UNIVERSITY OF TEXAS ARLINGTON | ENVIRONMENTAL HEALTH & SAFETY

LABORATORY SAFETY MANUAL

(Chemical Hygiene Plan)

PREPARED BY

THE UNIVERSITY OF TEXAS AT ARLINGTON

ENVIRONMENTAL HEALTH AND SAFETY

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FOREWORD

The Environmental Health & Safety Office (EH&S) supports the University in its quest to excel in research, teaching, and service. EH&S has prepared this manual to promote safe practices in laboratories. We hope it will provide information to faculty, researchers, and students to assist them in meeting their goals.

We have included information concerning safe practices, the use of personal protective equipment, emergency procedures, use and storage of reagents, and the proper methods of waste disposal. This information is intended to help those in the laboratory minimize the hazards to themselves and their colleagues.

We promote the ideas, information, and necessary resources for our university laboratory personnel to comply with the Texas Hazard Communication Act requirements. These requirements include chemical labeling, employee education, and ease of access to Safety Data Sheets.

Even though the University of Texas at Arlington does not currently fall under the jurisdiction of the Occupational Safety and Health Administration (OSHA), we provide information concerning the Bloodborne Pathogens Standard. Please contact us 817-272-2185 or visit the EH&S website for additional information.

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CHAPTER 1

INTRODUCTION

1.1 ORGANIZATION

The Environmental Health & Safety Office (EH&S) maintains an Environmental and Laboratory Safety section devoted to chemical and biological safety in the laboratory.

1.2 GOALS

The goals of the Environmental section include:

1) To facilitate the University of Texas at Arlington's (UTA) regulatory compliance with all applicable local, state, and federal waste management regulations by properly transporting, storing, and disposing of regulated wastes;

2) To facilitate the operations and waste minimization efforts of the various departments and divisions of the University while striving for regulatory compliance; and

3) To train individuals and inspect work areas where hazardous materials are stored and used.

1.3 KEY RESPONSIBILITIES

All lab personnel (faculty, staff, graduate students, post-docs, undergraduate students, technicians) are responsible for following the University procedures as described in this manual. The following outline summarizes the key responsibilities which are discussed in more detail throughout this manual.

Lab Personnel

- Complete Hazard Communication/RCRA (waste management) training.
- Meet labeling requirements of the Hazard Communication Act.
- Perform self-audit of the lab for health and safety conditions no less than once every six months. (APPENDIX X)
- Contact EH&S if fume hoods, safety showers, or eyewash are not working properly.
- Contact EH&S via the Chemical Environmental Management System (CEMS) to request Chemical Waste Removal when waste has been generated.

Faculty/Principal Investigator

- Ensure that all lab personnel who use or handle hazardous materials/machinery (chemicals, radioactive materials, biohazards, lasers) are trained in accordance with the Hazard Communication Act.
- Provide site-specific training to all lab personnel in accordance with the Hazard Communication Act.
- Ensure that lab personnel properly dispose of or transfer all hazardous materials before leaving the University.

EH&S

- Provide Hazard Communication/RCRA training online.
- Pick up hazardous waste for disposal as needed and when requests are received.
- Inspect all labs annually.
- Inspect labs using infectious agents in accordance with the CDC/NIH Guidelines.
- Test all fume hoods, safety showers, and eyewashes semi-annually.

1.4 FACILITIES

Facilities to which this manual applies include the main campus of The University of Texas at Arlington, the University of Texas at Arlington Research Institute (UTARI), and all of the University's remote sites.

CHAPTER 2
OBJECTIVES

The objectives of the Environmental and Laboratory Safety Section are to:

- Comply with regulatory requirements under its control, including transportation of waste from its users to the EH&S Materials Accumulation Center, storage of wastes, and shipment of wastes for disposal.

- Inspect all fume hoods, safety showers, and eyewashes semi-annually.

- Inspect all areas generating regulated waste for compliance with applicable regulations once each calendar year.

- Inspect all laboratories and other associated areas using hazardous materials (biological and chemical) for safe laboratory practices each year.

- Remove all regulated waste from the site of generation within three working days from the date of receiving a request for disposal via CEMS.

- Make online training available for all new employees working with hazardous materials (biological and chemical) as well as continuous training for all existing employees as needed.

CHAPTER 3
GENERAL SAFETY INFORMATION

3.1 LAB PROTOCOL

Everyone in the lab is responsible for their own safety and for the safety of others. Before starting any work in the lab, become familiar with the procedures, equipment, and reagents used in the lab. If you do not understand something, ask. The following guidelines are recommended for working safely in a lab.

Personal Practices

- Never wear loose clothing, shorts, sandals, flip-flops, clogs, or open-toed shoes in the lab. Do not wear synthetic fabrics, such as polyester, that burn easily. This is *not* a dress code. Rather it is intended to protect you from exposure to hazardous materials by minimizing the amount of exposed skin and lessening the degree of flammability.
- Wear a lab coat or apron, gloves, and eye and face protection at all times.
- Do not wear excessive jewelry that might get caught in equipment, trap reagents against your skin, or react with chemicals.
- Do not wear contact lenses in a lab because chemicals or particulates can get caught behind them and severely damage your eyes.
- Confine long hair.
- Do not allow children or pets in laboratories.
- Never pipette anything by mouth.
- Eating, drinking, handling contact lenses, applying cosmetics, and storing of food for human consumption is not permitted in University laboratory work areas. Remember, smoking is not allowed in any University building.
- Do not store food and drinks within the laboratory, this includes refrigerators.
- Do not wear lab coats, gloves, or other personal protective clothing out of the lab and into non-lab areas. This clothing may have become contaminated and you could spread the contamination.
- Wash your hands frequently throughout the day and before leaving the lab.
- Never work alone in a lab if it is avoidable. If you must work alone, make someone aware of your location and have them call or check on you periodically. This is also for your personal safety.

Housekeeping

- Clean your work areas throughout the day and before you leave.

- If necessary, clean equipment after use to avoid the possibility of contaminating the next person who needs to use it.
- Keep all aisles and walkways in the lab clear to provide a safe walking surface.

3.2 RECOMMENDED LAB TECHNIQUES

This section deals with techniques, equipment, and procedures commonly found within a laboratory. It is beyond the scope of this manual to describe all techniques and equipment that may be used in a particular lab. Your faculty member/principal investigator is responsible for site-specific training on these issues. For more information on this topic, see Reference 1.

Glassware

- Inspect all glassware before use. Discard any broken, cracked, or chipped glassware in a broken glassware box. These are available in the Chemistry Stockroom.
- Use vacuum-resistant reinforced plastic ware whenever possible. If you must use glass, tape or shield glass vacuum vessels to prevent flying glass in the case of an implosion.
- Do not use household Thermos bottles as substitutes for laboratory Dewar flasks; the walls are too thin.
- Always use secondary containment. Transport all glass chemical containers in rubber or polyethylene bottle carriers. Utilize a cart or make more than one trip if necessary
- Fire-polish all cut glass tubing and rods before use.

Practice the following when inserting glass tubes or rods into stoppers:

- The diameter of the tube must be compatible with the diameter of the stopper.
- Fire-polish the end of the glass tube.
- Lubricate the glass with water or glycerol.
- Wear heavy gloves and hold the glass not more than two inches from the end to be inserted.
- Insert the glass carefully with a twisting motion.
- Remove stuck tubes by slitting the stopper with a sharp knife.

Assembling Apparatus

- Keep work surfaces as uncluttered as possible.
- Only use equipment that is free from cracks, chips, and other defects.
- Set up a clean, dry apparatus, firmly clamped and back away from the edge of the lab bench.
- If possible, place a pan under a reaction vessel or other container to contain liquid if the glassware breaks.

- Do not allow burners or any other ignition sources nearby when working with flammable liquids.
- Lubricate glass stopcocks. Do not lubricate Teflon® stopcocks.
- Properly support and secure condensers and water hoses with clamps and wires. Be sure to direct the water hoses so that any drips that may come off the hoses do not splash down onto any electrical wires or the floor.
- Position an apparatus attached to a ring stand with the center of gravity over the base and not to one side.
- Assemble apparatus so that burners or baths can be removed quickly.
- Use an appropriate vapor trap and confine the setup to a fume hood if there is a possibility of producing hazardous vapors.
- Put the setup in a fume hood when conducting a reaction that could result in an implosion or explosion. Raise the sash no more than 18 inches above the counter. If it is not possible to use a fume hood, use a standing shield that is stabilized and secured.

Centrifuges

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

Ultraviolet Lamps

- Wear ultraviolet-absorbing protective safety glasses while working with ultraviolet light. Your ordinary eyeglasses and sunglasses are not designed to protect you from these intense UV rays.
- Wear a lab coat or long sleeves to protect your skin from potential burns.
- Shield any experiment in which ultraviolet light is used in order to prevent escape of the direct beam or scattered radiation.

Separatory Funnels

- Use extreme caution if the temperature of the materials is elevated.
- When you use a volatile solvent, swirl the unstopped separatory funnel first to allow some solvent to vaporize and to release pressure.

- Close the funnel and invert it with the stopper held in place, then immediately open the stopcock to release pressure.
- Do not vent the separatory funnel near a flame or any other ignition source and do not point it at a co-worker or equipment. It is best to vent the separatory funnel into a fume hood.
- Close the stopcock, swirl the funnel, then immediately open the stopcock with the funnel in an inverted position to vent the vapor again.

Cooling Baths and Cold Traps

- Always use caution when working with cryogenic coolants. Refer to the cryogenic materials section of this manual for additional details.
- Use temperature-resistant gloves and a face shield while slowly immersing an object to be cooled.
- Do not pour cold liquid onto the edge of a glass Dewar flask when filling because the flask may break and implode.
- Never lower your head into a Dry Ice chest; no oxygen is present.
- Wear temperature-resistant gloves while handling dry ice to prevent severe burns.

Vacuum Pumps

- If at all possible, vent vacuum pump exhaust into a fume hood.
- Guard all belt-driven vacuum pumps to prevent hands or loose clothing from getting caught in the belt pulley.
- Place a trap between the vacuum pump and the apparatus.
- Lubricate the pump regularly if possible. Check belt conditions and do not operate in a fume hood cabinet that is used for storage of flammables.

Odors in the Lab

- At least once a month, pour one liter of water into all floor drains and sinks in the lab, including cup sinks on lab benches and in fume hoods. If the traps are allowed to dry out, odors present in the sanitary sewer system will vent into the lab.

Electrical

- Examine all electrical cords periodically for signs of wear and damage. If you discover damaged electrical cords, unplug the equipment and send it off for repair. The OSHA electrical standards does not allow the use of electrical tape to make the repair of the jacket of a worn or frayed flexible cord.
- Properly ground all equipment.
- If you notice sparks while plugging or unplugging equipment or if the cord feels hot, do not use the equipment until an electrician can service it.

- Do not run electrical cords along the floor where they will be a tripping hazard and be subject to wear. If you must run a cord along the floor temporarily, protect it with a cord cover.
- Do not run electrical cords above the ceiling. The cord must be visible at all times to ensure it is in good condition.
- Do not plug too many items into a single outlet. Do not use cords that enable you to plug more than one item in at a time. You may use multi-plug strips if they are protected with a circuit breaker as long as you do not use them in series. In addition, do not use them for major pieces of equipment; plug these directly into a wall socket.
- Do not use extension cords for permanent wiring. If you must use extension cords throughout the lab, then it is time to have additional outlets installed.

Reference

1) Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards. National Academies Press, 2011.

CHAPTER 4
EMERGENCY PROCEDURES AND EQUIPMENT

All accidents, hazardous materials spills or other dangerous incidents must be reported to EH&S.

EH&S posts warning signs outside every laboratory, this sign has the telephone numbers of the Principal Investigator (PI), UTA Police Department (817-272-3003), and EH&S (817-272-2185). Callers should explain the situation clearly, calmly, and in detail.

The first step in responding to an emergency is to prepare for it in advance. In planning, be sure to consider the magnitude of all possible occurrences that can create or complicate an emergency, such as the following:

- What are potential spill locations? Can you consolidate any materials or move them to safer areas?
- What materials might be spilled? Are any incompatible with each other?
- What quantities may be involved in a spill? Are more materials being stored in the laboratory than you actually need?
- What are the materials' hazardous properties?
- What personal safety equipment might you need? Is it available? Are personnel trained to use it properly? Is appropriate equipment available for all possible needs?
- Since each laboratory is unique in its use of hazardous materials and physical surroundings, use the emergency procedures listed below but adapt them to your particular needs. The best plan becomes useless if specific basic safety equipment and supplies are not readily available when needed. Do not keep equipment for unlikely contingencies in laboratories because you can call emergency responders in these cases. Train personnel on whom to call if they do occur. Make trial runs once procedures and equipment become available.
- It is the responsibility of uninjured coworkers nearest an accident to take immediate action. Trained personnel or an emergency team can continue procedures after the initial action by personnel in the vicinity.
- You should assemble supplies and equipment and keep them on hand to deal with any potential spills. The extent to which spill equipment is available depends on the chemicals, the process, and the personnel working in the laboratory.
- You can obtain chemical spill control kits from EH&S by submitting a quest through the CEMS webpage.

Several Problems Can Complicate an Emergency:

- Failure of personnel to respond promptly to the emergency.

- Failure of personnel to recognize the need to summon additional help.
- Inadequately trained personnel taking the wrong actions in response to an emergency.
- Personnel lacking information pertinent to the nature of the emergency that would substantially change the proper response to the emergency.
- Personnel endangering themselves while attempting to rescue others.

4.1 PRIMARY EMERGENCY PROCEDURES FOR GENERAL SPILLS

Spill Equipment

- Supplies for cleaning up a minor chemical or biological spill should be readily available.
- Supplies for a chemical spill include an inert absorbent such as kitty litter or vermiculite, a plastic (non-sparking) scoop, plastic bags to contain the material, chemical-resistant gloves, goggles, sodium bicarbonate to neutralize acids, and citric acid to neutralize bases.
- Supplies for a biological spill also include paper towels and a fresh 1:10 bleach solution.

Procedure

- Attend to any person(s) who may have been contaminated and/or injured if it is safe to reach them. Use safety showers and eyewashes as appropriate. Call the UTA Police Department at 817-272-3003 for assistance with injuries, fire, or for performing rescues. Give the nature and the extent of the emergency; be as specific and detailed as possible. Emergency assistance will respond to your request.
- Notify persons in the immediate area about the spill, evacuating all non-essential personnel from the spill area and adjoining areas that may be impacted by chemical vapor or a fire (even if not started yet).
- If the spilled material is flammable, turn off all potential ignition sources.
- Notify EH&S (817-272-2185).
- Avoid breathing vapors of the spilled materials. Be aware that some materials either have no odors or anesthetize your nose so that you stop smelling the odor very quickly.
- Leave on or establish exhaust ventilation if it is safe to do so. Close doors to slow down the spread of odors.
- Use a spill control kit appropriate for material spilled.
- During cleanup, wear appropriate protective apparel.
- Cover liquid spills with compatible absorbent material such as spill pillows or a kitty litter/ vermiculite mix. Be sure to check compatibility. Powdered materials should be covered with wet paper towels (if compatible) to avoid dispersal. If appropriate

materials are available, neutralize corrosives prior to absorption. Clean spills from the outer areas first, then move towards the center.

- Place the spilled material into an impervious container, seal, and contact EH&S for disposal.
- Wash the affected surface with soap and water. Mop up the residues and containerize for disposal.
- A solvent such as ethanol may be necessary to clean surfaces contaminated with a water-insoluble chemical. Be sure to check the solubility of the spilled material and use the least dangerous effective solvent available. Be sure to wear appropriate protective equipment.
- Do not forget to notify your PI.

4.2 SPECIAL PROCEDURES FOR RADIOACTIVE HAZARD SPILLS

- Attend to any person(s) who may have been contaminated and/or injured if it is safe to reach them. Use safety showers and eyewashes as appropriate.
- Notify EH&S Radiation Safety Section 817-272-2185.
- Call the UTA Police Department at 817-272-3003 for assistance with injuries, fires, or rescues. Give the nature and the extent of the emergency; be as specific and detailed as possible. Emergency assistance will respond upon your request.
- Be sure to notify your PI.
- All personnel should immediately move away from spill area to a safe meeting location in the laboratory. Unless it is not safe to stay in the laboratory do not leave. This could track radioactive material throughout the building.
- Shut off ventilation, close windows and doors, turn off hoods if possible.
- Under the direction of the EH&S Radiation Safety section, check all personnel for skin and clothing contamination before leaving the laboratory.
- The EH&S Radiation Safety section will supervise any decontamination of personnel and spill area.
- Also refer to the UTA Radiation Safety manual.

4.3 **SPECIAL PROCEDURES FOR BIOHAZARD SPILLS**

If there is an emergency or if anyone is in danger, immediately call the UTA Police Department, 817-272-3003, for assistance. Give the nature and the extent of the emergency; be as specific and detailed as possible. Emergency personnel will be dispatched to help you. If, however, there is no immediate threat to health, you should use your best judgment to decide whether to call for help or to address the matter yourself. The guidelines below are intended to help you decide.

Prioritize your actions to deal with the spill:

- Call UTA Police dispatch at 817- 272-3003 for help if there is an emergency.
- Notify EH&S, 817-272-2185, and your PI.
- Determine exactly what has been spilled. Mostly you will only need to deal with one type of dangerous material at a time.

Biohazardous materials must first enter the body through a specific exposure route. Once in the body the host's immune response determines whether infection will occur. Knowing the identity of the infectious agent and the route of exposure is essential in being able to clean up spilled biohazardous materials safely.

However, if the spilled material contains a mixture of chemical, biological, and radioactive materials, consider the threats separately and address them in the following order.

- Chemical hazards. Many chemicals can cause immediate injury and you should address these first.
- Biological hazards - address these second.
- Radioactive hazards. Radioactive materials can spread very easily, and can be difficult to clean up. Time of exposure and distance from the material are key factors in determining a dose; the shorter the exposure time and the further away from it you are, the smaller the dose. Address these as soon as possible. Refer to the UTA Radiation Safety Manual.

Take the appropriate steps to deal with the spill. Each PI should be responsible for developing spill clean-up procedures that are appropriate for the materials used in that laboratory. Having a carefully planned biological hazards spill kit stored in a suitable place and updated regularly will make accident cleanup easier and also give a peace of mind in the laboratory. Anyone working with biohazardous materials must receive training in spill cleanup appropriate for materials routinely used. (Look below for items suggested for a biological hazards spill kit.) You should follow the following procedures to deal with a spill of biohazardous materials, either outside or inside a biological safety cabinet.

Biohazard Spills Outside a Biological Safety Cabinet

- Holding your breath, leave the room immediately and close the door(s).
- Notify persons in the immediate area about the spill. Warn others not to enter the contaminated area.
- In a different location, remove contaminated clothing and place it in a biohazard bag or properly-labeled container for autoclaving.
- In a different location, if you suspect that your shoes have been contaminated, remove them and place in a separate biohazard bag for decontamination.
- In a different location, thoroughly wash your hands, face, and any other exposed areas of the body. If the spilled material has soaked through laboratory clothing, take a complete body shower. Use safety showers and eyewashes as appropriate.

- If the spill involves potential exposure to bloodborne pathogens, follow UTA's bloodborne pathogen policy (Exposure Control Plan for Bloodborne Pathogens) for managing and reporting these exposures.
- Wait at least 30 minutes to allow aerosols to settle before entering the contaminated area.
- Put on protective clothing and equipment (laboratory coat/gown, gloves, masks, eye protection, and face shield) after assembling the needed cleanup materials and before re-entering the room. If your gloves are not puncture-resistant, be especially careful if the spill involves broken glass or other sharps.
- Apply appropriate disinfectant for the agent involved in the spill with a gentle flooding action to avoid secondary aerosols.
- Cover excess liquids with absorbent material, such as paper towels soaked with the decontaminant.
- Allow an adequate contact time for disinfectant to work.
- Use disinfectant solution to wipe over surrounding areas that are likely to have been contaminated with aerosols and splashes.
- Decontaminate boots, discard the gloves and masks/shields and either discard or decontaminate clothing (lab coat/gown) used during the cleanup.
- Place all contaminated spill cleanup materials (paper towels, glass, liquid, gloves, etc.) into an autoclavable bag/container and autoclave it according to standard directions, or call EH&S for disposal.
- Wash your hands thoroughly.

Spills outside the Laboratory (During Transport)
If a biohazardous agent spills during transport outside the laboratory, the main difference from the first procedure is to initiate the cleanup **immediately**. You can follow the procedures stated above for Biohazard Spills outside a Biological Safety Cabinet.

Biohazard Spills Inside a Biological Safety Cabinet
In order to prevent escape of contaminants from the cabinet while the cabinet continues to operate, initiate decontamination procedures at once.

- Spray or wipe walls, work surfaces, and equipment within the cabinet with a solution of an appropriate decontaminant for the agent involved. If your gloves are not puncture-resistant, be especially careful if the spill involves broken glass or other sharps. You can also use mechanical means such as tongs, forceps, or small disposable scoops.
- Flood the top work surface tray and, if it is a Class II biological safety cabinet, the drain pans and catch basins below the work surface with the decontaminant and allow to stand for 10-15 minutes. Extend the contact time to 30 minutes for large spills or spills containing large amounts of proteinaceous materials.

- Remove excess decontaminant from the tray by wiping with a sponge or cloth soaked in decontaminant. For Class II biological safety cabinets, drain the tray into the catch basin below the work surface. Lift out the tray and removable front intake grille and wipe off top and bottom (underside) surfaces with a sponge or cloth soaked in a decontaminant.
- Replace the grille and drain decontaminant from the cabinet base into an appropriate container and autoclave according to standard procedures. Be sure to place gloves, cloths, and/or sponges into an autoclavable container to be autoclaved.
- If the spill in the cabinet is quite substantial, it may be necessary to decontaminate the cabinet's fans, filters, and airflow plenums. An outside company must do this. Call EH&S (817-272-2185) for assistance.
- Notify your PI.

Biohazard Spills in a Centrifuge

When a spill or leak has occurred within a centrifuge, the procedure for cleanup depends upon the risk group of the sample involved as well as the construction of the equipment.

- Centrifuges with sealed rotors or buckets that are able to be autoclaved should be steam-sterilized intact at 121°C for an appropriate time.
- For centrifuges with non-sealed rotors and centrifuges not able to be autoclaved, allow 30 minutes for aerosols to settle first.
- Place the rotor or bucket in an appropriate non-corrosive disinfectant solution. Keep in mind that bleach will corrode stainless steel if left in contact with it for 30 minutes or more.
- After disinfection, remove larger pieces of broken glass/sharps using forceps and place in a biohazards sharps container. Carefully wipe the internal surfaces of the centrifuge bowl with disinfectant.

Biological Hazards Spill Kit

A well-designed biological hazards spill kit is highly recommended. The following items would be excellent choices for a kit:

- "DO NOT ENTER" sign to be posted on the laboratory door.
- An appropriate chemical decontaminant(s). In most cases 10% household bleach solution is a good choice, but keep in mind that bleach will corrode stainless steel if left in contact with it for 30 minutes or more. Whenever you use bleach to clean up spills of an infectious agent, prepare a fresh solution. After about one week, a bleach and water solution will lose its effectiveness for decontamination.
- For human blood and body fluids, iodophors or 70% alcohol is appropriate.
- Materials to absorb liquids after decontamination. This could include paper towels, absorbent laboratory pads, or special materials designed to absorb large volumes of liquid. Keep in mind the volumes of liquid typically used in the laboratory area when selecting an absorbent.

- Appropriate personal protective equipment to wear during cleanup. Gloves and a long-sleeved laboratory coat or gown are always necessary. Consider facial protection for large spills.
- A mechanical means for handling broken glass. Broken glass represents a high cutting danger. Do not touch it directly, especially if it is contaminated with a biohazardous agent. Mechanical means could include tongs, forceps, small disposable scoops and sponges, autoclavable dustpans, or any other method that prevents direct contact with the broken glass.
- Biohazard bags, sharps containers, and/or other containers to place the material in for further treatment and disposal.

4.4 **BUILDING EVACUATION PROCEDURES**

Building evacuation may be necessary if there is a chemical release, fire, explosion, natural disaster, or medical emergency.

- Be aware of the marked exits from your area and always know two ways out of the building. The way you came in may not be the best way out.
- The evacuation alarm is a recorded evacuation message. The fire alarm is also a notice to evacuate without a recorded message.
- To activate the building fire alarm system, pull the handle on one of the red boxes located by an exterior exit. If there is a fire, call UTA police at 817-272-3003 from a campus phone outside the alarm building or from a cell phone; or dial 911, give your name, and describe the location and size of the fire.
- *Whenever* the building evacuation alarm is sounded or when you are ordered to leave by the campus police, EH&S, or emergency response personnel, *walk quickly to the nearest marked exit* and ask others to do the same.
- Once outside, proceed to a clear area that is at least 150 feet from the affected building. Keep walkways clear for emergency vehicles. *Your laboratory should already have a designated meeting place.*
- To the best of your ability and without reentering the building, be available to assist EH&S and campus police in their attempts to determine that everyone has been evacuated safely.
- An Emergency Command Post will be set up near the emergency site by the emergency responders. Keep clear of the Post unless you have important information to report.
- Do not return to the building until campus police or EH&S tell you it is safe to do so.

4.5 EMERGENCY EQUIPMENT

Know the location of your emergency shower, eyewash, and fire extinguisher! In the event of an emergency, you do not want to waste time searching for them. Also, eye injuries may require that you find the emergency equipment without being able to see. In addition, it is a good practice to mark the location of all emergency equipment with a prominent sign.

Safety Showers

- To ensure a clean supply of water in the safety shower, if possible flush it weekly for 5 minutes to remove any rust or sediment that may have accumulated. Catch the water in a bucket and discard down the sink.
- Use an emergency shower to decontaminate a person who has been exposed to hazardous chemicals and to suppress a fire.
- Remove all clothing, jewelry, and shoes while standing under the shower. If you do not remove these items, they will hold the chemicals against your skin and increase the damage. Use a fire blanket as a modesty curtain for the person disrobing. Everyone can leave the laboratory while you shower.
- Remain under the shower for at least 15 minutes, and then seek medical attention.
- Always keep the area under an emergency shower (and eyewash) unobstructed. You do not want to waste time moving boxes, trash, tables, or other items. Electrical equipment in the area can present an electrocution hazard.
- Do not tie or secure the handle or ring of the shower if it will interfere with the operation of the shower.

Note: Be cautious, wet floors are slippery!

Eyewashes

Continuous flow eyewashes are preferred over the portable type. The portable eyewashes have several disadvantages: insufficient supply of water, they readily become contaminated with microorganisms, and they require the use of your hands, which prevents you from holding your eyelids open.

- To ensure a clean supply of water in the eyewash, if possible operate the eyewash weekly for 5 minutes to flush any rust or sediment that may have accumulated.
- Never hesitate to flush your eyes immediately if chemicals are splashed in them. Even a delay of a few seconds could cause permanent damage.
- You should not be wearing contact lenses, but if you are, remove them immediately. Materials could be trapped under the contacts on the surface of your eyes.
- If chemicals are splashed into your eyes, hold the eyelids open and flush with water continuously for at least 15 minutes.
- Move the eye up and down and sideways to wash thoroughly behind the eyeball where chemicals could be trapped.
- Seek medical attention.
- Notify your PI.

Note: EH&S inspects and tests emergency showers and eyewash fountains semi-annually. If these items are not operating properly, contact EH&S at 817-272-2185.

Fire Extinguishers

- Laboratories will be equipped with an ABC dry chemical powder fire extinguisher. Use the ABC extinguisher on a paper, chemical, or electrical fire. Never use a water fire extinguisher on an electrical fire.
- Only use a Class D combustible metal fire extinguisher on a metal (magnesium, sodium, potassium, etc.) fire. There are also commercially-available materials that can be applied to a burning metal fire. Class D extinguishers are yellow in color and located in the corridors outside the laboratories in buildings with combustible metals.
- Attempt to extinguish small fires yourself only if you have been trained and can safely do so. Always fight the fire from a position that allows an escape route behind you. Always activate the building fire alarm before attempting to extinguish a fire.
- To use a fire extinguisher, follow these four steps. The mnemonic is P.A.S.S.:

  -Pull the pin.
  -Aim the extinguisher nozzle at the base of the fire.
  -Squeeze the handle to release the extinguishing agent.
  -Sweep the nozzle from side to side at the base of the fire starting at the front and working to the rear until it goes out.
- If you cannot extinguish the fire in approximately 30 seconds, evacuate the area, closing the door as you leave.
- If a fire extinguisher is used, is vandalized, or for any other reason is in need of service, call the EH&S Fire section at 817-272-2185 for immediate replacement.
- For training in fire prevention, evacuation, reporting, hands-on fire extinguisher use, and determining fire extinguisher needs in your work area, call the EH&S Fire section at 817-272-2185.

- Notify your PI of any lab fires.

CHAPTER 5
HAZARD COMMUNICATION ACT

The 69th Legislature of the State of Texas in 1985 enacted the Texas Hazard Communication Act. The law became effective January 1, 1986, and was most recently revised in 1993 and amended in 2003. The purpose of this law is to inform workers and the general public about chemical hazards in the workplace and in the community. The Act requires public employers to provide their employees with information and training on hazardous chemicals to which they may be exposed to at work. UTA also has a Hazard Communication Manual for additional guidance.

5.1 REQUIREMENTS

Training:

New employees must complete the online Hazard Communication/Resource Conservation and Recovery Act (RCRA) training after they are hired and prior to working with or being exposed to chemicals. This training must cover the specific hazards in their work area.

- Employees must be retrained when new chemical hazards are introduced in their workplace or when new information is shown on updated Safety Data Sheets (SDS).
- Employees must be retrained when they are assigned to different workplaces that involve new chemical hazards.

In addition to the Hazard Communication/RCRA training, all employees must complete Site-Specific training for their individual workplaces. Site-Specific training must cover the unique hazards (chemical, biological, radiological) with which the employee works.

Labels:

A primary container is the one in which the hazardous chemical is received from the supplier. A supervisor, who receives an unlabeled or mislabeled hazardous chemical container from a supplier or from another laboratory or shop, which requires relabeling, shall ensure that prior to use by any employee such containers are relabeled with, at minimum:

- common chemical name as it appears on the SDS (in English),
- physical and health hazards, including the organs that would be affected,
- manufacturer's name and address

A secondary container is one into which the hazardous chemical is transferred after receipt from the supplier. Secondary containers must be labeled with at least the name of the hazardous chemical appearing on the SDS and the pertinent physical and health hazards, including the organs that would be affected. Laboratory chemicals that are common in the laboratory and which everyone in the laboratory knows the hazardous effects may be labeled with the

common English name from the SDS, however chemical formulas and abbreviations will not be acceptable.

Secondary containers must be constructed of materials that are compatible with their contents. Containers that previously contained consumable items, such as beverages, or which are intended as food containers, such as glasses or cups, must not ever be used as secondary containers for hazardous chemicals.

> **Exception: An employee who transfers the contents from a primary container into a secondary container for immediate use is not required to label the secondary container.**

All **secondary containers** of hazardous chemicals are clearly labeled to include:

a. The identity of the chemical as it appears on the SDS,

b. The appropriate hazard warnings.

UTA Lab Safety Evaluation requirement: Secondary containers, other than ones for immediate use, are labeled with the identity of their contents and the hazards associated with their contents.

Informational: The Hazard Communication Standard requires that labels for secondary containers must contain two key pieces of information: the identity of the hazardous chemical(s) in the container (e.g., chemical name as it appears on Safety Data Sheet) and the hazards present (see Labeling Secondary Containers pictograms poster). No abbreviations or chemical formulas unless listed on a posted cross reference sheet (see Labeling Secondary Containers pictograms poster).

An example of an acceptable Secondary container label:

HEXANE CAS NO. 110-54-3	
Physical Hazard:	Flammable or pictogram 
Health Hazard:	Irritant or pictogram  Consult Safety Data Sheet Before Using

Pictograms:

The Hazard Communication Standard (HCS) requires pictograms on labels to alert users of the chemical hazards to which they may be exposed. Each pictogram consists of a symbol on a white background framed within a red border and represents a distinct hazard(s). The pictogram on the label is determined by the chemical hazard classification.

HCS Pictograms and Hazards

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

Safety Data Sheets (SDS):

SDS provide information on a specific reagent or mixture and must be readily available for all the hazardous chemicals in the lab. SDS are available in specific departments and at EH&S as described in the next section. (See APPENDIX I for an example of an SDS.)

Posters:

Employee notification posters (UTA Hazardous Waste Satellite Accumulation Area posters) must be displayed in the workplace and should be covered in training. These posters must be kept current.

Employee Notification posters must also be posted whenever chemical hazards are present. These posters are available through EH&S.

5.2 SAFETY DATA SHEETS (SDS)

Because SDS are so important, they will be discussed in further detail. SDS are a critical component of the United States Occupational Safety and Health Administration's (OSHA) Hazard Communication Standard. This standard mandates that workers have a right to know what hazards are associated with the chemicals they use in the workplace. Both manufacturers of chemicals and employers with chemicals in their workplace must comply with this regulation.

EH&S maintains a master file (electronic copies) and can provide SDS to University personnel who need them. OSHA's Hazard Communication Standard (HCS) specifies certain information that must be included on SDS, but does not require that any particular format be followed in presenting this information.

The OSHA SDS format has the following required categories that must be on every SDS:

Section I.	Manufacturer's name and contact information
Section II.	Hazardous ingredients/identity information
Section III.	Physical/Chemical characteristics
Section IV.	Fire and explosion hazard data
Section V.	Reactivity data
Section VI.	Health hazard data
Section VII.	Precautions for safe handling and use
Section VIII.	Control measures

In order to promote consistent presentation of information, OSHA recommends that SDS follow the 16-section format established by the American National Standards Institute (ANSI).

The 16 sections of an SDS that are prescribed by the ANSI standard are as follows:

<u>Section 1 - Chemical product and company information</u>

- The name, address, and phone number of the company that makes the chemical
- The chemical name and any synonyms
- The Chemical Abstracts Service (CAS) number

<u>Section 2 – Composition and information on ingredients</u>

The product's individual hazardous chemicals and their relative percentages are listed. Many products contain mixtures of chemicals. All ingredients that meet OSHA Hazard Communication standard criteria of a hazardous chemical must be identified here.

The manufacturer has several options as to how the ingredients may be listed. The active ingredients regulated under federal, state, or local regulations must be listed. The nonhazardous ingredients may or may not be included. Some complex mixtures recognized as a single substance may be listed as a single component.

"Trade secrets" are protected and may be listed as such instead of identifying each component. Suppliers of these "trade secret" substances must still provide health hazard data on the SDS and additional information to safety professionals who have a documentable need to know.

This section should include the material's exposure limits if they are known. Several organizations recognized by OSHA have developed exposure limits for a variety of hazardous substances. It is worth noting that the combination of exposures to more than one hazardous chemical is far greater than exposure to individual hazardous chemicals. Exposure to certain hazardous materials may be acceptable, but only for periods of time not to exceed certain time limits and at concentration no greater than certain levels. This section lists these values so the employee handling the hazardous materials knows what precautions (protective equipment, ventilation, etc.) should be taken so as not to exceed these exposure limits. The employee can refer to later sections in the SDS that describe measures that can help reduce possible exposure.

Section 3 - Hazards Identification

This section includes routes of entry, target organs, potential short-term (acute) health effects, long-term (chronic) health effects, and medical conditions that may be exacerbated by exposure. Potential acute health effects include the symptoms of short-term exposure. Potential chronic health effects includes carcinogenic (cancer-causing) effects, mutagenic (mutation inducing) effects, teratogenic (birth defect-causing) effects, and developmental (prenatal or postnatal to the time of sexual maturity) toxicity.

Section 4 - First Aid Measures

If accidental exposure were to occur, then this section is valuable to determine the immediate first aid response. This section should indicate the proper first aid treatment for accidental exposure by inhalation, skin, eye, and ingestion. On almost every SDS the first statement says, "Call a Physician." In most cases, skin and eye exposure are standard, i.e., "immediately flush eyes or skin with plenty of water for at least 15 minutes." Inhalation is usually standard also, "remove to fresh air, if not breathing, give artificial respiration, if breathing is difficult, give oxygen."

The first aid response to ingestion does vary. One would believe that inducing vomiting would be the standard response. However, in many cases, this would result in greater respiratory damage than the damage by ingestion. An antidote may often be listed which can be administered by a layperson or a trained medical personnel.

Section 5 - Fire and Explosion Data

This section of the SDS describes the basic fire-fighting measures. This should include the fire and explosive properties of the material and the proper extinguishing materials. The precautions and safety procedures to put out a fire effectively are described here. This is important because knowing the flammable properties along with the chemical and physical properties provide a good indication of how dangerous the material is in a fire situation. Important flammable properties listed here should include:

- Flash point -- the lowest temperature at which a flammable liquid gives off enough vapor to form an ignitable mixture with air. In other words, the lowest temperature

at which a liquid can ignite if a spark is present. Liquids with very low flash points are dangerous fire hazards.

- Auto ignition temperature -- the temperature at which the liquid will set itself on fire without a flame or spark.
- Lower explosive limit (LEL) -- the minimum concentration of a flammable gas or vapor (% by volume in air) in which an explosion can occur if a flame or spark is present.
- Upper explosive limit (UEL) -- the maximum concentration of a flammable gas or vapor (% by volume in air) in which an explosion can occur if a flame or spark is present.
- Hazardous products of combustion -- In most fires, the greatest danger to human life is not the heat of the flames, but the toxic smoke that can fill the area. All the anticipated products of combustion are listed here. Laboratory fires are far more dangerous than common fires because the toxic fumes are often far more dangerous.

All SDS describe the fire extinguishing media in this section. Selecting the appropriate fire extinguisher is critical in an emergency situation.

Section 6 - Accidental Release Measures

When a hazardous material is accidentally spilled, the emergency can be minimized if proper response is immediate. Therefore, reviewing this section before using a chemical will prepare you in the event of a hazardous spill. This section describes evacuation procedures, containment and cleanup techniques, and other emergency advice like personal protective equipment and respirators.

Information from this section will allow you to plan for emergency responses, training of individuals using the hazardous material, and making available in the laboratory necessary equipment to quickly contain and clean up a spill or leak.

If the spill is small, the advice in this section can be very useful. However, if the spill is large, evacuate the area and call the UTA Police dispatch at 817-272-3003 and EH&S at 817-272-2185. Make sure that the doors of the affected area are closed and post people at them to prevent anyone from entering. Also be prepared to describe to the EH&S personnel the substance spilled and the extent of the spill.

Section 7 - Handling and Storage

General handling precautions and practices are described to prevent release into the environment and overexposure during contact with the material. In addition, this information will help you minimize continued contact after handling. For example, wash hands with soap and water after handling, especially before eating.

The storage of chemical reagents varies depending on the chemical's reactivity and flammability. The necessary storage conditions to avoid damage to containers, contact with incompatible materials and resulting dangerous reactions, evaporation, decomposition, and flammable and explosive atmospheres in the storage area are detailed in this section. For example, protect against sunlight, refrigerate, keep container tightly closed, and store separate from oxidizing materials.

Section 8 - Exposure Controls/Personal Protection

The intent of this section is to reduce exposure of the laboratory worker to the hazardous chemical. Exposure controls include engineering controls like fume hoods, ventilation, and glove boxes. Exposure controls also include administration controls such as training, labeling and warning devices.

This section provides the important information about personal protective equipment (PPE). Some examples of PPE are respirators, safety goggles, gloves, aprons, and boots. The PPE recommendations include both normal use and emergency response during a fire, spill, leak, or accidental release. The description of the PPE often includes details about what materials the PPE should be made of or the best type of respirator for vapor of the hazardous chemical.

Sometimes exposure limits like the OSHA PELs are listed here rather than in section 2. This information is important because there are many types of PPE available and the employer should have available the PPE that will provide the best protection for their employees.

To maintain a safe exposure level, the engineering controls are extremely important. If a laboratory has poor ventilation, then the exposure limits can be exceeded if the chemical is used repeatedly throughout the day. If the fume hood is cluttered with unnecessary items, the hood will not pull the vapors away properly. Do not store reagents or equipment in the fume hoods.

Section 9 - Physical/Chemical Characteristics

The information in this section may appear very scientific, but it is actually very basic. It tells you what conditions will change the chemical's form, thereby affecting the type and degree of the chemical's hazard; for example, boiling point, melting point, vapor pressure, vapor density, evaporation rate, solubility in water, and specific gravity.

Section 10 - Stability and Reactivity Data

This section contains information about what could happen if the chemical is mixed with air, water, or other chemicals. It explains what conditions and chemicals to avoid.

Section 11 - Toxicological Information

Information concerning the hazardous chemical's toxicity is listed in this section. However, this information can be listed in other sections of the SDS like the Health Hazard and First Aid section. This information reflects animal testing, and if known, human data if accidental human poisoning occurred and the amounts of exposure are known. This toxicity data is mainly intended for medical professionals, occupational health and safety professionals, and toxicologists.

The data may include acute, subchronic and chronic exposures through various routes:

- inhalation (inhal)
- ingestion (oral)
- intraperitoneal (ipr)
- subcutaneous (scu).

LD50, the dose that kills 50% of lab animals, is expressed in milligrams per kilogram and is used to represent oral, ipr, and scu exposures. LC50 is the concentration in air of a substance that kills 50% of lab animals and is used to express inhalation exposures. In addition, LDLo (LDL) and LCLo are sometimes listed and these values depict the lowest dose or concentration known to have caused death in a lab animal. The lab animals can include rats, mice, rabbit, and guinea pigs.

Section 12 - Ecological Information

Not all SDS have this section. If it does, this helps the environmental professional or hazmat personnel in evaluating the effect a chemical may have if it is released into the environment. The person using the chemical may use this information to determine waste treatment practices.

Ecotoxicity data may have information on acute and chronic toxicity to fish, invertebrates, plants, microorganisms, and toxicity to animals drinking water contaminated with the chemical. Chemical behavior in air, soil, and water may include persistence and degradation, soil mobility, bioaccumulation, and photolytic stability. All of this is important in evaluating the environmental impact of a chemical in the event of major spill or determining whether a chemical can be safely disposed of in a landfill.

Section 13-Disposal Considerations

The person responsible for waste management activities on campus will certainly find this section important so the University can stay within the law when removing the chemical from the premises. However, the lab worker using the reagent should also be aware of disposal aspects of the chemical so he/she does not inadvertently dispose of the waste improperly.

This section usually contains information on special disposal methods and waste management's options like recycling. Also included are limitations directed by federal, state, or local governments.

Note: These are methods recommended by the chemical manufacturer and are not necessarily in compliance with federal, state, or local regulations. RCRA training becomes important for waste disposal procedures, please refer to the Chemical Waste section of this manual, or contact the EH&S Hazardous Material Section at 817-272-2185.

Section 14-Transport Information

The shipping of hazardous materials is regulated by the Department of Transportation (DOT). This section provides the important DOT shipping name, ID (UN or NA numbers), hazard class, and labels required to be on the container.

Section 15 - Other Regulatory Information

This section provides the regulatory information for regulatory compliance personnel. These regulations are specified by OSHA, Toxic Substances Control Act (TSCA), Superfund Amendments and Reauthorization Act (SARA), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Reportable

quantities for spills, storage, and shipping may also be listed. Finally, international regulations, federal, state, and local regulations should be found in this section.

Section 16 - Other Information

This section is intended to be used for any additional important information not listed in other sections. This can include references, keys/legends, creation and revision dates, and hazardous ratings such as the National Fire Protection Association (NFPA) codes. The information here can complete the process of providing all necessary information to the person reading the SDS. Many SDS include a disclaimer in this section as well.

IMPORTANT: If you have any questions about how to read a SDS or about information contained in a SDS, ask your immediate supervisor or call EH&S at 817-272-2185.

SDS Terms and Acronyms:

Action level, AL – Certain OSHA regulations take effect if this exposure level (concentration. in air) is reached. These regulations include workplace air analysis, employee training, medical monitoring, and record keeping. This level is about half of the permissible exposure limit.

Ceiling, C – This is the employee's exposure, which shall not be exceeded at any time during the workday.

Immediately dangerous to life and health, IDLH – These values are used to determine the appropriate respirators for hazardous chemicals. These values stand for the maximum concentration from which a worker could escape within 30 minutes without any escape-impairing symptoms or irreversible health effects in the event of a respirator failure.

Lethal concentration 50, LC-50 – This concentration of a hazardous material in air is expected to kill 50% of a group of test animals when given as a single respiratory exposure in a specific time period.

Lethal concentration low, LC-LO – This value indicates the lowest concentration of a substance in air that caused death in humans or laboratory animals. The value may represent periods of exposure that are less than 24 hours (acute) or greater than 24 hours (subacute and chronic).

Lethal dose 50, LD-50 – The single dose, other than inhalation, that causes death in 50% of an animal population from exposure to a hazardous substance.

Lethal dose low, LD-LO or LDL – The lowest dose, other than inhalation, that caused death in humans or animals.

Milligrams per cubic meter of air, mg/m^3 – This is the unit for measuring concentrations of particulate (minute dust-like particles) in air.

Parts per million, ppm – This is a common unit of concentration of gas or vapor in air expressed with many exposure limits. It is defined as parts of gas or vapor per million parts of air by volume at 25°C and 1 atm pressure.

Permissible exposure limit, PEL – This is one of the most important OSHA limits used. It is defined as the allowable limit for air contaminant in which workers may be exposed day after day without adverse health effects.

Recommended Exposure Limit, REL – This is the highest allowable air concentration that will not injure a person.

Short-term exposure limit, STEL – This is the 15-minute time-weighted average exposure which must not be exceeded at any time during a workday.

Threshold limit value, TLV – This is the air concentration level of hazardous substances to which workers may be repeatedly exposed day after day without adverse health effects.

Threshold limit value time-weighted average, TLV-TWA – This is the time-weighted average concentration for an 8-hour workday and a 40-hour work week in which a worker may be repeatedly exposed without adverse health effects.

Threshold limit value short-term exposure limit, TLV-STEL – This is the maximum concentration to which workers can be exposed for 15 minutes continuously without adverse health effects. Only four of these 15-minute exposures are permitted per day and 60 minutes must pass between exposures. The TLV-TWA still must not be exceeded.

Threshold limit value ceiling – This is a defined boundary, unlike TLV, which are guidelines. It is the concentration, which should never be exceeded at any time during the working exposure.

Time-weighted average – This is the worker's average airborne exposure in any 8-hour workday of a 40-hour work week, which should not be exceeded.
Note: A sample SDS is included in APPENDIX I.

References

1. Texas Hazard Communication Act
   https://statutes.capitol.texas.gov/Docs/HS/htm/HS.502.htm
   United States Resource Conservation and Recovery Act (RCRA)
   https://www.epa.gov/rcra
2. United States Occupational Health and Safety Administration. 29 CFR 1910.1200(g) https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10099&p_table=STANDARDS
3. Toxic Substances Control Act. https://www.epa.gov/laws-regulations/summary-toxic-substances-control-act
4. Comprehensive Environmental Response, Compensation, and Liability Act. http://www.epa.gov/superfund/policy/sara.htm .

CHAPTER 6
CHEMICAL HAZARDS AND CONTROLS

NOTE: If you are pregnant or considering becoming pregnant, EH&S strongly advises you to discuss this with your research advisor. You may enroll in general chemistry, but you should seriously consider not enrolling in any course above general chemistry (organic, for example).

6.1 CHEMICAL CATEGORIES, USE, AND STORAGE

Before using any chemical, carefully review the Safety Data Sheet (SDS) and the label for information regarding the health hazards, personal protective equipment required for safe handling, and any other pertinent information associated with the use of that chemical. The information presented here is intended to aid you in determining the best way to store and use chemicals safely.

General Storage Guidelines (1, 2):

- *Date chemicals when received and opened.* This will assist you in using the oldest chemicals first, which will also decrease the amount of chemicals for disposal. If a particular chemical becomes unsafe upon storage, such as a peroxide former, then an expiration date should also be included. Keep in mind that expiration dates set by the manufacturer indicate the shelf life of the unopened container, and do not necessarily imply that the chemical is *safe* to use up to that date *after it has been opened.*
- Store all chemicals by their hazard class and not in alphabetical order. Storing chemicals by alphabetical order will often result in incompatible chemicals being stored next to one another. Segregate chemicals into groups according to their hazards, for example, flammables, toxins, reactives, and oxidizers. Within these groups, chemicals can be stored in alphabetical order to locate them. If a chemical exhibits more than one hazard, use the highest hazard(s) on the NFPA label to segregate it.
- Do not store chemicals near heat sources such as ovens or steam pipes. Also, do not store chemicals in direct sunlight.
- Do not use lab benches as permanent storage for chemicals. In these locations, the chemicals can be easily knocked over, incompatible chemicals can be stored next to one another, and the chemicals are unprotected from a fire. Each chemical should have a designated storage location and should be put there after use.
- Inspect your chemicals routinely for any signs of deterioration and for the integrity of the label. To comply with the Texas Hazard Communication Act, *all* chemicals must be clearly labeled to prevent chemicals from becoming unknowns.
- Do not store chemicals on the floor, especially chemicals in glass containers. It is too easy for containers to be knocked over, bumped into, or hit with a chair.
- Do not use fume hoods as a permanent storage location for chemicals with the exception of particularly odorous chemicals that may require ventilation. The more containers, boxes, equipment, and other items that are stored in a fume hood, the

greater the likelihood of having chemical vapors being drawn back into the room. Some chemical fume hoods have ventilated storage cabinets underneath, and this is a good place to put chemicals that require ventilation.

- Promptly contact EH&S for the disposal of any old, outdated, or unused chemicals.
- Seal chemicals that require refrigeration with tight-fitting caps and store them in a refrigerator labeled for this purpose.
- Do not store chemicals above eye level. If the container breaks, the contents can fall onto your face and upper body, which are generally unprotected areas.
- Do not store excessive amounts of chemicals in a lab as this wastes space and creates unnecessary hazards. Buying chemicals in bulk quantities has more disadvantages than advantages; for example, limited work space, creation of a serious fire hazard, and disposal costs of unused chemicals are often higher than the initial purchase costs.
- To simplify the discussion of safety considerations for particular chemicals that are found in laboratories, six categories have been developed. Many laboratory chemicals will fall within one of these six groups. Of course, many chemicals can fit into more than one category and in this case you must decide the most important characteristic about that chemical. For example, methanol does have toxic properties, but for the purpose of storage it should be stored with other flammables.
- In general, chemicals within these categories will react similarly and will have similar properties. Being aware of the properties and characteristics of these general chemical categories will aid in the proper storage, handling, and use of chemicals.

6.1.1 FLAMMABLES

General Characteristics

Flammable liquids are the most common chemicals in a laboratory. Flammables can readily catch fire and burn. It is the vapor of a flammable liquid that burns, not the liquid itself.

The rate at which a flammable liquid produces flammable vapors depends upon its vapor pressure. The higher the vapor pressure, the more readily the liquid will vaporize. A chemical's vapor pressure also increases with increasing temperature. This makes flammable chemicals more hazardous when heated.

The flash point of a chemical is the minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air. Many commonly-used flammables have flashpoints lower than room temperature; for example, the flashpoint of diethyl ether is –45.0ºC, acetone has a flashpoint of –20ºC, and isopropanol 11.7ºC.

The limits of flammability or explosivity define the range in which a flammable vapor or gas when mixed with air can ignite and burn. The low end of this range is called the lower explosive limit or LEL; the high end of this range is called the upper explosive limit or UEL. If the vapor concentration in air is below the LEL or above the UEL, the mixture will not burn, but if the concentration is within these limits there is a very high risk of an explosion. The vapor concentration in air must be within the limits of flammability in order for it to ignite and burn. Some flammable chemicals, such as benzene, have a very narrow flammability

range, while others, such as acetaldehyde, have a very wide flammability range.

Most flammable vapors have a vapor density greater than that of air. The result is that these vapors will seek the lowest elevations, in other words, they sink. Flammable vapors can also travel great distances. When working with flammables, you must consider all the possible ignition sources, which may be located at a lower level and a greater distance from where the flammables are used.

Use and Storage

- Store flammable liquids in safety cans, storage cabinets designed for flammables, or inside storage rooms specifically designed for flammables.
- Minimize the amount of flammable liquids stored in the lab.
- Use flammables only in an area free of ignition sources. Remember, smoking is not permitted inside any University building.
- When transferring flammables in metal containers, voltage potentials can result in static sparks capable of igniting flammable vapors. Flammable liquid-dispensing and receiving containers must be grounded before pouring. Large containers such as drums must also be grounded when used as a dispensing or receiving vessel. All grounding connections must be metal-to-metal. Safety catalogs carry the necessary grounding wires.
- Never heat flammables by using an open flame. Use steam baths, water baths, oil baths, sand baths, heating mantles, or hot air baths.
- Never store flammable chemicals in a standard household refrigerator. There are several ignition sources located inside a standard refrigerator that can set off a fire or violent explosion. Flammables can only be stored cold in a lab-safe or explosion-proof refrigerator. Another alternative is to use an ice bath to chill the chemicals. Remember, there is no safety benefit in storing a flammable chemical in a refrigerator if the flashpoint of that chemical is below the temperature of the refrigerator.

Health Hazards

Flammable and combustible liquids can cause health problems depending on the specific material and route of exposure (breathing the vapor/mist, eye or skin contact, or swallowing). The following symptoms are typical for the respective routes of entry.

Inhalation of flammable liquids can cause irritation to the respiratory passages, headaches, muscle weakness, nausea, drowsiness, confusion, disorientation, loss of coordination, unconsciousness, and even death.

Skin contact with flammable liquids can cause the skin's oils to be removed which results in irritated, cracked, dry skin, rashes, & dermatitis.

Eye contact with flammable liquids can cause burning, irritation, and eye damage.

Ingestion of flammable liquids can irritate the digestive tract, poisoning, and death.

First Aid

For inhalation, remove the person from the contaminated area if it is safe to do so. Get medical attention and do not leave the person unattended.

For ingestion, remove the person from the source of contamination. Get medical attention. Do not induce vomiting.

For skin contact, remove the person from the source of contamination. Remove clothing, jewelry, and shoes from the affected areas. Flush the affected area with water for at least 15 minutes and get medical attention for excessive exposure.

For eye contact, remove the person from the source of contamination. Flush the eyes with water for at least 15 minutes. Get medical attention.

Personal Protective Equipment

Always use a fume hood while working with flammable liquids. Nitrile and neoprene gloves are effective against most flammables. Wear a heat and fire resistant lab coat to provide a barrier to your skin. Always wear safety glasses.

6.1.2 OXIDIZERS

General Characteristics

Oxidizers or oxidizing agents present fire and explosion hazards on contact with combustible materials. Depending on the class, an oxidizing material may increase the burning rate of combustibles with which it comes in contact, causing the spontaneous ignition of combustibles with which it comes in contact, or undergo an explosive reaction when exposed to heat, shock, or friction. Oxidizers are generally corrosive.

Perchloric acid is an oxidizing agent of particular concern. The oxidizing power of perchloric acid increases with an increase in concentration and with an increase in temperature. Cold, 70% perchloric acid is a strong, non-oxidizing corrosive. A 72% perchloric acid solution at elevated temperatures is a strong oxidizing agent. An 85% perchloric acid solution is a strong oxidizer at room temperature.

Do not order or use anhydrous perchloric acid, $HClO_4$. It is unstable at room temperature and can decompose spontaneously with a severe explosion. Anhydrous perchloric acid will explode in contact with wood or other organic materials.

Examples of common oxidizers include peroxides, nitrates, nitrites, perchlorates, chlorates, chlorites, hypochlorites, dichromates, permanganates, and persulfates.

Use and Storage

- In general, store oxidizers away from flammables, organic compounds, and combustible materials.
- Store strong oxidizing agents like chromic acid in glass or some other inert container, preferably unbreakable. Do not use corks or rubber stoppers.
- Do not heat reaction vessels containing appreciable amounts of oxidizing material in oil baths, but rather on a heating mantle or sand bath.

Use and Storage of Perchloric Acid, $HClO_4$

Perchloric acid deserves special mention within the category of oxidizing materials. As mentioned above, a heated solution of perchloric acid is a very strong oxidizing agent.

Do not attempt to heat perchloric acid if you do not have access to a properly functioning perchloric acid fume hood. Perchloric acid can only be heated in a hood especially equipped with a washdown system to remove any perchloric acid residue. The hood should be washed down after each use and it is preferred to dedicate the hood to perchloric acid use only.

- Whenever possible, substitute a less hazardous reagent for perchloric acid.
- Perchloric acid should be stored in a perchloric acid fume hood. Keep only the minimum amount necessary for your work. Another acceptable storage site for perchloric acid is on a metal shelf or in a metal cabinet away from organic or flammable materials. Store the bottle of perchloric acid in a glass secondary container to contain any leakage.
- Do not allow perchloric acid to come in contact with any strong dehydrating agents such as sulfuric acid. The dehydration of perchloric acid is a severe fire and

explosion hazard.

Health Hazards

Oxidizers have been chosen as a group primarily because of their potential to add to the severity of a fire or to initiate a fire. But some generalizations can be made regarding the health hazards of an oxidizing material. In general, oxidizers are corrosive and many are highly toxic.

First Aid

In general, if a person has inhaled, ingested, or has directly contacted oxidizing materials, the person must be removed from the source of contamination as quickly as possible if it is safe to do so. Summon medical help. In the case of an exposure directly to the skin or eyes it is imperative that you take the exposed person to an emergency shower or eyewash immediately. Flush the affected area for a minimum of 15 minutes then get medical attention.

Personal Protective Equipment

Be sure to consult a glove compatibility chart to ensure the glove material is appropriate for the particular chemical. Also consult the glove manufacturer for additional information.

You must wear chemical splash goggles if the potential for splashing exists or if exposure to corrosives, vapor, or gas is likely.

Always use oxidizing materials in a chemical fume hood as most do pose a hazard via inhalation. Cylinders of compressed gases should be kept in ventilated cabinets.

6.1.3 CORROSIVES

General Characteristics

Corrosives are most commonly acids and bases, but many other materials can also be severely damaging to living tissue. Corrosives can cause visible destruction or irreversible alterations at the site of contact. Inhalation of the vapor or mist can cause severe bronchial irritation. Corrosives are particularly damaging to the skin and eyes.

Certain substances considered noncorrosive in their natural dry state are corrosive when wet, such as when in contact with moist skin or mucus membranes. Examples of these materials are lithium chloride, halogen fluorides, and allyl iodide.

Sulfuric acid (H_2SO_4) is a very strong dehydrating agent and nitric acid is a strong oxidizing agent. Dehydrating agents can cause severe burns to the eyes due to their affinity for water.

Examples of corrosives include sulfuric acid, ammonium bifluoride, chromic acid, bromine, stannic chloride, sodium hydroxide, and ammonium hydroxide.

Use and Storage

- Always store acids separately from bases. Also, store acids away from flammables, since many acids are also strong oxidizers.
- Do not work with corrosives unless an emergency shower and continuous flow

eyewash are available.

- *Always add acid to water*, never add water to acid. This is to prevent splashing from the acid due to the generation of excessive heat as the two substances mix.
- Never store corrosives above eye level. Store them on a low shelf or cabinet.
- It is a good practice to store corrosives in secondary containment to contain any leakage.
- When possible, purchase corrosives in containers that are coated with a protective plastic film that will minimize the danger to personnel if the container is dropped.
- Store corrosives in an appropriate corrosive chemical storage cabinet.
- Do not store hydroxides in glass containers. Hydroxides slowly react with glass to produce silicates. Instead, use plastic containers.

Use and Storage of Hydrofluoric Acid, HF:

Hydrofluoric acid is extremely hazardous and deserves special mention. Hydrofluoric acid can cause severe burns and inhalation of anhydrous hydrogen fluoride gas can be fatal. Hydrofluoric acid readily penetrates the skin damaging underlying tissue. Fluoride ions can then cause destruction of soft tissues and decalcification of the bones. Only persons fully trained in the hazards of hydrofluoric acid should use it. Always double-glove and wear a lab coat.

- *Do not use hydrofluoric acid without having a tube of calcium gluconate nearby*. Calcium gluconate bonds to free fluoride ions before they can penetrate the skin.
- Always use hydrofluoric acid in a properly functioning fume hood. Ideally a fume hood or section of a fume hood should be dedicated to hydrofluoric acid use.
- If you suspect that you have come in direct contact with hydrofluoric acid, wash the area with water for at least 15 minutes, remove clothing, apply calcium gluconate liberally, then seek prompt medical attention. If you suspect that you have inhaled hydrogen fluoride vapors, move immediately to an uncontaminated atmosphere if it is safe to do so, keep warm, and seek prompt medical attention. Death from inhalation or skin contact can occur!
- Never store hydrofluoric acid in a glass container because it is incompatible with glass. Store it in its original container. If you must remove some to dilute it, use a plastic vial.
- Store hydrofluoric acid separately from other acids and keep only the amount necessary in the lab.

Health Hazards

All corrosives possess the property of being severely damaging to living tissues.

Skin contact with alkali metal hydroxides such as sodium hydroxide and potassium hydroxide is more dangerous than with strong acids. Contact with alkali metal hydroxides normally causes deeper tissue damage because there is less pain than with an acid exposure. The exposed person may not wash it off thoroughly enough or seek prompt medical attention.

Acids on contact with skin generally form a protein layer which prevents further penetration and is painful, where alkali metal hydroxides do not.

All hydrogen halide acids are serious respiratory irritants and also cause severe burns.

Hydrofluoric acid is particularly dangerous. At low concentrations, hydrofluoric acid does not immediately show any signs or symptoms upon contact with skin. It may take several hours for the hydrofluoric acid to penetrate the skin before you would notice a burning sensation. However, by this time permanent damage, such as second and third degree burns with scarring, can result.

First Aid

- For **inhalation**, remove the person from the source of contamination if it is safe to do so. Get medical attention. Keep person warm and quiet and do not leave unattended.
- For **ingestion**, remove the person from the source of contamination. Get medical attention and inform emergency responders of the name of the chemical swallowed. Do not induce vomiting.
- For **skin contact**, remove the person from the source of contamination and take immediately to an emergency shower or source of water. Remove clothing, shoes, socks, and jewelry from affected areas, cutting them off if necessary, as quickly as possible. Be careful not to get any corrosive on your skin or inhale the vapors. Flush the affected area with water for a minimum of 15 minutes. Get medical attention.
- For **eye contact**, remove the person from the source of contamination and take immediately to an eyewash or source of water. Rinse the eyes for a minimum of 15 minutes. Have the person rotate their eyes up and down and from side to side while flushing with water. Get medical attention. Do not let person rub their eyes or keep them tightly shut.

Personal Protective Equipment

Neoprene and nitrile gloves are effective against most acids and bases. Polyvinyl chloride (PVC) is also effective for most acids.

- Always wear the proper gloves when working with acids.
- Wear a rubber-coated apron and goggles.
- If splashing is likely to occur, wear a face shield over the goggles.
- Always use corrosives in a chemical fume hood.

6.1.4 REACTIVES

General Characteristics

Polymerization Reactions

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

polymerization reaction is polyvinyl benzene.

Water-Reactive Materials

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

Examples of water-reactive materials include alkali metals, silanes, alkyl aluminums,

magnesium, zinc, and aluminum.

Pyrophoric Materials (3)

Note: see the separate SOP on pyrophoric materials on the EH&S web site.

- Pyrophoric materials can ignite spontaneously in the presence of air at less than 45°C (130°F).
- They react with water in the air, oxygen, or both.
- Examples of pyrophoric materials include calcium carbide, diethyl zinc, triethyl aluminum, andother compounds.

Peroxide-Forming Materials (4)

Note: see the separate SOP on peroxide-forming materials on the EH&S web site.

Peroxides are very unstable, and some chemicals that can form them are commonly used in laboratories. This makes peroxide-forming materials some of the most hazardous substances found in a lab.

Peroxide-forming materials are chemicals that react with air, moisture, or impurities to form organic peroxides. Peroxide formation by most of these materials is greatly increased by evaporation or distillation. Organic peroxide compounds are extremely sensitive to shock, sparks, heat, friction, impact, and light.

Many peroxides formed from materials used in laboratories are more shock-sensitive than trinitrotoluene (TNT). Just the friction from unscrewing the cap of a container of an ether containing peroxides can provide enough heat to cause a severe explosion. Examples of peroxide forming chemicals include sodium amide, tetrahydrofuran, styrene, and diethyl ether.

Other Shock-Sensitive Materials

chemicals containing nitro groups
fulminates
hydrogen peroxide (30% +)
ammonium perchlorate
benzoyl peroxide (when dry)
picric acid (when dry)
anhydrous perchloric acid

compounds containing the following functional groups:
acetylide, azide, diazo, halamine, nitroso, and ozonide.

Note: See APPENDIX-III for a more complete list of potentially explosive chemicals.

Use and Storage

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

Water-Reactive Materials

Store water-reactive chemicals in an isolated part of the lab. A cabinet away from any water sources, such as sinks, emergency showers, and chillers, is an appropriate location.

Clearly label the cabinet "Water-Reactive Chemicals – No Water".

Pyrophorics

- Store pyrophorics in an isolated part of the lab in a clearly-marked cabinet, or preferably in a glove box or other controlled atmosphere.
- Do not store pyrophorics near flammables and ignition sources.
- Be sure to routinely check the integrity of the container and have the material disposed of through EH&S if the container is corroded or otherwise damaged.

Peroxide-Forming Materials

Do not open the reagent container if peroxide formation may have occurred. The act of opening the container could be sufficient to cause a severe explosion. Visually inspect liquid peroxide-forming materials for crystals, liquid stratification, or unusual viscosity before opening. The presence of any of these signs indicates the potential for a shock sensitive container**.** *Do not move the container and contact EH&S as soon as possible.* Pay special attention to the area around the cap. Peroxides usually form upon evaporation, so they will most likely be formed on the threads under the cap.

Date all peroxide-forming materials with the date received, opened, and the expected shelf life. Chemicals such as isopropyl ether, divinyl acetylene, sodium amide, and vinylidene chloride should be discarded after three months. Chemicals such as dioxane, diethyl ether, and tetrahydrofuran should be discarded after one year. Many chemical companies now routinely print an expiration date on containers of the worst peroxide formers.

Store all peroxide-forming materials away from heat, sunlight, and sources of ignition. All organic peroxides are highly flammable and sunlight accelerates the formation of peroxides.

Secure the lids and caps on these containers to discourage the evaporation and concentration of these chemicals.

Store peroxide formers in sealed, air-impermeable containers such as dark amber glass with a

tight-fitting cap. Metals inhibit the formation of peroxides in some materials, which is why diethyl ether and some other materials are sold in metal cans.

Inhibitors are added to some chemicals, and whenever possible purchase peroxide formers with added inhibitors. However, be aware that these free-radical inhibitors will be depleted over time as peroxides are formed.

A chemical test can be performed to check for the presence of peroxides in liquids. However, if you suspect that peroxides may be present, it is probably wise to call EH&S for disposal.

Never distill any peroxide-former, especially alcohols and ethers, unless it is known to be free of peroxides.

Other Shock Sensitive Materials

Store these materials separately from other chemicals and in a clearly-labeled cabinet.
Never allow picric acid to dry out; it is extremely explosive. Always store picric acid in a wetted state.

Health Hazards

Reactive chemicals are grouped together as a category primarily because of the safety hazards associated with their use and storage and not because of similar acute or chronic health effects. For health hazard information on specific reactive materials consult the SDS, the manufacturer, or EH&S.

However, there are some hazards common to the use of reactive materials.

- Injuries can occur due to heat or flames.
- Hearing loss can result.
- Respiratory injuries can occur because of inhalation of fumes, vapors, and reaction products.
- A very serious hazard is flying debris which can inflict physical injuries.

First Aid

If someone is seriously injured, your most important step is to contact emergency responders as quickly as possible. This is best accomplished by directly calling the UTA Police Department, 817-272-3003. Explain the situation clearly and accurately.

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

If a person is on fire, have them drop immediately to the floor and roll. If a fire blanket is available put it over them. An emergency shower can also be used to douse flames if one is immediately available.

If a person is going into shock, have them lie down on their back if it is safe to do so and raise their feet about one foot above the floor or above their heart.

Personal Protective Equipment

Wear appropriate personal protective clothing while working with highly reactive materials. This might include impact-resistant chemical splash goggles, a face shield, gloves, a lab coat (to minimize injuries from flying glass or an explosive flash), and a shield.

Conduct work within a chemical fume hood as much as possible and pull down the sash as far as is practical. When the experiment does not require you to reach into the fume hood, keep the sash closed.

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

6.1.5 TOXINS

General Characteristics

Any chemical at the right dose could be toxic to humans. However, there are some chemicals that are known to be hazardous at very low concentrations, over a very short exposure time, or after repeated exposures. These chemicals are toxins, poisons, and carcinogens.

A toxin may be *mutagenic* (causes a change in the gene structure) or may also be *teratogenic* (causes a malformation of an embryo or fetus.) Pregnant women and persons in their childbearing years should not work with or, at a minimum, use extreme caution while handling these materials.

Toxicity is the degree to which a substance (a toxin or poison) can harm humans or animals. An acute toxin can cause an adverse effect after a single or short duration exposure. A chronic toxin causes an adverse effect after repeated exposures, after a long duration single exposure, or after a long latency period. Carcinogens are examples of chronic toxins that have a long latency period before the effects of the exposure are observed. Refer to SOP-Carcinogens on EH&S web site.

Examples of acute toxins include hydrogen cyanide, diisopropyl fluorophosphate, hydrogen sulfide, hydrofluoric acid, nitrogen dioxide, and phosgene.

Examples of chronic toxins include all carcinogens and many metals and their compounds.

Use and Storage

Minimize your exposure to chemicals that are known to be highly toxic by substituting a less hazardous chemical, decreasing the exposure time to the chemical, wearing protective clothing, practicing safe laboratory techniques, and using properly functioning laboratory safety equipment such as fume hoods or biological safety cabinets as appropriate.

- Do not eat, drink, smoke, or apply cosmetics in an area where toxic chemicals are used or stored, or without washing hands after using such chemicals.
- Thoroughly wash your hands and arms before leaving the work area and at the end of the day.
- Store containers of toxic materials in pans, trays, or other secondary containers to minimize hazards if the containers were to break or the contents spilled.
- Use absorbent paper on the work surface to contain spills.

- Restrict access where toxic materials are used and post signs if special toxicity hazards exist.
- Vacuum pumps that are used with materials having high chronic toxicity should be protected by high-efficiency scrubbers or high efficiency particulate air (HEPA) filters and vented into a chemical fume hood.
- Store toxic chemicals separately in a clearly-labeled cabinet. Do not allow personnel to work with toxins until they have been properly trained in their hazards, use, storage, and proper handling. If other hazards also apply to toxic chemicals, store as appropriate to those hazards.

Health Hazards

The health hazards of toxic materials vary greatly. For information on specific materials contact EH&S or the manufacturer or check the SDS.

First Aid

Remove the person from the source of contamination if it is safe to do so. Get medical attention immediately. Try to determine exactly what the person has been exposed to and provide this information to the emergency responders. Provide a copy of the MSDS to the emergency responders if at all possible.

Personal Protective Equipment

Protect your skin, eyes, and respiratory tract by using the appropriate engineering controls such as fume hoods and glove boxes and by using personal protective clothing such as gloves and lab coats.

Before beginning work, you can contact EH&S to have the chemical fume hood tested. If a positive pressure glove box is used, the box must be tested for leaks before each use and the exit gasses must be passed through a suitable trap or filter.

6.1.6 COMPRESSED GAS CYLINDERS

General Characteristics

Cylinders of compressed gases can pose a chemical hazard as well as a physical hazard. If the valve were to break off a cylinder, the amount of force present could propel the cylinder through a brick wall. For example, a cylinder of compressed breathing air used by SCUBA divers has the explosive force of 1 1/2 pounds of TNT.

Use and Storage

- Use toxic, flammable, or reactive gases only in a fume hood or other ventilated enclosure. Use a sensor/detector specific for each toxic gas
- Always use the appropriate regulator on a cylinder. If a regulator will not fit a cylinder's valve, replace the cylinder, not the regulator. *Do not ever* attempt to adapt or modify a regulator to fit a cylinder for which it was not designed. Regulators are designed to fit only specific cylinder valves to avoid improper use.

- Inspect regulators, pressure relief devices, valves, cylinder connections, and hose lines frequently for damage.
- Never use a gas cylinder that cannot be positively identified. Color coding is not a reliable way of identifying a gas cylinder because the colors can vary from supplier to supplier.
- Do not use oil or grease on any cylinder component of an oxidizing gas because a fire or explosion can result.
- Never transfer gases from one cylinder to another. The gas may be incompatible with the residual gas remaining in the cylinder or may be incompatible with the material of which the cylinder is made.
- Never completely empty cylinders; rather, leave approximately 25 psi of pressure. This will prevent any residual gas in the cylinder from becoming contaminated.
- Position all cylinders so that the main valve is always accessible.
- Close the main cylinder valve whenever the cylinder is not in use.
- Remove regulators from unused cylinders and always put the safety cap in place to protect the valve.
- **Always secure cylinders, whether empty or full**, to prevent them from falling over and damaging the valve (or falling on your foot). Secure cylinders by chaining or strapping them to a wall, lab bench, or other fixed support.
- Oxygen should be stored in an area that is at least 20 feet away from any flammable or combustible materials or separated from them by a noncombustible barrier at least 5 feet high and having a fire-resistance rating of at least 1/2 hour.
- To transport a cylinder, put on the safety cap and strap the cylinder to a hand-truck in an upright position. Never roll a cylinder.
- Always clearly mark empty cylinders and store them separately.
- Be careful while handling compressed gas cylinders and never drop or strike a cylinder against anything.
- Use only wrenches or other tools supplied by the cylinder supplier to open a valve. Open cylinder valves slowly.

Gas Cylinder Procedure

Because of the tremendous cost involved with the disposal of non-returnable compressed gas cylinders and the potential safety risks associated with unknown cylinders, the University discourages the purchase of any gases in non-returnable cylinders.

All users will be responsible for returning all cylinders to the manufacturer/distributor.

Cylinders of gases classified as corrosive or highly reactive shall be returned to the manufacturer/distributor within one year of the purchase date and all other gases within three years.

6.1.7 CRYOGENIC MATERIALS

General Characteristics

A cryogenic fluid is a refrigerated, liquefied gas having a boiling point colder than -90 °C (-130 °F) at 14.7 psi..
Some examples are Dry Ice, liquid nitrogen, and liquid oxygen.

Use and Storage

Do not store cryogenic cylinders or Dewars in rooms or environmental chambers that do not have fresh air ventilation. A leak or venting from the container could cause an oxygen-deficient atmosphere.

Do not place cryogenic fluids on tile or laminated counters. They will destroy the adhesive.

Never store Dry Ice in glass or other sealed, air-tight containers or coolers. A pound of Dry Ice sublimes into 8.3 ft^3 of carbon dioxide gas in about 1 hour.

Only use containers designed for cryogenic liquids with lids that are vented to allow off-gassing (1 L liquid nitrogen vaporizes to ~0.7 m^3 of gas).

Keep liquid oxygen containers, piping, and equipment clean and free of grease, oil, and organic materials.

Always use cryogenic-rated piping and tubing for cryogenic fluids.

Large stationary cryogenic systems and piping have additional requirements. Contact EH&S (817-272-2185) for guidance.

Health Hazards

The health hazard associated with **cryogenic materials** is exposure to cold temperatures that can cause severe burns.

First Aid

Remove any clothing not frozen to the skin that may restrict circulation to the frozen area. Do not rub frozen parts, as tissue damage may result. Obtain medical assistance as soon as possible.

Place the affected part of the body in a warm water bath (not to exceed 40^{o} C). Never use dry heat.

Personal Protective Equipment

- Avoid contact with skin and eyes.
- Wear a face shield, chemical safety goggles, and cryogenic gloves when dispensing from cylinder or Dewar.
- Never handle cryogenic materials with your bare hands. Wear appropriate insulated gloves to protect from the extreme cold when handling cryogenic containers.
- Gloves need to be loose-fitting so that they can be readily removed in the event liquid is splashed into them.

- Never allow an unprotected part of the body to touch uninsulated pipes or containers of cryogenic material.

6.2 PERSONAL PROTECTIVE CLOTHING

The most important thing to remember about protective clothing is that it only protects you if you wear it. Safety Data Sheets or other references should be consulted for information on the type of protective clothing that is required for the particular work you are performing.

Protective Eyewear

Goggles provide the best all-around protection against chemical splashes, vapors, dusts, and mists. Goggles that have indirect vents or are non-vented provide the most protection, but you may need to apply an anti-fog agent. Standard safety glasses also provide protection against impact. These glasses are rated ANSI Z87.1.

If using a laser, wear safety glasses or goggles that provide protection against the specific wavelength of that laser and have been approved by the University's Laser Safety Officer as part of the laser's standard operating procedure.

Remember, *ordinary prescription eyeglasses do not provide adequate protection in a laboratory setting.* However, you can purchase prescription safety glasses meeting the ANSI Z87.1 standard from most opticians (LensCrafters, Target, etc.) Also, the University has arranged with a vendor to supply prescription safety glasses to personnel at a reduced cost. Contact EH&S at 817-272-2185, for further information.

Contact lenses should not be worn in a laboratory because they can trap contaminants under them and reduce or eliminate the effectiveness of flushing with water from an eyewash. Contact lenses may also increase the amount of chemical trapped on the surface of the eye and decrease removal of the chemical by flushing with tears. If it is absolutely necessary to wear contact lenses in a lab, wear protective goggles at all times.

Protective Gloves

Chemicals can permeate any glove. The rate at which this occurs depends on the composition of the glove, the chemicals present and their concentration, and the exposure time to the glove. This is why it is important to replace your gloves frequently throughout the day. Also, wash your hands regularly and remove gloves before answering the telephone or opening the door to prevent the spread of contamination.

If you are not certain which type of glove provides you with the protection you need, contact the manufacturer and ask for specifics on that glove.

- Check gloves for cracks, tears, and holes before use.
- Butyl, neoprene, and nitrile gloves are resistant to most chemicals, such as alcohols, aldehydes, ketones, most inorganic acids, and most caustics.
- Disposable latex and vinyl gloves protect against some chemicals, most aqueous solutions, and microorganisms as well as reduce the risk of product contamination.
- Leather and some knit gloves will protect against cuts, abrasions, and scratches, but do not protect against chemicals.

- Temperature-resistant gloves protect against cryogenic liquids, flames, and high temperatures.

Other Protective Clothing

There are many types of lab coats available. The primary purpose of a lab coat is to protect you from splashes and spills. A lab coat should be nonflammable and be easily removed. Teaching or research laboratory users working with hazardous chemicals must wear closed-toe shoes, long pants or skirts which fully cover the legs, and a lab coat.

Rubber-coated aprons can be worn to protect against chemical splashes and may be worn over a lab coat for additional protection.

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

Wear shoes which fully cover your feet. If you plan to perform work that includes moving large and heavy objects such as 55-gallon drums, then you must wear steel-toed shoes.

6.3 CHEMICAL SAFETY EQUIPMENT

Chemical safety equipment includes chemical fume hoods and canopy hoods. Laboratories provide this equipment to enable you to work safely with chemicals. In order to use this equipment properly you should have a general understanding of how it works.

Chemical Fume Hood Description

Here are some examples of different types of chemical fume hoods: standard, bypass, auxiliary air, perchloric acid, and radioisotope hoods.

All chemical fume hoods work in the following way:

- air is drawn through the front opening of the fume hood, across the work surface, and through one or more baffles at the rear of the hood;
- air flows up through the ductwork and into the blower, which should be located on the roof;
- air flows through the exhaust stack and into the atmosphere, away from the building and any air intakes.

Standard Fume Hoods

Standard fume hoods consist of a vertically sliding sash (which may have horizontally sliding panes of glass), rear baffle(s), a blower, and ductwork that connects the hood to the blower.

The fan selected will draw a certain volume of air through the face of the hood at a certain rate, usually 100 feet per minute (fpm). The velocity through the hood opening will vary depending on the position of the sash. As the sash is lowered, the velocity through the hood opening will increase. The hood should not be operated with the sash raised above the height indicated on the EH&S inspection sticker, typically 18 inches.

The velocity can be so great that it can knock over graduated cylinders or pull paper up into the blower. This is a disadvantage of this type of hood.

Bypass Fume Hoods

Bypass fume hoods consist of the same elements as a standard fume hood with the addition of a bypass. The bypass is a grille or set of louvers located at the upper front side of the hood.

The operation of the bypass depends on the position of the sash. When the sash is wide open, the bypass is blocked - when the sash is lowered, air will flow through the bypass as well as through the front opening of the hood.

This design keeps the velocity through the face of the hood fairly constant and eliminates the problem of having very high velocities at the hood opening.

Auxiliary Air Fume Hoods

An auxiliary air fume hood consists of the same elements as a bypass hood with the addition of an outside air supply. An additional blower and ductwork are required to supply outside air to the hood opening.

This fume hood design is energy efficient because a smaller volume of conditioned room air is exhausted through the hood.

Auxiliary air fume hoods also have disadvantages. Cold or hot outside air may be blown onto the user of the hood, and these hoods are difficult to design so that they perform properly.

Perchloric Acid Fume Hoods

A perchloric acid fume hood is a special adaptation of a standard, bypass, or auxiliary air fume hood for the use of perchloric acid. The hood is constructed of stainless steel and other non-reactive materials. It is equipped with water sprays along the length of the exhaust duct, including near the blower and inside the top of the fume hood.

The water sprays are activated to wash down any perchloric acid residues that may have been deposited within the fume hood system. The fume hood should be washed down after each use. As mentioned previously, perchloric acid residues are potentially explosive.

Ideally, perchloric acid fume hoods should be used for perchloric acid only. If organics must be used in a perchloric acid hood, thoroughly wash down the fume hood first. Never use perchloric acid and organics in the hood at the same time. Perchloric acid in contact with organic materials can cause ignition.

Radioisotope Fume Hoods

This type of hood is constructed and sealed to eliminate any cracks or crevices that may allow the accumulation of radioactive materials. It may be a standard, bypass, or auxiliary air fume hood.

The interior of the fume hood should be designed to be easy to clean and contain any spills that might occur within it.

Proper Use of Chemical Fume Hoods

- Place equipment and other materials at least six inches behind the sash. This will reduce the exposure of personnel to chemical vapors that may escape into the lab from air turbulence.
- When the hood is not in use, pull the sash all the way down. While personnel are working at the hood, pull down the sash as far as is practical. The sash is your protection against fires, explosions, chemical splashes, and projectiles.
- Do not keep loose papers, paper towels, or cleaning wipes in the hood. These materials can get drawn into the blower and adversely affect the performance of the hood.
- Do not use a fume hood as a storage cabinet for chemicals. This is not what they are designed for. Excessive storage of chemicals and other items will disrupt the airflow in the hood. In particular, do not store chemicals against the baffle at the back of the hood. This is where the majority of the air is exhausted.
- If large equipment must be kept in a fume hood, raise it 1.5 inches off the work surface to allow air to flow underneath. This dramatically reduces the turbulence within the hood and increases its efficiency.
- Do not place objects directly in front of a fume hood (such as refrigerators or lab coats hanging on the manual controls) as this can disrupt the airflow and draw contaminants out of the hood.
- Keep in mind that modifications made to a fume hood system, for example, adding a snorkel, can render the entire system ineffective.
- Minimize the amount of foot traffic immediately in front of a hood. People walking past hoods cause turbulence that can draw contaminants out of the hood and into the room.
- EH&S inspects chemical fume hoods semi-annually to ensure they are working properly. If you suspect that your fume hood is not working properly or for any other questions regarding fume hoods call the EH&S at 817-272-2185.

Canopy Hoods

Canopy hoods are generally suspended from the ceiling, usually overhanging an exhaust port of some equipment. The capture velocity of a canopy hood quickly diminishes at a distance from the source of the contaminant. This makes canopy hoods very limited in their effectiveness at removing contaminants. Use only with non-toxic, non-hazardous items that evolve inert vapors, steam or smoke.

Gloveboxes and Isolators

Gloveboxes and isolators are used to contain hazardous substances or materials that must not come in contact with the outside environment. Gloveboxes and isolators are used for both protecting personnel and the isolated product by maintaining secure containment fields. These fields are necessary for handling hazardous materials including pyrophoric or toxic compounds.

Gloveboxes and isolators are typically airtight containers that provide oxygen- and moisture-controlled environments. They have specially-sealed ports that are fitted with gloves allowing operators to manipulate the objects and substances inside the isolator.

Gloveboxes and isolators use gloves and gauntlets designed to function in a hazardous

environment. The gloves can be made of specially-treated rubber, neoprene, polyurethane, and other materials depending on the application. The gloves may also be treated with electrostatic powder to minimize static electricity.

Gloveboxes and isolators also come with optional features depending on the materials being handled in the containment isolator, such as microprocessor controllers, carbon or HEPA filters, cryogenic traps, gas purifiers, vacuum pumps, and even closed circuit television to monitor experiments.

References

1. UTA EH&S web site - Manuals and Guidelines
2. Chemical Segregation & Incompatibilities Guidelines
3. UTA EH&S web site -SOPs

CHAPTER 7
BIOLOGICAL HAZARDS AND CONTROL

Since its publication in 1984, *Biosafety in Microbiological and Biomedical Laboratories* (BMBL) (1) has become the cornerstone of biosafety practice and policy in the United States. The principles of biosafety introduced in the first edition of BMBL and carried through in the revision of fifth edition (2009) address the safe handling and containment of infectious microorganisms and hazardous biological materials. These principles are *containment* and *risk assessment*. The fundamentals of containment include the microbiological practices, safety equipment, and facility safeguards that protect laboratory workers, the environment, and the public from exposure to infectious microorganisms that are handled and stored in the laboratory. Risk assessment is the process that enables the appropriate selection of microbiological practices, safety equipment, and facility safeguards that can prevent laboratory-associated infections (LAIs).

Work with infectious agents has expanded and organizations and laboratory directors are compelled to evaluate and ensure the effectiveness of their biosafety programs, the proficiency of their workers, as well as the capability of equipment, facilities, and management practices to provide containment and security of microbiological agents. Similarly, individual workers who handle pathogenic microorganisms must understand the containment conditions under which infectious agents can be safely manipulated and secured. The use of vaccines may provide an increased level of personal protection. Application of all this knowledge and the use of appropriate techniques and equipment will enable the microbiological and biomedical community to prevent personal, laboratory, and environmental exposure to potentially infectious agents or biohazards.

This section of the UT Arlington Laboratory Safety Manual gives the tools to:

- Protect personnel from exposure to infectious agents or other viable biological materials that may cause harm to them or others after secondary transmission;
- Protect visitors and others not employed by UTA who may be on the premises or in proximity of biohazards;
- Provide an environment for high quality research while maintaining a safe work place; and
- Comply with applicable federal, state, and local requirements

The handling and manipulation of infectious biological agents (bacterial/fungal/parasitic /rickettsial/viral agents, arboviruses & zoonotic viruses, prions, microbial toxins, recombinant or synthetic nucleic acid molecules, and other viable material) requires the use of precautionary measures. This section of the manual provides assistance in the evaluation, containment, and control of biohazards associated with safety planning and concerns related to the safe use and handling of biohazardous agents. All personnel, students, volunteers, visiting professionals, or other individuals working with these materials on the premises of all UTA facilities should become familiar with this section of the manual and are encouraged to seek additional advice or training when necessary.

7.1 BIOLOGICAL HAZARDS – EVALUATION

Biological Risk Assessment

Biological risk assessment is an important responsibility for principal investigators (PIs) of microbiological and biomedical laboratories. Institutional biosafety committee (IBC), animal care and use committee (IACUC), biological safety professionals, and laboratory animal veterinarians share in this responsibility. Risk assessment is a process used to identify the hazardous characteristics of a known infectious or potentially infectious agent or material, the activities that can result in a person's exposure to an agent, the likelihood that such exposure will cause a LAI, and the probable consequences of such an infection.

The information identified by risk assessment will provide a guide for the selection of appropriate biosafety levels and microbiological practices, safety equipment, and facility safeguards that can prevent LAIs and protect persons that are not directly associated with the laboratory.

The primary factors to consider in risk assessment and selection of precautions are *agent hazards* and *laboratory procedure hazards*. Use careful judgment so that you neither underestimate the risks nor burden the laboratory unnecessarily with too rigorous safeguards.

Agent Hazards

The biological risk assessment should consider the agent's:

- Biological and physical nature
- Stability in the environment and its endemic nature
- Origin (non-indigenous agents are of special concern because of their potential to introduce risk of transmission or spread of human and animal or infectious diseases from foreign countries into the United States)
- Capability to infect and cause disease in a susceptible human or animal host (host range)
- Infective dose
- Virulence as measured by the severity of disease
- Probable routes of transmission of laboratory infection
- Availability of preventive measures and effective treatments for the disease

The agent summary statements contained in BMBL identify the primary agent and procedure hazards for specific pathogens and recommended precautions for their control.

Governmental agencies have performed risk assessments on many wild-type microbial agents. Risk assessments establish a Risk Group (RG) classification that takes into account characteristics of the microorganism and its potential to do harm to health care workers, the public health of the nation, the environment, the national economy, or the agriculture products of the country. Agents are classified into four risk groups according to their relative pathogenicity for healthy adult humans by the following criteria:

Risk Group 1	Agents are not associated with disease in healthy adult humans
Risk Group 2	Agents are associated with human disease, which is rarely serious, and for which preventive or therapeutic interventions are *often* available
Risk Group 3	Agents are associated with serious or lethal human disease for which

	preventive or therapeutic interventions *may be* available
Risk Group 4	Agents are likely to cause serious or lethal human disease for which preventive or therapeutic interventions are *not usually* available

High Risk Individuals/Prenatal Considerations

The PI must determine special hazards and exceptions. The PI is primarily responsible for establishing the safety of personnel under his/her supervision. Persons who are immunocompromised or otherwise particularly susceptible to infection need to be identified so that additional precautions for microbiological safety can be taken when necessary. It may be inadvisable for a person in an immunocompromised condition to work with hazardous microorganisms. This includes individuals under systemic corticosteroid therapy, chemotherapy for malignancies, radiation therapy, and those who have certain diseases (for example, lymphomas, leukemia, and acquired immunodeficiency syndrome (AIDS) which induce severe impairment of immune competence. One needs to seek medical advice regarding possible work restrictions. Any student that has a medical condition that s/he feels might be compromised by exposure to reagents or cultures in the laboratory is encouraged to discuss the matter with her/his PI/supervisor.

Additionally, certain microbes such as *Toxoplasma gondii*, rubella virus, cytomegalovirus, and vesicular stomatitis virus pose a hazard to pregnant women who should carefully evaluate the risk of working with or near these agents. Toxoplasmosis is a disease acquired from cats that if acquired by a pregnant woman during pregnancy can cause birth defects and other disorders in a fetus. Pregnant women are also known to be at high risk of infection by *Listeria monocytogenes*. Therefore, for her own safety, any female student or staff member who is or thinks that she may be pregnant should discuss the matter with the PI prior to commencing work with *L. monocytogenes.*

Pregnant women can work in animal facilities, but certain tasks may present a hazard to the fetus. Women who become pregnant should notify their PI/supervisor and obtain a release from their personal health care physician.

Laboratory Procedure Hazards

The biological risk assessment should consider the potential hazards associated with laboratory procedures:

- Work practices
- Safety equipment
- Facility safeguards

Work Practices

Workers are the first line of defense for protecting themselves, others in the laboratory, and the public from exposure to hazardous agents. Protection depends on using good microbiological practices and using of safety equipment correctly. A risk assessment should identify any potential deficiencies in the practices of the laboratory workers. There may also be hazards that require specialized personal protective equipment (PPE) in addition to safety glasses, laboratory gowns, and gloves. PIs should train and retrain their staff to the point where aseptic techniques and safety precautions become second nature. Inadequate training in the

proper use of PPE may reduce its effectiveness, provide a false sense of security, and could increase the risk to the laboratory worker.

Safety Equipment
Safety equipment such as biological safety cabinets (BSCs), centrifuge safety cups, and sealed rotors are used to provide a high degree of protection for the laboratory worker from exposure to microbial aerosols and droplets. Safety equipment that is not working properly is hazardous, especially when the user is unaware of the malfunction. The containment capability of a BSC is compromised by poor location, room air currents, decreased airflow, leaking filters, raised sashes, crowded work surfaces, and poor user technique. The safety characteristics of modern centrifuges are only effective if the equipment is operated properly. Training in the correct use of equipment, proper procedure, routine inspections, and potential malfunctions, and periodic re-certification of equipment, as needed, is essential.

Facility Safeguards
Consideration of facility safeguards is an integral part of the risk assessments. Facility safeguards help prevent the accidental release of an agent from the laboratory. Their use is particularly important at biosafety levels (BSLs) 3 and 4 because the agents assigned to those levels can transmit disease by the inhalation route or can cause life-threatening disease.

One facility safeguard is directional airflow that helps to prevent aerosol transmission from a laboratory into other areas of the building. Directional airflow is dependent on the operational integrity of the laboratory's heating, ventilation, and air conditioning (HVAC) system. HVAC systems require careful monitoring and periodic maintenance to sustain operational integrity. Loss of directional airflow compromises safe laboratory operation.

<u>An Approach to Assess Agent and Procedure Risks and to Select Appropriate Safeguards</u>

Biological risk assessment is a subjective process that requires consideration of many hazardous characteristics of agents and procedures. BMBL describes a five-step approach that gives structure to the risk assessment process:

- *First, identify agent hazards and perform an initial assessment of risk.* Consider the principal hazardous characteristics of the agent, which include its capability to infect and cause disease in a susceptible human host, severity of disease, and the availability of preventive measures and effective treatments.
- *Second, identify laboratory procedure hazards.* The principal laboratory procedure hazards are agent concentration, suspension volume, equipment and procedures that generate small particle aerosols and larger airborne particles (droplets), and use of sharps. Procedures involving animals can present a number of hazards such as bites and scratches, exposure to zoonotic agents, and the handling of experimentally generated infectious aerosols. The complexity of a laboratory procedure can also present a hazard.
- *Third, make a final determination of the appropriate biosafety level and select additional precautions indicated by the risk assessment.* The final selection of the appropriate BSL and the selection of any additional laboratory precautions require a comprehensive understanding of the practices, safety equipment, and facility

safeguards.

- *Fourth, evaluate the proficiencies of laboratory workers regarding safe practices and the integrity of safety equipment.* The protection of laboratory workers, other persons associated with the laboratory, and the public will depend ultimately on the laboratory workers themselves. In conducting a risk assessment, the PI should ensure that laboratory workers have acquired the technical proficiency in the use of microbiological practices and safety equipment required for the safe handling of the agent, and have developed good habits that sustain excellence in the performance of those practices. An evaluation of a person's training, experience in handling infectious agents, proficiency in the use of sterile techniques and BSCs, ability to respond to emergencies, and willingness to accept responsibility for protecting oneself and others is important insurance that a laboratory worker is capable of working safely.

  The PI should also ensure that the necessary safety equipment is available and operating properly. For example, a BSC that is not certified represents a potentially serious hazard to the laboratory worker using it and to others in the laboratory. The PI should have all equipment deficiencies corrected before starting work with an agent.

- *Fifth, review the risk assessment with a biosafety professional/subject matter expert.* A review of the risk assessment and selected safeguards by knowledgeable individuals is always beneficial and sometimes required by regulatory or funding agencies. Adopting this step voluntarily will promote the use of safe practices in work with hazardous agents in microbiological and biomedical laboratories.

7.2 ROUTES OF EXPOSURE

There are four routes of exposure or four ways in which a person can encounter infectious agents. These routes are:

- Direct skin, eye, or mucosal membrane exposure to an agent
- Parenteral inoculation by a syringe needle or other contaminated sharp, or by bites from infected animals and arthropod vectors
- Ingestion of liquid suspension of an infectious agent, or by contaminated hand to mouth exposure
- Inhalation of infectious aerosols

Each of these routes of exposure is discussed below.

Contact with Skin, Eye, or Mucosal Membrane

Spilled material can come into direct contact on the skin, as can droplets produced by pipetting, removal of screw caps, and vortex mixing of unsealed tubes.

The control of a contact exposure is accomplished through the wearing of appropriate protective clothing such as a face shield, gloves, safety glasses, a mask, and laboratory coat. Other ways to control contact exposure include using absorbent paper on the workbench, performing all procedures carefully, and frequently wiping work surfaces with a disinfectant.

It is also important to keep all non-essential items away from the area where work is being performed to protect personal items from contamination. Handle and store all contaminated wastes properly to prevent contact exposure of lab personnel as well as housekeeping staff and waste handlers.

Inoculation

Inoculation in a laboratory usually occurs with a needle/syringe concept. Exercise extreme caution whenever using a needle. Restrict needle use: Whenever an alternative to a needle is possible, use it. Inoculation can also occur through animal bites and other sharps such as Pasteur pipettes and razor blades.

The control of an inoculation hazard is accomplished by the safe use, handling, and storage of needles and other sharps. After using a needle, do not re-cap, bend, break, remove it from the syringe, or manipulate it in any way. Many people have been accidentally stuck with a needle during the process of re-capping it. Simply place the needle and other sharps into a sharps container to prevent any injuries. Contact EH&S at 817-272-2185 for sharps containers.

Ingestion

Ingestion may occur either directly or indirectly. Exposure may occur from mouth pipetting or splashing from a container into the mouth or by contaminating the hands and then touching the mouth or items, such as a coffee cup, food, or lip balm, which then touches the mouth.

The control of an ingestion exposure is accomplished through the use of mechanical pipetting devices whenever pipetting and by practicing good personal hygiene, such as washing hands frequently throughout the day and not eating or drinking in the work area. Food items cannot be stored in refrigerators that contain hazardous materials or in the laboratory where work with infectious agents is being performed.

Inhalation

It is generally known that aerosols are the primary means by which infectious diseases are spread and contracted. An agent capable of transmitting disease through respiratory exposure to infectious aerosols is a serious laboratory hazard, both for the person handling the agent and for other laboratory occupants. An aerosol can be either a liquid or a dry particle. An aerosol with a diameter of five microns or less can easily be inhaled and carried to the alveoli of the lungs. These aerosols can remain airborne for a long period and can spread wide distances, especially after entering the building ventilation system. Particles with a diameter larger than five microns tend to settle rapidly and can contaminate the skin or other surfaces. There are many commonly performed procedures in the laboratory that can create aerosols. Examples include centrifuging, sterilizing inoculating loops in flame, using a blender, blowing out the last drop in a pipette, and changing animal bedding.

The control of an inhalation exposure is accomplished by a combination of using the appropriate safety equipment such as BSC and by performing procedures carefully to minimize the creation of aerosols. Refer to the following section on Laboratory Equipment for additional information.

7.3 LABORATORY EQUIPMENT

Biological Safety Cabinets

A biological safety cabinet (BSC) is used as a primary barrier against exposure to infectious biological agents. A BSC has High Efficiency Particulate Air (HEPA) or Ultra Low Particulate Air (ULPA) filters. The airflow in a BSC is laminar, in other words, the air moves with uniform velocity in one direction along parallel flow lines. A BSC must be used in conjunction with safe laboratory techniques, because potentially dangerous aerosols can still escape.

Depending on the design, a BSC may be vented to the outside or the air may be exhausted into the room. BSCs are not chemical fume hoods. A percentage of the air is recirculated in most types of BSCs. Therefore, the levels of explosive, flammable, or toxic materials will be concentrated within the cabinet. HEPAULPA filters only trap particulates, allowing any contaminant in non-particulate form to pass through the filters.

Classification of BSCs

BSCs are designed to provide personnel, environmental, and product protection when appropriate practices and procedures are followed. Three types of BSCs, designated as Class I, II, and III, have been developed to meet varying research and clinical needs.

Class I

In Class I BSCs, the exhaust air is HEPA/ULPA-filtered so the user and the environment are protected, but the product inside the cabinet is not. With a class I cabinet, the user's hands and arms while inside the cabinet are exposed to the infectious materials. The class I BSC is designed for general microbiological research with low to moderate risk agents, and is useful for containment of mixers, blenders, and other equipment.

Class II

There are different types of Class II BSCs, but they all offer HEPA/ULPA-filtered supply and exhaust air. This type of cabinet will protect the user, environment, and the product, and is suitable for work assigned to BSLs 1, 2, or 3. Class II cabinets are the type most commonly used.

Class III

These cabinets are often referred to as glove boxes. The class III cabinet is gas-tight and under negative pressure. All work in the cabinet is performed through rubber gloves attached to entry portals. The Class III cabinet offers the highest level of protection from infectious aerosols. Class III cabinets are most suitable for work with agents that require BSL-3 or BSL-4 containment.

Certification of BSCs

The operational integrity of a BSC must be validated before it is placed into service and after it has been repaired or relocated. Relocation may break the HEPA/UPLA filter seals or damage the filters/the cabinet. Each BSC should be tested and certified at least annually to ensure continued, proper operation.

NSF Standard #49 for Class II BSCs (2) establishes performance criteria and provides the

minimum testing requirements that are accepted in the United States. Cabinets that meet the Standard and are certified by NSF bear an NSF Mark.

The purpose and acceptance level of the operational tests ensure the balance of inflow and exhaust air, the distribution of air onto the work surface, and the integrity of the cabinet and the filters. BMBL strongly recommends that accredited field certifiers be used to test and certify BSCs. The certification sticker is fixed to the front glass pane of the BSC.

Working in Class II BSC

A BSC must be used properly to effectively protect the worker and the product.

Following are some tips how to work safely in a BSC:

WORKING SAFELY IN CLASS II BSC
1) Plan the experiment and gather all needed materials. Prevent unnecessary opening and closing of room doors when working in the BSC as this will disrupt the airflow. Post a sign on the door stating that the cabinet is in use.
2) You should not have to penetrate the air barrier of the cabinet once work has begun. In-and-out movement affects the containment air curtain at the cabinet face so place everything necessary inside the cabinet before beginning work, including a waste container.
3) Only place materials needed for the immediate operation inside of the cabinet. Spare supplies should go outside on a cart. Overloading of the cabinet will affect the airflow adversely.
4) On initial startup of the blower, allow the cabinet to purge for 5 minutes. Wipe the interior and all supplies with an appropriate disinfectant, e.g., 70% alcohol.
5) Always wear lab coat while using the cabinet.
6) Adjust stool, place arms in cabinet, wait one minute, work at least 4 inches inside of the front grill.
7) Absorbent toweling/disinfectant soaked towel may be used to reduce splashes/contain any spatters or small spills that might occur. Do not place anything on the air intake grilles, as this will block the air supply.
8) Reduce in/out movements of arms.
9) Do not work in the BSC while the ultraviolet (UV) light is on. UV light can quickly injure the eyes.
10) Open flames are not required in the near microbe-free environment of a BSC. An open flame creates turbulence that disrupts the airflow. When necessary touch-plate microburners equipped with a pilot light to provide a flame on demand may be used. Use disposable sterile loops whenever possible.
11) Connect aspirator bottles or suction flasks to an overflow collection flask containing appropriate disinfectant, and to an in-line HEPA or equivalent filter. This combination will provide protection to the central building vacuum system or vacuum pump as well as to the personnel who service this system.
12) Place discards in pans with disinfectant and allow appropriate contact time before removal from cabinet for discard into biohazard boxes.

WORKING SAFELY IN CLASS II BSC
13) Alternatively, autoclave prior to disposal. Add water into kill load biohazard bags while still inside the cabinet before removing it for autoclaving.
14) Surface decontaminate all supplies/equipment before removing them from the cabinet. Do a final surface decontamination on all cabinet surfaces and interior of glass. Remove gloves and wash hands before touching any surfaces outside of cabinet.
15) Operate the cabinet for five minutes after performing any work in it in order to purge airborne contaminants. Remove protective clothing and wash hands and arms thoroughly before leaving the laboratory.

Clean Benches

Clean benches are not considered laboratory safety equipment. However, they deserve mention because they may be confused with BSCs. Clean benches direct HEPA-filtered air over the work area to protect biological specimens from particulate contamination by bathing the work area with HEPA-filtered air that is free of particulate contamination. Because they do not provide protection to the user, they should not be used in conjunction with biohazardous material, toxins, or radionuclides.

Pipetting Devices

Pipets are among the most commonly-used pieces of equipment in the biological laboratory, and their misuse has been related to a significant number of LAIs. Regrettably, many laboratory workers were taught to pipette by mouth, even after the associated hazards were recognized. With the availability of mechanical pipetting devices, mouth pipetting is now strictly prohibited. To minimize aerosol production, drain a pipet with the tip against the inner wall of the receiving vessel. Never forcibly expel any hazardous material from a pipette.

Centrifuges, Sonicators, Homogenizers, and Blenders

All of these instruments can create aerosols, and this must be considered with each use. If hazardous materials such as carcinogens, highly toxic, or infectious agents are going to be placed in any of these instruments, then you must take precautions to prevent an exposure of laboratory personnel to aerosols or liquids.

<u>Centrifuges</u>

Centrifugation is an operation that involves a lot of energy and finely-tuned mechanical instruments. There are many documented cases of occupational laboratory exposures due to centrifugation accidents, which nearly always result from aerosol exposure to the room occupants. To minimize the risk of mechanical failure, place centrifuges on a strict maintenance schedule, use according to the manufacturer's instructions, and routinely inspect to ensure leakage is not occurring. Users should be properly trained in their operation. Safety precautions should be prominently posted on each unit.

Aerosols are also created by practices such as filling centrifuge tubes, removing plugs or caps from tubes after centrifugation, removing supernatant, and re-suspending pellets. Severe aerosol hazards can be created when a tube with infectious materials breaks during centrifugation. To minimize the generation of aerosols when centrifuging biohazardous

material, the following procedure should be followed:

WORKING SAFELY WITH CENTRIFUGES
1) Use sealed tubes placed inside of capped safety buckets (safety cups) that seal with O-rings. Before use, inspect tubes, O-rings, cups, and buckets for cracks, chips, erosions, bits of broken glass, etc. Do not use aluminum foil or any other loose caps to close centrifuge tubes.
2) Fill, open, and seal centrifuge tubes, rotors, and accessories inside a BSC. Avoid overfilling of centrifuge tubes so closures will not become wet while spinning in a horizontal or angled position.
3) After tubes are filled and sealed, wipe them down with disinfectant before placing them in the rotor.
4) Always balance buckets, tubes, and rotors properly before centrifugation.
5) Select the type of centrifuge tube (glass type, or plastic-polymer type) that is best suited to the chemicals you will be using and the speed at which you are spinning to avoid melted or shattered tubes.

Sonicators, Homogenizers, and Blenders

Operation of these or similar instruments may create hazardous aerosols and lead to exposure of personnel unless you exercise extreme caution. Depending on the nature of the material being used in these instruments, it may be necessary for them to be used or opened only in a BSC. When working with infectious agents, blenders should have leak proof bearings and a tight-fitting, gasketed lid.

Inspect the lid and gaskets routinely to ensure that they are in good condition. Household blenders do not prevent the spread of aerosols. In addition, hearing protection may be required while using a sonicator.

7.4 PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) is defined as specialized clothing or equipment worn by a laboratory worker for protection against a hazard. General work clothes (for example, uniforms, pants, shirts, or blouses) are not intended to function as protection against a hazard and are not considered PPE. The type of PPE required in microbiological/biochemical laboratories will depend upon the assigned BSL for that laboratory (see Biosafety Levels section.)

University departments will provide at no cost to the employee, appropriate PPE to prohibit blood or other potentially infectious materials (OPIM) to pass through to or reach the employee's work clothes, street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time that the protective equipment will be used.

All PPE shall be removed prior to leaving the laboratory.

Gowns, Apron and Other Protective Body Clothing

The protective clothing suitable for a typical undergraduate laboratory is a lab coat to prevent street clothes from being soiled. Restrain long hair if Bunsen burners are in use.

Teaching or research laboratory users working with hazardous chemicals must wear closed-toe shoes, long pants or skirts which fully cover the legs, and a lab coat

Protective clothing needs to be left in the laboratory and is not to be worn to other non-laboratory areas.

Cleaning, Laundering, and/or Disposal of Personal Protective Equipment

If a personal protective clothing becomes contaminated (garment is penetrated by blood or OPIM it should be removed immediately or as soon as feasible. Contaminated laundry should be handled as little as possible with a minimum of agitation and be bagged (in red bags) or containerized without sorting or rinsing in the location of use. If contaminated laundry is sent to a facility that does not utilize Universal Precautions in the handling of all laundry, the department must ensure that the red bags are labeled with the universal biohazard symbol and the word “biohazard”.

Whenever contaminated laundry is wet and presents a reasonable likelihood of soak-through or of leakage from the bag or container, the laundry should be placed and transported in bags or containers that prevent soak-through and/or leakage of fluids to the exterior.

Gloves

Gloves must be worn when it can be reasonably anticipated that the laboratory worker may have hand contact with biohazardous agents, blood, OPIMor any infectious materials.

Disposable, single-use gloves need to be replaced as soon as practical when contaminated or as soon as feasible if they are torn, punctured, or when their ability to function as a barrier is compromised.

Disposable gloves are meant to be used only once and should then be discarded. Latex gloves used in a wet procedure should be replaced after one hour of use. In between glove changes, hands and arms have to be washed thoroughly. Disposable, single-use gloves shall not be washed or decontaminated for reuse.

Utility gloves may be decontaminated for reuse if the integrity of the glove is not compromised. However, they must be discarded if they are cracked, peeling, torn, punctured, or exhibit other signs of deterioration or when their ability to function as a barrier is compromised.

Masks, Eye Protection and Face Shields

Masks in combination with eye protection devices, such as goggles or glasses with solid side shields, or chin-length face shields, have to be worn whenever splashes, spray, spatter, or droplets of biohazardous materials, blood or OPIM may be generated and eye, nose, or mouth contamination can be reasonably anticipated.

7.5 BIOSAFETY LEVELS

The Centers for Disease Control and Prevention (CDC) and the National Institutes of Health (NIH) have developed standard procedures providing protection against biological hazards. BMBL (1) provides specific descriptions of combinations of microbiological practices, laboratory facilities, and safety equipment, and recommends their use in four biosafety levels (BSLs) of operation with infectious agents. These BSLs are described below. The BSLs described in the NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (NIH Guidelines) (2016) (3) are based on and consistent with the BSLs presented here.

A BSL is based on the potential hazard of the agent and the functions of the laboratory. BSL-1 is for work with agents that pose the least hazard and BSL-4 is for work with agents that pose the greatest hazard. Only BSL-1 and 2 laboratories exist at UTA. All work with infectious agents at the University should follow the CDC/NIH guidelines. If you are uncertain which BSL your work should be performed at, please contact EH&S at 817-272-2185 for assistance.

7.5.1 Biosafety Level 1

BSL-1 is suitable for work involving well-characterized agents not known to cause disease in healthy adults, and of minimal potential hazard to laboratory personnel and the environment. The laboratory is not necessarily separated from the general traffic patterns in the building. Work is generally conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is not required nor generally used. Laboratory personnel have specific training in the procedures conducted in the laboratory and are supervised by a scientist with general training in microbiology or a related science.

Standard Microbiological Practices (BSL-1)

1. Access to the laboratory is limited or restricted at the discretion of the PI when experiments or work with cultures and specimens are in progress.
2. Persons wash their hands after they handle viable materials, after removing gloves, and before leaving the laboratory.
3. Eating, drinking, handling contact lenses, applying cosmetics, and storing food for human consumption are not permitted in the work areas. Persons who wear contact lenses in laboratories should also wear goggles or safety glasses. Food is stored outside the work area in cabinets or refrigerators designated (and labeled) and used for this purpose only.
4. Mouth pipetting is prohibited; mechanical pipetting devices are used.
5. All procedures are performed carefully to minimize the creation of splashes or aerosols.
6. Work surfaces are decontaminated at least once a day and after any spill of viable material.
7. Take special care when using "sharps," in other words, syringes with needles, Pasteur pipettes, capillary tubes, scalpels, and other sharp instruments, or when handling broken glassware to reduce risk of sharps injuries.

8. All cultures, stocks, and other regulated wastes are decontaminated before disposal by an approved decontamination method, such as autoclaving. Materials to be decontaminated outside of the immediate laboratory are to be placed in a durable, leak proof container and closed for transport from the laboratory. Materials to be decontaminated off-site from the laboratory are packaged in accordance with applicable local, state, and federal regulations, before removal from the facility. If you have questions concerning biohazardous waste disposal, contact EH&S, 817-272-2185.
9. An insect and rodent control program is in effect.

Special Practices (BLS-1)
None.

Safety Equipment (Primary Barriers) (BSL-1)

- Special containment devices or equipment such as a BSC are generally not required for manipulations of agents assigned to BSL-1.
- Protective laboratory coats, gowns, or uniforms are recommended to prevent contamination or soiling of personal clothing.
- Gloves must be worn to protect hands from exposure to hazardous materials. This is especially important if the skin on the hands is broken or if a rash exists.
- Always wear protective eyewear when conducting procedures that have the potential to create splashes of microorganisms or other hazardous materials. You should not wear contact lenses in laboratories without eye protection.

Laboratory Facilities (Secondary Barriers) (BSL-1)

- Laboratory door(s) are for access control.
- Each laboratory contains a sink for hand washing.
- The laboratory is designed so that it can be easily cleaned. Carpets and rugs in laboratories are not appropriate.
- Laboratory furniture is sturdy. Spaces between benches, cabinets, and equipment are accessible for cleaning.
  Bench tops are impervious to water and resistant to moderate heat, acids, alkalis, organic solvents, and other chemicals.
- If the laboratory has windows that open, they are fitted with insect-proof screens.

Examples of BSL-1 Agents

- *Bacillus subtilis*
- *Escherichia coli*
- Infectious canine hepatitis virus

7.5.2 Biosafety Level 2

BSL-2 builds upon BSL-1 and is suitable for work involving agents of moderate potential hazard to personnel and the environment. It differs from BSL-1 in that

- laboratory personnel have specific training in handling pathogenic agents and are directed by scientists competent in handling infectious agents and associated procedures,

- access to the laboratory is limited when work is being conducted,
- extreme precautions are taken with contaminated sharp items, and
- certain procedures in which infectious aerosols or splashes may be created are conducted in BSC or other physical containment equipment.

Standard Microbiological Practices (BSL-2)
Same as BSL-1.

Special Practices (BSL-2)
Access to the laboratory is limited or restricted by the PI when work with infectious agents is in progress. In general, persons who are at increased risk of acquiring infection, or for whom infection may be unusually hazardous (immunocompromised, immunosuppressed, pregnant women), are not allowed in BSL-2 laboratories or animal rooms.

- The PI establishes policies and procedures whereby only persons who have been advised of the potential hazard and meet specific entry requirements (for example, appropriate immunization) may enter the laboratory or animal rooms.
- When the infectious agent(s) in use in the laboratory require special provisions for entry, the universal biohazard sign must be posted on the entrance door to the laboratory. The appropriate information to be posted on the entrance door include: biosafety level, list of infectious agent(s), name(s) and telephone number(s) of the principal investigator, contact information after work hours, and any PPE that must be worn in the laboratory.
- Laboratory personnel receive appropriate immunizations or tests for the agents handled or potentially present in the laboratory (for example, hepatitis B vaccine or TB skin testing).
- When appropriate, considering the agent(s) handled baseline serum samples for laboratory and other at-risk personnel are collected and stored. Additional serum specimens may be collected periodically, depending on the agents handled or the function of the facility.
- Site-specific biosafety procedures are prepared and adopted in addition to this UTA EH&S Laboratory Safety Manual. The site-specific procedures should advise personnel about special hazards and practices / procedures that are required to be followed when working in the laboratory.
- Laboratory and support personnel receive appropriate training on the potential hazards associated with the work involved, the necessary precautions to prevent exposures, and the exposure evaluation procedures. Personnel receive annual updates, or additional training as necessary for procedural or policy changes.
- Always take a high degree of precaution with any contaminated sharp item, including needles and syringes, slides, pipettes, capillary tubes, and scalpels.
- Restrict needles and syringes or other sharp instruments for use only when there is no alternative, such as parenteral injection, phlebotomy, or aspiration of fluids from laboratory animals and diaphragm bottles.

- Use only needle-locking syringes or disposable syringe-needle units (in other words, needle is integral to the syringe) for the injection or aspiration of infectious materials.
- Do not bend, shear, brake, recap or remove needles from disposable syringes, or otherwise manipulate them by hand before disposal. Place used disposable needles and syringes carefully in puncture-resistant containers used for sharps disposal. These sharps containers will be supplied and removed by EH&S for disposal. Place non-disposable sharps in a hard-walled container for transport to a decontamination area, in other words, autoclave room. Do not handle broken glassware directly. Use a brush and dustpan, tongs, or forceps. Plasticware should be substituted for glassware whenever possible.
- Place cultures, tissues, or specimens of body fluids in a container that prevents leakage during collection, handling, processing, storage, transport, or shipping.
- Routinely decontaminate laboratory equipment and work surfaces with an appropriate disinfectant, after you finish work with infectious materials, and especially after overt spills, splashes, or other contamination by infectious materials. Decontaminate equipment according to any local, state, or federal regulations before it is sent for repair or maintenance or packaged for transport in accordance with applicable local, state, or federal regulations, before removal from the facility.
- Immediately report spills and accidents which result in overt exposures to infectious materials to the PI and EH&S, 817-272-2185. Medical evaluation, surveillance, and treatment are provided as appropriate and written records are maintained.
- Animals and plants not involved in work being performed are not permitted in the laboratory.

Safety Equipment (Primary Barriers) (BSL-2)

- Properly maintained BSCs, preferably Class II, other appropriate PPE, or other physical containment devices are used whenever:
    - Procedures with a potential for creating infectious aerosols or splashes are conducted. These may include centrifuging, grinding, blending, vigorous shaking or mixing, sonic disruption, opening containers of infectious materials whose internal pressures may be different from ambient pressures, inoculating animals intra-nasally, and harvesting infected tissues from animals or embryos.
    - High concentrations or large volumes of infectious agents are used. Such materials may be centrifuged in the open laboratory if sealed rotor heads or centrifuge safety cups are used, and if these rotors or safety cups are opened only in a BSC.
- Eye and face protection (goggles, face shield or other splatter guards) is used for anticipated splashes or sprays of infectious or other hazardous materials to the face, when the microorganisms must be manipulated outside the BSC.
- Protective laboratory coats, gowns, smocks, or uniforms designated for laboratory use are worn while in the laboratory. This protective clothing is removed and left in

the laboratory before leaving for non-laboratory areas (for example, cafeteria, library, administrative offices). All protective clothing is either disposed of in the laboratory or laundered by the institution. It is recommended that personnel do not take laboratory clothing home.

Gloves are worn to protect hands from exposure to hazardous materials.

- Glove selection should be based on an appropriate risk assessment. Alternatives to latex gloves should be available. Wearing two pairs of gloves may be appropriate: If a spill or splatter occurs, the hand will be protected after the contaminated gloves are removed. Change gloves when contaminated, integrity has been compromised, or when otherwise necessary. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory. Never wash or reuse disposable gloves. They should be disposed with other contaminated laboratory waste. Disposable gloves are not worn outside the laboratory.
- Emphasize the importance of hand-washing!

Laboratory Facilities (Secondary Barriers) (BSL-2)

- Laboratory doors are lockable.
- Each laboratory contains a sink for hand washing.
- The laboratory is designed so that it can be easily cleaned. Carpets and rugs in laboratories are inappropriate.
- Laboratory furniture is capable of supporting anticipated loading and uses. Spaces between benches, cabinets, and equipment are accessible for cleaning. Chairs and other furniture used in laboratory work should be covered with a non-fabric material that can be easily cleaned and decontaminated.
- Bench tops are impervious to water and resistant to moderate heat, acids, alkalis, organic solvents, and other chemicals.
- If the laboratory has windows that open, they are fitted with fly-proof screens.
- Install (BSCs in such a manner that fluctuations of the room air supply and exhaust do not interfere with proper operations. Locate BSCs away from doors, windows that can be opened, heavily traveled laboratory areas, and other possible airflow disruptions.
- HEPA/ULPA filtered exhaust air from a Class II BSC can be safely re-circulated back into the laboratory environment if the cabinet is tested and certified at least annually and operated according to manufacturer’s recommendations. BSCs can also be connected to the laboratory exhaust system by either a thimble (canopy) or a direct (hard) connection.
- An eyewash station is readily available.
- A method for decontamination of infectious or regulated laboratory wastes is available (for example, autoclave, chemical disinfection, incinerator, or other approved decontamination system).

- There are no specific ventilation requirements. However, planning of new facilities should consider mechanical ventilation systems that provide an inward flow of air without re-circulation to spaces outside of the laboratory.

Examples of BSL-2 Agents

- *Bordetella pertussis*
- *Campylobacter jejuni* subsp. *jejuni*
- *Clostridium tetani*
- *Listeria monocytogenes*
- *Mycobacterium tuberculosis*
- *Salmonellae*
- Shiga toxin-producing *Escherichia coli* strains
- *Shigella* spp.
- *Toxoplasma* spp.
- *Vibrio cholera*
- *Yersinia pestis*
- Hepatitis A & E virus
- Measles virus

7.5.3 Biosafety Level 3

BSL-3 is applicable to clinical, diagnostic, teaching, research, or production facilities where work is done with indigenous or exotic agents that may cause serious or potentially lethal disease through inhalation route exposure. A BSL-3 laboratory has special engineering and design features. Laboratory personnel have specific training in handling pathogenic and potentially lethal agents and are supervised by scientists who are experienced in working with these agents. All procedures involving the manipulation of infectious material are conducted within BSCs or other physical containment devices, or by personnel wearing appropriate personal protective clothing and equipment.

No BSL-3 laboratories exist at UTA.

Examples of BSL-3 Agents

- *Bacillus anthracis* (bacterial agent): For work involving production quantities or high concentrations of cultures, screening environmental samples from anthrax-contaminated locations, and for activities with a high potential for aerosol production.
- *Coxiella burnetii* (richettsial agent): For activities involving inoculation, incubation, and harvesting of embryonated eggs or cell cultures, necropsy of infected animals, and manipulation of infected tissues.
- *Francisella tularensis* (bacterial agent): During manipulations of cultures and for experimental animal studies.
- *Neisseria meningitis* (bacterial agent): For activities with a high potential for droplet or aerosol production and for activities involving production quantities or high concentrations of infectious materials.
- Yellow fever virus
- West Nile virus

7.5.4 Biosafety Level 4

BSL-4 practices, safety equipment, and facility design and construction are applicable for work with dangerous and exotic agents that pose a high individual risk of life-threatening disease, which may be transmitted via the aerosol route and which there is no available vaccine or therapy. Agents with a close or identical antigenic relationship to BSL-4 agents also should be handled at this level. When sufficient data are obtained, work with these agents may continue at this or lower level.

Laboratory staff must have specific and thorough training in handling extremely hazardous infectious agents and understand the primary and secondary containment functions of standard and special practices, containment equipment, and laboratory design characteristics. All laboratory staff and supervisors must be competent in handling agents and procedures requiring BSL-4 containment.

There are two models for BSL-4 laboratories:

- A *Cabinet Laboratory* where all handling of agents must be performed in a Class III BSC.
- A *Suit Laboratory* where personnel must wear a positive pressure protective suit.

BSL-4 cabinet and suit laboratories have special engineering and design features to prevent microorganisms from being disseminated into the environment.

No BSL-4 laboratories exist at UTA.

Examples of BSL-4 Agents

- Ebola (*Filovirus*)
- Hendra virus
- Nipah virus
- Omsk Hemorrhagic Fever (*Flavivirus*)

7.6 BLOODBORNE PATHOGENS AND UNIVERSAL PRECAUTIONS

In December 1991, the Occupational Safety and Health Administration (OSHA) promulgated the final rule (4) for occupational exposure to bloodborne pathogens. The rule, commonly referred to as the Bloodborne Pathogen standard, became effective March 6, 1992. OSHA published the revised standard in the *Federal Register* on January 18, 2001, which took effect on April 18, 2001. The objective is to provide guidelines to eliminate or minimize employee exposure to human bloodborne pathogens. Although UTA is not covered by OSHA's Bloodborne Pathogen standard, we are covered by the Health and Safety Code (5), which requires the Texas Department of State Health Services to establish an exposure control plan designed to minimize exposure of governmental entity employees to bloodborne pathogens.

A human bloodborne pathogen is a pathogenic microorganism present in human blood/OPIM that can cause disease in humans. Employees face a significant health risk from occupational exposure to these materials since they may contain bloodborne pathogens, including hepatitis B virus (HBV) that causes hepatitis B, a serious liver disease, and human immunodeficiency virus (HIV), which causes acquired immunodeficiency syndrome (AIDS).

The standard includes the Centers for Disease Control and Prevention (CDC) guidelines referred to as Universal Precautions. The concept behind Universal Precautions is to treat all

human blood and certain human body fluids as if known to be infected with HIV, HBV, and other bloodborne pathogens.

In an effort to eliminate or minimize exposure to bloodborne pathogens, the standard requires employers to institute:

- a program of engineering and work practice controls,
- personal protective clothing and equipment,
- informational training,
- hepatitis B vaccination,
- post exposure evaluation and follow-up,
- sign and label programs.

The standard also requires other provisions for employees who may be reasonably anticipated to be exposed to blood or OPIM during the performance of their duties. Tissue cultures/cells/cell lines may also unknowingly contain human pathogens, and this is why all human and non-human primate specimens and cell cultures must be handled using Universal Precautions.

Contact EH&S for information regarding Bloodborne Pathogen training if during the course of your work you have the potential for coming into contact with human blood or OPIM.

Universal Precautions are summarized below and should be practiced whenever encountering human blood/OPIM.

UNIVERSAL PRECAUTIONS/BLOODBORNE PATHOGENS PRACTICES
Bloodborne Pathogens (BBP) Training that needs to be taken annually is online. Taking the course online will automatically document completion of the training.
Identification of those that are at risk is important. If job duties have changed, and you now know that you are at risk, please notify EH&S of the change.
An Exposure Control Plan for Bloodborne Pathogens Manual can be found on EH&S website. Review of this manual and completion of the online BBP-training meet the Universal Precautions/BBP requirements for research areas.
Availability of free HBV vaccine and prophylaxis for needle sticks or other exposure incidents involving BBP.
Extreme sharps precautions, protective clothing and glove use, splash protection, and disinfection: Refer to the Special Practices and Safety Equipment (Primary Barriers) section for BSL-2 laboratories in this manual.

7.7 LABORATORY ANIMALS

Some animals can carry pathogens that can be transmitted to humans through contact with their body fluids, similar to human BBP. This contact can occur through biting, spitting, or contamination of broken skin or mucus membranes with bodily secretions from the animal.

The EH&S has adopted the National Research Council's "Guide for the Care and Use of

Laboratory Animals" (the Guide) (6) as a primary reference on animal care and use. The goal of the Guide is to promote humane care of animals used in research, teaching, and testing. Each institution should establish and provide resources for an animal care and use program that is managed in accord with the Guide and in compliance with applicable federal, state, and local laws and regulations such as the Federal Animal Welfare Regulations (7) and Public Health Service Policy on Humane Care and Use of Laboratory Animals (PHS Policy) (8).

Departments conducting animal research must have an effective occupational health and safety program that ensures that the risks associated with the experimental use of animals are reduced to acceptable levels. Potential hazards such as animal bites, chemical cleaning agents, allergens, and zoonoses that are inherent in or intrinsic to animal use should be identified and evaluated.

The Institutional Animal Care and Use Committee (IACUC) is a peer review committee that is charged with reviewing research protocols for the humane use of experimental animals. The IACUC must approve the work before experimental animals can be purchased. When the animal research involves the use of recombinant or synthetic nucleic acid molecules, the investigator must receive approval from the Institutional Biosafety Committee (IBC) for that agent's use in animals, before the IACUC can approve the animal work. Work with experimental animals is thus strictly regulated. Only those authorized can enter animal facilities or work with experimental animals in the facility. Access to animal facilities is controlled by ID badge key card entry. Before key card is activated, personnel must deliver and document animal operational and safety training.

7.8 EMERGENCY PROCEDURES

Refer to the Emergency Procedures and Equipment: Special Procedures for Biohazard Spills section of this manual for important information on emergency procedures. Some biological materials when spilled or released can lead to significant infection exposures of personnel. This is particularly hazardous when the agent spilled or released is classified as a BSL-2 agent. In the section, some specific instructions are given for the cleanup of a biological spill.

7.9 WASTE DISPOSAL

There are many types of waste generated in a microbiological laboratory and all need to be handled, treated, stored, and disposed of properly. Please, refer to the Biological (or Special) Wastes section of this manual.

References

1. *Biosafety in Microbiological and Biomedical Laboratories* (BMBL) 5th Edition, revised 20079.
2. Class II Biosafety Cabinet, NSF International Standard/American National Standard, NSF/ANSI 49 – 2002).
3. NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acid Molecules (NIH Guidelines), April 2016.
4. United State Department of Labor, Occupational Safety and Health Administration (OSHA),

Title 29 of the Code of Federal Regulations (CFR) 1910.1030,1992. Revised standard: April 18, 2001.

5. Health and Safety Code, §§81.301 – 81.307. Title 25. Health services, part 1. Department of State Health Services, Chapter 96. Bloodborne Pathogen Control, Amendments §§96.101, 96.201- 96.203, 96.301- 96.304, 96.401, 96.402, 96.501, Repeal §96.601, Bloodborne Pathogen Control, Bloodborne Pathogens, (Contaminated Sharps Injuries, Needlestick Prevention)**,** 2006.
6. Guide for the Care and Use of Laboratory Animals, National Research Council, 8th Edition 2011.
7. United States Department of Agriculture (USDA) Animal Welfare Act and Animal Welfare Regulations, 2017.
8. Public Health Service Policy on Humane Care and Use of Laboratory Animals (PHS Policy), Office of Laboratory Animal Welfare ((OLAW), 2002.

CHAPTER 8
IONIZING RADIATION HAZARDS AND CONTROL

8.1 Radioactive Materials

The University's Radiation Safety Manual covers radiation hazards and control pertaining to the use of radioactive materials.

The topics included in the manual are:

- Radiation safety program management
- Radiation facilities
- Operational radiation safety procedures
- Radioactive material accountability
- Radiation instrumentation
- Required tests and records
- Radioactive waste management and disposal
- Emergency procedures

Contact the Radiation Section of EH&S at 817-272-2185 for copies of the manual and/or to schedule required Radiation Safety Training.

Note: Radioactive decay in storage waste that is also regulated chemical waste should be managed in accordance with the procedures described in a following chapter entitled Chemical Waste. Radioactive waste not decayed in storage should not be mixed with hazardous waste.

8.2 Radiation Producing Machine (X-Ray Machines)

The University's Radiation Producing Machine Safety Manual covers radiation hazards and control pertaining to the use of radiation producing machines.

The topics included in the manual are:

- Administration and responsibility
- Radiation Producing Machines
- Protective Measures
- Emergency Procedures

Contact the Radiation Section of EH&S for copies of the manual and/or to schedule required Radiation Producing Machine Safety Training.

8.3 Laser Safety

The University's Laser Safety Manual covers radiation hazards and control pertaining to the use of lasers.

The topics included in the manual are:

- Laser safety program management
- Laser safety training
- Laser Registration
- Laser Standard Operating Procedures
- Laser Controlled Areas

Contact the Radiation Section of EH&S for copies of the manual and/or to schedule required Laser Safety Training.

CHAPTER 9
CONTROLLED SUBSTANCES, PRECURSOR CHEMICALS, AND CHEMICAL LABORATORY APPARATUS

Introduction

The objective of the implementation of a Memorandum of Understanding (MOU) is to define an institutional policy for the use of controlled items (chemical precursors and certain lab apparatus) on the campus of UTA. This procedure applies to all laboratories at UTA and is written in accordance with the MOU issued by the Texas Department of Public Safety (DPS) and the Texas Higher Education Coordinating Board (THECB), which became effective March 1, 1996, and revised June 13, 2006.

Scope

This guidance document establishes procedures for maintaining controlled substances, controlled substance analogs, chemical precursors, and chemical laboratory apparatus used in educational or research activities at institutions of higher education. The objective of the MOU is to heighten the awareness regarding the potential problem of the diversion of laboratory chemicals and apparatus to illegal drug operations. Each Principal Investigator (PI) at UTA intending to work with controlled substances shall apply for and receive an individual researcher registration from the U.S. Drug Enforcement Agency (DEA) and DPS. Each authorized registrant shall be directly responsible to the DEA and Texas DPS for the accurate logging, dispensing and security of controlled substances under their charge. Under no circumstances shall registrants dispense drugs to others without first ensuring procedural compliance with DEA regulations and a valid chain of custody is documented. Each registrant's records are subject to audit by EH&S. Additionally, the DEA may audit records and procedures used by each registrant, acting as the regulatory authority over the registrants. Procurement, logging of use, transfer, secure storage and disposal shall strictly follow the procedures outlined below.

The following is a list of the controlled items whose purchase, use, and disposal must be monitored:

9.1 LIST OF PRECURSOR ITEMS

Precursor Chemicals	Laboratory Apparatus
Methylamine	Condensers
Ethylamine	Distilling apparatus
D-lysergic acid	Vacuum dryers
Ergotamine tartrate	Three-necked flasks
Diethyl malonate	Distilling flasks
Malonic acid	Tableting machines
Ethyl malonate	Encapsulating machines
Barbituric acid	Filter funnels, buchner funnels, and
Piperidine	separatory funnels
N-acetylanthranilic acid	Erlenmyer flasks, two-necked flasks, single-neck flasks,
Pyrrolidine	round-bottom flasks, Florence
Phenylacetic acid	flasks, thermometer flasks, and filtering flasks
Anthranilic acid	Soxhlet extractors
Hypophosphorus acid	Transformers
Ephedrine	Flask heaters
Pseudoephedrine	Heating mantles
Norpseudoephedrine	Adapter tubes
Phenylpropanolamine	Condensers
Red phosphorus	Distilling apparatus

The MOU, which was signed by the Director of the DPS and the Commissioner of the Texas Higher Education Coordinating Board, commits the University to establish procedures that specify:

- personal responsibility for secure use of controlled items;
- record-keeping requirements for purchases;
- procedures for disposal of unused controlled items;
- security procedures governing use of the controlled items; and
- liaison between the University and DPS.

As written in the MOU, "the institution or site shall prohibit the sale, furnishing, or transfer of controlled items, including glassware, covered by this MOU to any person or entity not holding a DPS permit, unless the recipient is specifically exempted by law or rule." Full compliance with this Memorandum is required.

Full text of the MOU is available at the EH&S Office (817-272-2185) or online at http://www.thecb.state.tx.us/reports/PDF/1210.PDF.

9.2 RESPONSIBILITY

Any person (herein called the Responsible Party, RP) who wishes to purchase or accept controlled items must bear full responsibility for establishing security measures regarding their purchase, acceptance, use, and ultimate disposal. If the control items are to be used in a

research program supervised by an individual faculty member, the PI therefore becomes the RP, and must assume full responsibility. If the controlled items are to be used in a teaching laboratory or in a demonstration for an organized class, the Chair of the department through which the academic course is offered becomes the RP. Sharing of drug materials with non-registrants is strictly prohibited. Sharing of drug materials with registrants not approved for a specific listed drug is also prohibited. Registrants will ensure that only the registrant or his/her DEA approved designee (Power of Attorney required) will place the order for DEA controlled substances. **Under no circumstances will the registrant allow the academic department's office staff to call in the order for DEA controlled substances. Drugs shall be delivered by the shipper directly to the registrant or his/her DEA approved designate.** Under no circumstances can UTA personnel sign for and/or receive a package of DEA controlled substances for delivery. Should the registrant or his/her DEA approved designate not be available, **the package will be refused and returned to the shipper**. Registrants shall sign for receipt of the drugs ordered and initiate a usage log for the material purchased and received. Additionally, the invoice or DEA form 222 MUST be initialed and dated the day the material was received. If possible, also get a witness to initial receipt date on the invoice.

9.3 PURCHASE ORDERS

Registrants wishing to procure or otherwise acquire a listed drug shall first ensure that it is one for which they are currently registered. Authorized registrants shall only procure or otherwise control inventories that are directly related to teaching or research activities. Procurement Services has put in place a purchasing and record-keeping program to assist in tracking controlled items. These records can be obtained upon request by the RP (as defined above) or by any state or federal agency so authorized by law. All orders for a controlled item must be submitted by the RP to Procurement Services on a purchase requisition form. **RPs will not be able to order any of the controlled items utilizing the Procurement Card Program for small orders.** The controlled items on the purchase requisition form must be highlighted and followed by a statement that the item ordered is a controlled item. The location of use or storage of the item must be included on the purchase requisition form. Furnishing these items of information to Purchasing will enable them to maintain the records as required.

9.4 SURPLUS PROPERTY

The University will not place any of the controlled items on the MOU list into surplus property sales. Any RP wishing to dispose of controlled items should contact EH&S; any laboratory apparatus listed on the MOU will be destroyed by EH&S. The Supervisor of the University's Surplus Property will inform EH&S of any controlled items that come in for sale. EH&S will pick up these items and dispose of them properly.

9.5 DISPOSAL

DEA controlled substances that have expired or otherwise remain unused and are no longer needed by the registrant shall be disposed of through EH&S, via the UT System hazardous waste contractor registered with the DEA as a Reverse Distributor, who is authorized to take possession of Controlled Substances and destroy them at their incineration facilities.

9.6 SECURITY PROCEDURES GOVERNING USE OF CONTROLLED ITEMS

Controlled item security consists of site security, operational security, written inventory monitoring log, and loss reporting procedures. The responsible individual is also required to provide means by which the controlled items can be stored in accordance with recommendations of the manufacturer and the **Texas Commission on Environmental Quality (TCEQ)**. The procedures for storage and handling of controlled items must also adhere to all applicable state and federal laws.

9.7 SITE SECURITY

Drugs shall be stored within the DEA approved safe solely under the control of the registrant. The location of this safe is subject to approval by the institution and DEA. The facility or room where the safe is stored shall be secured when the registrant or his/her direct report is not present. UTA Police Department is available to assist in evaluating and making recommendations regarding site security.

Specific locations (for example, a laboratory or storage area assigned to the RP) should be established where controlled items are utilized and/or stored. All doors and windows must be locked when any room containing controlled items (or any rooms providing access to such a room) is not occupied.
Access to rooms containing controlled items must be restricted to personnel so authorized by the RP, and key control must be established so that only those so authorized can have access to the site. University Key Control Services stands ready to assist the RP in establishing assurance over keyed access to their assigned laboratories or storage areas.

9.8 OPERATIONAL SECURITY

Written procedures must be established by each RP to assure the proper use of controlled items in laboratories and storerooms. These procedures should be available for inspection by DPS and EH&S personnel at any time.

Personnel authorized by the RP to use, handle, or store the controlled items must be alert to any unauthorized personnel entering laboratories containing controlled items, and appropriate actions must be taken to assure the security of the controlled items when visitors are present.

9.9 INVENTORY AND REPORTING OF LOSS

The existence of the institutional record or copies does not in any way relieve the DEA registrant of his/her direct responsibilities under the federal regulations for documentation of receipt, usage or destruction. The registrant shall continually maintain usage logs in a manner available for inspection by the DEA regulatory authority and/or EH&S. Written prudent procedures must be established by the RP to quantitatively monitor the consumption and use of the controlled items. These procedures should be available for inspection by DEA, DPS and EH&S personnel at any time.

Personnel authorized by the RP to use, handle, or store the controlled items must be alert and attentive to the disappearance of any controlled items. In the event of a security breach to the laboratory involving theft and or loss of DEA controlled substances, the registrant must immediately report (within the next business day) the event to the UTA Police Department (UTPD) at 817-272-3003 and EH&S. EH&S, UTPD and the registrant will immediately conduct an inventory of the controlled substances on hand. Any theft or loss will be reported

to the DEA on Form DEA-106.

In the event of a security breach to the laboratory which is discovered by UTPD or reported to UTPD by someone other than the registrant, the UTPD will file a report and notify EH&S. EH&S will immediately initiate attempts to contact the registrant either at his/her UTA Laboratory, UTA office, at home and or cell phone. EH&S, UTPD and the registrant will then conduct an inventory of the controlled substances on hand. Any theft or loss will be reported to the DEA on Form DEA-106.

10.1 DESIGNATION OF A UNIVERSITY LIAISON

The Chief of Police of the University of Texas at Arlington is designated as the liaison between the Department of Public Safety and the University, and the DPS has been so informed.

Reference/ Forms

1. A Memorandum of Understanding (MOU) in accord with Health and Safety Code, Section 481.0621 (b) http://www.thecb.state.tx.us/reports/PDF/1210.PDF .
2. Record of Controlled Substances Administered/Dispensed form.
3. Controlled Substances Biennial Inventory Record form

CHAPTER 10
CHEMICAL WASTE

10.1 HAZARDOUS WASTES

A hazardous waste is a solid waste that can pose a substantial threat or potential hazard to the health of the public and/or the environment.

There are several types of hazardous wastes which include F, K, P, and U-listed waste. If a waste does not meet any of the four listed criteria, it is still classified as a hazardous waste if it exhibits any of the following characteristics: ignitability, corrosivity, reactivity, or toxicity (APPENDIX V).

The proper disposal of hazardous waste, such as chemicals, is necessary to prevent chemical exposure, preventable reactions, and to allow for cost-effective disposal.

The Environmental Health and Safety office (EH&S) is responsible for the removal of hazardous waste and for ensuring the proper transport, packaging, and disposal of said waste. Always handle waste as if it were hazardous and contact EH&S for disposal recommendations. The sole information available on safety data sheets (SDS) is not reliable because Texas state and local regulations may not have been taken into account in the preparation of SDS.

10.2 REGULATED WASTES

There are many wastes not defined as “hazardous wastes” that are regulated by the state and local agencies. Any questions regarding disposal of any waste, other than normal "household" trash, should be directed to EH&S.

10.3 GAS CYLINDERS

Gas cylinders should never be refilled by the laboratory and cannot be disposed of with normal trash. When a cylinder, other than lecture bottles, is ready for disposal, the gas distributors should be contacted for collection of said cylinder. By law, protective caps must be in place at all times while not in use and particularly when returned to the distributor (49 CFR § 173.301). The longer a cylinder is obtained, the more it will cost. Prompt return of cylinders will result in lower demurrage costs.

It is necessary to return cylinders as soon as possible after they are depleted. Never keep a cylinder longer than three years. Return all cylinders after a year, whether the entire contents have been used are not, if they contain corrosive or reactive gases (i.e. ammonia, chlorine, hydrogen chloride, ethylene oxide, silane, phosphine, or arsine). Many companies will not refund deposits or accept a cylinder for return if it has been on-site over one year. Lecture bottles can be costly to dispose of, to prevent expensive disposal cost, cylinders should be purchased and returned to the manufacture. Lecture bottles may need to be disposed of as hazardous waste unless the bottles can be proven as empty. When selecting a cylinder vendor, it is crucial to insure that company will accept the return of used cylinders.

Special attention must be given to deteriorated cylinder valves and unknown cylinders. A cylinder’s valve will deteriorate over time as the cylinder ages (especially if it contains a corrosive gas). If any noticeable deterioration has occurred, a specialist must be notified for proper disposal. Unknown gas cylinders also require specialized handling because the age

and contents of the cylinder is unknown. Special testing and handling is required to dispose of said cylinders. It is necessary to have an up-to-date inventory to avoid unknown and deteriorated cylinders.

EH&S Hazardous Materials Section can dispose of many varieties of gases if they cannot be returned to the manufacturer. For a partial list of what this office can handle, see the cylinder list in APPENDIX IV.

10.4 CONTAINERS

Disposal procedures for empty containers depend on the previous contents and the efficiency of emptying them. Containers of pourable contents must be completely emptied with no significant amount of the contents remains. Containers of thick or solidified materials must be scraped out or drained until no more than one inch of material remains in the bottom of the container or no more than 3% of the original weight of the contents remains. Chemical containers that meet these criteria are considered empty and may be disposed of through normal trash collection procedures, given the following provisions:

- If the container labels are removed or made unreadable by painting over or affixing an "empty" sticker over the previous label (stickers are available from EH&S)
- If the sole active ingredient of the previous contents was not acutely hazardous (see list of acutely hazardous waste in APPENDIX VI).
- If containers are triple-rinsed with water or other suitable solvent and air-dried to ensure that the container is free of any residue.

Note: Containers in excess of 20 gallons must be disposed by EH&S.

If containers cannot be emptied or if they contain acutely hazardous waste, submit a request via CEMS to have EH&S collect and dispose of the waste in accordance with the procedures described in this manual. You can also utilize a used container to temporarily hold waste for pickup if the waste is compatible with the residue and is in good condition with no visible signs of leaking and placed in appropriate secondary containment.

10.5 BROKEN GLASSWARE

Broken glassware that may be capable of transmitting infectious disease should be handled as a "sharp" and placed in a sharps receptacle. Chemically contaminated broken glassware should be placed in a puncture-resistant container and EH&S should be contacted for proper disposal. Non-contaminated broken glassware must be placed into the puncture-resistant containers that are provided and disposed of by Facilities Management Custodial Services. Please contact a supervisor in Custodial Services at (817)-272-2602 to obtain the “glass only” puncture-resistant containers. Once a “glass only” container is a third full or weight is not exceeding 40 pounds, the receptacle should be closed and placed in hallway for pickup by custodial staff members.

10.6 PCB LIGHT BALLASTS

Polychlorinated biphenyls (PCBs) were commonly used in small capacitor within fluorescent light ballast. These were once widely manufactured by combining chlorine gas, iron filings, and biphenyls until production of PCBs was banned in 1979. Intact PCB containing light ballast do not pose any health or environmental hazard. However, leaking

PCB ballast can pose health hazards to occupants and is difficult and costly to clean up.
Any person who encounters a leaking light ballast should avoid contact with the leaking liquid, evacuate the room, and immediately notify EH&S and Facilities Management at (817) 272-3571.
If a ballast is not clearly marked with "NO PCBs", it should be assumed to contain PCBs and placed into DOT-approved steel drums designated for PCB light ballasts. The marking must appear on the original manufacturer's label, not written on or added to the label after manufacturing. All PCB-containing ballasts should be inspected for signs of leaks. Leaking content is likely to be PCBs if clearish-yellow or to be tar if black. A leak of either or both should be considered a leak of PCBs unless the ballast is labeled "NO PCBs".
If an electrician discovers a leaking ballast, while rubber gloves, they should cut and cap the power wire. The fixture should then be marked. The electrician should contact EH&S at (817) 272-2185. The electrician will need to be present when EH&S response team arrives. EH&S must dispose of all ballasts marked "NO PCBs" on the original manufacturer's label. Note: EH&S will furnish all drums upon request but advanced notice is required large ballast removal jobs.

10.7 BATTERIES

Alkaline batteries can be recycled through the University of Texas at Arlington’s Office of Sustainability’s recycling program. These batteries do not have sufficient contaminants to treat satisfactorily. Contact the Sustainability Office at (817) 272-9299 for pickup. Nickel-cadmium, lead acid, lithium, and mercury batteries should all be disposed of through EH&S. Broken or leaking batteries require to be cleaned up promptly, contact EH&S for cleanup. Parts and residues of broken or leaking batteries are classified as hazardous waste and will be disposed of by EH&S.

10.8 USED OIL AND FILTERS

Used oils such as pump oils, motor oil, and oil filters require proper waste request through CEMS for EH&S to pick up. EH&S will determine whether to treat the used oil as hazardous materials or to ship off-site for recycling or re-refining.

10.9 EXPLOSIVES

EH&S will dispose of explosive or potentially explosive materials. Use the request procedures outlined in the manual. Some of these materials may be left on-site for stabilization before transport to the accumulation facilities. Pickups of explosives will not be done on the same schedule or with the same frequency as other chemical waste. A partial list of explosive or potentially explosive chemicals is located in APPENDIX III.

10.10 RADIOACTIVE WASTE

A number of government statutes and regulations govern the disposal of radioactive waste. Before attempting to dispose of any such waste, contact both the EH&S Radiation Section for special instructions. Required training related to radioactive materials and the Radiation Safety Manual is available by calling the Radiation Safety Section of EH&S at 817-272-2185.

10.11 FLUORESCENT LAMPS

Fluorescent and high-intensity discharge (HID) lamps contain a small quantity of elemental mercury that can be harmful to the environment and to human health when improperly managed. When broken, mercury vapors are released into the air and causes an occupational hazard. Mercury is regulated under the Resource Conservation Recovery Act (RCRA), which is administered by the EPA. Under current law, mercury-containing lamps, such as fluorescent and HID lamps, may be regulated as hazardous waste. EH&S manages all fluorescent and HID lamps through recycling. Recycling allows the mercury to be separated from the glass, aluminum, and other lamp components, all material is then reused in manufacturing other products.

In the event that you have a broken lamp in your area, evacuate the immediate area, and notify EH&S for cleanup.

CHAPTER 11
BIOLOGICAL (OR SPECIAL) WASTES

11.1 DEFINITION OF BIOLOGICAL (OR SPECIAL) WASTE

The Texas Department of State Health Services (DSHS) has identified biological or special waste as requiring special handling to protect human health or the environment. The items selected for regulation were deemed to have the highest potential to transmit infectious disease(s) if improperly treated or handled.

The term "biological (or special) waste" refers to regulated waste, including the following:

- microbiological waste
- sharps
- human blood, blood products, and other potentially infectious materials (OPIM)
- pathological waste
- bedding of animals intentionally exposed to pathogens
- animal waste

The Texas Commission on Environmental Quality (TCEQ) and the Texas Department of State Health Services (DSHS) regulate biological waste.

11.2 RECORD KEEPING

Personnel who treat and dispose special wastes onsite in accordance with the guidelines described in this section must keep the following records:

- date of treatment (also time for incineration)
- amount of waste treated
- method/conditions of treatment
- name (printed) and initials of person(s) performing treatment
- for generators of more than 50 pounds per month, a written procedure for the operation and testing of any equipment used and a written procedure for the preparation of any chemicals used in treatment

Personnel must maintain records for three years and must have them available for review on request.

11.3 MICROBIOLOGICAL WASTE

Microbiological waste includes:

- Discarded cultures and stocks of infectious agents and associated biologicals

- Discarded cultures of specimens from medical, pathological, pharmaceutical, research, clinical, commercial, and industrial laboratories
- Discarded live and attenuated vaccines, but excluding the empty containers thereof
- Discarded, used disposable culture dishes
- Discarded, used disposable devices used to transfer, inoculate, or mix cultures

Note: *In vitro* tissue cultures that have not been intentionally exposed to pathogens are exempt from these regulations.

Microbiological waste can either be treated on-site in the laboratory or can be given to EH&S for disposal. Request biowaste removal through Chemical Environmental Management System (CEMS) (https://cems.uta.edu/) by following the instructions in the SOP – Request for Biological Waste Removal.

Treatment Methods

Acceptable methods of treatment and disposal of microbiological waste at UTA include steam sterilization, chemical disinfection, and incineration.

Steam Sterilization

To allow sufficient steam access/penetration to the waste, the waste shall be packaged and loaded into the autoclave chamber according to the instructions given by EH&S in the SOP: Steam Autoclaves, and autoclave operated according to the recommendations provided by the manufacturer.

When subjecting waste to steam under pressure:

- The temperature in the autoclave chamber must reach at least 121^{o}C (250^{o}F)
- The gauge pressure must be at least 15 pounds per square inch (psi)
- The treatment time must be at least 30 minutes

EH&S will check autoclaves' performance used for waste treatment. The efficacy is monitored with biological indicators (*Geobacillus stearothermophilus* spores) at an appropriate frequency to ensure that the sterilization parameters are effective in treating biohazardous waste.

Chemical Disinfection

Use a chemical agent that is registered with the U.S. Environmental Protection Agency in accordance with the manufacturer's instructions.

When immersing solid waste in a liquid disinfectant, use e.g.:

- A freshly prepared solution of household bleach diluted 1:10 with water or
- A solution of 70% by volume 2-propanol (isopropyl alcohol)

Waste that has been immersed in a liquid disinfectant must be thoroughly drained before disposal.

Liquid biohazardous waste including blood, blood products, cultures and stocks of etiological agents and viruses, cell culture material, and products of recombinant/synthetic

nucleic acid molecule technology may be disinfected by adding household bleach to the liquid to be decontaminated until a 10% concentration of household bleach is achieved.

Disposal of Steam Sterilized or Chemically Disinfected Waste

Microbiological waste that has been treated in accordance with the methods described above can be disposed of through the regular trash as long as the following procedures are followed:

- Place a label on the original bag or container stating "Treated in accordance with the provisions of 25 TAC §1.136(a)" (2) relating to approved methods of treatment
- Place the bag or other container into another bag or container that is a different color and is opaque, e.g., a black or green trash bag

If treated waste is in a liquid form it can be disposed of through the campus sanitary sewage system after an appropriate contact time (at least 30 minutes). The treated material should be rinsed down with copious amount of water.

Note: If you are unable to treat and dispose of microbiological waste yourself, contact EH&S at 817-272-2185 for assistance.

Incineration

The incinerator is located on the roof of the Life Science Building. The above listed information in this section “Record Keeping” about the incineration must be entered in the log books located in the Office of Department of Biology, in the Animal Care Facility, or EH&S.

Operational procedures for the use of the incinerator:

- The incinerator is designed to destroy up to 100 pounds per hour of biological waste. Do NOT overload the incinerator.
- Operate the incinerator only during daylight hours.
- Do not burn aerosol cans, closed containers, or flammable liquids**.**
- Do not attempt to burn paper such as office records, computer paper, or telephone books.
- Weigh waste, and log pounds (lb.) of waste in the log in addition to date, time, operator info, and description of incinerated waste.
- When loading waste into the incinerator, make sure that all waste is on the burning chamber hearth and not on the door block. Close the door, set the timer for a minimum of two hours, and let it burn down.
- Do not open the door or add more trash until the load has burned down. This could cause two problems:
- Overloading of the incinerator
- The possibility of explosion which could injure the operator

- If the main charging door is opened while the incinerator is operating, the primary burner will be shut off by the door safety switch.
- Always open and close charging door slowly to avoid flame and smoke puffs.
- Do not use water to cool hot refractory or brick.
- If ashes build up above the bottom of the burner port or obstruct air passages, contact EH&S to arrange the cleaning of the incinerator.

11.4 SHARPS

Sharps that are considered special waste include:

- hypodermic needles
- hypodermic syringes with attached needles
- scalpel blades
- razor blades
- disposable razors
- Pasteur pipettes
- broken glassware if it may be capable of transmitting infectious disease (if glassware is not potentially infectious, see sections concerning "Containers" and "Broken Glassware" in the preceding chapter entitled "Chemical Waste")

All of the above listed items shall be disposed of as infectious waste and deposited into the sharps containers available through EH&S. Sharp containers will be delivered, picked up, and disposed of for departments by EH&S at no cost to the departments or laboratories. In order for the sharps containers to be picked up, please send a request for disposal through CEMS by following the instructions in the SOP – Request for Biological Waste Removal.

Sharps containers shall be kept in each work area that generates sharps and the following rules followed in connection to the work with sharps:

- To avoid accidental sticks hypodermic needles must be placed directly into the containers and not recapped, bent, broken, clipped, or removed from disposable syringes
- Do not attempt to treat (decontaminate) sharps yourself for any biohazard
- Do not overfill the sharps containers (they should not be more than ¾ full when picked up)
- Do not dispose of these containers with the regular trash
- Do not incinerate sharps containers

11.5 HUMAN BLOOD, BLOOD PRODUCTS, AND OTHER POTENTIALLY INFECTIOUS MATERIALS

Human blood and blood products mean:

- Discarded waste human blood
- Serum
- Plasma
- Other blood components, materials containing free-flowing blood and blood products

The following human body fluids are referred to as "other potentially infectious materials" (OPIM) considering that these materials may also contain bloodborne pathogens, including hepatitis B virus (HBV) that causes hepatitis B, a serious liver disease, and human immunodeficiency virus (HIV) that causes acquired immunodeficiency syndrome (AIDS):

- Semen
- Vaginal secretions
- Cerebrospinal fluid
- Synovial fluid
- Pleural fluid
- Pericardial fluid
- Peritoneal fluid
- Amniotic fluid
- Saliva (in dental procedures)
- Any bodily fluid that is visibly contaminated with blood
- All body fluids in situations where it is difficult or impossible to differentiate between body fluids

All human blood, blood products, and OPIM need to be treated by steam sterilization or chemical disinfection before disposal (see above Microbiological Waste**,** Treatment Methods). If you need special assistance regarding disposal of human blood, blood products, and OPIM, contact EH&S.

11.6 PATHOLOGICAL WASTE / ANIMAL CARCASSES

Pathological waste includes human biopsy materials such as tissues, organs, body parts, and anatomical remains. Pathological waste and animal carcasses must be incinerated.

11.7 BEDDING OF ANIMALS INTENTIONALLY EXPOSED TO PATHOGENS

Bedding of animals intentionally exposed to pathogens can be treated on-site by steam sterilization or chemical disinfection. Another option is to submit the waste to EH&S for disposal. Double-bag the bedding into biohazard bags and store waste in secondary container. Request disposal through CEMS by following the instructions in the SOP – Request for Biological Waste Removal.

REFERENCES

1. The Texas Commission on Environmental Quality (TCEQ) rules: 30 Texas Administrative Code (TAC), Chapter 330.

2. The Texas Department of State Health Services (DSHS) rules: 25 Texas Administrative Code (TAC), 1.131 – 37.

CHAPTER 12
DISPOSAL OF CHEMICAL WASTE

12.1 SANITARY SEWER DISPOSAL

Very few hazardous chemicals are allowed to be disposed into a sink that leads to publically owned treatment works. For best practices, do NOT dispose of any hazardous wastes by pouring down the drain. The following types of chemicals are particularly problematic when disposed of into the sanitary sewer:

- Flammable and combustible solvents including benzene, toluene, xylenes, hexane, acetone, ethers, formaldehyde, tetrahydrofuran, and ethyl acetate.
- Halogenated solvents including chloroform, dichloromethane, carbon tetrachloride, and chlorinated fluorocarbons.
- Phenolic and amine compounds including phenols, hydroquinone, acrylamide, and ethanolamine.
- Corrosive materials including sulfuric acid, hydrochloric acid, acetic acid, sodium hydroxide, and potassium hydroxide.
- Aqueous solutions containing any quantity of metalloids or metals such as arsenic, barium, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, or zinc.
- Cyanide and sulfide compounds including organic nitriles and mercaptans.
- Poisons such as bromine, ethidium bromide, benzidine, and osmium tetroxide.
- Explosive compounds including picric acid and organic peroxides (APPENDIX III).
- Commercial products including strippers, paints, dyes and some concentrated cleaners.
- Radioactive substances such as uranium, selenium-75 or zinc-65.
- Untreated special liquid and liquid biological waste.
- Acid or base solutions containing organic or inorganic impurities such as base baths or acidic solutions used to clean glassware.
- Photographic chemicals such as developer or fixer solutions.

Collect these solutions in the appropriate containers for disposal by EH&S personnel. If you have any questions about sink disposal of any material, contact EH&S for assistance. Violations of the City of Arlington wastewater discharge permit or other waste disposal regulations could result in interruption of laboratory activities, financial penalties, or prison sentences.

12.2 STORM SEWER DISPOSAL

The storm sewer system is designed to carry runoff from rain to local creeks and other waterways. The inlets to this system are commonly at curbs or at low outdoor areas such as loading dock ramps. Some older buildings also have basement drains that are connected to the sewer system. Drain disposal of chemicals, products, or other substances to the storm sewer system is NOT permitted under any circumstances. If you are not sure whether a drain is connected to the storm or sanitary sewer system, contact EH&S for clarification.

12.3 WASTE CONTAINERS

Containers holding waste must have a lid, be in good condition, not leaking, and compatible with the waste being stored. The container must be kept closed at all times during storage, except when waste is added. Do not place hazardous waste in unwashed containers that previously held an incompatible material (APPENDIX II).

If a container holding hazardous waste is not in good condition or if it begins to leak, you must transfer the waste from this container to a container that is in good condition. Please contact EH&S if you require assistance.

EH&S will provide 6 or 10-liter Nalgene® containers for laboratories generating large quantities of liquid hazardous waste.

Any waste that may be incompatible with other accumulated waste must be stored separately to prevent unknown reactions.

All waste containers must be:

- Marked with the words “hazardous waste”.
- Tagged with a Hazardous Waste Inventory Tag containing information such as the building, room number, name of requester, telephone number, chemical type, chemical name, and weight or volume of all ingredients in each container. EH&S cannot pick up the hazardous waste without this tag being completely and properly filled out.
- Free of any old labels. Old labels must be removed or defaced.
- Kept at or near the site of generation and under control of the generator.
- Compatible with contents (for example, acids should not be stored in metal cans).
- Closed at all times except when waste is added to container.
- Safe for transport with non-leaking screw-on caps.
- Filled to a safe level (not beyond the bottom of the neck of the container or a 2-inch headspace for 55 gallon drums). Do not overfill waste containers for the following reasons:
    - Containers are hard to pour safely.
    - Containers are inclined to burst.
    - Containers are likely to leak.
    - Containers are capable of endangering the operator through splashing.

12.4 WASTE ACCUMULATION

An important step in the chemical disposal sequence involves the temporary storage of waste at or near the point of generation. A generator of possible hazardous waste at a satellite accumulation area (SAA) may accumulate up to a total of 10 liters of each type solvent waste, which may be determined to be hazardous by EH&S, or one quart of listed acutely hazardous waste (APPENDIX VI). All solvent waste containers stored at a SAA must be in secondary containment. Except when single chemicals are accumulated for recycling or recovery, waste accumulation generally involves bulking several materials into one container. For example, compatible solvents and other organic liquids can be consolidated since they are bulked into a 55-gallon drum for transportation off-site at the EH&S Materials Accumulation Center.

Please adhere to the following guidelines for safe accumulation of chemical waste:

- Clearly mark containers and date them when accumulation starts at the SAA. Use the pre-labeled hazardous waste containers that are available from EH&S. Date containers when accumulation begins.
- Label containers with words that clearly identify the contents the FIRST time you put waste into them. Liquid waste must be segregated into the following groups:
    - Non-halogenated organics
    - Halogenated organics
    - Heavy metals
    - Inorganic bases
    - Inorganic acids
    - Cyanides
    - Photo fixers

  Keep in mind that you must complete a waste characterization sheet (WCS) listing ALL of the chemical components before EH&S can accept the waste for off-site disposal.
- Separate incompatible wastes streams.
- Keep waste collection containers closed at ALL times during storage except when adding or removing waste. This is true for solids as well as liquids. Many containers, such as beakers or flasks, for example, are not acceptable accumulation containers.
- Keep waste containers clean by cleaning up any spilled material that may contaminate the side of the container. To prevent splashing and spills, use a compatible funnel and pour your waste slowly. Sloppy containers will not be accepted be EH&S.

- Designate an area in your lab as a chemical waste accumulation area. Using a hood for this purpose is only acceptable for temporary storage of small quantities of waste, providing that there are no experiments in said hood.
- Contact EH&S for removal of full waste containers from the laboratory.

Whenever possible, keep different hazardous wastes separate so that disposal options remain clear and more cost-effective. In all cases, do not mix incompatible wastes or other materials in the same container or place wastes in an unwashed container that previously held an incompatible waste or material (APPENDIX II). However, if separation is not practical, collect waste in compatible containers and try to keep it segregated into the following categories:

- Collect miscellaneous solids, for example, gloves, rags or towels, and other lab debris separately from liquid wastes.
- Halogenated solvents, such as methylene chloride, chloroform, carbon tetrachloride.
- Non-halogenated solvents such as xylene, toluene, and alcohols.
- Used oil must be kept as uncontaminated as possible in order to be recycled. You should keep oils separate from other chemicals, particularly solvents, pesticides, and PCBs.
- Acids
- Bases
- Metal-bearing waste whether dry, flammable, corrosive or other. Specific metals of concern are arsenic, barium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and thallium.
- Accumulate waste that is both flammable and corrosive separately from waste that is either flammable or corrosive.
- Collect some kinds of wastes, such as cyanide, sulfide, pesticides, oxidizers, organic acids, explosives, peroxides, and acute toxins, individually whenever possible.

Note: Disposal of non-halogenated solvents contaminated with halogens or heavy metals costs 4-5 times as much as non-halogenated solvents.

12.5 WASTE CONTAINER LABELING

Before EH&S can pick up any chemical waste, a Hazardous Chemical Inventory Tag is required (APPENDIX IX). Fill it out and attach it to each waste container. Use the information on the tag to categorize and treat the waste. Please fill it out legibly, accurately, and completely (APPENDIX IX-A). Include the following information:

- Date - Date waste was generated.

- Principal investigator - Name of the individual responsible for supervising the process generating the waste.
- Building, room number, and phone number.
- Indicate overall volume or weight - Write in the total volume or weight of each material in the container.
- Specify Chemical Contents – List the specific, full chemical name (no formulas or abbreviations) for each chemical constituent in this container. Product names or trade names are acceptable if you can supply the manufacturer's name and address or an SDS with the material. Vague statements such as "hydrocarbons", "organic waste", “various salts of …" make it impossible to comply with EPA treatment standards and will delay the pickup until sufficiently detailed information is provided and submitted to EH&S.
- Volume % - Percentage of the total volume to which each chemical amount is equal (should add up to 100%) or the actual weight or volume of each constituent.

Note: Biological waste and sharps containers do not require chemical inventory tags.

12.6 REQUEST FOR DISPOSAL

When your container is ready for disposal and is properly tagged, at least three working days prior to reaching the accumulation limits referenced in Section 12.4 above, contact EH&S by sending a Request for Disposal via CEMS (APPENDIX VIII; APPENDIX VII). Refer to SOP for Chemical Waste Removal on CEMS.

Log into the Chemical Environmental Management System (CEMS) http://cems.uta.edu. Sign-in by selecting your name and using your CEMS password. Click “Request Waste Removal” in the section “Hazardous Waste” of the “My Responsibilities” window.

EH&S makes pickups regularly and will come to your site within three working days (72 hours) of receiving your request. The information for each container listed on the request form must be identical to the information on the Hazardous Chemical Inventory Tag located on each of the container(s) (APPENDIX IX; APPENDIX IX-A).

Complete requests for biological waste or sharps disposal by following the instructions on the SOP Request for Biological Waste Removal.

Note: The more information provided, the better. This allows our staff to safety handle each waste we come into contact with.

CHAPTER 13
POLLUTION PREVENTION

13.1 GENERAL INFORMATION

There are two primary types of pollution prevention, source reduction and waste minimization. Of these two approaches, source reduction is always preferred from an environmental perspective**.** Source reduction includes any activity that reduces or eliminates the generation of hazardous waste at the source or the release of a pollutant or contaminant, usually within a process. The best way to limit or eliminate the need for and cost of hazardous waste disposals is to limit or eliminate processes that generate such waste, or substitute less toxic but still effective compounds. Becoming aware of problems and alerting others is a good first step.

- Plan ahead with waste minimization in mind. Review procedures and experiments beforehand. Order only the amount of chemicals needed for the experiment.
- Buy wisely. Most of the time, disposal costs are greater than the original purchase price for many chemicals and are funded by research overhead. Bulk purchases of chemicals are great for lower prices, but generally, most of the stock will expire and be given up for disposal without ever being used.
- Rotate stock often to avoid chemicals becoming unused and expired.
- Properly store chemicals to prevent aging, spills, and fires. Make use of flammable storage cabinets and corrosive cabinets for storing the related chemicals.
- Handle lab spills promptly and appropriately to minimize personal danger and the volume of waste material generated.
- Substitute less hazardous materials as alternatives whenever possible.
- Be knowledgeable of what is or is not a "hazardous chemical."
- Lab Protocols should include proper waste segregation and containerization so that disposal options can remain clear and cost effective.
- The facts on waste removal request forms should be accurate and complete.
- Prevent "unknowns" by keeping all containers labeled, no matter the size.
- Use pre-existing chemicals before buying a fresh bottle.
- Explore new procedures and/or equipment modifications aimed at reducing waste generation. Using instrumental methods instead of wet chemical techniques will generally require smaller quantities of chemicals.
- Distill and reuse chemical solvents when possible. This not only reduces the amount of waste generated, but decreases the amount of chemicals that need to be ordered.

13.2 SPECIAL OPTIONS FOR EDUCATIONAL INSTITUTIONS

Pollution prevention options available can be classified into three general groups. These waste reduction methods are improved material management practices, improved laboratory practices, and improved practices in other departments.

Improved Material Management Practices

- Order reagent chemicals in exact amounts to be used. Do not order extra chemical quantities to take advantage of unit cost savings. The net savings will be lost due to eventual disposal costs if the chemical is not used.
- Encourage chemical suppliers to become responsible partners in a waste minimization program by ordering chemicals from suppliers who will provide quick delivery of small orders and will accept return of unopened product.
- Establish an inventory control program that can trace usage from purchase to consumption. This will promote sharing of chemicals between common users, provide data on the location of extremely hazardous chemicals, identify the high volume users, locate caches of unused reagents, and delineate where waste reduction options need to be implemented. Reagent chemicals having remaining shelf life can be monitored for approaching expiration by using the chemical inventory feature in CEMS.
- Rotate chemical stocks to use chemicals before their shelf life expires (first-in-first-out stock usage).
- Develop a running inventory of unused reagent chemicals for use by other laboratories or faculty. The inventory control program should extend to all laboratories, including those of individual professors.
- Appoint a safety and waste management officer for each department to work with EH&S. Centralizing responsibilities will facilitate a coordinated and efficient implementation of regulations, institution policy, and waste reduction goals.
- Educate professors, students, and staff on the benefits of waste reduction. This should include instruction on specific techniques for reducing waste generation.
- Establish annual goals for institution-wide and departmental waste reduction. First, determine past yearly totals of waste generation, and then assess economic and technical feasibility for establishing and achieving specific reduction goals.
- Provide routine self-audits for laboratories, professors, students, and staff to minimize reagent accumulation and maximize recycling.

Improved Laboratory Practices

- Substitute less hazardous chemicals in experiments. For example, substitute sodium hypochlorite for sodium dichromate; use alcohol for benzene; substitute cyclohexane for carbon tetrachloride in the standard qualitative test for halide ions; stearic acid can replace acetamide in phase change and freezing point depression experiments; and use 1,1,1-trichloroethane instead of carbon tetrachloride and/or chloroform. A number of laboratories are using detergents, potassium hydroxide, or sonic baths as substitutes for the chromic acid solutions used to clean glassware.
- Pre-weigh chemicals for undergraduate usage**.** This will reduce spills and other wastes generated by students performing their own weighing. It will also increase laboratory productivity by reducing lab time per student.
- When cleaning with solvents, reuse the spent solvent for the initial cleaning of subsequent articles and use fresh solvent only for the final rinsing. This reuse will decrease the amount of reagent solvent used.
- Platinum, palladium, and rhodium contained in catalysts can be recovered using chemical procedures specific to the particular metals. Segregate these wastes so that off-site recycling may be possible.
- Investigate if unused reagent chemicals and their containers can be returned to the manufacturer. Sealed bottles of stable chemicals may be reusable by the supplier.
- Destroy wastes as an integral step in experiments**.** This will reduce the need for off-site disposal. If done in undergraduate laboratories, it will develop an awareness of proper waste management and waste reduction. Some chemical wastes can be destroyed by students as a step in experiments.
- Keep individual waste streams segregated. Keep hazardous waste segregated from nonhazardous waste. All waste contaminated with a hazardous substance must be treated as hazardous waste. Keep recyclable waste segregated from non-recyclable waste.
- Ensure that the identity of all chemicals and wastes is clearly marked on all containers. When researchers leave an institution, they often leave laboratory chemicals behind. These include unused reagent chemicals, unlabeled containers, and an assortment of mixtures and solutions. Unlabeled containers present a particularly troublesome waste management problem since unidentified wastes cannot legally be shipped for disposal. Analysis is required to identify the contents, which can be very costly. It is also a violation of the Texas Hazard Communication Act to store any chemicals in unmarked containers.

Improved Practices in Other Departments

- Replace oil-based paints with water-based paints in art instruction and maintenance operations. Non-toxic (solvent, lead, and chrome-free) paints should be used wherever possible.

- Modify spray-painting techniques to reduce paint waste. Set the correct air pressure for the spray gun and use the following stroking technique:

    1) overlap the spray pattern by 50%,
    2) maintain a distance of 6 to 8 inches from the workplace,
    3) hold the gun perpendicular to the surface, and
    4) trigger the gun at the beginning and end of each stroke.
- Reduce generation of pesticide waste by reducing pesticide application, using non-chemical pest control methods, preparing exactly the amount needed, and using only the required minimum quantity of pesticide for the job. Investigate the use of irrigation injection of pesticides through the sprinkler system (with back flow protection), or the use of dry pesticides that are spread on the grounds and watered into the ground. This practice will eliminate the need for pesticide-spraying operations and the resulting contaminated wash water.
- Collect waste oil and solvents for recycling. Segregate recyclable oils and solvents from non-recyclable wastes.
- Use biodegradable aqueous or detergent cleaners instead of solvents that are more toxic and hazardous.
- Provide training in hazardous waste management practices for students in courses/departments that generate waste and also for Facilities Management maintenance personnel.

CHAPTER 14
CHEMICAL ENVIRONMENTAL MANAGEMENT SYSTEM (CEMS)

The University of Texas at Arlington utilizes The Chemical Environmental Management System (CEMS), a barcode-based system, to record and manage information about the quantity, location and properties of chemical stock, biological agents, and hazardous waste. It has the capability to automate record-keeping and waste removal requests for material in its original container, allows campus labs to share materials, and can broadcast messages.

Key features and benefits of CEMS that users can take advantage of include:

- Saving money and space by reducing or completely eliminating unnecessary purchases; saving time by maintaining stock at an appropriate level.
- Increasing efficiency by making chemicals easy to locate.
- Maintaining a current and up to date inventory of all chemicals.
- Calculation of total amount of certain chemicals to comply with the Department of Homeland Security's Chemical Facility Anti-Terrorism Standards.
- Providing access to more than 65,000 Safety Data Sheets (SDS).
- Knowing when to remove old or expired chemicals by identifying chemicals with specific shelf life and specific storage requirements.
- Requesting chemical and biological waste removal.
- Tracking Peroxide Forming Chemicals.

EH&S personnel can use CEMS to provide periodic reports to emergency service providers. Equipped with this information, EH&S can provide support to firefighters or hazmat teams if they respond to a spill or fire in a laboratory. Some of the potential chemical hazards that could be found in a lab may include: flammable materials, water reactive, corrosive or explosive. Information on chemicals in surrounding rooms would be vital information to emergency responders and can also be obtained from CEMS. Inventory updates can be performed quickly with a hand-held PC and a barcode scanner. http://cems.uta.edu/

CHAPTER 15

SELECTED BIBLIOGRAPHY

Selected Bibliography

1. American Chemical Society. Safety in Academic Chemistry Laboratories, 1990.

2. Centers for Disease Control and National Institutes of Health. Biosafety in Microbiological and Biomedical Laboratories, Fifth Edition, Feb 2007.

3. Chemical Rubber Company. CRC Handbook of Laboratory Safety, Third Edition, 1990.

4. Nancy Magnussen, Texas A&M University Chemistry Safety Coordinator. Safe Storage and Handling of Laboratory Chemicals – A Review of Safe Storage and Handling Practices for Laboratory Chemicals.

5. National Research Council. Biosafety in the Laboratory, Prudent Practices for the Handling and Disposal of Infectious Materials, 1989.

6 National Research Council. Guide for the Care and Use of Laboratory Animals, 1996.

7. University of Texas at Arlington, Environmental Health & Safety Office. UT Arlington Hazard Communication Program, Revised 1994.

8. Texas Department of State Health Services. Employee Training Guide, Texas Hazard Communication Act.

9. Texas Department of State Health Services. Rules for Definition, Treatment, and Disposition of Special Waste from Health-Care Related Facilities, 1991.

10. Texas Department of State Health Services. Solid Waste Management Rules for Medical Waste Management, Disposal, Transportation, Collection, and Storage, 1991.

11. Texas Engineering Extension Service, Texas A&M University System. Hazardous Waste Operations and Emergency Response for Colleges and Universities, Occupational and Environmental Safety Training Division.

12. National Research Council. Prudent Practices in the Laboratory, Handling and Disposal of Chemicals, 1995.

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