plans/procedures as necessary to protect the safety of laboratory users, ensures this CHP is available to all occupants of the lab, provides "prior approval" when necessary, and ensures that hazard determinations are conducted for substances synthesized in the lab. In academic laboratories, ensures that hazards and safety precautions (that at a minimum meet this CHP) are clearly communicated to lab users for each academic laboratory exercise undertaken, and closely supervises lab users to ensure safe practices and this plan are being followed.

3. Chairperson of Each Affected Department – is responsible for monitoring chemical hygiene/lab safety within their department and taking corrective action as required. The Chairperson of each affected department is also responsible for assisting Risk Management to implement and maintain this plan as described below.

4. Risk Management – Implements this CHP including the following:

    a) Work with administrators, other employees, and students to improve and implement chemical hygiene policies and practices.

    b) Monitor procurements, usage and disposal of chemicals used in the laboratories via Hazard Communication and Regulated Waste Management programs.

    c) See that appropriate audits are conducted.

    d) Assist laboratory users to develop precautions and adequate facilities.

    e) Know the current legal requirements concerning regulated substances.

    f) Seek ways to improve the chemical hygiene program.

    g) Utilize resources within the University and the community to develop and refine this CHP to keep the information up-to-date and assist in safety training.

    h) Develop, implement and continue updating the chemical hygiene training program.

In addition, the **Chairperson of each affected department** and **Risk Management** have responsibility for the implementation and maintenance of this CHP. This includes responsibility to:

a) Ensure that all Laboratory Supervisors and their delegates know and follow the rules contained in this CHP.

b) Ensure that appropriate protective equipment is available and assign responsibility to ensure proper working condition of the equipment.

c) Provide required training to all appropriate personnel.

d) Conduct regular, formal chemical hygiene and housekeeping inspections at least once per year in each lab, including routine inspections of emergency and ventilation equipment.

e) Know the current legal requirements concerning regulated substances used in the laboratories and incorporate any new regulation in this CHP.

f) Assist in determining the required levels of protective apparel and equipment for laboratory users.

g) Provides guidance on safe laboratory procedures and assists in the annual review and update of this CHP.

5. Deans – Oversee departmental compliance with the CHP. Review reports from Risk Management. Initiate enforcement action for non-compliance with the plan if required. Determine and assess fiscal responsibility on the departments resulting from fines and or damages stemming from non-compliance with the plan.

6. University Safety Committee – Is an advisory body that serves as the University Chemical Hygiene Committee, reviews this CHP annually, and reviews and recommends university policy on laboratory safety. Reviews compliance and accident reports and formulates improvements to this CHP to reduce risk of recurrence.

II. REGULATORY OVERVIEW

OCCUPATIONAL EXPOSURE TO HAZARDOUS CHEMICALS IN LABORATORIES – 29 CFR 1910.1450

A full copy of the standard is available in the office of Risk Management, and on the OSHA website. Generally, the standard requires:

A. Exposure Limits

For OSHA-regulated substances, adherence to Action Levels, or, in their absence, Permissible Exposure Limits (PELs) for laboratory employees. However, it is TWU's policy to limit employee and student exposure to the lowest published exposure limit for each substance. See the TWU Respiratory Protection Program for more information.

B. Exposure Determination

Initial monitoring and, when necessary, periodic monitoring of employee exposures to OSHA-regulated substances when there is a reason to believe that an Action Level, or in its absence, a PEL (or other published exposure limit), has been exceeded. Laboratory users must be notified within 15 working days of the results of the monitoring.

C. Chemical Hygiene Plan

A CHP must be developed. When implemented, the plan must be capable of protecting employees from health hazards associated with chemicals in the laboratory and must keep exposures below occupational exposure limits.

D. Employee Information and Training

Employees must be provided with information and training regarding the requirements of the OSHA standard and the CHP, and the hazards of chemicals present in the work area. This training must be provided when an employee is initially assigned to a laboratory area, or when new hazards are introduced.

E. Medical Consultations/Examination

Laboratory employees shall be provided with medical examinations at a hospital or clinic participating in the workers' compensation health care network under the following conditions:

1. When an employee develops signs or symptoms of exposure to a hazardous chemical in the laboratory;
2. When monitoring reveals exposure in excess of an Action Level, PEL, or other published exposure limit;
3. When an event, such as a spill or explosion takes place, where there is a likelihood of exposure.
4. When an injury occurs while working that requires medical attention.

To find participating hospitals and clinics contact Risk Management or The Office of Human Resources. These examinations shall be provided at no cost to the employee.

Students should obtain medical examinations from Student Health Services, or at nearby hospital or clinic if Student Health Services is not available, under the three conditions listed above. Any cost associated with these examinations are the responsibility of the student.

F. Hazard Determination

Laboratories must comply with the TWU Hazard Communication Program. However, the Hazard Communication Program does not detail how to determine the health and physical hazards associated with substances that are created in the lab, versus those materials obtained from outside suppliers (and which are provided with SDSs). For substances created in the laboratory, the laboratory supervisor is required to ensure that a hazard determination is conducted based on all available information about the substance. The hazard determination should identify all health and physical hazards, and these hazards must be communicated to the laboratory users.

G. Respiratory Protection

Where the use of respirators is necessary to maintain exposure below exposure limits, TWU shall provide, at no cost to employees, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of the OSHA Respiratory Protection standard (29 CFR 1910.134) and the TWU Respiratory Protection Program. Voluntary use of respirators (respirators used where there is no exposure over an applicable exposure limit), must also comply with the TWU Respiratory Protection Program.

H. Recordkeeping

Results of exposure monitoring as well as medical consultations and exams must be kept in accordance with OSHA's Access to Employee Exposure and Medical Records standard (29 CFR 1910.1020). These records will generally be maintained by Risk Management with the exception of patient records maintained by Student Health Services for their patients.

III. CHEMICAL HYGIENE PLAN ELEMENTS

The OSHA standard requires that the CHP, when implemented, be capable of protecting laboratory users from health hazards associated with chemicals in the laboratory and that it keep exposures below occupational exposure limits*. The CHP must be made readily available to all laboratory users, and must contain the following elements:

- SOPs for laboratory safety and health.
- Criteria that TWU will use to determine and implement control measures to reduce employee exposures to hazardous chemicals.
- Documentation of requirements that fume hoods and other protective equipment are functioning properly, and measures that will be taken to ensure their adequate performance.
- Provisions for laboratory user information and training, as detailed in the OSHA standard.
- Documentation of circumstances under which certain laboratory operations will require prior approval.
- Provisions for medical consultations and exams, as detailed in the OSHA standard.
- Provisions for additional laboratory user protection when working with "particularly hazardous substances", as defined in the standard.

IV. STANDARD OPERATING PROCEDURES (SOPs)

The following SOPs are generic and apply to most laboratories where chemicals are used. They should be modified, as appropriate, for each specific laboratory. SOPs specific to procedures and operations in a particular laboratory must be developed and maintained in each laboratory.

A. Emergency Procedures

1. Priorities

An emergency is any event that requires an immediate stop in work and the following of a special procedure to protect life, health, and property. The best time to know what to do in an emergency is before, not after, it happens. The best time

* *At TWU, these occupational exposure limits include either Threshold Limit Values (TLVs), which are established by the American Conference of Governmental Industrial Hygienists (ACGIH) or Permissible Exposure Limits (PELs) promulgated by Federal OSHA, whichever is LOWER.*

to read this SOP, then, is at your leisure -- before the fire begins, and before the chemical is spilled. Though no single SOP can possibly cover the range and combination of events that can constitute an emergency, it is hoped that careful reading of the following emergency procedures will help you begin the planning process that will best fit your situation. Your experimental protocols or written procedures must always include safety measures, and at times may need to include specific emergency procedures. In any case, all such emergency procedures will need to be practiced and reviewed periodically. Most emergencies will be small, consisting of a single unexpected event. More serious emergencies involve a series of events which stem from an initial incident, expanding in sequence. Under any circumstance, decisions may have to be made quickly, often without adequate information, in a context that may have no precedent. Use the best and calmest judgment you have, and try to stay within the following general priorities:

LEAVE the area of danger. This is of paramount importance to enable rescuers to do what is necessary to protect life. If the area includes other people's work space, make sure they leave, too. If you can safely and quickly turn off equipment as you go, do so.

ALERT all personnel that there is an emergency as you go.

EVACUATE the building if necessary. Pull the fire alarm as you go to activate the fire alarm system if the building is so equipped.

CALL TWU Police (TWUPD) from the nearest safe area (940-898-2911, x2911 on a Denton campus phone). Calling TWUPD takes precedence over everything except evacuation in emergencies. This also applies for seemingly minor emergencies; it is far better to make an occasional unnecessary call than to fail to call and needlessly endanger life or health. Calmly state your name; the location and nature of the emergency; whether an ambulance or firefighting equipment is needed; any hazards that might threaten persons on the scene or responding; and a phone number and location at the scene where you can be reached. After calling, stay off the phone. The only exception is in cases of poisoning, when you may need to call the national poison control hotline: 1-800-222-1222.

PROTECT the life and health of anyone who may be injured. The first aid advice given in this SOP is contingent on rescue equipment and **qualified personnel** being 2 or 3 minutes away. In an isolated experiment station this may not be the case; suitable modifications to the emergency procedures should be made. Only qualified personnel, i.e. those who have received first aid training, should attempt to follow the first aid advice provided here.

After calling TWUPD, do what you can to continue to preserve life, but do no more than the necessary first aid procedures unless you are specifically trained to do so. Subsequent steps will depend on the nature of the emergency and your assessment of its severity. In each of the following situations, be sure you are in a safe place, summon help quickly, and try to protect the lives of those involved.

2. Injury

Ideally, only people with first aid training should render first aid. In an emergency, however, untrained help may be better than none. Stay calm, do only what you must before help arrives, and follow these priorities without putting yourself at risk:

REMOVE THE VICTIM FROM THE AREA OF DANGER (fire, spill, fumes, etc.). If the victim is not conscious - **DO NOT ENTER THE AREA** - proceed immediately to step 2, "Call for help."

[*NOTE: If the victim is in contact with electricity, he or she becomes "the area of danger". Avoid direct physical contact with the injured and the source of power; disconnect the power, or push/pull the victim away from the circuit with a non-conductive material (broomstick, board, rope, etc.)*]

CALL FOR HELP from TWUPD at x2911. Always initiate the process to get trained medical help before you take any other extensive action. For a serious injury (very heavy bleeding, chemical in eyes, etc.), you will often need to stabilize the situation briefly before calling. Common sense will dictate this potentially difficult decision, but in no case should calling be delayed except for the most immediate life-threatening situation. If two people are available, one can go for help while the other begins first aid.

REESTABLISH CIRCULATION through cardio-pulmonary resuscitation (CPR) and/or an Automatic External Defibrillator (AED). Only those trained in this procedure should attempt it.

CONTROL BLEEDING (Review TWU's Bloodborne Pathogen Exposure Control Plan before attempting this) by applying direct pressure to the wound using a clean cloth or your hand. If possible, elevate the injured area above the heart. Keep the victim warm and lying down.

Treat for **CHEMICAL CONTACT**. If the chemical was ingested, call TWUPD (x2911) and then the poison control (1-800-222-1222). Follow their instructions. If for some reason you cannot reach professional advice, do not give the victim water, milk, or anything else unless so directed by the Safety Data Sheet (SDS) for the substance. Induce vomiting only if directed to do so by poison control.

If the chemical was inhaled **and the victim is conscious**, call TWUPD (x2911) and then carry or drag the victim to fresh air if it can be done safely. Do not let the victim walk unassisted or engage in any unnecessary activity that will increase the circulation of poison in the bloodstream. If you need to use artificial respiration, be careful you do not inhale the poison from the victim. **If the victim is not conscious**, **do not enter the area**; the victim may have been overcome by gases in the area, or by a lack of oxygen in the space. There have been many documented instances, some on University campuses, of would-be rescuers becoming additional victims.

If the chemical was splashed in the eye, immediately seek an eyewash, safety shower, or spigot. The eye must be washed for at least 15 minutes with the eyelids held apart to allow maximum exposure of the eyeball (unless otherwise directed by the SDS). While washing, check for contact lenses by looking into the eye, and by asking the victim. Ask the victim to remove them if possible. Otherwise, contacts may be removed under gentle water pressure. Do not attempt to remove contacts by hand or with any other object. Emergency personnel are trained to do this. Be careful not to rub the eyes.

If chemicals are on the skin, follow the recommendations in the First Aid section of the SDS. Remove any clothing contaminated with chemicals; be careful that the rescuer does not become contaminated as well. Be aware of the possibility of inadvertent injection or unnoticed introduction of chemicals into the body. Many solids, oily liquids, or water solutions can enter through cuts in the skin. In addition, many oily liquids and oil soluble solids will be absorbed by the skin. Keep victim quiet and wait for medical assistance.

Treat for **SHOCK.** Though in appearance less dramatic than the above injuries, shock can kill just as quickly. If a person goes into severe shock, treatment for shock takes priority over all first aid except for reestablishing airway, control of bleeding, and CPR.

Symptoms of shock include paleness, cold and clammy skin, weakness, nausea/vomiting, shallow breathing, rapid pulse, cold sweat, chills and shaking. If possible, treat the cause of shock (*e.g.*, control heavy bleeding). Keep victim warm and lying down. Elevate legs if no spinal or head injuries are suspected. Keep airway open and give non-alcoholic liquids if the victim can swallow and does not have an abdominal injury.

3. Fires and Explosions

As you evacuate, turn off equipment and move explosive materials away from possible heat, **ONLY IF THERE IS TIME TO DO SO SAFELY.** Your leaving quickly is **THE HIGHEST PRIORITY.**

4. Chemical Spills

General procedures for handling spills in laboratories are given in Appendix 1. However, specific, more detailed procedures for handling spills of certain chemicals or within certain labs should be developed by Principal Investigators as necessary. If there has been any chemical contamination of personnel or clothing, follow Emergency Procedures for Chemical Contact (see Section 2. above).

5. Identifying Hazardous Substances in Emergencies

To help identify hazardous substances involved in an emergency, look for container labels or refer to SDSs for products used in the area in question.

6. Reporting Accidents

In the event of a laboratory accident, TWUPD must be called at x2911 and an incident report filed. If employees are injured as part of the incident, the appropriate workers compensation/accident investigation forms must also be completed. This allows valuable information to be collected to determine causes and prevent future accidents in the laboratory, and should be completed for all laboratory accidents, no matter how minor.

7. Power Failures

If your laboratory loses power during an emergency, evacuate the building as quickly as possible. Be certain to shut down any reactions or experiments that may cause additional hazards if it is safe to do so. Call TWUPD at x2911 from the nearest safe area to report the power failure and await assistance. If the building is so equipped, the emergency generator will start within a few seconds and emergency lighting will be available to facilitate escape. Emergency generators do not power the fume hood system. They generally only power emergency lighting and other building systems critical to evacuation and fire detection and suppression.

B. General Laboratory Behavior

1. Safety Rules

a) Know the location of laboratory and building exits.

b) Know the location of and how to use the safety showers and eyewashes.

c) Know the location and proper use of spill kits. Only trained personnel can clean up a spill.

d) Know the location of a phone that can be used in an emergency.

e) Know the potential hazards of the materials, facilities, and equipment with which you will work. If you are uncertain ask your instructor, your supervisor, or Risk Management at x4001.

f) Use the proper safety equipment for your procedure. This could include a fume hood, glove box, biosafety cabinet, shields or other equipment.

g) Wear eye protection while working in the laboratory whenever there is the potential for eye injury. Safety glasses are sufficient for most work; however, splash goggles are required for wet chemical work where a significant splash hazard is present, and work with fine dusts and powders that pose an eye hazard.

h) Wear other personal protective gear when laboratory or experimental conditions dictate. This includes laboratory aprons, lab coats, gloves, gauntlets, glass blowers' goggles, face shields, dust masks, respirators*, and other equipment.

i) Wear clothes that protect the body against chemical spills, dropped objects, and other accidental contact. Knee length, buttoned lab coats are required to be worn at all times in the lab. Individuals working with hazardous chemicals must wear long pants or skirts/dresses which fully cover the legs. O**pen shoes and sandals are prohibited in the laboratory**.

j) Confine long hair when in the laboratory. Remove or secure ties or other articles of clothing or jewelry that might become entangled in equipment.

k) Do not consume food or drink in laboratories. Do not store food or drink in the laboratory or in refrigerators used to store chemicals, or use laboratory equipment for eating or drinking.

l) For reasons of both safety and security, it is prudent to avoid working alone in the laboratory, particularly after hours. The laboratory supervisor is responsible for determining and implementing procedures to provide for emergency notification and periodic checks of an individual dependent on the nature of the laboratory work and the degree of potential hazard.

m) **Do not pipette by mouth**. Use only mechanical pipetting devices.

n) Wash hands frequently when handling chemicals and before leaving the laboratory. Beware of contamination of clothing or of door knobs, frames, etc. Remove protective gloves **before** leaving the laboratory. As a precaution it is best to remove all other protective gear, aprons, lab coats etc. to help prevent the spread of contamination.

o) Follow written protocols or instructions. Perform only authorized experiments.

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* *Anyone requiring respiratory protection must participate in the TWU Respiratory Protection program.*

p) Do not move or disturb equipment in use without consent of the user.

q) Horseplay is not allowed in the laboratory.

r) Cell phones should not be used while handling hazardous materials.

s) Follow good housekeeping practices -- clean up as you go, and keep work areas, aisles and exits uncluttered.

t) Do not deface labels on chemical containers. Make sure all container labels correctly identify their contents.

u) Report all unsafe conditions to your instructor, supervisor or Risk Management (x4001 ext. 5).

v) All lab workers should be alert as possible. Therefore, items such as headphones or earbuds that can impede hearing should be avoided since they may reduce awareness of hazards or incidents occurring in the workspace.

2. Additional Rules for Instructors and Supervisors

a) Take responsibility, in attitude and action, for the safety conditions of your laboratory.

b) Observe all rules and see that they are enforced.

c) Set an example by wearing protective equipment and by following proper laboratory procedures to promote safe work habits.

d) Carefully review all laboratory experiments for possible safety problems before the experiments are begun by laboratory users or students.

e) Make both preventative and remedial safety measures part of your instruction. Be sure all students and laboratory users are familiar with emergency procedures and equipment.

f) Be alert for unsafe conditions. Inspect often and intelligently; take effective corrective action promptly.

g) Assume responsibility for visitors and require that they follow the same rules as students and other laboratory users.

3. Rules for Custodial Workers

a) You may sweep, mop, wash the floors and remove normal trash from any laboratory.

b) Do not touch anything on the lab bench or in the lab hood.

c) Do not touch any material, container, or waste container with a biohazard symbol or radiation symbol on it.

d) You must not touch, disturb, move, or handle any containers of any chemicals or materials except those issued to you by your department. If you need chemicals or other laboratory materials moved in order to perform your duties, have the laboratory supervisor arrange for this to be done, or contact your supervisor.

e) If the contents of any containers (other than those issued to you) are spilled, DO NOT TOUCH THEM OR ATTEMPT TO CLEAN THEM UP. Tell your supervisor or the laboratory supervisor or contact TWUPD at x2911 if it is an emergency.

f) Do not eat, drink, or apply cosmetics in a laboratory.

g) If you have any questions, contact the laboratory supervisor, your supervisor, or Risk Management (x4001).

4. Rules for Maintenance Workers

a) Before working in a laboratory, in a chemical fume hood or any part of the associated ductwork, inform the laboratory supervisor of what you will be doing, and when you will be working.

b) The laboratory supervisor is responsible for assuring that your work area within the room is free from physical, chemical, and/or biological hazards. Your work area may include hoods, sinks, cabinets and benches, bench tops, floors, and/or equipment. You may be required to repair, move, remove, paint, replace equipment, etc. as part of your duties.

c) Do not handle or move chemicals in the laboratory. If you need chemicals moved in order to perform your duties, have the laboratory supervisor arrange for this to be done.

d) Generally, you should not move or handle equipment in the laboratory. If your work requires you to move, remove, or replace a piece of equipment, have the laboratory supervisor assure you that the equipment is free of any physical, chemical and/or biological hazards.

e) Do not eat, drink, or apply cosmetics in the laboratory.

f) In situations where the hazard cannot be totally removed, specific work procedures will be developed in conjunction with the laboratory supervisor, and Risk Management. If there is a chance your work may bring you in contact with chemical hazards (e.g., working on laboratory fume hoods) or when working in rooms where chemical experiments are taking place, have the laboratory supervisor provide you with any necessary protective equipment, including gloves, safety glasses, goggles, etc.

g) When working on a fume hood, ask the room supervisor if the hood was used for perchloric acid or radioactive materials. Contact Risk Management before performing maintenance on any part of a perchloric acid or radioactive materials fume hood system (including: hood, base, duct, fan, stack, etc.). Lubricate perchloric acid hood fans with fluorocarbon grease only.

h) If you are working in a room labeled with a radiation symbol, Contact the laboratory supervisor or the Radiation Safety Officer (Dr. Nathanial Mills in Biology at x2364) before beginning work to have all radioactive materials/sources removed from the work area.

i) If you have any questions, contact the laboratory supervisor, your supervisor, or Risk Management (x4001).

j) If you encounter a spill, do not attempt to clean it up. Leave the area and call TWUPD at x2911 and report it. TWUPD will contact the necessary emergency personnel. Notify your supervisor of the situation.

5. Procedures for Service Animals

a) Allowance for service animals in laboratories will be granted on a case by case basis in consultation with Risk Management, Disability Support Services, the respective academic department, and the individual in need of the service animal.

b) Consideration will be given to the health and safety of other lab users, the health and safety of the animal, the hazards of the specific laboratory, and other reasonable accommodations that might be made.

c) After consideration detailed above, service animals may be not allowed if the risk to the animal or occupants is too high, required to stay in isolated areas of the lab, required to don personal protective equipment, or be required to undertake other reasonable requirements.

C. Safety Systems

1. Personal Protective Equipment

a) Eye Protection

Safety Glasses – Safety glasses provide protection from impact hazards such as broken glass or flying objects and some protection from liquid splashes. Safety glasses must be worn whenever there is the potential for such injuries.

Splash Goggles – Eyes are particularly sensitive to any contact with chemicals; therefore, splash goggles must be worn at all times in laboratories where there is a significant risk of splash or when, fine dusts, or powders are being used outside of a fume hood. Safety glasses do not offer sufficient protection from liquids or particles entering from the side.

Shields – Standing shields and face shields protect the face and neck. Shields of good rigidity and strength which protect the face and neck should be used for vacuum work, when working with low or high pressure systems, or where mild explosions may be anticipated. Face shields **must be worn with either safety glasses or splash goggles**, they may never be worn alone.

b) Respiratory Protection

Dust masks, cartridge respirators, self-contained breathing apparatus, or any other type of respiratory protection is usually not necessary in a properly designed laboratory. If you believe you may nevertheless require such protection, contact Risk Management (x4001) for information and recommendations. Respiratory protection may only be used in accordance with the TWU Respiratory Program; which in part states that any individual using respiratory protection equipment must complete specialized training, receive a medical evaluation, and be fit tested for the exact make, model, and size of respiratory annually.

c) Skin and Body Protection

Gloves – Gloves protect the hands against contact with chemicals and also against abrasion and extremes of heat and cold. Check gloves before each use for worn spots, cracks, and other signs of wear. When removing gloves, be careful to avoid touching the outside of the gloves with your bare hands; also avoid touching door knobs, light switches, etc., with the gloves. Always remove gloves (and all other potentially contaminated protective gear) before leaving the laboratory.

Different kinds of gloves offer different levels and types of protection. Gloves made of cotton or cotton with leather protect against abrasion, sharp objects, and glass; however, they offer virtually no wet chemical protection, and may actually absorb chemicals and keep them in contact with the skin. Surgical type gloves made of rubber or synthetic rubber offer some hand protection and also allow dexterity. For more substantial protection against some acids and most other corrosives, heavy rubber gloves are available with various lengths of forearm protection. Heavy rubber gloves do not effectively protect against a number of concentrated acids, organic solvents, or PCBs. These substances require gloves made of a synthetic material, for example neoprene nitrile rubber or Viton, depending on the chemical being used. Insulated gloves should be used when dealing with temperature extremes. Proper fit and comfort must also be considered when selecting gloves. One must also be careful about allergies to latex and to avoid using latex gloves if they are or suspect that they may be allergic to latex.

Clothes – Employees working with hazardous chemicals in laboratories must wear long pants or skirts which fully cover the legs. This means the garments extend from the waste to the top of the shoes.

Aprons and Lab Coats – Aprons and lab coats protect the body as gloves do the hands. Heavy duty rubber aprons should be used for protection against strong acids and bases. As discussed above, heavy rubber will not protect against all materials, in which case a synthetic material must be used. Vinyl aprons are recommended for general use; cloth lab coats are also useful, but mainly for limited protection for clothing.

As with gloves, lab coats and aprons should remain in the laboratory. Many of the substances which are found in the laboratory can be inadvertently taken home on lab coats and aprons.

Shoes – Sturdy closed shoes should be worn in the laboratory at all times to protect against spills and splashes which reach the floor. Leather shoes offer better protection against corrosion than canvas shoes; **open-toed shoes are prohibited in the laboratory**.

d) Hearing Protection

Standards for hearing protection and acceptable noise levels have been established by OSHA regulations and the TWU Hearing Conservation Program. If you feel that a noise hazard is present in your laboratory, contact Risk Management (x4001) for evaluation and recommendations.

e) Fire Protection

In the event of a fire you are required to EVACUATE IMMEDIATELY and to pull the fire alarm and/or notify TWUPD (x2911) as soon as it is safe to do so. Alert others as you evacuate the building if the fire alarm is not active and you can do so safely.

Do not attempt to fight a fire unless TWUPD has been notified or evacuation is underway, the fire is small and contained, you have the proper type of extinguisher, and your escape route is not threatened in any way.

Do not re-enter the building until TWUPD tells you it is "All Clear" and safe to do so.

All laboratory personnel are to follow the policies outlined in TWU's Emergency Management Plan.

2. Laboratory Equipment

a) Fume Hoods

There are two types of fume hoods at TWU:

- Ventilated Fume Hoods – the "standard" fume hoods that are vented to the outside atmosphere (the most common and safest).
- Ductless Fume Hoods – units that use self-contained HEPA or adsorbent filters to remove particulates, vapors, and fumes from the air and then recirculate the air back into the lab. Ductless fume hoods require additional procedures and precautions than those listed in this subsection. See subsection b) Ductless Fume Hoods below for further information. Note, ductless fume hoods are not the same as biosafety cabinets or laminar flow hoods (which should not be used for chemical hazards generally).

Fume hoods are a common engineering control for exposure to toxic substances. The type of hood used should depend on the materials involved; for example, hydrofluoric acid will etch glass, perchloric acid requires a stainless steel hood interior and duct, and wash-down system and radioisotopes may require stainless steel ducts. A chemical fume hood is designed to operate most effectively at an optimum air velocity, usually 75 - 100 linear feet per minute. While it is good practice to work with the sash as low as possible, TWU lab hoods are marked with a maximum height sash position where this air velocity can be achieved. This air velocity will result in a laminar air flow pattern which will capture most fumes and vapors likely to be given off within the hood. Lower air velocities may be insufficient to capture and remove most fumes and vapors. Higher velocities can lead to a turbulent air flow which may not capture some of the fumes and vapors as well. Higher or lower air velocities may be acceptable in certain cases with Risk Management approval. All lab hoods within the University are annually tested and serviced by Facilities Management & Construction and Risk Management to determine if they are operating at acceptable levels. If your fume hood does not have a maximum sash position sticker, or if you have a new hood, please contact Risk Management.

The following are guidelines for safe fume hood use, and are to be followed when using a fume hood. All laboratory supervisors should periodically review these procedures with all laboratory personnel.

1. Use the fume hood with the sash as low as possible, at or below the indicated operating height. The operating height should be clearly marked by a label with an arrow or line along the sash track. These

labels are placed on a hood when its face velocity is tested. If your fume hood does not have an operating height sticker on it, call Risk Management as the hood may not have been tested for proper face velocity. If you need to move large pieces of equipment into or out of the hood, raise the sash for as long as is necessary, and lower it as soon as possible. Do not work on the hood with the hood sash fully open. The fume hood operates more effectively with the sash at or below the operating height. Additionally, this will allow the sash to serve as a physical barrier between your body and the contents of the fume hood.

2. Minimize storage of chemicals or equipment that are not currently being used in the hood. An exception to this would be when Risk Management determines that the fume hood is the safest location to store the particular chemical or piece of equipment.

3. Raise large pieces of equipment up on blocks approximately 2", to allow air to pass under the equipment and allow more even air flow through the hood.

4. Do not place equipment or chemicals very close to the slot openings in the baffles at the rear of the hood, or very close to the front edge of the hood. Putting items in those spots will interfere with even air-flow through the hood. Keep materials at least six inches back from the front edge whenever possible.

5. Keep the sash glass clean, and never obstruct your view with paper, notices, decals, or other items.

6. Avoid sudden movement past the face of the hood when it is operating. Simply walking briskly past the hood can disrupt air currents, and pull vapors out of the hood.

7. Keep your head outside the fume hood.

8. NEVER use perchloric acid in a fume hood not specifically designed for this purpose. A properly designed perchloric acid hood has a stainless steel liner, with a stainless steel duct that runs vertically to the roof. It is designed with a water wash-down system to periodically remove dangerous perchloric acid residues. Using perchloric acid in a conventional fume hood can leave explosive residues on the hood, duct, or fan.

9. If your hood is equipped with a flow indicating device, check to see that it is functioning properly before use. If your hood is not equipped with a flow-indicating device, you can periodically check

it with a hand-held velocity meter or by hanging a small (approximately 1" x 4") piece of tissue, Kimwipe®, or similar light-weight paper from the bottom of the hood sash. This should be drawn in when the hood is operating normally and will hang straight down, when the hood is operating marginally or not at all. If your fume hood is not operating properly, first check to see that it is on and that the rear slots are not blocked. If that is not the problem, stop work requiring a fume hood then call Facilities Management (x3137) immediately to arrange to have the hood repaired.

10. Some fume hoods are equipped with dust filters or chemical cartridges which must be changed as per the hood manufacturer's specifications. It is each department's responsibility to maintain such equipment in their department.

11. Keep in mind that a chemical fume hood is an important piece of laboratory safety equipment. Using and maintaining a fume hood properly will help protect you and your fellow lab users from potential chemical hazards in the laboratory. If you have questions about fume hood use, or need training on the proper use of a chemical fume hood, please contact Risk Management (x4001).

b) Ductless Fume Hoods

Due to numerous limitations and lower levels of protections, ductless fume hoods are not accepted as an alternative to ventilated fume hoods in most cases. Therefore, all uses of a ductless fume hood require approval from Risk Management. Ductless fume hoods are not recommended, or approved in many cases, for the following reasons:

1. NFPA 45 Chapter 7.4.1 states "Air exhausted from chemical fume hoods and other special local exhaust systems shall not be recirculated." Additionally, the explanatory material, Annex A.7.4.1, states "ductless chemical fume hoods that pass air from the hood interior though an adsorption filter and then discharge the air into the laboratory are only applicable for use with nuisance vapors and dusts that do not present a fire or toxicity hazard."
2. Filters for ductless fume hoods are chemical-specific. Therefore, the use of chemicals in a ductless fume hood must be strictly controlled to ensure adequate user protection. Alternatively; filters, which are expensive, would have to be changed when chemicals change. Strict control of usage is hard to achieve in an academic research setting with numerous hood users (including students), changing research projects, numerous chemicals used etc.

3. Chemicals adsorbed into the filter remain in the lab and are susceptible to release back into the lab due to off-gassing, saturation exceedance, or de-absorption where chemicals are released when the filter is exposed to other chemicals for which the charcoal has a greater affinity.
4. Assessing filter life requires performing complex, chemical-specific calculations, which are only theoretical. Whenever multiple chemicals are used, the filter can reach saturation quickly and without lab users realizing it. Furthermore, built-in sensors are unreliable and not an acceptable alternative to assessing filter life through control of chemical usage and manual calculation.
5. A false sense of safety can occur through the improper assumption that the ductless fume hood operates like a ventilated fume hood. For example, unknowingly using a chemical for which the selected filter will not remove from the recirculated air will potentially expose the user.

i. Approval Process:

All uses of ductless fume hoods require approval from Risk Management. The following items should be submitted prior to purchase and/or usage:

1. An SOP for each planned experiment/process, applicable lab user training, and maintenance schedule for the unit.
2. A list of all chemicals to be used in the unit.
3. The filter type to be used, the planned filter replacement schedule and how it was developed.

The Lab Supervisor shall notify Risk Management of any changes in the equipment, process or chemicals used for additional review and approval.

ii. Ductless Fume Hood Guidelines

- Fully comply with Risk Management approved SOPs as per above.
- Use only approved/acceptable chemicals in approved quantities. Particularly hazardous substances are prohibited from use in ductless fume hoods.
- Keep all chemical containers closed while not adding or removing material.
- Heating processes within he hood must be avoided as they can liberate contaminates from the filter cartridges.
- Follow all manufacturer guidelines.

c) Glove Boxes

Where highly toxic substances must be contained, or reactive substances must be handled in an inert or dry atmosphere, it may be necessary to use a completely enclosed unit such as a glove box. Disposable glove bags may be a cheaper alternative where appropriate.

d) Eyewashes

An emergency eyewash unit should be accessible from every laboratory and should deliver a gentle flow of clean, aerated water. The eyewash must be kept free of obstructions. When a chemical has splashed into the eye, irrigate the eye immediately. Flush the eye with a copious amount of water under gentle pressure. If the victim is wearing contact lenses, have him or her remove them at once if possible. Forcibly hold the eye open to wash thoroughly behind the eyelids. The victim must be given prompt medical attention regardless of the severity of the injury. Continue irrigating for at least 15 minutes before transport to a hospital or health center.

Eyewash units and safety showers are installed and maintained by Facilities Management & Construction, and tested periodically. Risk Management in cooperation with the various departments determine the need and location for new showers and eyewash stations. If there is a need for an eyewash or safety shower contact Risk Management (x4001).

e) Safety Showers

Each laboratory should have a safety shower in an easily accessible location, often in a corridor. The shower area must be kept clear of obstructions. In case of chemical contamination over a large part of the body, the contaminated clothes must be removed immediately and the person doused with water continuously for 15 minutes or until medical help arrives. Call x2911 immediately to summon help.

f) Ground Fault Circuit Interrupters

A ground fault circuit interrupter is an electrical device that protects against leakage of electrical current to ground. If even a minor leakage is detected, the device opens the circuit, preventing possible electrocution. Ground fault circuit interrupters can be portable -- placed within the laboratory where needed -- or installed in the outlet or circuit breaker box by Facilities Management & Construction.

These devices are required where damp or wet conditions are likely (such as near sinks).

g) Spill Containment

Only those laboratory users who have received proper training should attempt to respond to spills. Procedures using larger amounts of liquid should be performed in or over spill trays. Every lab must be equipped with a spill kit appropriate to the type and quantity of chemicals being handled. Additional absorbent material is available from Risk Management and Facilities Management & Construction for containing and neutralizing large spills. Specialized kits for the cleanup of some spills (such as mercury) are also available. Be sure to use each kit only for the materials designated on the kit container. All spills requiring the use of a kit should be reported to the Risk Management (x4001) or TWUPD (x2911). Risk Management is also responsible for the proper disposal of any wastes resulting from a spill.

D. Preparing For Laboratory Work

Before beginning any laboratory work, a plan should be made describing: objectives for the experiment, chemicals and equipment needed and the sequence of steps to be followed, including safety measures.

1. Chemicals

Full descriptions of chemicals used in the laboratory can be found on Safety Data Sheets (SDSs), which contain information on physical characteristics, hazards, disposal, and routine and emergency precautions. The OSHA Hazard Communication standard (29 CFR 1910.1200) requires, among other things, that persons who may be exposed to chemicals be trained in general and specific chemical hazards and chemical safety. In accordance with TWU's Hazard Communication Program, the primary source for SDSs used at the University is the online database found at the following address: http://hq.MSDSonline.com/texaswomansuniversity. SDSs may optionally also be maintained in each laboratory for quick reference. The information on the SDS should be made available to every laboratory worker who will be handling the chemical in question. Design your procedure to use the least hazardous chemicals and the minimum possible quantity of each chemical that will still allow meaningful results. Using smaller quantities of chemicals means that less can be spilled or volatilized, and that less must be treated and/or disposed as hazardous waste.

2. Equipment

Specific information must be obtained about any equipment to be used. Most equipment is sold with this information, ranging from one page instruction sheets to complete books. This information must be read thoroughly and followed exactly for safest use of the equipment. When used equipment is sold or donated to the University, recipients must obtain operating instructions if at all possible.

3. Written Procedures

Developing a protocol is basic to the experimental process, and should result in a written set of procedures. Writing the procedures allows the researcher or instructor to go through the experiment in the planning stage, and identify areas where special precautions may be necessary. The written protocol will provide lab users with step-by-step instructions, minimizing the chance of errors. A good written protocol will allow for modifications and will include safety precautions (e.g., "wear splash goggles," "pour acid into water," "perform this operation in fume hood"). In addition, a laboratory notebook should be kept during the procedure, documenting each action and its result. In the event of an accident, a set of written procedures and laboratory notebook may indicate what went wrong and possibly why.

4. Setting Up

Just before beginning the work, review the written procedures, following the expected sequence of the experiment. Review the materials to be used as to their degree and nature of hazard, including flammability, volatility, reactivity, etc. All equipment and supplies should be in place before actual work begins, including proper protective equipment (e.g., hoods, glove boxes, gloves, aprons, safety goggles, shields, and lab coats). The work area should be uncluttered and orderly. Where areas of possible contamination and exposure might exist, take precautionary measures, such as lining the work surface with absorbent paper. Also, have on hand all the necessary equipment to deal with a spill or accident (more absorbent paper, spill-control kits, etc.).

E. General Laboratory Equipment Setup

1. Preparing the Work Space

The workspace should be uncluttered. Only necessary materials, equipment, protocols, instructions, notebook, and pen or pencil should be present. Books, unnecessary materials, and scraps of paper should be removed and stored properly. Keep measuring equipment, such as glass cylinders, where it will not be easily knocked over. Do not place equipment on the floor of a working area where it may trip others or be knocked over.

Chemicals must not be kept or used near sinks or drains to avoid spills that may contaminate the sanitary sewer. If chemicals must be used in close proximity to sinks or drains (including fume hood cup sinks), spill trays must be used.

Use only equipment that is free of flaws (cracks, chips, inoperative switches, frayed cords, etc.). Ensure that all necessary guards are in place before using equipment. Examine glassware carefully. All defective glassware should be returned to the stockroom for replacement, or should be discarded safely. All defective electrical equipment must be repaired before use, or discarded.

Set up clean, dry apparatus, firmly clamped and well back from the edge of the laboratory bench. Keep burners and open flames a safe distance from solvents and reagent bottles. Allow enough space for the equipment used, and enough working space to avoid crowding other lab users and disturbing their apparatus. Select vessels of the proper capacities for each experiment. Place a tray or absorbent paper under the apparatus where appropriate to confine spilled liquids.

All equipment must be properly supported to prevent unnecessary movement and to maintain proper alignment during the experiment. Apparatus attached to a ring stand should be positioned so that the system's center of gravity is over the base and not to one side. Securely attach clamps to stands. Set up the equipment with adequate space and configuration for removing burners or baths. Orient equipment so that stopcocks, hoses, and other attachments will not be loosened by gravity. Use a retainer ring or spring where necessary.

Use a fume hood if the experiment is expected to evolve noxious odors, or toxic or flammable gases, vapors, or fumes. Do not use perchloric acid, hydrofluoric acid, or radioisotopes in hoods that are not specifically approved for those materials.

Use a protective shield when conducting a reaction which may result in an explosion or when using a vacuum system (which may implode). Use a face shield that is sufficiently large and strong to protect your face and neck AND wear safety glasses or goggles underneath it, or use a standing shield. A standing shield is indicated if an explosion hazard exists. Standing shields must be adequately stabilized with weights or fasteners to prevent from being knocked over by an explosion, and should be secured near the top. Eye protection must also be worn even when using the shields.

2. Glassware

Pyrex or borosilicate glassware is recommended for all laboratory glassware except for special experiments which use ultraviolet or other light sources. The only soft glass provided in the laboratory should be reagent bottles, measuring equipment, stirring rods, and tubing. Any sizable nonspherical glass equipment to be evacuated, such as suction flasks, should be specially designed with heavy walls. Dewar flasks and large vacuum vessels should be taped or otherwise screened or contained in a metal jacket to avoid flying glass from an implosion. Thermos bottles, with thin walls, are not adequate substitutes for Dewar flasks.

Large bottles and jars containing acids or corrosive chemicals should only be moved in suitable acid bottle carriers.

Cuts from glass constitute the most common laboratory accident, and potentially one of the most dangerous, as the open cut provides a way for toxic chemicals to enter the bloodstream directly. Do not begin any operation of cutting, bending, or inserting glass into a stopper or hose without understanding the complete procedure and each separate step.

1. When cutting glass tubing, be sure to hold the tubing firmly, and to make a single steady stroke with a sharp file. When breaking the tubing at the cut, cover the tubing with cloth and hold it in both hands, well away from the body. Push out on the tubing but do not deliberately bend the glass with your hands. Wetting the nick will help open the fracture. Be sure that you are well away from others in the laboratory. Be especially careful in cutting a short piece from a long piece of tubing, since the long end may whip around and injure a nearby person. Finally fire polish the freshly cut ends to eliminate sharp edges.

2. When boring a stopper, be sure the borer is sharp and one size smaller than that which will just slip over the tube to be inserted. In the case of a rubber stopper, lubricate with water, or preferably glycerol. Holes should be bored by slicing through the stopper, twisting with moderate forward pressure, grasping the stopper only with the fingers and keeping the hand away from the back of the stopper. Place the stopper on a wooden board or block to avoid damaging the cutting edge of the borer. Keep the index finger of the drilling hand against the barrel of the borer and close to the stopper in order to stop the borer when it breaks through. Preferably drill only part way through, then finish by drilling from the opposite side. Discard a stopper if a hole is irregular or does not fit the inserted tube snugly, if the stopper is cracked, or if it leaks.

3. Stoppers should fit so that 1/3 to 1/2 of the stopper is inserted into the joint. Corks should first be softened by rolling and kneading. With hands close together to minimize being cut in case the vessel breaks, gently but firmly twist the stopper in place. Avoid exerting

any pressure on inserted glass tubes. When available, ground glassware is preferable. Glass stoppers and joints should be clean, dry, and lightly lubricated. Stuck glass stoppers can be removed using commercially available bottle stopper remover. Students should ask instructors for assistance when glass connections, stoppers, or corks are stuck.

4. Fire polish all glass tubing and rods, including stirring rods. Unpolished glass has a razor-sharp edge which will not only lacerate the skin, but will cut into a stopper or rubber hose, making it difficult to insert the glass properly. After fire polishing or bending glass, allow ample time for it to cool; grasp it gingerly at first, in case it is still hot.

5. To remove a glass tube from a stopper, use a lubricated, dulled cork borer or the tang of a small file, inserted between tube and stopper. Lubricate as separation progresses. Sometimes it may be useful to roll the stopper with a block of wood under enough pressure to flex the rubber. If none of these procedures works, remove the tube by cutting the stopper with a single edged razor blade or an X-Acto® knife. If this is not feasible, discard the stopper and tube.

6. When inserting glass tubing or rods into rubber hoses, fire polish both ends of the glass to be inserted. Lubricate the glass with water, or preferably glycerol. Wrap a cloth around the glass and hold it close to the hose (not more than 5 cm). Protect the hand holding the hose with a cloth or glove. Insert the glass into the hose with a slight twisting motion, avoiding too much pressure and torque.

3. Electricity

Electricity becomes a hazard in the laboratory when the current comes in contact with a person or a flammable or explosive material. Care with electrical connections, particularly with grounding, and not using frayed electrical cords can reduce such dangers.

Equipment in the laboratory must have grounded (three-prong) plugs or be double insulated. Temporary wiring and the use of extension cords are prohibited. All wiring must meet the National Electric Code specifications. Where wet conditions are likely, ground fault circuit interrupters must be used. All switches that are not directly and obviously attached to a piece of equipment should be labeled to show the equipment they control; in-line cord switches are discouraged.

If, when you touch a piece of electrical equipment, you feel a shock or "tingle," you should disconnect it and report it for repair immediately. Shorts in circuitry get worse, and delay in repair greatly increases the hazard. If you suspect a piece of equipment to be electrically dangerous, take it out of service and call Facilities Management (x3137) or Research & Sponsored Programs Scientific Equipment Repair Service for repairs (x3381). Never attempt to repair any electrical equipment with the current on. Equipment that is faulty or broken must be unplugged and moved, or locked out, in such a way that it cannot be accidentally plugged in or turned on. The equipment should be clearly labeled as unsafe and not to be used while awaiting repair.

4. Vacuum Operations

Because of the pressures involved, equipment used in vacuum operations must be carefully inspected frequently and regularly. Apparatus must be assembled so as to avoid strain, and heavy assemblies must be supported from below as well as by the flask neck. Vacuum apparatus should always be placed well back from the edge of the bench top or hood sill, where it will not be accidentally struck. Inspect frequently for signs of fatigue, wear or cracks.

a) Shielding

Either standing shields, face shields, or appropriately taped equipment should be used in all vacuum operations using glassware, especially when the apparatus contains flasks of 0.5 liter or larger. Alternatively, plastic flasks designed for vacuum operations may be used as a substitute to glassware where feasible.

b) Vacuum Desiccators

Vacuum desiccators should be enclosed in a box or approved shielding device for protection in case of an implosion. When opening a desiccator that has been under vacuum, make sure that atmospheric pressure has been completely restored. A "frozen" vacuum desiccator lid can be loosened by a single-edge razor blade carefully inserted as a wedge and then tapped with a wooden block to raise the lid.

c) Water Aspirators for Vacuum

Water aspirators for vacuum are used mainly for filtration purposes; use only equipment that has been approved for this purpose. Never apply a vacuum to a flat bottom flask unless the flask is a heavy walled filter flask designed for the purpose. Place a trap and a check valve between the aspirator and the apparatus so that water cannot be sucked back into the system if the water pressure should fall unexpectedly while filtering. These recommendations also apply to rotary evaporation operations where water aspirators are being used for vacuum.

d) Vacuum Pumps

A cold trap should be placed between the apparatus and the pump so that volatiles from a distillation do not get into the pump oil or out into the atmosphere of the laboratory. Exhausts from pumps should be vented properly. All pumps must also have a belt guard to prevent hands or loose clothing from being pulled into the belt pulley.

e) Vacuum Distillations

When performing vacuum distillations always allow the apparatus to cool to room temperature before breaking the vacuum. It is preferable to first fill the apparatus with an inert gas such as Nitrogen or Argon.

f) Pressure Operations

As with vacuum operations, the equipment used in high pressure procedures must be regularly and frequently inspected for any signs of wear or fracture. Each pressure vessel should be clearly stamped or labeled with its basic allowable working pressure, the allowable temperature at this pressure, and the material of construction. Always use a pressure relief disk or other suitable device in pressure systems. The relieving pressure and setting data should be printed on a tag attached to installed pressure-relieving devices, and the setting mechanisms should be sealed.

Before any pressure equipment is altered, repaired, stored, or shipped, it should be carefully vented and cleaned. When assembling such apparatus, avoid strain and excessive force. Threads must match correctly. Never use oil or hydrocarbon-based lubricant on apparatus that will contain oxygen. Kel-F oils or greases (polychlorotrifluoroethylene oils or greases) are the proper lubricants for these systems. In assembling copper tubing, avoid sharp bends and allow flexibility. Check for hardening and cracking in the copper; renew if necessary.

All reactions under pressure must be shielded, and prominent signs should be placed to warn others of high pressure hazard.

5. Heating

a) Open Flame

Wherever possible, use heating mantles, heating tapes, or laboratory hot plates in place of gas (Bunsen) burners. When using a heating mantle, always operate below the maximum allowable voltage for that mantle. It is obvious that open flame must never be used where explosive or flammable chemicals are present, but the presence of such chemicals may be unsuspected or sudden. If a burner must be used, distribute its heat with a flame retardant wire gauze, or by moving the burner about underneath the container being heated. Test tubes being heated in this way should be held with a test tube holder at about a 45 degree angle and heated gently along the side, not at the bottom, to minimize superheating which may cause the contents to be ejected. Avoid pointing a test tube toward yourself or any nearby person.

b) Gas Shut Off Valves

Laboratories with piped in gas supply are equipped with manual shut off valves, and some are equipped with main "emergency stop" buttons outside the labs. When gas is not in use the manual valve must be in the "off" position. If there is an emergency situation that requires all gas to be turned off, or there is a leak from an unknown location, the main "emergency stop" can be used to cut off all gas to the lab (if so equipped). This is done by depressing the red "mushroom" button. To turn on the room gas supply back on, CHECK ALL THE GAS VALVES IN THE ROOM TO BE CERTAIN THEY HAVE BEEN TURNED OFF. Then pull the mushroom button back out.

c) Hot Oil Baths

Hot oil used for heating purposes is often overlooked as a hazard, yet it carries serious dangers: (1) spattering caused by water falling into hot oil, (2) smoking caused by decomposition of the oil or of organic materials in the oil, and (3) fire caused by overheated oil bursting into flame. Operating baths should not be left unattended unless a high temperature cut off is installed. Precautions should be taken to contain any spills of hot oil caused by breakage or overturning of the baths. Fiberboard, cardboard, or other combustible components must not be used in heated apparatus.

In evaluating a hot oil bath setup, carefully consider the size and location of the bath, the operating temperature and temperature-control device, the type of oil used (silicone oil is suggested for most heating baths), the ventilation available, and the method of cooling the hot oil. A label on the bath should include the name of the oil and its safe working temperatures. Silicone oil is a safe non-flammable fluid that can be used in heating baths to 250° C (about 480°F) without decomposition.

d) Temperature Control

The rates of all reactions increase as the temperature increases. Highly exothermic reactions may become dangerously violent unless provisions are made for cooling, for example, by bringing a cooling bath up around a flask. Virtually all reactions require some temperature control, and thus apparatus should be assembled in such a way that either heating or cooling can be quickly applied or withdrawn. A suitable thermometer should be used in a boiling liquid where a strong exothermic reaction is likely so that there will be warning and time to apply cooling.

Boiling stones or boiling sticks should be used in unstirred vessels of boiling liquid (other than test tubes) to prevent superheating and "bumping". Do not reuse boiling stones or sticks. Do not add them or any other solid material to a liquid that is near its boiling point since this is likely to cause splattering or boil over.

6. Cooling

a) Flowing Water

When cooling with flowing water, it is best to use a recirculating cooling bath so that limited amounts of water will be discharged in the event of a failure. If constant flowing water from the sink must be used, beware of differences in water pressure when operations have to be left unattended for long periods, particularly overnight. Although it is strongly discouraged, it is sometimes necessary to conduct an experiment requiring cooling overnight. Before conducting the experiment following steps must be implemented. Set up the experiment, you must clamp all rubber or plastic tubing to metal or glass connections to help prevent the tubing from detaching, thus reducing the risk of a flood. Make two signs giving your name and the date and stating that there is an experiment being conducted overnight. Post one on the hood screen and the other outside the door. **Call TWUPD to inform them that you are conducting an experiment overnight.** It may be necessary to install an automatic water regulator in the line to keep the flow even or institute some other additional contingency method if wire alone will not prevent floods.

b) Cooling Baths

When ice water is not cool enough as a bath, salt and ice may be used. For even lower temperatures, dry ice may be used with an organic liquid, such as acetone, ethanol, isopropanol or ethylene glycol. Ethylene glycol, with a flash point 111^{o} C (230^{o} F), is the best of the three listed above, considering flammability. When choosing a liquid for use with dry ice, you must consider the viscosity, flammability, volatility, solubility in water, and the possibility of toxic vapors.

Few, if any, liquids are free from all of these hazards. Your choice must also be made based on the temperature requirements of your procedure and the limitations of your equipment.

c) Cryogenics

Cryogenic equipment setups involve hazards due to extremely low temperatures, and also hazards associated with the high pressure gases that are often part of such setups (see the following section on Compressed Gases). Be careful to control ignition sources and to monitor the formation of very high or very low concentrations of oxygen.

Safe management of the hazards associated with extremely low temperatures requires thorough understanding of the unique conditions created. For example, the extreme cold of liquid nitrogen can make metals and other materials brittle. Uninsulated equipment can condense oxygen from the air to yield dangerously high concentrations of liquid oxygen, which can explosively ignite many combustibles. On the other hand, liquid nitrogen, left open, reduces the oxygen content of air as the oxygen condenses and the nitrogen evaporates. A person working in an inadequately vented area could lose consciousness without warning, and will die without rescue. Good ventilation is essential in all cryogenic operations, along with an understanding of the low-temperature behavior of the substances involved.

Contact of liquefied gases with eyes or skin produces serious burns. Damaged tissue should be flooded with a gentle stream of water, not warmer than body temperature (using an eyewash, for example). The affected area should then be dried very gently (excluding eyes) and protected until medical assistance arrives. To avoid contact with liquefied gases, wear goggles, face shield, and insulated gloves that fit loosely enough to throw off in case of a spill. The body should be completely covered, with no skin exposed. Wear no jewelry, and avoid clothing with cuffs or pockets that could trap and hold a cryogenic liquid close to the skin.

Put objects into a cryogenic liquid slowly, and pour liquids into containers slowly in order to minimize the inevitable boiling and splashing.

For the same reason, dry ice should be added to liquid slowly and in small amounts, to avoid foaming and boil over. Handle dry ice with dry leather or insulated gloves, and never lower your head into a dry ice chest, as the oxygen content may be inadequate and suffocation can result.

Dewar flasks and cold traps should be taped to prevent flying glass in case of breakage. Avoid pouring cold liquid over the edge of a Dewar flask, as it may break and implode.

7. Compressed Gases

Gases are supplied in cylinders under great pressures, some as much as several thousand pounds per square inch. If the valve is broken off at the cylinder neck, the cylinder becomes a potentially deadly rocket, propelled with great momentum and high speed. Gas cylinders have been documented to cause extensive property damage, injury, and death. For this reason, all gas cylinders, full or empty, must always be strapped or chained to a sturdy support to prevent the cylinder from falling and breaking off the valve. All cylinders of compressed gas should be treated as high energy sources and therefore regarded as potential explosives.

In addition, released gas can rapidly displace the breathing air in a room, causing suffocation. Many gases are toxic or corrosive and can cause injury if inhaled or contacted in even small amounts. Many gases are reactive with other materials or gases. Oxygen, in greater than normal concentrations, greatly increases the risk of fire and explosion.

Compressed gas cylinders have certain safety features, including special valves, fittings, and caps. For example, many gases have special valves that prevent the inadvertent mixing of incompatible gases. The best protection, though, lies in following the guidelines developed over years of experience with the hazards of compressed gas.

a) Use

Always keep cylinders secured to a solid support except during transport to and from the stockroom or the vendor’s truck. Cylinders in storage or otherwise not currently being used must have the regulator removed and the valve cap installed.

Begin with thorough knowledge of the substances and equipment involved. Always know the identity of the gas in a cylinder; if for some reason a cylinder is unlabeled, return it to the vendor; do not guess. Know the properties and potential of the gas to be used, and the procedures for using it. Be careful not to exceed the design pressure of the apparatus. Always wear safety glasses when handling or using compressed gases.

Carefully inspect fittings, regulators, and apparatus for damage before using. Do not use damaged equipment. Use only regulators, gauges, and connections with matching threads and are designed to be used with the gas or gasses involved. Never lubricate, modify, force, or tamper with a cylinder valve.

Only those tools approved by the cylinder vendor should be used on cylinder connections. Do not modify or alter cylinders or their attachments. Use cylinders and manifold systems only with their appropriate pressure regulators.

Use cylinders only in well ventilated areas. Corrosive gases should be used only in locations with access to safety showers and eyewash stations. Corrosive, toxic, and flammable gases should be used only in fume hoods designed for use with the particular gas or group of gases. Use flammable gases only after proper bonding and grounding connections have been made.

Do not expose cylinders to temperatures higher than about 50^{o} C (122^{o}F). Some rupture devices on cylinders will release at about 65^{o} C (149^{o}F). Some small cylinders, including those not fitted with rupture devices, may explode if exposed to high temperatures.

Open cylinder valves slowly. Rapid release of a compressed gas will cause an unsecured gas line to whip dangerously and also may build up a static charge which could ignite a combustible gas. Never direct high pressure gases at a person, or use compressed gas or compressed air to blow away dust or dirt; resultant flying particles can be dangerous. Close cylinder and bench valves when the cylinder is not in use; the pressure regulator is not sufficiently strong to assure safe closure.

Do not extinguish a flame involving a highly combustible gas until the source of the gas has been shut off. Otherwise, it can re-ignite, causing an explosion.

Always use a trap to prevent back siphonage of liquid chemicals, and a check valve to prevent back flow of gases into the cylinder.

When gas is passed from a cylinder into a vessel containing a liquid, contamination of the cylinder gas with other chemicals is a real possibility. Such contamination makes the gas unsuitable for future use and may result in explosion with resultant injury, damage, or even death. Use of a safety trap to contain liquid and a check valve to prevent back flow of gas will eliminate this possibility. These are installed immediately after the pressure regulator, and before the vessel containing the liquid. The safety trap should have a volume of about one and one half times the total liquid volume in the system.

Never bleed a cylinder completely empty. Always leave a residual pressure (about 25 psig) to keep contaminants out. Promptly remove the regulators from empty cylinders, being sure to bleed the gas from the regulator first. Replace the protective caps at once. Mark the cylinder "EMPTY" as described for used cylinders below. Never refill a cylinder.

b) Used Cylinders

Handle used cylinders as you would full cylinders. Keep them strapped or chained at all times. Store the used cylinders separately, if possible, from full cylinders so there is no chance of confusing them. Mark all used cylinders "EMPTY."

c) Leaking Cylinders

A leaking cylinder is an immediate hazard to health and property and must be addressed immediately. The properties of the leaking gas determine the hazard and the degree of response. It may be necessary to contact the vendors emergency contact number **(or Chemtrec at 1-800-424-9300)** for further instruction in addition to following the appropriate emergency procedures.

Keep in mind certain types of gas containers such as liquid Helium and Nitrogen are designed to continuously vent. This is normal and these vessels **must never be stored in a confined space**.

POISON GASES If a cylinder containing a poisonous gas is found to be leaking outside of a hood and it can't be turned off, you must evacuate the building by pulling the fire alarm and/or contacting TWUPD (x2911). Contact TWUPD as soon as you are safely out of the building. You will be required to provide important information to assist the emergency responders.

FLAMMABLE GASES If a cylinder containing a flammable gas is found to be leaking follow the procedure outlined for poisonous gases.

OXYGEN If an Oxygen cylinder is found to be leaking, evacuate the work area immediately contact TWUPD at x2911. Oxygen enriched atmospheres cause normally noncombustible materials to be extremely flammable. Many substances will burst into flame in the presence of pure oxygen. Be prepared to evacuate the building.

NON-FLAMMABLE GASES Although these gasses are not toxic themselves they can displace the oxygen in a room and cause asphyxiation. If there is a leak from a cylinder containing this type of gas, evacuate the room and contact Risk Management at x4001 ext. 5. If Risk Management is unavailable you must contact TWUPD at x2911.

d) Transportation

Do not move a cylinder unless the cap is in place. Transportation of a cylinder without the cap (even worse, with a regulator still attached) is dangerous and not permitted.

Generally, cylinders must be transported on a hand truck to which they can be strapped or chained. Cylinders may be rolled on edge only for very short distances. Use an elevator, if possible, to move cylinders to upper or lower floors. If stairs must be used, move cylinders on a hand truck that is equipped for stairs.

When handling cylinders, always consider them to be full. Do not allow them to strike each other, or to be dropped, cut, scraped, or otherwise damaged.

e) Storage

Keep only those cylinders that are necessary in the laboratory; store the minimum number of cylinders possible. Cylinders, in use or in storage, must be secured to a sturdy object, such as a wall, bench, or stand, using a strong strap or chain.

Store full and used (empty) cylinders only in isolated areas that are ventilated and protected from direct sunlight, rain, snow, damp ground, heat, fire, and electrical contact. Temperatures in storage should be maintained between -20^{o}F and 120^{o}F unless the manufacturer indicates otherwise. Storage can be indoors or outdoors under shelter. Never store or use cylinders in corridors, stairwells, or in high traffic areas.

Cylinders of the same gas should be stored together. Oxidizing, toxic, pyrophoric, flammable, corrosive, and/or unstable gases must all be separated by at least 20 feet of space, or by a half-hour rated firewall. Combustible waste, vegetation, and similar materials shall be kept a least 10 feet from all cylinders, or separated by a non-combustible partition. In addition, store used (empty) and full cylinders separately and clearly indicate whether they are full or empty.

Keep caps on all cylinders except when connected for use, and keep cylinders upright, whether in use or storage.

F. Handling Chemicals

The following are guidelines and principles for safety in the direct manipulation of chemicals -- holding, pouring, mixing, transporting, storing, and so on. The list of situations covered is far from exhaustive; emphasis is instead on the most common ways in which chemicals are handled in the laboratory. Safety precautions for use of laboratory equipment can be found in Safety Systems, Section 3, and General Laboratory Equipment Setup, Section 5.

1. Personal Contact

The primary safety goal in handling chemicals is to prevent the chemicals from entering your body. It cannot be said too often that protective gear must be worn at all times, and precautions for avoiding personal contact with the chemicals must always be in mind.

a) Avoid direct contact of any chemical to the hands, face, and clothing. Be aware of what you touch; for example be careful not to touch gloves to your face. After any skin contact, and always before you leave the laboratory, wash face, hands, and arms. Leave all equipment in the laboratory.

b) Never taste chemicals or sniff from chemical containers.

c) Dispense and handle hazardous materials only in areas where there is adequate ventilation.

d) If you believe that significant ingestion, inhalation, injection, or skin contact has occurred, call TWUPD at x2911 for medical assistance and follow the emergency procedures given in Section F. under "Emergency Procedures".

2. Handling Containers

Clearly label all chemical containers. The TWU Hazard Communication Program requires that labels on incoming chemical containers not be removed or defaced. Do not use any substance from an unlabeled or improperly labeled container. Printed labels that have been partly obliterated or scratched over, or crudely labeled by hand, should be relabeled properly. Whenever possible, containers not labeled by the manufacturer or supplier should be labeled with properly completed third edition Hazardous Materials Information System (HMIS III) labels as per the Hazard Communication program. If another method of labeling is used in a laboratory, the laboratory supervisor must ensure that **all laboratory personnel receive instruction in, and understand**, the labeling system to be used. Whenever possible, labels should also be such that Risk Management or emergency responders can understand them.

Unlabeled chemical containers are a violation of the federal and state Hazard Communication standards and the TWU Hazard Communication Program. If you encounter unlabeled containers with unknown contents, contact Risk Management at x4001.

Carefully read the label before removing a chemical from its container. Read it again as you promptly recap the container and return it to its proper place. Names of distinctly different substances are sometimes nearly alike; mistakes are easy to make and can be disastrous.

When picking up a bottle, first check the label for discoloration, and if it is clean, grasp it by the label. Spilled chemical will show up on the label better than on the glass; holding the container by the label will protect you from prior spills, and protect the label from present ones. After use, wipe the bottle clean.

If a stopper or lid is stuck, use extreme caution in opening the bottle. Friction caused by removing tops may cause explosions with some substances (such as peroxides formed from ethers or dry picric acid).

Support beakers by holding them around the side with one hand. If the beaker is 500 ml or larger, support it from the bottom with the other hand. If the beaker is hot, use beaker forceps or tongs, and place the beaker on a heat-resistant pad.

Grasp flasks by the center neck, never by a side arm. If the flask is round bottomed, it should rest on a proper sized cork ring when it is not clamped as part of a reaction or distillation assembly. Large flasks (greater than 1 liter) must be supported at the base during use.

Never look down the opening of a vessel, in case of unforeseen volatility or reaction.

3. Pouring

Do not pour toward yourself when adding liquids or powders. Stoppers too small to stand upside down on the bench should be held at the base and outward between two fingers of the pouring hand.

Use a funnel if the opening being poured into is small. If a solid material will not pour out, be careful when inserting anything into the bottle to assist removal. Students should seek advice from instructors before proceeding.

Always add a reagent slowly; do not "dump" it in. Observe what takes place when the first small amount is added and wait a few moments before adding more.

When combining solutions, always pour the more concentrated solution into the less concentrated solution or water. Stir to avoid violent reactions and splattering. The more concentrated solution is usually heavier and any heat evolved will be better distributed. This procedure is particularly applicable in preparing dilute acid solutions. Be sure to wear goggles and use the hood when diluting solutions.

Remember the A-W rule. Always add acid to water, never water to acid. Make sure the stopcock is closed and has been freshly lubricated before pouring a liquid into an addition or separatory funnel. Use a stirring rod to direct the flow of the liquid being poured. Keep a beaker under the funnel in case the stopcock opens unexpectedly.

Use extreme caution and wear an apron and gloves, in addition to goggles, whenever pouring bromine, hydrofluoric acid, or other very corrosive chemicals, to avoid painful chemical burns.

4. Pipetting

Never pipette by mouth. Use an aspirator bulb, or another mechanical Pipetting device. Constantly watch the tip of the pipette and do not allow it to draw air.

5. Storage

Keep as few chemicals as possible on the bench top. All chemicals not immediately needed should be properly stored.

Chemicals must never be stored or placed on the floor. This poses a risk of spillage and/or injury to lab personnel.

Do not store incompatible materials together or in close proximity.

Store large containers of reagents on low shelves, preferably in a tray adequate to contain spills or leakage. All hazardous materials must be stored and handled in such a manner as to limit a spill scenario to less than 20L (5 gallons).

Dispense corrosive liquids in small containers, no larger than 500 ml, preferably in chemically resistant coated containers. Never take more than is immediately needed.

If chemical waste is stored in a fume hood that has a cup sink that is not plugged, it must be kept in secondary containment.

6. Cold Storage

Ordinary household refrigerators constitute a hazard when used for storage of flammable or unstable chemicals. These units produce conditions which can lead to explosion. Domestic (household-type) refrigerators may not be used for flammable chemical storage. Laboratory safe or explosion proof (if the room is also potentially flammable) refrigerators must be used instead. Every refrigerator, freezer, or cooler is to be prominently marked to indicate whether or not it meets the requirements for safe storage of flammable liquids, regardless of if any chemicals are stored in it.

When searching for an item in a refrigerator used for chemical storage, be careful not to inhale vapors that may have built up in the cabinet.

Refrigerators should be cleaned on a regular schedule, and old chemicals should be properly discarded in accordance with the TWU Regulated Waste Management Procedure.

Food must NEVER be stored in any refrigerator used to store chemicals. Food meant for human consumption that is found by Risk Management in a chemical storage refrigerator will be confiscated and/or a written report will be issued to the lab supervisor and department Chairperson or Dean.

7. Storage of Flammable Chemicals

Storage of flammable chemicals must be in compliance with the NFPA Standard on Fire protection for Laboratories Using Chemicals (NFPA 45); including the limitations on quantities in use and in storage, and allowable container sizes. Keep all flammables away from direct sunlight and sources of heat.

Keep flammables in use in the laboratory in safety cans specifically designed for that purpose whenever possible, especially if the flammable material is no longer in its original container. In the event that such cans are not available, glass bottles may be used with the proper precautions. However, while containers used by the manufacturer must meet certain standards for shipping, these same containers are not always suitable for routine use. The shipping container must be sealable and of suitable shape and strength for transport. This transport is usually within another container - carton, crate, etc.

Keep flammables in flammable storage cabinets when not actively in use. Quantities outside of storage shall be maintained at the lowest possible level necessary for the work performed. Flammable storage cabinets are designed to protect the contents from external fires. For this reason, the door(s) must be kept closed except when removing or replacing the cabinet's contents. Cabinets shall be labeled in conspicuous lettering, "FLAMMABLE--KEEP FIRE AWAY".

Flammable storage cabinets do not necessarily protect people from solvent vapors during normal use of the cabinet. There are vent kits available for flammable storage cabinets, however the NFPA Flammable & Combustible Liquids Code (NFPA 30) recommends against venting these cabinets as this practice may defeat the designed purpose. Where particularly noxious or toxic chemicals are being used, cabinets may be vented, with prior Risk Management approval. If the cabinet is to be vented, only fire rated vents may be used.

The interior of a flammable storage cabinet is capable of withstanding the effects of vapors from solvents, but not of other materials such as corrosives. Flammable storage cabinets are also designed with a lip to contain a two-inch depth of a spilled liquid.

8. Storage of Acids

Acid storage cabinets are designed to withstand corrosion, contain spills, keep like materials together, and protect the contents from physical damage. Acid should be stored in acid storage cabinets whenever possible, especially if ordinary cabinets used for acid storage show signs of deterioration. As acids are incompatible with alkalis, flammables, and other classes of chemicals, only acids may be stored in these cabinets. Acids and other chemicals may not be stored on the floor.

Dichromate cleaning solution is highly toxic and a very strong oxidizing agent. It attacks almost all oxidizable materials, often violently and with fire and/or explosive results. Although storage of this common cleaning solution in the glass shipping container is a common laboratory practice, it has led to several serious incidents. Occasionally, the dichromate solution will contain sufficient amount of organic material from previous glass cleanings to evolve a large enough quantity of carbon dioxide to explosively rupture a screw topped glass bottle. To prevent a possible explosion, and subsequent potential injury, a stopper is recommended. Use of dichromate cleaning solutions is strongly discouraged.

9. Chemical Inventories

In accordance with the TWU Hazard Communication Program, all laboratories must prepare, maintain, and update a list of all chemicals present in the laboratory. This should be done within the Hazmat function of Campus Optics. The list should include; the product or chemical name of the contents, the CAS Number (Chemical Abstracts Service Number) if it is a single chemical (not a mixture), and the size and number of containers. This inventory is used by Risk Management to acquire the SDSs needed to carry out work both safely and in compliance with the OSHA standards. For example, identification of a substance as a Particularly Hazardous Substance and a carcinogen and taking the appropriate precaution in its use, would not be possible without compiling this list. For more information, Section IX, "Provisions for Employee Protection when working with Particularly Hazardous Substances."
Furthermore, inventories are needed for regulatory reporting requirements.

It is the responsibility of the laboratory supervisor to maintain the inventory within Campus Optics and ensure it is verified **annually by December 21st**.

In the case of shared spaces, information on chemicals present should be provided by a user to another user, upon request.

10. Transportation

Bottles of 2 liters or more should be transported in bottle slings or bottle carriers that could completely contain the substance in the event of breakage. This is particularly important in transporting corrosive, toxic, or flammable liquids. If you need to move several such containers at once within a building, use bottle carriers and a properly designed cart. All containers should be tightly capped during transport.

Smaller bottles can be carried by their handles, or by grasping the label and placing the little finger under the base of the bottle. Never try to balance a bottle by holding it solely from underneath. Approach all doors with caution.

If you do drop and break a container, you have the responsibility of calling TWUPD (x2911) immediately to report the spill and to request assistance in cleanup.

G. Chemical Hazards

This section contains descriptions of the general categories of chemical hazard, and the principles of safety associated with each. This section purposefully does not contain advice for handling specific chemicals. Safe work in a chemical laboratory requires very detailed knowledge of the nature, potential, and compatibility's of each substance used; cursory or selective description in this plan would be misleading and, as a result, unsafe. Anyone planning an experiment or procedure should acquire and review a Safety Data Sheet (SDS) for each substance, as well as for all likely products and byproducts (if SDSs are available for these).

SDSs for each chemical present in the laboratory must be available to every laboratory worker. At TWU, Safety Data Sheets (SDSs) which are received must be forwarded to Risk Management. SDSs are available by calling x4001 or can be obtained online at the following address: https://twu.campusoptics.com/sds. Local collections of paper SDSs may also be maintained for each area or laboratory, but these should not be considered to be the primary resource as printed SDSs tend to be out of date when compared to the online database.

The following categories provide a structure for thinking about -- and planning protection against -- common chemical hazards. In actual practice, such hazards do not group themselves in neat categories, but usually occur in combination and/or sequence. The categories and concepts are provided as an aid to awareness, and as encouragement for consistent safe planning and practice.

1. Flammability

Flammability is one of the most common chemical hazards. The exact degree of hazard, however, depends on the specific substance and the conditions you expect to use it in. To handle a flammable substance safely, you must know its flammability characteristics: flash point, upper and lower limits of flammability, and ignition requirements. This information appears on each SDS.

- Flash Point – For a liquid, the flash point is the lowest temperature at which the liquid gives off enough vapor to form an ignitable mixture with air and produce a flame when a source of ignition is present. Many common laboratory solvents and chemicals have flash points that are lower than room temperature.

- Ignition Temperature – The ignition temperature of a substance -- solid, liquid, or gas -- is the minimum temperature required to initiate self-sustained combustion. Some ignition temperatures can be quite low (for example, carbon disulfide at 90^{o}C (194^{o}F).

- Autoignition – Autoignition or spontaneous combustion occurs when a substance reaches its ignition temperature without the application of external heat. This characteristic is particularly important to keep in mind in the storage and disposal of chemicals.

- Limits of Flammability – Each flammable gas and liquid (as a vapor) has a limited range of flammable concentration in mixtures with air. The lower flammable limit (or lower explosive limit) is the minimum concentration below which a flame is not propagated when an ignition source is present -- such a mixture would be too lean to burn. The upper flammable limit (or upper explosive limit) is the maximum concentration of vapor in air above which a flame is not propagated -- such a mixture is too rich. The flammable range (or explosive range) lies in between the two limits.

Listed measurements of all these characteristics -- flash points, ignition temperatures, limits of flammability -- are derived through tests conducted under uniform and standard conditions that may be very different from actual practice. For example, concentrations of vapor in air in a laboratory are rarely uniform, and point concentrations can be quite high. It is good practice to set maximum allowable concentrations at 10 percent of the listed lower limit of flammability within closed systems. (It is important to note that, generally, this 10 percent limitation is still well above the maximum concentration considered to be safe for health considerations.)

a) Precautions for Flammable Liquids

Flammable liquids do not burn; their vapors do. For a fire to occur, there must be 1) a concentration of vapor between the lower and upper flammable limits, 2) an oxidizing atmosphere, usually air, and 3) a source of ignition. As it is unlikely that air can be excluded, and unrealistic (given the constant possibility of a spill) to assume that the vapor concentration can be controlled, the primary safety principle for dealing with flammable liquids is strict control of ignition sources.

Ignition sources include electrical equipment, open flames, static electricity, and, in some cases, hot surfaces. Others working in the laboratory should be informed of the presence of flammable substances so that ignition sources can be eliminated. Obviously, it is very important to know which of those sources is capable of igniting a substance you are using.

Remember, most flammable vapors are heavier than air, and will spread out horizontally for considerable distances until an ignition source is contacted.

If possible, flammable liquids should be handled only in areas free of ignition sources. Heating should be limited to water and oil baths, heating mantles, and heating tapes.

Static-generated sparks can be sudden ignition sources. When transferring flammable liquids in metal equipment, take care that metal lines and vessels are bonded together and grounded to a common ground.

Ventilation is very important. A fume hood should be used when flammable liquids are allowed to stand in open containers or are handled in any way.

b) Precautions for Flammable Gases

Leakage of compressed or liquefied gases can quickly produce a flammable or explosive atmosphere in the laboratory. This is obviously true where the gases themselves are flammable and under high pressure, but may also be true in the use of non-pressurized liquefied gases. For example, even relatively safe liquefied gases such as liquid air or liquid nitrogen, if kept in open vessels for too long, will generate concentrations of liquid oxygen which can contribute to an explosion. Proper care with compressed gas cylinders and cryogenic setups is essential (see General Laboratory Equipment Setup, Section 5).

2. Explosiveness

Ignition of flammable vapors or gases can occur with such speed that an explosion results. There are other substances that are explosive in themselves -- in response to heat, mechanical shock, or contact with a catalyst. With some substances, very tiny amounts of impurity are sufficient to begin a reaction that quickly becomes explosive. Finally, some substances, including several common solvents, have the ability to form heat, friction, or mechanical shock-sensitive explosive peroxides. For further information, see Appendix 6 Safe Handling of Peroxide Forming Chemicals.

a) Precautions

Become aware of all the hazards of each chemical you are using. It is crucial that you know its potential including its compatibility with other substances. This information can be obtained from SDS sheets or other chemical reference dictionaries available from Risk Management.

Be alert to any unusual change in the appearance of a reaction mixture. Rapid unexpected temperature rise or fuming are signals for emergency measures such as removing the heat source, quickly applying a cooling bath, or leaving the room.

Explosive compounds should be protected from the conditions to which they are sensitive (mechanical shock, heat, light, etc.). Check the SDS or other reference to see what those conditions are. Such substances should be brought to the laboratory only as required, and only in the smallest quantities absolutely necessary. Reactions involving or producing explosives should be designed on as small a scale as possible, and should be done behind a suitable barricade.

Special care should be taken that equipment is maintained (for example, that oil is routinely changed in vacuum pumps) and that heating methods used do not cause, or increase the potential for ignition.

Other laboratory users must be notified when an explosive hazard is present, through direct announcement and conspicuous warning signs.

b) Personal Protection

Highly exothermic or potentially explosive reactions must never be left unattended.

In addition to protection otherwise required in the laboratory, wear face shields, and heavy gloves at all times when handling known explosive substances. Laboratory coats of a flame-resistant material or treatment may help reduce minor injuries from flying glass or flash fire. When a serious explosive hazard is anticipated, shields and barricades will be necessary, along with devices for manipulating equipment at a safer distance (long-handled tongs, stopcock turners, mechanical arms, etc.). Contact Risk Management if you plan to run an experiment with a significant explosion potential.

3. Toxicity

Toxicity is the potential of a substance to cause injury by direct chemical action with the body tissues. Whether the effect is acute or chronic, the only way to avoid such injury is to prevent or greatly minimize contact between toxic chemicals and body tissues.

a) Measurement

Dose, or amount of chemical, you are exposed to determines the body's response. In the workplace, there are certain guidelines or regulations which limit your exposure to hazardous substances. These guidelines, which are set by various regulatory or professional organizations are referred to as "workplace exposure limits".

A workplace exposure limit is the airborne concentration of a material below which most persons can be exposed for long periods of time without adverse effect. These limits are based on an 8-hour time weighted average (TWA) over a working lifetime. Permissible Exposure Limits (PEL) are those set by OSHA. Other workplace exposure limits that may be listed on SDSs include Threshold Limit Values (TLV) or Recommended Exposure Limits (REL).

A Short-Term Exposure Limit (STEL) is the maximum concentration limit for a continuous 15 minute exposure period, provided that the daily TWA is not exceeded. Because workplace exposure limits are generally expressed as average concentrations, excursions above these values are permitted. The exposure levels during such excursions must be below the STEL. However, there are certain levels which must never be exceeded even instantaneously. These are known as the "ceiling" exposure limit, often noted as PEL-C or TLV-C.

All these measurements, though often based on data from animal research, refer to the exposure and resistance of a healthy adult. These levels do not necessarily apply to pregnant women, their unborn fetuses, or adults who are ill or under special stress. In such situations the individual and his/her supervisor or instructor must carefully consider all pertinent information. Risk Management can be consulted in such matters.

b) Acute Toxicity

Acute toxic effects are usually produced by a single large dose, generally well above workplace exposure limits, received in a short period of time. The effects are immediate, and may be partially or totally reversible. Acute toxic effects include:

Simple asphyxiation: the body does not receive enough oxygen (for example, when gaseous nitrogen has displaced the air in a room).

Chemical asphyxiation: the body is prevented from using oxygen (for example, when carbon monoxide instead of oxygen is absorbed in the blood).

Anesthetic: causes dizziness, drowsiness, headaches, and coma (for example, by the vapors of many organic solvents).

Neurotoxic: the brain's control of the nervous system is slowed down or changed.

Corrosive: body tissue is directly damaged by reaction with chemicals (for example, by strong acids or bases -- see separate subtopic below).

Allergic: repeated exposure to a chemical produces sensitizing, until there is an allergic reaction at the contact site (usually skin).

c) Chronic Toxicity

Chronic toxicity refers to adverse or injurious effects that can result from prolonged exposure to a substance, sometimes at dose levels just above the workplace exposure limits. Damage may not appear for many years and is often irreversible. As a result, this class of hazard is both very difficult and very important to guard against. The body can filter and process levels of toxicity that might seem surprisingly high, but over extended periods of time, even with the dose very low, the filtering process may fail, and damage may occur.

Types of chronic toxic effects include:

Carcinogenicity: produces cancer (for example, asbestos and vinyl chloride are known to produce cancer in humans).

Mutagenicity: alters cell genes; subsequent generations show genetic damage.

Teratogenicity: harms developing fetus.

Reproductive toxicity: interferes with the reproductive system in men or women.

Specific organ toxicity: damages specific organs (for example, carbon tetrachloride can cause liver damage).

d) Precautions

The precautions to take against contact with toxic substances are repeated many times throughout this plan. With chemicals of low acute toxicity, it may be tempting to be less rigorous; yet it is precisely those chemicals which most require continual caution -- an unvarying habit of safety.

You must protect your body against all forms of chemical contact: absorption, inhalation, ingestion, and injection. Never eat, drink or smoke in the laboratory; wear the appropriate protective gear, and always remove it before you leave the laboratory. Make sure you carefully wash your hands before leaving the laboratory.

Remember that the chemicals you bring home on your clothes will have a more powerful effect on growing children and elderly people than on most adults.

In order to know what level of personal protection will be adequate, refer to the appropriate SDSs. SDSs are updated regularly, and you should consult the most recent data each time you begin a new procedure. The best precaution is to treat all chemicals as toxic.

4. Corrosives

Corrosiveness is a form of acute toxicity sufficiently common and hazardous to merit separate discussion. Corrosive chemicals include strong acids, strong bases, oxidizing agents, and dehydrating agents. When they come in contact with skin, eyes, or, through inhalation, the surface tissues of the respiratory tract, they react with the tissues they touch and cause local injury.

a) Liquid Corrosives

A liquid corrosive will act on the skin rapidly or slowly depending on concentration and length of contact. These chemicals react directly with the skin: dissolving or abstracting from it some essential components; denaturing the proteins of the skin, or disrupting the skin cells. Mineral acids, organic acids, and bases are among the typical liquid corrosives.

When handling liquid corrosives, contact with them must be scrupulously avoided. Wear goggles, rubber or suitable synthetic gloves, and a face shield. A rubber or synthetic apron and rubber boots may also be necessary. Since many liquid corrosives also release irritating vapors, procedures using these materials should be performed in a fume hood.

b) Solid Corrosives

Solid corrosives interact with the skin or other surfaces when dissolved by the moisture there. Damage then occurs both from the corrosive action and from the heat of reaction with water. Because they are solid, these chemicals are relatively easy to remove; but because they may not react immediately and may not be painful at first (as with the caustic alkalis), they may cause much damage before being detected.

Solid corrosives are most commonly dangerous in a finely divided state. Dust control and good exhaust ventilation are essential, as well as goggles, gloves, and other protective clothing. In case of chemical contact, much care must be taken during the emergency shower irrigation to remove all particles of solid matter that might be lodged in the skin or clothes.

c) Gaseous Corrosives

Gaseous corrosives pose the most serious health hazard of all corrosives because of possible damage to the lungs, including spasm, edema, pneumonia, and even death. Different corrosive gases affect different parts of the lung (for example, ammonia affects the upper respiratory tract, while phosgene affects the lung, causing pulmonary edema), but all are to be avoided.

It is thus crucial that corrosive gases not be inhaled. Careful design and the use of fume hoods is essential. Skin and eyes must also be protected, as gases contact all exposed parts of the body.

5. Impurities and Combinations

SDSs and chemical reference books contain information on pure chemicals, known mixtures, and proprietary materials. Unfortunately there is less information for other materials found in the laboratory, including solutions, mixtures of unknown or uncertain composition, and byproducts of reactions, all common in the laboratory. Impurities, synergistic effects, formation of unexpected products and byproducts, insufficiently clean equipment, and the combination of vapors from your experiment with that of your neighbor's can all produce sudden and unanticipated hazards.

There is no absolute protection against all contingencies, but it helps to wear protective gear, to clean equipment scrupulously, to be aware of experiments in progress in nearby areas, and to be completely familiar with emergency procedures.

H. Cleanup and Waste Disposal

1. Cleanup

Cleaning up should be a continual process, performed during as well as after an experimental procedure. Cleaning should include yourself and your clothing, laboratory surfaces, equipment, and containers. Wash hands frequently while working in the laboratory; when you leave, remove protective gear and inspect clothing.

Care with gear and clothing will prevent taking chemicals home with you; care with equipment and containers will help avoid future contamination and surprise mixtures. Such care requires planning as well as good housekeeping. Cleanup and disposal methods should be part of your written procedures.

When washing glassware, work with a few items at a time, and allow them to drain where they will not fall over. If anything falls, let it fall rather than risk severe cuts by grabbing it as it breaks. If glass has broken into a sink containing water, drain the water and then use appropriate gloves or tongs when picking out broken pieces.

Clean vessels or equipment with appropriate materials (water, soap, acid, etc.). Do not proceed unless you are sure which materials to use; check SDSs and other references for advice on proper cleaning materials to use with the specific substance to be cleaned up. Follow directions carefully. If you have any questions, contact your supervisor or Risk Management (x4001).

2. Waste Disposal

TWU has programs for the management of waste generated in University laboratories. Details of the programs are given in the following Appendices and documents:

Appendix 2: Policy for the Disposal of Laboratory Glass

TWU Regulated Waste Procedure

V. CRITERIA TO DETERMINE AND IMPLEMENT CONTROL MEASURES

A. Determination

Whenever possible, SDSs or other respected chemical references for chemicals used in the laboratory will be reviewed prior to the use of a chemical. The lab supervisor or principal investigator will use this information, along with information on the conditions under which the chemical is to be used and other potential hazards related to the lab work, to determine the degree of protection required. In certain circumstances, Risk Management will conduct exposure monitoring to determine adequacy of controls and to determine if additional control measures are necessary. The following criteria will be used to determine and implement control measures:

1. **Occupational exposure limits** - usually an OSHA Action Level (AL) or Permissible Exposure Limit (PEL), an ACGIH Threshold Limit Valve (TLV), or other equivalent standard -- Generally, substances with lower exposure limits require higher levels of protection.

2. **Vapor pressure** - Generally, substances with higher vapor pressures require higher levels of protection.

3. **Exposure potential** - This will be determined by reviewing experimental procedures. Exposure potential is generally increased with increased temperature or pressure, when working with open rather than closed systems, during transfer of materials, during the use of hazardous substances with live animals, etc. Exposure can occur via inhalation, skin contact (with liquid, solid or vapor) or through accidental ingestion. Generally, greater exposure potential requires higher levels of protection.

4. **Exposure monitoring results** – Risk Management can use results of personal or area exposure monitoring to make judgments on appropriate control strategies.

B. Implementation

Once the required degree of control is determined, control measures will be selected from one of the following categories:

1. Engineering Controls

Engineering controls reduce an exposure at its source. Engineering controls are the method of choice for reducing exposures and will be used whenever possible/practicable. Examples of some engineering controls include:

1. Substitution of hazardous materials or operations with those which are less hazardous

2. Use of laboratory fume hoods

3. Use of glove boxes or other enclosures

4. Use of local exhaust ventilation (e.g. "elephant trunks", slotted exhaust hoods, and canopy hoods).

2. Administrative Controls

Administrative controls are work practices which are designed to control exposures. Administrative controls will be used in conjunction with engineering controls or when engineering controls are impractical or infeasible. Examples of administrative controls include:

1. Limiting time of exposure to maintain levels below acceptable exposure limits

2. Utilizing good housekeeping procedures to reduce exposures.

3. Personal Protective Equipment

Personal protective equipment (PPE) does not reduce the source of exposure, but rather protects the individual. PPE will be used in addition to engineering controls, while engineering controls are being installed or when engineering controls are impractical or infeasible. Some examples of personal protective equipment include:

1. Respirators -- This includes dust masks, as well as other types of respiratory protective equipment. TWU relies primarily upon engineering controls to prevent employee exposure to hazardous chemicals below occupational exposure limits. If you think you need respiratory protection in your workplace you must call Risk Management at x2924 to have the workplace evaluated. All employees using respirators (with the exception of voluntary use of dust masks and certain medical masks) are required to comply with the TWU Respiratory Protection Program.

2. Gloves, aprons, boots, and other skin protection.

3. Goggles or face shields with safety glasses.

VI. DOCUMENTING PROPER FUNCTIONING: FUME HOODS AND OTHER PROTECTIVE EQUIPMENT

A. <u>Fume Hoods</u>

All renovated/retrofitted or newly installed fume hoods will be equipped with a flow indicating device. In the absence of such a device, other methods can be used to determine if a fume hood is functioning (e.g., checking the face velocity with small hand-held velocity meter, or by hanging a small piece of tissue, or a "tell-tail" from the sash).

Facilities Management & Construction/Risk Management or an outside testing firm shall survey all fume hoods annually to determine if they are functioning in accordance with university requirements. Facilities Management & Construction shall be responsible for all required repairs. Risk Management will maintain a copy of the results on file. Any fume hoods found not to be operating in accordance with these requirements due to the user's actions (e.g., hood is cluttered) will be referred to the user for correction. All other hood malfunctions will be reported to Facilities Management & Construction for repair. Fume hoods must be taken out of service (i.e. no work that creates fumes, vapors or other indoor air quality issues may be conducted) until such repairs can be made.

B. Safety Showers and Eyewashes

All safety shower and eyewash units will be inspected weekly. Safety shower and eyewash units found not to be operating in accordance with University requirements will be repaired immediately. If repairs cannot be made immediately, they will be placed "out of service" until such repairs are completed. This may require limiting work with caustic or corrosive materials in the surrounding area.

C. Biological Safety Cabinets

All biological safety cabinets at TWU shall be certified annually or whenever they are relocated. Certification is performed by an outside vendor under contract with the affected department.

VII. EMPLOYEE INFORMATION AND TRAINING

The intent of the information and training program is to inform employees and students of the physical agents and hazardous chemicals in their laboratory, and the nature of the risks associated with handling these materials. Before working with any of these hazardous materials, lab users will be informed of the conditions under which the materials may be harmful or may cause injury. They will be trained in the proper control methods (engineering, personal protective equipment, etc.) and appropriate procedures necessary to control occupational exposure to hazards in the laboratory. This training is designed to satisfy the requirements of the OSHA Occupational Exposure to Hazardous Chemicals in Laboratories standard. Employees working in laboratories will also need to complete training covering the requirements of the TWU Hazard Communication Program, as well as other applicable training (such as Regulated Waste Management, Biosafety, Radiation Safety, and Respiratory Protection).

The information and training will be provided to University laboratory employees in **three parts. First**, classroom training on Chemical Hygiene/Lab Safety will be provided, scheduled, and documented by Risk Management. The training will cover the topics outlined below under "Classroom Training." **Second,** "Hands-On" training will be provided by Risk Management in a mock laboratory setup on topics listed below under "Hands-on Training."

Third, "Laboratory-Specific" training specific to the lab user's work area must be and given by their lab supervisor or the principal investigator. This session must cover the items listed below, under "Laboratory Training (Specific to Work Area)". Documentation of this hands-on training session must be maintained by the departments for each lab user.

A. Classroom Training

The classroom training required under this plan will be provided by Risk Management or designee and will consist of the following topics (some of this material will be covered in the separate Hazard Communication training):

1. **Regulatory Review** – The contents of the applicable OSHA standards will be reviewed, and a copy will be made available in the Risk Management office and online.

2. **Chemical Hygiene Plan** – The contents of this plan will be reviewed. The location where copies of the plan can be obtained will also be discussed.

3. **Physical and Health Hazards** – The physical and health hazards of chemical exposure will be reviewed, including, but not limited to: biohazards, carcinogens, compressed gases, corrosives, cryogenic materials, embryotoxins, explosives, flammables, mutagens, oxidizers, poisons, radioactive materials, reactive materials, sensitizers, and teratogens.

4. **Methods of Determining Exposure** – The following methods of determining exposure will be reviewed:

    a. Exposure monitoring

    b. Evaluation of work practices

    c. Use of senses: sight and emphasis on sense of smell (while keeping in mind the odor threshold of materials with poor warning properties).

5. **Permissible Exposure Limits (PELs)** – PELs and other occupational exposure limits will be reviewed. If a material is considered hazardous but has no published exposure limits, Risk Management will help establish controls for working with the material safely.

6. **SDSs** - Employees will be informed that the university maintains Safety Data Sheets (SDSs) online for hazardous materials in the workplace. Employees will be informed of the location and availability of these hazard information resources. Additional reference materials, available in Risk Management and individual departments, on the hazards, safe handling, and storage of hazardous materials will also be discussed.

7. **Chemical Exposure Prevention** – The following exposure prevention mechanisms will be reviewed:

    a. **Engineering Controls**:

        i. Substitution – Substitute less hazardous materials for more hazardous material, whenever possible.
        ii. Isolation/Enclosure – Enclose the lab experiment or procedure, (e.g., utilize glovebox).
        iii. Ventilation – Remove airborne toxic materials from lab users breathing zone through use of local exhaust ventilation (e.g. fume hoods).

    a. **Administrative Controls** – Minimize exposure through good housekeeping procedures, by minimizing exposure time, through good work practices.

    b. **Personal Protective Equipment** – Use of personal protective equipment will be discussed, including: eye and face protection, skin protection (e.g. gloves, aprons, lab coats), and respiratory protection.

B. Hands-On Training

The hands-on training will be provided by Risk Management or their designee and will consist of the following topics:

1. **Chemical Fume Hoods –** Proper use of fume hoods will be covered, including: annual testing records, operational checks, sash management, fume hood arrangement, and airflow monitoring. A fog machine will be used to demonstrate principles.

2. **Incident Response –** A mock spill (using water) will be setup and students required to clean it up appropriately. Topics covered will include: response steps, spill cleanup materials, PPE selection, SDS consultation, and material disposal.

3. **SDS Interpretation -** Trainees will be required to find SDSs on TWU's Online Database and answer relevant questions on topics including: chemical hazard assessment, exposure controls, use and storage, medical attention and first aid, and decontamination and spill response.

4. **Lab Inspection –** Trainees will conduct an assessment of the mock training laboratory to identify and note items that are unsafe/not up to standards covered in the Classroom Training portion. The sections of the assessment will include items in the following categories: general lab safety, chemical labeling and storage, safety equipment, waste management, electrical safety, and emergency response.

C. **Laboratory-Specific Training (Specific to Work Area)** to be provided by laboratory supervisor or principal investigator

1. **SOPs** – Standard Operating Procedures developed for that specific lab will be reviewed, if required.

2. **Emergency Procedures** – Emergency procedures and equipment for the lab (e.g. location and use of eyewash, safety showers, spill kits, exit routes, etc.) will be reviewed.

3. **Safety Equipment** – Safety equipment used in the lab (e.g. fume hoods, face shields, standing shields, gloves, etc.) will be reviewed.

4. **Labeling System** – Approach to labeling of containers used in the lab if HMIS labels under the TWU Hazard Communication program are not used.

5. **Designated Areas** – Designated areas and any special procedures for handling extremely hazardous substances will be reviewed.

6. **Signs and Symptoms of exposure** – Signs and symptoms associated with exposure to the specific materials in the laboratory will be reviewed. In addition, the methods and observations that can be used to detect the presence or release of these hazardous materials in the laboratory will be covered in the hands-on training.

VIII. MEDICAL CONSULTATIONS AND EXAMS

A. Medical Consultation

1. Offering Consultations

A laboratory user will be offered a medical consultation or examination at no cost (employees) under the following circumstances:

a) If it is likely that the user has been exposed to a substance at a level in excess of either the OSHA recommended Action Levels, or in their absence, Permissible Exposure Limit (PEL) or the Threshold Limit Value (TLV) recommended by the ACGIH. Risk Management should be consulted for assistance in assessing the exposure or potential for exposure.

b) If a laboratory user develops signs or symptoms associated with exposure to a chemical being used.

c) In the event of an exposure to chemicals through a spill, explosion, or accident.

d) When an injury occurs while working that requires medical attention.

2. Procedure

All medical consultations for **TWU employees** are provided at no cost at a hospital or clinic participating in the workers' compensation health care network (see Section II.E above for additional information). **Students** may receive medical consultations at Student Health Services for non-emergency situations during normal business hours.

a) In case of exposure to a chemical spill, accident, explosion, etc., or onset of symptoms associated with a chemical being used, the supervisor of the laboratory shall refer the exposed individual to a local clinic or hospital. If it is an emergency, the exposed individual will be sent to the nearest hospital whether or not it is in the workers' compensation network.

b) The lab supervisor, with assistance from Risk Management, shall collect as much information as possible about the exposed individual, chemical(s) involved, SDSs, symptoms, exposure monitoring results, and other relevant data, and present this information to the attending medical professional, as needed.

c) The attending medical professional will inform the exposed individual about the medical examination results, related conditions, tests required, and any follow-up required.

d) Risk Management and the lab supervisor will be advised of the results of the medical consultation only as is necessary to protect laboratory users from future exposures.

3. Medical Records

Any records provided to TWU by attending medical professionals conducting consultations must be maintained for the length of the exposed individual's employment plus thirty years.

a) Upon written request, such records shall be made available for review by the exposed individual or an authorized representative.

b) All such records shall be maintained and made available for review in accordance with the OSHA medical records standard 29 CFR 1910.1020.

IX. PROVISIONS FOR PROTECTING EMPLOYEES WHEN WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES

The procedures described in this section must be followed when performing laboratory work with any "particularly hazardous substance"; which includes carcinogens, reproductive toxins, any substance that has a high degree of acute toxicity, any drug listed on the NIOSH List of Antineoplastic and Other Hazardous Drugs in Healthcare Settings, or a chemical whose toxic properties are unknown.

A. Definitions

The following definitions apply:

1. **Select carcinogen:** Any substance which meets **any** of the following criteria:

   a) It is regulated by OSHA as a carcinogen, which currently includes the following:

- Asbestos
- alpha-Naphthylamine
- Methyl chloromethyl ether
- 3,3'-Dichlorobenzidine (and its salts)
- bis-Chloromethyl ether
- beta-Naphthylamine
- Benzidine
- 4-Aminodiphenyl
- Ethyleneimine
- beta-Propiolactone
- 2-Acetylaminofluorene
- 4-Dimethyl aminoazobenzene
- N-Nitrosodimethylamine
- Vinyl chloride
- Inorganic arsenic
- Chromium (VI)
- Cadmium
- Benzene
- Coke oven emissions
- 1,2-dibromo-3-chloropropane
- Acrylonitrile
- Ethylene oxide
- Formaldehyde
- Methylenedianiline
- 1,3-Butadiene
- Methylene chloride

b) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition).

c) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer (IARC) in Cancer Monographs (latest editions).

d) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(1) After inhalation exposure of 6–7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3;

(2) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(3) After oral dosages of less than 50 mg/kg of body weight per day.

2. **Reproductive toxin**: Any substance described as such in the applicable SDS. Example reproductive toxins include, but are not limited to the following:

Metals	Pesticides	Solvents
Antimony Arsenic Boron Cadmium Lead Lithium Manganese Mercury Selenium	Aldrin Carbaryl Chlordane DDT Dieldrin Hexachlorobenzene Kepone (Chlordecone) Lindane Methoxychlor Mirex	Benzene Carbon Disulfide Chloroform Glycidyl Ethers Hexane Methylene Chloride Perchloroethylene Toluene Trichloroethylene Xylene
Glycol Ethers		
Ethylene Glycol Monomethyl Ether (also called Methyl Cellosolve or Methoxyethanol) Ethylene Glycol Monoethyl Ether (also called Ethyl Cellosolve or Ethoxyethanol) Other Glycol Ethers (many varieties)		
Other Organic Chemicals		
Aminopterin 1,3-Butadiene Chlorambucil Chlorcyclizine Chloroprene Cycloheximide Cyclophosphamide Cyhexatin Cytarabine DBCP (Dibromochloropropane) Diethylstilbestrol	Dimethyl Formamide Dinitrotoluene Dinoseb Diphenylhydantoin Epichlorohydrin Ethyl alcohol in alcoholic beverages Ethylene Dibromide Ethylene Oxide Ethylene Thiourea Etretinate Fluorouracil	Hydrochloride Isoretinoin Mechlorethamine Methotrexate Methyl Mercury PCB (Polychlorinated Biphenyl) Thalidomide Tobacco Smoke Valproate Vinyl Chloride Warfarin

3. **Substances with a high degree of acute toxicity**:

   a) Any substance for which the median lethal dose (LD_{50}) data described in the applicable SDS cause the substance to be classified as a "highly toxic chemical" as defined in ANSI Z129.1:

      (1) A chemical that has a LD_{50} of 50 mg or less per kg of body weight when administered orally into albino rats weighing between 200 - 300 grams each, or

      (2) A chemical that has a LD_{50} of 200 mg or less per kg of body weight when administered by continuous contact for 24 hours (or less, if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kg each, or

(3) A chemical that has a median lethal concentration (LC_{50}) in air of 200 ppm by volume or less of gas or vapor, or 2 mg per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less, if death occurs within one hour) to albino rats weighing between 200 and 300 grams each, provided such concentrations and/or conditions are likely to be encountered in a reasonably foreseeable manner.

b) Or: Any substance with a **Category 1** in the following Globally Harmonized System (GHS) classifications

(1) Acute Toxicity by Inhalation or Dermal Exposure
(2) Acute Toxicity by Oral Exposure
(3) Specific Target Organ Toxicity

Example of some chemicals with a High Degree of Acute Toxicity		
• acrolein	• hydrogen cyanide	• osmium tetroxide
• arsine	• hydrogen fluoride	• ozone
• chlorine	• methyl fluorosulfonate	• phosgene
• diazomethane	• nickel carbonyl	• sodium azide
• diborane (gas)	• nitrogen dioxide	• sodium cyanide

4. **Chemotherapy (aka Antineoplastic) and Other Hazardous Drugs:** Any drug on the NIOSH List of Antineoplastic and Other Hazardous Drugs in Healthcare Settings is considered a 'particularly hazardous substance'.

5. **Particularly hazardous substances**: For the purposes of this CHP, chemicals in the above four categories will be referred to as "particularly hazardous substances".

6. **Designated area**: A hood, glove box, portion of a laboratory, or an entire laboratory room designated as the area where work with particularly hazardous chemicals shall be conducted.

B. Conditions for Usage

A "designated area" in the laboratory for use of the particularly hazardous substance must be established. Lab users must comply with the following requirements, and the requirements should also be incorporated into SOPs for laboratories with designated areas:

1. Designated areas shall be posted with the following (available from Risk Management) and their boundaries clearly marked.

DESIGNATED AREA

- ☐ Select Carcinogens
- ☐ Reproductive Toxins
- ☐ Highly Toxic Chemicals

(Check all that apply)

Authorized Personnel Only

2. Only those persons trained to work with particularly hazardous substances will work with those chemicals in a designated area.

    a. Lab supervisors / principal investigators should keep signed and dated records of the lab users that receive training.
    b. EH&S may require that lab supervisors / principal investigators keep records of the names and respective chemicals used by individuals for certain highly hazardous particularly hazardous substances in the lab.

3. Use the smallest amount of chemical that is consistent with the requirements of the work to be done.

    a. If possible, do not work with particularly hazardous chemicals in solid or powder form. If it is necessary to purchase it in powder or solid form, purchase pre-diluted or pre-weighed agent in the least quantity needed to perform work when possible.

4. Use containment devices such as fume hoods or glove boxes; fume hoods must achieve an average face velocity of between 95 and 125 feet per minute to be used with particularly hazardous substances.

5. Use high-efficiency particulate air (HEPA) filters or high-efficiency scrubber systems to protect vacuum lines and pumps.

6. Decontaminate designated areas as appropriate (specific procedures for decontamination must be included in lab-specific SOPs), this may include covering work surfaces with removable absorbent plastic-backed paper. Work surfaces must be decontaminated before work and at the end of the procedure or work day, whichever is sooner.

7. Prepare wastes from work with particularly hazardous chemicals for waste disposal in accordance with specific disposal procedures consistent with the TWU Regulated Waste Management Procedure.

8. All lab users should wash their hands and arms immediately after the completion of any procedure involving particularly hazardous substances, versus just when they leave the lab.

9. Because the decontamination of jewelry may be difficult or impossible, avoid wearing jewelry when working in designated areas.

10. Appropriate PPE that prevents the particularly hazardous substances from penetrating to street clothes, skin or eyes should be worn. This may require long-sleeved disposable clothing and gloves known to resist permeation by the chemicals used when working in designated areas in some cases. For example, chemotherapeutic (antineoplastic) drugs require the use of chemotherapy gloves.

    a. Take extra precautions when there is a significant risk of permeation, including double gloving and changing gloves every 30 minutes or less.

    b. For further guidance on selection of protective clothing, contact Risk Management at x2924.

11. Principal Investigators must conduct a "dry run" of procedures involving particularly hazardous substances, especially before allowing these procedures to be performed by lab users.

X. LABORATORY OPERATIONS THAT REQUIRE PRIOR REVIEW AND APPROVAL

In general, prior approval must be obtained when a laboratory procedure presents a significant risk of injury, illness, or exposure to hazardous substances. The risk is considered significant when there are very large quantities of particularly hazardous substances involved or the experimental procedures exacerbate the potential for a hazardous condition. Obviously, these conditions must be applied on a case-by-case basis.

A. Prior Review and Approval by a Lab Supervisor

For routine operations, other than those detailed under "Prior Review and Approval by the University Safety Committee," the lab supervisor, or someone designated by the lab supervisor may review and approve operations. Only the lab supervisor or their designees who have attended TWU Chemical Hygiene training may review and approve laboratory operations.

B. Prior Review and Approval by University Safety Committee

The University Safety Committee is an advisory body to the University composed of a cross section of the University community, including science faculty. Its role is to facilitate dialog to promote regulatory compliance and safety. Its recommendations represent a peer review of proposed projects and operating procedures. The University Safety Committee is not empowered to stop any projects that it does not approve. The findings will be forwarded to the proper administrative level for their review and action.

The following would require prior approval by the University Safety Committee before proceeding with a particular experiment or activity:

1. When it is likely that occupational exposure limits could be exceeded or that other harm is likely if a single safeguard/control were to fail.

2. When there was an incident during a procedure that resulted in (or a near-miss that could have resulted in) injury, illness, or overexposure of a laboratory user to a hazardous material, the University Safety Committee must grant approval before the procedure may be undertaken again.

3. There was or nearly was an explosion or uncontrolled reaction that did or could have resulted in damage to property.

Lab supervisors who wish to obtain prior approval from the University Safety Committee must provide the committee with information about the experiment or activity sufficient to allow for a decision to be made regarding the adequacy of the planned safety precautions. If animals are to be used in this research activity, you must obtain approval from the TWU Institutional Animal Care and Use Committee.

APPENDIX 1

CHEMICAL SPILL RESPONSE GUIDELINES

The following are general guidelines to be followed for a chemical spill. These guidelines do not apply to spills of biological or microbiological materials. Follow procedures specific to your lab if they have been developed.

YOU SHOULD NOT CLEAN UP A SPILL, MAJOR OR MINOR IF:

- You don't know what the spilled material is
- You lack the necessary protective gear, equipment, or knowledge to do the job safely
- The spill is too large to contain
- The spilled material is highly toxic or poses a fire hazard
- You experience any symptoms of exposure

MAJOR SPILL
In the event of a spill which involves the release of a type or quantity of a chemical that poses an immediate risk to health or involves an uncontrolled fire or explosion:

- If you can do so safely: Quickly identify the spilled material, extinguish nearby ignition sources and/or stop the spill at the source.
- Notify everyone in the lab, move victims from the area (if possible), close doors, activate the fire alarm and evacuate the building.
- Call 911 and provide as much detail about the incident as possible.
- Administer first aid if needed: Wear PPE, locate nearest emergency eyewash or safety shower, remove contaminated clothing from the victim and flush all areas in contact with chemicals for at least 15 minutes.

MINOR SPILL
In the event of a spill involving the release of a type or quantity (less than 1 liter) of a chemical which does not pose an immediate risk to health and does not involve chemical contamination to the body:

- Notify everyone in the lab, isolate the area.
- For flammable materials, extinguish ignition sources and unplug nearby electrical equipment.
- For volatile materials, establish exhaust ventilation. Turn on fume hoods, and open windows if possible.
- Locate SDS and spill kit.
- Choose appropriate PPE and spill cleanup materials based on the SDS.
- Contain the spill using absorbent materials and/or neutralizers from the outside in.
- Spill response materials, including recovered chemicals, must be placed into appropriate, sealable containers for disposal through EH&S.
- Wet mop spill area after cleaning as much of the chemical as possible.

Report all spills to EH&S (940-898-4001 ext.5) after the response, or any time assistance is needed.

APPENDIX 2

POLICY FOR DISPOSAL OF LABORATORY GLASS

The purpose of this policy is to ensure the safe disposal of all laboratory glass, which includes preventing injuries to anyone who must handle discarded glass. This policy applies to all laboratory glass, intact as well as broken, except for glass that is contaminated with radioisotopes, biomedical waste, or other regulated wastes, which are covered under the Radiation Safety Manual, Bloodborne Pathogen Exposure Control Plan, and Regulated Waste Management Procedure respectively.

Procedure

Place all glass, intact as well as broken, into a specially marked rigid container designed for this purpose. A properly labeled thick-walled, rigid cardboard container may be substituted. The container must be able to withstand penetration by the glass it contains, and must be lined with a leak-resistant liner (e.g., a polyethylene or polypropylene bag). Seal the container and clearly mark it "BROKEN GLASS" to describe its contents.

Rinse all empty hazardous chemical containers three times with small amounts of a suitable solvent or appropriate detergent solution (triple-rinsing) before discarding. The solvent may be any liquid which is effective (e.g., water or water-detergent solutions effectively clean water-soluble substances and water-dispersible substances; acetone is useful in dissolving many oily materials). Collect the rinsate for disposal as a hazardous material if appropriate (refer to the TWU Regulated Waste Management Procedure or contact Risk Management for guidance). Then deface or remove all labels. After this step, they may be discarded as ordinary trash.

Seal filled glass disposal containers before placing them for disposal. Ordinary, uncontaminated, discarded glass, when packed as described above, may be disposed of with the regular trash. If a container of ordinary non-contaminated glass is so heavy or bulky that special handling is required, call Custodial Services for proper disposal.

Do NOT put glass originating in the laboratory into a recycling container.

APPENDIX 3

ALTERNATIVE USE OF LABS - TEACHING LABS FOR RESEARCH or RESEARCH LABS FOR TEACHING

This policy is intended to assure the health and safety of the students participating in the laboratory activities sponsored by TWU. Teaching laboratories are necessary for instructing students in the art and science of chemical phenomena. TWU instructs students of all skill levels. As a result, a portion of the student population has little understanding of chemical hazards and chemical reactions outside of the material being presented by the instructor. For this reason it is necessary to closely monitor and/or restrict the use of the teaching laboratories for research and storage of hazardous chemicals. Similarly, use of research labs with elevated chemical and physical hazards should be closely monitored when used for teaching with students of lower experience levels.

Standard Operating Procedures (SOPs) for Teaching Laboratories

Teaching laboratories while not being used, should not have any reagents, chemicals or solutions remaining from previous courses if it will be used by a different course afterwards. It is the responsibility of the lab coordinator to be sure that when the last section is finished that all chemicals pertaining to that lab are properly put away and waste is collected and sent to the prep room for storage prior to disposal.

It is acceptable practice to set up for a lab ahead of time and stage the chemicals in the hood or an appropriate place in the laboratory. Laboratory experiments may continue for some time before every section is finished with the experiment. Therefore it is necessary to place a label to identify the materials for the lab and show that it is in current use.

Storage of stock chemicals is not permitted in the teaching laboratories except by written permission of Risk Management. Stock chemicals should be stored in prep or bulk storage rooms. There are several reasons for this but they stem from the fact that there is no one faculty member assigned to the room and responsible for its upkeep. Federal and state regulations require that inventories and SDS sheets be kept for these materials and be available for emergencies. Materials stored in such common areas have a tendency to become "lost or forgotten" and this leads to wasting money by purchasing materials we already have in stock. The procedure for obtaining this permission is outlined below in the "Use of Teaching Laboratories for Research Purposes" and is subject to the same restrictions.

Use of Teaching Laboratories for Research Purposes

The use of teaching laboratories for research is not permitted without WRITTEN PERMISSION of Risk Management and the Chairperson of the department. A protocol and form are provided below to obtain permission. This protocol is intended to help prevent the accumulation of spent, waste surplus materials in teaching areas as well as to be certain that the proposed work will not interfere with classes that may be taught there.

All too often someone will endeavor upon a research project in a teaching lab and then leave the material there for someone else to dispose of. Not only is this inconsiderate of others who also use the building but it is dangerous to the workers who must then go back and clean it up. It also costs a great deal more for us to dispose of the material since there is no one available to describe what the material is. However, it is also true that sometimes there is no alternative but to use the teaching areas to get work done.

The individual desiring to use a teaching laboratory for research must make a request to Risk Management, the lab coordinator and the Chairperson of the department controlling the lab. It must include the following information:

1. Name of the Graduate Assistant and/or the Principal Investigator
2. Which lab is to be used and what area
3. Duration the teaching lab is to be used
4. Complete protocol to be followed while doing research in the teaching lab
5. List of chemicals to be used/stored in the teaching lab during this time

Records of such requests will be maintained by Risk Management.

The GA and/or PI doing research in the teaching laboratory is responsible for keeping the work areas neat and to promptly and properly dispose of all chemical wastes as spelled out earlier in this program.

This permission automatically expires six months from the date of issue.

<u>Use of Research Laboratories for Teaching Purposes</u>

The use of research laboratories for teaching undergraduate level courses is not permitted without WRITTEN PERMISSION of Risk Management and the Chairperson of the department. Graduate level courses where the students have been trained and are familiar with the higher level hazards of the respective research lab are exempt from this requirement. This protocol is needed due to the fact that research labs often have much higher hazards requiring additional training than that of teaching laboratories (e.g. radioactive materials, biohazardous materials, particularly hazardous substances, increased physical hazards, etc.). The higher hazards present unnecessary risk if alternative spaces can be secured for the activities. However, sometimes it is necessary to use research labs for teaching courses.

The individual desiring to use a research laboratory for teaching must make a request to Risk Management, the lab manager/PI and the Chairperson of the department controlling the lab. It must include the following information:

1. Name of the Graduate Assistant and/or the Instructor of record
2. Which lab is to be used and what area
3. Duration the research lab is to be used
4. Complete procedures to be followed
5. Description of any unique hazards in the research laboratory that would not normally be present in the teaching laboratory/exercise and how these hazards will be controlled to ensure student safety

Records of such requests will be maintained by Risk Management.

The GA and/or PI doing research in the teaching laboratory is responsible for keeping the work areas neat and to promptly and properly dispose of all chemical wastes as spelled out earlier in this program.

This permission automatically expires six months from the date of issue.

APPROVAL FORM FOR USING A TEACHING LABORATORY FOR RESEARCH

This form is intended to assure that the proposed activities will not interfere with class schedules and will not pose undue safety hazards to students. When completed have the project approved by the Chairperson of the Department, lab coordinator and Risk Management.

Name of project:____

Laboratory and area to be used: ____

Principal Investigator: ____

Department: ____

Dates the teaching lab will be used: From ____/____/____ , To ____/____/____ .

List all individuals who have been trained in this procedure and will be working in the teaching laboratory:

____

Provide a brief description of the activity which will be carried out. Activities can include, but are not limited to: a particular reaction, a reaction system, use of a particular chemical, use of additional or new components to a new or old system, initiation of a new research project, or the addition of a new chemical to an old procedure. A copy of the written procedure may be attached to satisfy this requirement.

____

____

____

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____

____

____

Attach a list of chemicals that will be used and stored in the Teaching Laboratory for the project as well as a list of expected waste products.

APPROVAL:

Risk Management: ____ Date: __________

Lab Coordinator: ____ Date: __________

Chairperson: ____ Date: __________

APPROVAL FORM FOR USING A RESEARCH LABORATORY FOR TEACHING

This form is intended to assure that the proposed activities are suitable in a research lab, will not interfere with research activities, and will not pose undue safety hazards to students. When completed, have the request approved by the Chairperson of the Department in charge of the lab, the Chairperson of the Department in charge of the course (if different),Principal Investigator (PI) or lab coordinator, and Risk Management.

Name of Class:

____

Professor/Instructor:

____

Laboratory and area to be used:

____

Department and PI/lab coordinator responsible for the lab:

____

Dates the research lab will be used: From ____/____/____ , To ____/____/____ .

List all individuals (Professor, Instructor, Teaching Assistants etc.) who have been trained on the hazards present in the research lab and are responsible for ensuring student health and safety during teaching exercises within the lab:

____

____

Provide a brief description of the teaching activities which will be carried out. A copy of the written procedures may be attached to satisfy this requirement.

____

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____

Provide a brief description of any unique hazards in the research laboratory that would not normally be present in the teaching laboratory/exercise and how these hazards will be controlled to ensure student safety. e.g. radioactive materials, biohazardous materials, particularly hazardous substances, dangerous chemicals etc.

____

____

APPROVAL:

Risk Management: ____ Date: ___________

Research Lab Coordinator/PI: _____________________________________ Date: ___________

Chairperson: ____ Date: ____________

Chairperson: ____ Date: ____________

APPENDIX 4

POST-INCIDENT PROCEDURE REVIEW POLICY

A safety review is to be completed prior to initiating an experimental procedure in which an accident or near miss as described below has previously occurred at Texas Woman's University:

1. When an accident has occurred in which a laboratory user has been exposed to a hazardous chemical or biological material(s) in excess of the occupational exposure limit.
2. When a laboratory user becomes ill due to exposure chemical or biological material associated with an experimental procedure.
3. When there is an incident related to an experimental procedure that either did or could have resulted in injury or illness to a laboratory user.
4. There was an uncontrolled reaction that either resulted in an explosion or involved circumstances that could have resulted in damage to property.

Once this post-incident review is completed, and identified safeguards implemented, the procedure is generally regarded to be safe and may be performed again in any properly equipped laboratory on campus. Further safety review is not required unless accidents or near misses persist with the procedure.

Posting/distribution/recording requirement:
To encourage awareness of potential safety hazards the completed Post-Incident Procedure Review form shall be posted in the laboratory where the incident previously occurred for one year. In addition, the completed form shall be distributed to all current lab supervisors who work in related research and teaching areas. Finally, a permanent record of all completed forms shall be maintained by Risk Management. Risk Management shall be responsible for completing the posting/distribution/recording requirement.

POST-INCIDENT PROCEDURE REVIEW

Date of Review ___________________

Principal Investigator/Instructor ____

Laboratory User(s) ____

Department ____

Departmental Chair ____

Building ___________________________ Room ___________________

Phone _____________________________

DESCRIPTION OF PREVIOUS SAFETY INCIDENT

Describe the safety incident (accident or near miss) and identify the specific cause of the accident/near miss.

____
____
____
____
____
____
____

CHEMICAL/BIOLOGICAL/EQUIPMENT TO BE USED

Use additional forms or attach documentation if necessary

Name ____________________________CAS No.________________________________

Synonyms ____

Location of Use ____

Use Condition ____

Location of Storage ____

Period/Frequency of Use ____

Quantity to be Used ____

PERSONNEL PROPOSED FOR THIS PROJECT

For a teaching laboratory state the course number

____

____

____

EXPERIMENTAL PROCEDURE(S)

Describe the procedures that will involve the use of material/equipment. Attach additional pages if necessary.

____

____

____

____

CONTROL PROCEDURES

Describe controls that will be employed to protect the individuals participating in this research.

____

____

____

DECONTAMINATION AND DISPOSAL

Decontamination procedures (surfaces, materials, instruments, equipment, etc.):

____

____

____

DISPOSAL PROCEDURES *(wastes and unused stock):*

____

____

____

The following sections will be completed by Risk Management.

MONITORING PROCEDURES
If there is a possibility of exposures exceeding permissible exposure limits.

Medical and/or personnel monitoring procedures for evidence of personnel exposure.

____

____

____

Monitoring procedures to detect environmental contamination.

____

____

AUTHORIZATION

The Post-Incident Procedure Review has been completed and procedure is approved for future use.

______________________________ Date_______________
Safety Committee Chair

Posting/distribution completed: _______________ (date, Risk Management initial)

APPENDIX 5

LABORATORY INSPECTION POLICY

In the interest of employee and community safety, the University has embarked upon a regular program of inspecting its laboratories to ensure proper compliance with all applicable state and federal regulations. In particular, attention is focused on EPA, TCEQ, OSHA and NFPA regulations. Inspections are conducted using the Campus Optics web-based system.

Each inspection will be composed of an initial inspection and, if necessary, a follow-up. If the laboratory is for research, it is preferred that the principal investigator who has been given charge of the laboratory be present for comprehensive inspections. However, inspections may be conducted unannounced and unaccompanied. Risk Management will conduct the inspections and note any violations observed during the inspections.

After an inspection, Risk Management will issue a report through email and Campus Optics with copies going to the Department, Principal Investigator (if applicable) and the Dean's office. The person responsible for the laboratory will use Campus Optics to review the report which includes corrective action requirements. Once items are corrected in the lab, the person responsible for the laboratory shall mark the items as complete in Campus Optics to formally close them out. If a follow-up inspection is required, It will be scheduled no sooner than two weeks later, unless otherwise agreed among the parties involved, to verify that the deficiencies are corrected or that proper steps have been made to abate the problem.

If proper steps have not been made a follow-up report is issued and the outstanding items will be escalated to the Dean's office.

APPENDIX 6

SAFE HANDLING OF PEROXIDE FORMING CHEMICALS

Some chemicals can inadvertently form peroxides during storage, particularly as they age and/or are exposed to light, air, and heat. Other chemicals are polymerizable compounds that can contribute to an explosive polymerization reaction catalyzed by peroxides. Distillation, evaporation, or other concentration of some relatively common peroxide-forming chemicals, such as diethyl ether, tetrahydrofuran, acetaldehyde, or dioxanes, can increase the concentration of peroxides and present a high hazard. Peroxides may explode when subjected to heat, friction, or mechanical shock. Because of these potentially dangerous properties, the procedures outlined in this Appendix should be followed when working with peroxide forming chemicals. There are four hazard classes of peroxide forming chemicals based on the method of reaction. See Table 2 for further information and examples.

A. PURCHASING AND INVENTORY

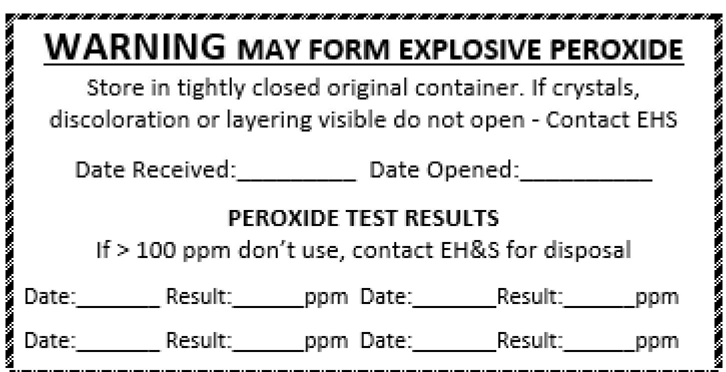
Ideally, only purchase the amount of peroxide forming chemicals you need to complete an experiment within the chemical's safe shelf life. This requires careful experiment planning and often, not purchasing in bulk. If available and it does not interfere with the use of the chemical, peroxide-forming chemicals should be ordered with inhibitor added. Ensure each container of peroxide forming chemical is entered into inventory upon receipt, and removed from inventory upon depletion or disposal.

B. LABELING

Peroxides tend to form in materials as a function of age. Therefore, it is critical that lab users are aware of the age of their peroxide forming chemicals. The best way to track and communicate peroxide forming chemical age is through good inventory and labeling practices.

All containers of peroxide forming chemicals should be labeled with a TWU Peroxide Former Label. At a minimum, the label should contain the date received, and the date opened. In addition, if testing is conducted all peroxide test dates and results must be recorded. Labels can be obtained from Risk Management.

SAMPLE LABEL:


WARNING MAY FORM EXPLOSIVE PEROXIDE
Store in tightly closed original container. If crystals, discoloration or layering visible do not open - Contact EHS

Date Received:_________ Date Opened:__________

PEROXIDE TEST RESULTS
If > 100 ppm don't use, contact EH&S for disposal

Date:_______ Result:______ppm Date:_______Result:______ppm
Date:_______ Result:______ppm Date:_______Result:______ppm

C. STORAGE

Store peroxide forming chemicals in sealed, opaque, airtight containers with tight-fitting caps and away from light and heat sources. Peroxide-forming chemicals should be stored in their original manufacturer's container whenever possible. This is especially important in the case of diethyl ether because the iron in the steel containers that the material is shipped in acts as a peroxide inhibitor. Do not store peroxide forming chemicals beyond their expiration date or suggested shelf life unless appropriate testing is being conducted, as detailed below.

Table 1: Safe storage period for peroxide forming chemicals[1]	
Peroxide Forming Chemical Classification	**Dispose or Test Within[2]**
Unopened chemicals from the manufacturer	12 months/expiration date[3]
Opened containers	
Class A Chemicals	3 months/expiration date[3]
Class B Chemicals	12 months/expiration date[3]
Uninhibited Class C Chemicals	24 hours (mandatory disposal)
Inhibited Class C Chemicals[4]	12 months/expiration date[3]
Class D Chemicals	12 months/expiration date[3]

1. Never open or test containers of unknown origin or age, or that have visible evidence of peroxides.
2. After initial storage period, peroxide-forming chemicals should be re-tested every six months for Class B, C, and D chemicals, and monthly for Class A chemicals.
3. Whichever is sooner.
4. Do not store under inert atmosphere.

D. HANDLING

Before use, verify the identity and class (see Table 2) of the peroxide forming chemical. Next, ensure it is within the recommended safe storage period (see Table 1 and/or Table 2), or has an acceptable peroxide test result for continued safe use within the required timeframe. Finally, verify the container shows no visible discoloration, liquid stratification, or crystallization. If so, do not open or test the chemical. Furthermore, never use or test containers of unknown age or origin. Old bottles may contain concentrated peroxides, or may have crystallized peroxides in the cap threads, which would present a serious hazard when opening the bottle for use or testing. **Do not open a container of a peroxide forming chemical that has obvious crystal formation** as the friction from opening can cause an explosion. Call Risk Management immediately at 940-898-4001 ext. 5.

E. DISTILLATION

Distillation greatly increases the hazards of peroxide formation and explosion. Test all peroxide forming chemicals that are to be distilled regardless of age, especially those in Class B, (which includes di/ethyl ether, and tetrahydrofuran). If no peroxides are present, the material can be distilled. If any peroxides are present, or if you are unsure, eliminate the peroxides with a chemical reducing agent or pass the solvent through activated alumina. Adding mineral oil to the distillation pot has the combined effect of "cushioning" any bumping, maintaining dilution of peroxide concentration, and serving as a viscous reaction moderator in case the peroxides begin to decompose. Carefully monitor the distillation process to ensure that it does not dry out completely, and then overheat. Distillation can concentrate peroxides, especially if taken to a dry state. Peroxides will be present mainly in the still bottoms. Small pieces of sodium metal can be added to the distillation vessel to reduce peroxides. Use benzophenone as an indicator for the presence of sodium metal (benzophenone in the presence of sodium metal forms a radical with a deep-blue color). When the blue color disappears, add more sodium metal to the vessel.

F. TESTING AND DISPOSAL

There are several test methods for peroxide detection, but the easiest and most reliable is the use of peroxide "test strips" available through various manufacturers such as Sigma Aldrich and Fisher Scientific. Ensure the test strips purchased and used are in the 0-100 ppm range as other ranges will not adequately determine safe use in accordance with these guidelines. All manufacturer guidelines, including expiration date of the test strips, should be adhered to.

By the end of the safe storage date for the particular peroxide forming chemical, the user shall either dispose of it, or test it for peroxide content. Any container found to have a peroxide concentration greater than or equal to 100 ppm should be disposed of (contact EH&S for assistance). Materials which are older than the suggested shelf life but have been tested and the peroxide concentration is less than 100 PPM may be retained, but should be tested at the intervals below.

- All peroxide forming chemicals which are to be distilled must be tested prior to distillation, regardless of age.
- Class A chemicals should be tested monthly after opening and/or after the suggested shelf life if the chemical is to be kept in the lab.
- Class B, C, and D chemicals should be tested every 3 months (quarterly) after opening and/or after the suggested shelf life if the chemical is to be kept in the lab.

Assessing peroxide level results:

<25 ppm	Considered safe for general use
25-100 ppm	Not recommended for distilling or concentrating
>100 ppm	Avoid handling and contact EHS for safe disposal

All peroxide test results must be recorded on TWU Peroxide Former Label attached to the container.

TABLE 2 Peroxide Forming Chemicals

The following lists contain some common peroxide forming chemicals, but it is not comprehensive. For additional information regarding potential peroxide forming chemicals, refer to NFPA 400, Annex F.

Class A – Chemicals that form explosive levels of peroxides without concentration.[a]
Suggested Safe Storage Period: If unopened from the manufacturer, up to 12 months or manufacturer expiration date, whichever comes first. After opening, chemicals should be discarded or tested for peroxides within **3 months.** If not discarded after the suggested safe storage period (either opened or unopened), then you must **test for peroxides monthly**.

Butadiene[c]	Chloroprene[d]	Divinylacetylene
Isopropyl ether	Tetrafluoroethylene	Vinylidene Chloride

Class B – Chemicals that form explosive levels of peroxides on concentration (evaporation or distillation).[b]
Suggested Safe Storage Period: If unopened from the manufacturer, up to 12 months or manufacturer expiration date, whichever comes first. After opening, chemicals should be discarded or tested for peroxides within **12 months** or manufacturer expiration date, whichever comes first. If not discarded after the suggested safe storage period (either opened or unopened), then you must **test for peroxides every 6 months**.

Acetal	Diethyl ether	2-pentanol
Acetaldehyde	Diethylene glycol	4-penten-1-ol
Benzyl alcohol	Dimethyl ether	1-phenylethanol
Isopropyl ether	Dioxanes	2-phenylethanol
Cyclohexanol	Ethylene glycol dimethyl ether	Tetrahydrofuran
2-cyclohexen-1-ol	4-heptanol	Tetrahydronaphthalene
Cumene	Methyl acetylene	Vinyl ethers
Decahydronaphthalene	Methyl isobutyl ketone	Other 2° alcohols
Diacetylene	3-methyl-1 butanol	
Dicyclopentadiene	Methyl cyclopentane	

Class C – Chemicals that can autopolymerize as a result of peroxide accumulation.
Suggested Safe Storage Period: If unopened from the manufacturer, up to 12 months or manufacturer expiration date, whichever comes first.

- **After opening, chemicals without inhibitors must be disposed of within 24 hours.**

- After opening, chemicals **with** inhibitors should be discarded or tested for peroxides within **12 months** or manufacturer expiration date, whichever comes first. If not discarded after the suggested safe storage period (either opened or unopened), then you must **test for peroxides every 6 months**.

Acrylic acid	Chlorotrifluoroethylene	Vinyl acetate
Acrylonitrile	Methyl methacrylate	Vinyl acetylene
Butadiene[e]	Stryene	Vinyl chloride
2-butanol	Tetrafluoroethylene[c]	Vinyl pyridine

Class D – Other peroxide forming chemicals that cannot clearly be placed into Classes A-C.

Suggested Safe Storage Period: If unopened from the manufacturer, up to 12 months or manufacturer expiration date, whichever comes first. After opening, chemicals should be discarded or tested for peroxides within **12 months** or manufacturer expiration date, whichever comes first. If not discarded after the suggested safe storage period (either opened or unopened), then you must **test for peroxides every 6 months**.

Acrolein	p-Chlorophenetole	n-Hexyl ether
Allyl ether	Cyclooctene	o.p-Iodophenetole
Allyl ethyl ether	Cyclopropyl methyl ether	Isoamyl benzyl ether
Allyl phenyl ether	Diallyl ether	Isoamyl ether
p-(n-Amyloxy)benzoyl chloride	p-Di-n-butoxybenzene	Isobutyl vinyl ether
n-Amyl ether	1,2-Dibenzyloxyethane	Isophorone
Benzyl n-butyl ether	p-Dibenzyloxybenzene	b-Isopropoxypropionitrile
Benzyl ether	1,2-Dichloroethyl ethyl ether	n-Methylphenetole
Benzyl ethyl ether	2,4-Dichlorophenetole	2-Methyltetrahydrofuran
Benzyl methyl ether	Diethoxymethane	3-Methoxy-1-butyl acetate
Benzyl-1-napthyl ether	2,2-Diethoxypropane	2-Methoxyethanol
1,2-Bis(2-chloroethoxyl)ethane	Diethyl ethoxymethylenemalonate	3-Methoxyethyl acetate
Bis(2-ethoxyethyl)ether	Diethyl fumarate	2-Methoxyethyl vinyl ether
Bis(2-(methoxyethoxy)ethyl) ether	Diethyl acetal	b-Methoxypropionitrile
Bis(2-chloroethyl) ether	Diethylketene	m-Nitrophenetole
Bis(2-ethoxyethyl) adipate	m,o,p-Diethoxybenzene	1-Octene
Bis(2-methoxyethyl) carbonate	1,2-Diethoxyethane	Oxybis(2-ethyl acetate)
Bis(2-methoxyethyl) ether	Dimethoxymethane	Oxybis(2-ethyl benzoate)
Bis(2-methoxyethyl) phthalate	1,1-Dimethoxyethane	b,b-Oxydipropionitrile
Bis(2-methoxymethyl) adipate	Di(1-propynl) ether	1-Pentene
Bis(2-n-butoxyethyl) phthalate	Di(2-propynl) ether	Phenoxyacetyl chloride
Bis(2-phenoxyethyl) ether	Di-n-propoxymethane	a-Phenoxypropionyl chloride
Bis(4-chlorobutyl) ether	1,2-Epoxy-3-isopropoxypropane	Phenyl-o-propyl ether
Bis(chloromethyl) ether	1,2-Epoxy-3-phenoxypropane	p-Phenylphenetone
2-Bromomethyl ethyl ether	p-Ethoxyacetophenone	n-Propyl ether
beta-Bromophenetole	1-(2-Ethoxyethoxy)ethyl acetate	n-Propyl isopropyl ether
o-Bromophenetole	2-Ethoxyethyl acetate	Na 8-11-14-eicosatetraenoate
p-Bromophenetole	(2-Ethoxyethyl)-a-benzoyl benzoate	Sodium ethoxyacetylide
3-Bromopropyl phenyl ether	1-Ethoxynaphthalene	Tetrahydropyran
tert-Butyl methyl ether	o,p-Ethoxyphenyl isocyanate	Triethylene glycol diacetate
n-Butyl phenyl ether	1-Ethoxy-2-propyne	Triethylene glycol dipropionate
n-Butyl vinyl ether	3-Ethoxypropionitrile	1,3,3-Trimethoxypropene
Chloroacetaldehyde diethylacetal	2-Ethylacrylaldehyde oxime	4-Vinyl cyclohexene

2-Chlorobutadiene
1-(2-Chloroethoxy)-2-Phenoxyethane
Chloroethylene
Chloromethyl methyl ether
b-Chlorophenetole
o-Chorophenetole

2-Ethylbutanol
Ethyl-b-ethoxypropionate
2-Ethylhexanal
Ethyl vinyl ether
Furan
2,5-Hexadiyn-1-ol
4,5-Hexadien-2-yn-1-ol

Vinylene carbonate

[a] Store under nitrogen, if practical.
[b] WARNING! May become unstable if concentrated intentionally or accidentally by user.
[c] When stored as an inhibited liquid monomer.
[d] When stored as a liquid monomer.
[e] When stored as a gas.

References

NFPA 400, Chapter 14 Organic Peroxide Formulations and Annex F Typical Organic Peroxide Formulations.
National Research Council, Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards, Updated Version, 2011.
University of California, Guidelines for Explosive and Potentially Explosive Chemicals Safe Storage and Handling.