TEXAS A&M UNIVERSITY-CORPUS CHRISTI

LABORATORY SAFETY MANUAL

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Chapter 1

INTRODUCTION

It is the policy of Texas A&M University-Corpus Christi (TAMU-CC) to provide and maintain a safe environment for its faculty, staff, students, and visitors.

Environmental, Health & Safety (E,H&S) is committed to working with faculty and staff to ensure that campus laboratories are a safe place in which to work and learn. It is the responsibility of *all* who work or study in laboratories to do so in a safe and environmentally responsible manner.

E,H&S has established this **Laboratory Safety Manual** as a resource for faculty and laboratory personnel, as well as anyone interested in laboratory safety. This manual is intended to comply with federal, state, and local regulations, as well as industry best practices. The **Laboratory Safety Manual** is a compilation of suggested work practices, protocols, and procedures to work safely in TAMU-CC laboratories. The document is *not* exhaustive and should not be considered the only reference for health and safety. In addition to this manual, Environmental, Health and Safety is always available to address health and safety concerns.

- Laboratory Safety incorporates safety principles from a variety of areas, including fire and life safety, chemical safety, biological safety, and radiation safety. The hazards encountered in a laboratory touch every field in safety and may be similar, although potentially greater in quantity or severity, to hazards encountered in the average home or workplace.

- Environmental, Health and Safety works with the departments to ensure that safe practices are utilized, and federal and state safety standards or requirements are followed. This is accomplished through conducting laboratory inspections, inspecting chemical fume hoods and other safety equipment, and providing general laboratory safety training. This document contains information on the different hazards that may be found in laboratories - including chemical hazards, physical hazards, biological hazards, and radiological hazards, how to minimize the risks associated with those hazards, how to protect lab workers when working in a laboratory, and how to plan for an emergency situation in the laboratory.

- For specific questions relating to Laboratory or Chemical Safety, contact the E,H&S Department at University extension 5555 or (361) 825-5555.

SECTION 1: CONTACT INFORMATION

1.1 EMERGENCY

1. In case of an emergency, contact the University Police Department (UPD) by dialing 911 or 4444 from any campus phone. If 911 is dialed from a cell phone notify UPD at 361-825-4444 so they can assist with the emergency.
2. If an ambulance is needed, alert UPD.
3. When the fire alarm sounds or when there is a fire, instruct the class to shut off any ignition sources, evacuate the class calmly and orderly to a location outside of the building and stay at least 100 feet from the building until an "ALL CLEAR" is given by UPD.

1.2 NON-EMERGENCY

- Ethics Point: 1-888-501-3850. This anonymous tip line may be called to report risk (generally unsafe conditions) or misconduct (waste of campus resources, fraud, etc.) on campus.
- University Police Department (UPD): 361-825-4242.
- Environmental, Health & Safety (E,H&S): 361-825-5555.

1.3 Accident Reporting

- Employees must report accidents to their supervisor who will submit a new incident report in Origami Risk (https://bit.ly/2XUxIJW).
- The applicable TAMUCC employee will complete a new incident report for visitors, volunteers, students, tenants and/or non-TAMU-CC Employees Origami Risk (https://bit.ly/2XUxIJW).

SECTION 2: E,H&S LABORATORY SAFETY - PROGRAMS AND SERVICES

Programs and services provided by the Environmental, Health and Safety office include the following:

- Disseminate information concerning safety regulations, policies, protocols, and practices to members of the TAMU-CC community.
- Evaluate facilities through laboratory safety inspections. These evaluations help assure compliance with safety and health regulations, protocols, and practices in order to maintain safe work environments.
- Respond to emergencies such as gas odors or chemical spills.
- Measure environmental parameters such as chemical vapors or noise.
- Provide the TAMU-CC Hazard Communication Program as required by the Texas Hazard Communication Act, Texas Precursor Chemical and Bloodborne Pathogen Training.

SECTION 3: STUDENT/INSTRUCTOR SAFETY POLICIES

BIOLOGY, MICROBIOLOGY and BIOMEDICAL INSTRUCTIONAL LABORATORY SAFETY POLICY

Instructors and students shall comply with the following safety standards while present in a TAMU-CC Biology, Microbiology, and Biomedical Instructional Laboratories.

HYGIENE:

1. FOOD, CHEWING GUMS, DRINKS, TOBACCO PRODUCTS, AND COSMETIC USAGE ARE PROHIBITED AT ALL TIMES.
2. Mouth Pipetting is prohibited - use mechanical pipettes.

LABORATORY SAFETY PROCEDURES:

1. No horseplay (pushing, shoving, prank, etc.) is allowed.
2. Avoid working alone in the laboratory. All work should be performed with a partner. The Lab Coordinator, Teaching Assistant or the Instructor must be around to check on the students.
3. Begin experiments only as directed by the Instructor.
4. No unauthorized or unsupervised experiments are to be performed.
5. Wear disposable gloves when working with chemicals or performing biohazardous tasks. To prevent cross-contamination remind students not to touch any personal items while wearing gloves.
6. Wear splash goggles when working with or near biological or chemical hazards.
7. Wear splash goggles when examining specimens from the jars. Splash goggles are also required when removing and returning specimens to the jar.
8. Perform procedures involving potentially volatile or toxic chemicals under a vent hood.
9. Dispose of sharps (needles, scalpels, broken slides, etc.) in a sharp's container on the bench top.
10. Dispose of non-biohazardous broken glass in the broken glass container. Do not place broken glass into the trash can.
11. Dispose of biohazardous waste in an appropriate, labeled biohazardous waste container.
12. Do not re-sheath needles.
13. Perform all procedures carefully to minimize splashes and aerosols. When splashes and aerosols may occur, perform biohazardous procedures under a certified biosafety cabinet.
14. Decontaminate the work surfaces with disinfectants that are effective against the agent of concern on completion of the lab session, at the end of the day and after any spills or splashes of viable material.
15. Wash their hands after removing gloves and before leaving the laboratory.

SAFETY EQUIPMENT: Know the location of the following:

1. Fire extinguisher
2. Safety shower
3. Eye wash station
4. Fire blanket
5. First Aid Kit
6. Safety Data Sheet Binder
7. Chemical Spill kit

PROPER ATTIRE - The following is ALWAYS required upon entering a Biology or Microbiology lab, regardless of class activities (lectures, meeting, or lab practices.)
Instructor and students will:

1. Wear lab coats.
2. Wear long pants that meet the shoes (no shorts, capris pants, leggings, panty hose, dresses, or tights).
3. Wear closed-toe closed-heel shoes, no high heels or platform shoes.
4. Tie back long hair & head scarves.
5. Ensure students wear proper attire upon entering the laboratory.

HOUSEKEEPING PROCEDURES:

1. Stow books and all personal items in the lab cabinet, lockers outside the lab, or under the bench tops if lab cabinets or lockers are not available.
2. Keep aisles clear of materials to prevent slip, trip, and fall hazards.
3. Report all spills or leaks immediately to you.
4. Clean their glassware and bench tops at the conclusion of the lab.
5. Properly label & dispose of all waste. Details for disposal can be found on the E,H&S website at http://safety.tamucc.edu/.
6. Properly dispose of chemicals.
7. Students are responsible for cleaning their glassware and bench top at the end of the lab session.

CHEMICAL SPILL CLEAN UP

1. Instructors should know where the spill kit is in the lab and how to clean up a small spill (up to a quart container).
2. For larger spills, contact the Lab Coordinator.

LABORATORY SAFETY TRAINING:

1. Access to a lab is limited only to students registered and who have completed the required online Student Safety Training assignment in Blackboard.
2. All students must complete the online Student Safety Training before the twelfth day of class.

CHEMISTRY INSTRUCTIONAL LABORATORY
SAFETY POLICY

Instructors and students shall comply with the following safety standards while present in a TAMU-CC Chemistry Instructional Laboratories.

HYGIENE:

1. FOOD, CHEWING GUMS, DRINKS, TOBACCO PRODUCTS, AND COSMETIC USAGE ARE PROHIBITED AT ALL TIMES.
2. Mouth Pipetting is prohibited - use mechanical pipettes.

LABORATORY SAFETY PROCEDURES:

1. No horseplay (pushing, shoving, prank, etc.) is allowed.
2. Avoid working alone in the laboratory. All work should be performed with a partner. The Lab Coordinator, Teaching Assistant or the Instructor must be around to check on the students.
3. Lab experiments will begin only as directed by you, the Instructor.
4. No unauthorized or unsupervised experiments.
5. Wear disposable gloves when working with chemicals.
6. Wear splash goggles when chemicals are present in the laboratory.
7. Procedures involving potentially volatile chemicals must be performed under a vent hood.
8. Dispose of broken glass in the broken glass container. Do not place broken glass into the trash can.
9. Students must wash their hands after removing gloves and before leaving the laboratory.

SAFETY EQUIPMENT:

1. Fire extinguisher
2. Safety shower
3. Eye wash station
4. Fire blanket
5. First Aid Kit
6. Safety Data Sheet Binder
7. Chemical Spill kit

PROPER ATTIRE:

The following is ALWAYS required upon entering a Chemistry lab, regardless of class activities (lectures, meeting, or lab practices.)

1. Wear lab coat.
2. Wear long pants that meet the shoes (no shorts, capris pants, leggings, panty hose, dresses, or tights).
3. Wear a shirt that covers and protects the chest, stomach, sides, back, shoulders and upper arms. The skin on the torso must not be exposed at any time in the lab.
4. Wear closed-toe closed-heel shoes, no high heels or platform shoes (no shoes with cut-outs or vents that leave skin exposed).
5. Tie back long hair & head scarves.
6. Ensure your students wear proper attire upon entering the laboratory.

HOUSEKEEPING PROCEDURES:

1. Stow books and all personal items in the lab cabinets, outside the lab, or under the bench tops.
2. Keep aisles clear of materials to prevent slip, trip, and fall hazards.
3. Report all spills or leaks immediately to you.
4. Clean up their glassware and bench tops at the conclusion of the lab.
5. Properly label & dispose of all wastes. Details for disposal can be found on the E,H&S website at http://safety.tamucc.edu/.
6. Properly dispose of chemicals.
7. Students are responsible for cleaning their glassware and bench top at the end of the lab session.

CHEMICAL SPILL CLEAN UP

1. Instructors should know where the spill kit is in the lab and how to clean up a small spill (up to a quart container).
2. For larger spill, contact the Lab Coordinator.

LABORATORY SAFETY TRAINING:

1. Access to a lab is limited only to students registered and who have completed the required online Student Safety Training assignment in Blackboard.
2. All students must complete the online Student Safety Training before the twelfth day of class.

GEOLOGY INSTRUCTIONAL LABORATORY
SAFETY POLICY

Instructors and students shall comply with the following safety standards while present in a TAMU-CC Geology Instructional Laboratory.

HYGIENE:

1. FOOD, CHEWING GUMS, DRINKS, TOBACCO PRODUCTS, AND COSMETIC USAGE ARE PROHIBITED IN THE LAB AT ALL TIMES.
2. Mouth Pipetting is prohibited – use mechanical pipettes.

LABORATORY SAFETY PROCEDURES:

1. No horseplay (pushing, shoving, pranks, etc.)
2. Avoid working alone in the laboratory. All work should be performed with a partner. The Lab Coordinator, Teaching Assistant or the Instructor must be around to check on the students.
3. Lab experiments will begin only as directed by Instructor.
4. No unauthorized or unsupervised experiments.
5. When chemicals are utilized in the laboratory the following items are required: lab coat, long pants that meet the shoes, splash goggles, and disposable gloves. To prevent cross contamination do not touch any personal items while wearing gloves.
6. Wear splash goggles when chemicals are present in the laboratory.
7. Dispose of broken glass in the broken glass container. Do not place broken glass into the trash can.
8. Students must wash their hands after removing gloves and before leaving the laboratory.

SAFETY EQUIPMENT:

Students should know the location of the following:

1. Fire extinguisher
2. Safety shower
3. Eye wash station
4. Fire blanket
5. First Aid Kit
6. Safety Data Sheet Binder
7. Chemical Spill kit

PROPER ATTIRE:

The following is ALWAYS required upon entering a Geology lab, regardless of class activities (lectures, meeting, or lab practices.)

1. Wear closed-toe closed-heel shoes.
2. Tie back long hair & head scarves.

HOUSEKEEPING PROCEDURES:

1. Stow books and all personal items in the lab cabinets, outside the lab, or under the bench tops.
2. Keep aisles clear of materials to prevent slip, trip, and fall hazards.
3. Report all spills or leaks immediately to the Instructor.

4. Properly label & dispose of all waste as directed by the Instructor. Details for disposal can be found on the E,H&S website at http://safety.tamucc.edu/.
5. Properly dispose of chemicals.
6. Students are responsible for cleaning their glassware and bench top at the end of the lab session.

LABORATORY SAFETY TRAINING:

1. Access to a lab is limited only to students registered and have completed the required online Student Safety Training assignment in Blackboard.
2. All students must complete the online Student Safety Training before the twelfth day of class and present instructor with printout completion.

PHYSICS INSTRUCTIONAL LABORATORY
SAFETY POLICY

Instructors and students shall comply with the following safety standards while present in a TAMU-CC Physics Instructional Laboratory.

HYGIENE:

1. FOOD, CHEWING GUMS, DRINK, TOBACCO PRODUCTS, AND COSMETIC USAGE ARE PROHIBITED IN THE LAB AT ALL TIMES.
2. Mouth Pipetting is prohibited – use mechanical pipettes.

LABORATORY SAFETY PROCEDURES:

1. No horseplay (pushing, shoving, pranks, etc.)
2. Avoid working alone in the laboratory. All work should be performed with a partner. The Lab Coordinator, Teaching Assistant or the Instructor must be around to check on the students.
3. Lab experiments will begin only as directed by Instructor.
4. No unauthorized or unsupervised experiments.
5. Dispose of broken glass in the broken glass container. Do not place broken glass into the trash can.
6. Students must wash their hands after removing gloves and before leaving the laboratory.

SAFETY EQUIPMENT: Students should know the location of the following:

1. Fire extinguisher
2. Safety shower
3. Eye wash station
4. Fire blanket
5. First Aid Kit
6. Safety Data Sheet Binder
7. Chemical Spill kit

PROPER ATTIRE: The following is ALWAYS required upon entering a Physics lab, regardless of class activities (lectures, meeting, or lab practices.)
Students will:

1. Wear closed-toe closed-heel shoes.
2. Tie back long hair & head scarves.
3. PPE must protect from dangers present in the room. When chemicals are present, goggles are required. When projectiles or poking hazards are present, safety glasses or safety goggles are required.

HOUSEKEEPING PROCEDURES:

1. Stow books and all personal items in the lab cabinets, outside the lab, or under the bench tops.
2. Keep aisles clear of materials to prevent slip, trip, and fall hazards.
3. Report all spills or leaks immediately to the Instructor.
4. Students are responsible for cleaning their glassware and bench tops at the conclusion of the lab.
5. Properly label & dispose of all waste as directed by the Instructor. Details for disposal can be found on the E,H&S website at http://safety.tamucc.edu/.
6. Properly dispose of chemicals as directed by the Instructor.
7. Students are responsible for cleaning their glassware and bench top at the end of the lab session.

LABORATORY SAFETY TRAINING:

1. Access to a lab is limited only to students registered and have completed the required online Student Safety Training assignment in Blackboard.
2. All students must complete the online Student Safety Training before the twelfth day of class and present instructor with printout completion.

SECTION 4: LABORATORY SAFETY IS EVERYONE'S RESPONSIBILITY

Ensuring laboratory safety is an endeavor of many individuals on the TAMU-CC campus, including deans, department heads, faculty, and staff. Anyone providing direct or administrative oversight of laboratory facilities is responsible for maintaining safety in those areas. Specific responsibilities are as follows.

4.1 RESPONSIBILITIES OF THE E,H&S

E,H&S has a variety of responsibilities, related to laboratory safety. Provided below is more detailed information on some of those responsibilities.

Environmental, Health & Safety: E,H&S is responsible for the following:

a. Develop and approve appropriate safety policies.
b. Recommending changes to improve the safety environment and/or correct safety concerns
c. Ensure employees with the appropriate chemical or biohazard exposure are assigned Texas Hazard Communication, Texas Precursor Chemical and /or Bloodborne Pathogens training.
d. Develop and provide safety-related training.
e. Investigate reported laboratory accidents, especially those resulting in injury, to evaluate for trends. Recommend action with the purpose of reducing the likelihood of another accident.
f. Provide technical guidance on matters of laboratory safety.
g. Assist laboratory personnel in the development of a Plan of Action for responding to incidents in the laboratory.
h. Assist laboratory personnel in evaluating, preventing, and controlling hazards.
i. Oversee the adoption and implementation of all TAMU-CC environmental, health and safety policies.

Laboratory Inspections

E,H&S is responsible for conducting safety inspections in all campus laboratory facilities. Inspections are conducted annually and as needed or requested. The E,H&S uses a laboratory inspection form when conducting laboratory safety inspections.

When conducting laboratory inspections, faculty members and/or laboratory coordinators are welcome to be present. However, if the appropriate contact is unavailable or is unresponsive, E,H&S will proceed with the safety inspection. E,H&S may conduct unannounced safety inspections or accident investigations. Please be aware that federal, state, and local inspectors may also conduct unannounced inspections.

Reporting Laboratory Inspection Results
Laboratory inspections are documents using the Origami Risk platform. The Origami Laboratory Inspection-Standard form is used to document the inspection and findings. Findings are reported to the person responsible for the laboratory (a principal investigator (PI), laboratory manager or coordinator, etc.) using Origami Corrective Actions. The laboratory personnel are responsible for correcting or coordinating correction of noted safety findings.

If a Corrective Action is reported, the laboratory will be re-inspected by E,H&S to verify that the noted findings have been resolved. Origami Corrective Actions is used to document the follow-up inspections. Follow-up inspections will take place after the initial corrective action report is sent. The Origami Corrective Actions will be updated to show which findings have been corrected and the date this was verified.

In addition to E,H&S inspections, laboratory personnel should routinely conduct inspections of their work areas to ensure continued compliance with safety requirements.

Fume Hood Inspections
Chemical fume hoods will be tested by a qualified vendor on an annual basis. Fume hood certification reports will be sent to the designated laboratory contact. Fume hoods that pass testing will have a certification sticker affixed to them, indicating the date of testing. If a fume hood does not pass testing requirements, a sign will be posted on the fume hood indicating that it is not to be used.

NOTE: *Signs indicating a fume hood is inoperable may only be removed by E,H&S personnel.*

Biological Safety Cabinet and Laminar Flow Hood Certifications
To schedule certification of a biological safety cabinet or laminar flow hood, contact Administrative Operations.

Laboratory Construction and Renovation Projects
In order to ensure the safety of new and renovated laboratories, specific design and construction features are required by state and federal codes, all plans for design, construction, and Project Initiation Request (PIR)to laboratory facilities must be reviewed by Environmental, Health & Safety and Administrative Operations.

4.2 RESPONSIBILITIES OF TAMU-CC ADMINISTRATION, PERSONNEL, AND STUDENTS

TAMU-CC Administrators, Including Deans
Deans or their delegates are responsible for the following:

a. Providing and maintaining the facilities and equipment required for a safe work environment.

b. Establishing methods for disseminating safety information and policies.
c. Establishing criteria for implementing safety policies and protocols.
d. Establishing a system for safety accountability.
e. Ensuring that uncorrected significant safety issues are immediately resolved.

Department Chairs and Directors

Department Chairs and Directors are responsible for promoting safety and loss prevention by:

a. Controlling or eliminating occupational hazards.
b. Conducting periodic safety and loss control evaluations, including those necessary for teaching laboratories.
c. Ensuring that employees are adequately trained in safety policies and protocols and maintaining training documentation.
d. Ensuring that employees are provided with appropriate personal protective clothing and equipment for safe job performance.
e. Notifying faculty and staff of TAMU-CC health and safety policies.
f. Ensuring that significant safety issues identified in Laboratory Inspection Reports have been corrected.

Faculty/Principal Investigators (PIs)

Faculty and PIs are responsible for the following:

a. Performing their jobs in the safest prescribed manner.
b. Eliminating and/or reporting workplace hazards.
c. Following injury reporting procedures.
d. Complying with and implementing all applicable safety and health policies, and protocols in their laboratories.
e. Developing written standard operating procedures, including safety procedures, applicable to their research and workers.
f. Implementing laboratory practices and providing/using engineering controls that reduce the potential for exposure to hazards.
g. Informing all laboratory staff and students of the potential hazards associated with laboratory operations, including biohazards and the hazardous properties associated with chemicals in the laboratory (e.g., toxic, flammable, peroxidizable, explosive).
h. Informing all laboratory personnel of the proper procedures for dealing with accidents and spills.

i. Supervising laboratory personnel and/or students to ensure that safe practices and engineering controls are utilized.

j. Instructing laboratory personnel on the location and use of all safety equipment in the facility.

k. Designating at least one person to serve as a safety contact in the absence of the faculty member or PI.

l. Posting telephone numbers for all emergency response and safety contacts in a noticeable area in the laboratory and on the door to the laboratory. Ensure the posting is updated during sabbaticals or other absences or when there is a change in staff.

m. Correcting issues identified by Laboratory Inspection Form within 45 days.

n. Ensuring that pertinent Safety Data Sheets (SDS) are available.

Employees and Students

Employees and Students are responsible for:

a. Following all safety and health procedures specified in the Laboratory Safety Manual and by their laboratory supervisor.

b. Completing required health and safety training sessions.

c. Reporting accidents, unhealthy and unsafe conditions, near misses, and minor injuries to their supervisor,

d. Notifying their personal physician and/or the Employee Development and Compliance Services Office if any personal health conditions could lead to serious health situations in the laboratory. For example, someone with a compromised immune system or pregnancy, etc. may need to take extra precautions when working with chemical and biological agents.

NOTE: *Accidents resulting in injury to a person must be reported by their supervisor in Origami* (https://bit.ly/2XUxIJW)

Chapter 2

MITIGATING HAZARDS IN THE LABORATORY

The type of work performed in laboratories is wide-ranging. Hazards found in laboratories can vary depending on the nature of the work performed. Laboratory safety may include one or more areas of safety: chemical safety, fire safety, electrical safety, radiation safety, physical/equipment safety, laser safety and biological safety. In this chapter the variety of hazards that may be found in a laboratory and methods for mitigating the risks are discussed.

SECTION 1: GENERAL LABORATORY SAFETY PRACTICES

1.1 SAFE PRACTICES

a. Refer to the Quick Reference Guide to Campus Emergencies on how to respond to emergencies in your laboratory.

b. Know the hazards associated with the materials (chemical, electrical, biological, etc.) and equipment in your laboratory. Refer to the appropriate safety information, such as Safety Data Sheets (SDSs), Standard Operating Procedures (SOPs), and equipment operating instructions, and follow the recommended safe practices. Consider the hazards of procedures to be performed and what training, knowledge, safety equipment, etc. are required to do the procedure safely.

c. Use appropriate safety equipment, such as fume hoods and biological safety cabinets, to minimize exposure to hazardous materials. Verify that safety equipment is working properly prior to use.

d. Follow proper operating procedures when using a biosafety cabinet or chemical fume hood. Keep the sash at the correct working height (8”-10” for biosafety cabinets or less than 18” for fume hoods) and close the sash completely when the hood is unattended.

e. Wear appropriate personal protective equipment (PPE) and clothing. Remove PPE and wash hands before leaving the laboratory.

f. Avoid working alone in a laboratory, especially when conducting hazardous procedures or handling hazardous materials.

g. Keep doors closed and the laboratory secured when it is unattended. Limit unauthorized entry into laboratories, especially when hazardous procedures are being conducted.

h. Do not eat, drink, use tobacco products, chew gum, apply cosmetics, or handle contact lenses in the laboratory.

i. Do not store food and drinks in laboratories or in laboratory refrigerators or freezers. Do not prepare food in the laboratory or wash utensils used for food and drink in laboratory sinks. Refrigerators and freezers used for the storage of food and beverages should be kept in a separate room (break area) with a door separating the laboratory from the break area. Label these units "Food Use Only."

j. Laboratory equipment that could be used for the preparation of food or beverages (such as microwave ovens, hot plates, and ice machines) should be dedicated exclusively for laboratory use. Clearly label such equipment to indicate "Lab Use Only," "No Food or Drink," and/or "Not for Human Consumption."

k. Do not pipet chemicals or biological materials by mouth. Use mechanical pipettes or pipetting devices instead.

l. Do not leave reactions or other potentially hazardous procedures unattended. Protect operations from utility failures and other potential problems that could lead to overheating or other hazardous events.

m. Clean equipment contaminated with chemical, biological or radiological materials immediately upon completion of the task. Have a spill kit on hand and clean up minor spills immediately. Call Environmental, Health & Safety for radiological spills, major chemical spills, or major biological spills.

n. Avoid using dry ice in enclosed areas. Dry ice can produce elevated carbon dioxide levels.

o. Avoid contaminating equipment with mercury. Replace mercury thermometers with a non-hazardous type. Contact E,H&S immediately if a mercury spill occurs.

p. Minor children are not permitted in laboratories or other hazardous areas without authorization from the Dean or their designee.

q. Keep work areas neat, clean, and free of clutter.

r. Keep hallways, corridors, and exit ways clear of equipment or clutter.

IMPORTANT: *Never underestimate the hazards associated with a laboratory. If you are unsure about what you are doing, get assistance. Do not use unfamiliar chemicals, equipment, or procedures without proper training and supervision.*

1.2 SECURITY

Laboratory security is vital to ensuring safety on campus. Not only should you protect your work area from theft and mischievous activities, but you should also keep unauthorized or unsuspecting persons from potentially becoming exposed to hazardous conditions. Follow these steps to secure your laboratory:

a. Close and lock laboratory doors when the laboratory is unoccupied.

b. Secure stocks of organisms and hazardous chemicals, especially when the laboratory is unoccupied. Lock refrigerators, freezers, and chemical storage cabinets located in areas open to public access.

c. Keep an accurate record of chemicals, stocks, cultures, etc. and any items or equipment that support project activities.

d. Notify the University Police Department (UPD) if materials are damaged or missing from laboratories or if unauthorized entry into a laboratory has been attempted.

e. Inspect all packages arriving at the laboratory. Do not accept suspicious or unexpected packages.

f. At the end of the day, ensure that all hazardous materials, whether chemical or biological have been properly stored and secured.

g. Greet all visitors to the laboratory immediately and determine their reason for entering your laboratory. Ask them to exit the room if they are not authorized to be there.

h. Implement other security requirements as necessary for your work.

i. Post current Emergency Contact Information on all laboratory doors.

j. Never prop open a laboratory door, except for a brief time to move items in and out.

1.3 TRAINING

TEXAS PRECURSOR CHEMICAL TRAINING- #2113304

The Texas Precursor Chemical course is a one-time training assigned to employees/students in designated administrative locations (Adlocs) to familiarize them with the responsibilities in regard to the regulated chemicals and apparatus (such as glassware) referenced in the Memorandum of Understanding between the Department of Public Safety and Texas Higher Education Coordinating Board.

- Employees and their supervisors are notified of the assignment via TrainTraq by email. Employees have 30 days to complete the training. All employees that are required to complete the Texas Precursor Chemical Training are also required to complete the Hazard Communication Training (2111466).
- It is the responsibility of the supervisor to ensure the employee completes all training assigned by the scheduled due date.
- E,H&S receives a monthly report from TrainTraq and performs a monthly spot check to verify that the training has been completed.

HAZARD COMMUNICATION TRAINING- # 2111466

The Texas Hazard Communication Act (THCA) is a state "worker right-to-know" law that requires public employers to provide their employees with specific information and training on the hazardous chemicals to which employees may be exposed in the workplace. Texas A&M University- Corpus Christi employees are assigned Hazard Communication training by administrative location or by their job duties.
Employees identified are assigned the Texas A&M University System Hazardous Communication training 2111466 in TrainTraq (see table below).

- New employees with a potential occupational exposure to Hazardous Chemicals are assigned this training prior to being required to use or handle hazardous chemicals.
- Employees and their supervisors are notified of the assignment via TrainTraq by email. Employees have 5 days to complete the training. All employees that are required to complete the Hazard Communication Training (2111466) are also required to complete the Texas Precursor Chemical Training (2113304).
- It is the responsibility of the supervisor to ensure the employee completes all training assigned by the scheduled due date.
- E,H&S receives a monthly report from TrainTraq and performs a monthly spot check to verify that the training has been completed.

BLOODBORNE PATHOGEN TRAINING- #2111525

Texas A&M University-Corpus Christi per the Bloodborne Pathogen (BBP) Standard as specified in the Texas Health and Safety Code §81.304 is required to provide BBP training to employees who have a risk of exposure to blood or other potentially infectious material. The university has developed an Exposure Control Plan (ECP) that identifies these employees. The ECP can be found at http://safety.tamucc.edu/

Employees identified are assigned the Texas A&M University System Bloodborne Pathogen training (2111525) in TrainTraq (see table below).

- Training for all employees is conducted prior to initial assignment to tasks where occupational exposure may occur.
- Job Classifications listed below have been added to job descriptions on WorkDay, resulting in the auto assignment of training in TrainTraq. At this time, only Faculty and Staff have been auto assigned.
- BBP Exposure Training shall be offered to applicable new employees in TrainTraq.
- Employees and their supervisors are notified of the assignment via TrainTraq by email. Employees have 7 days to complete the training.
- The employee's supervisor will ensure that an employee completes the BBP initial training in TrainTraq within five (7) days of assignment.

Job Classification	Department
Environmental, Health & Safety Staff	Environmental, Health & Safety-assigned by adloc. Director assigned to the BBP Group
Assistant Athletic Director for Facilities & Operation Head Athletic Trainer Assistant Athletic Trainer Facilities Coordinator Athletic Training Director Athletic Training Clinical Education Coordinator	Athletics-assigned to the BBP Group
RN LVN Associate Director Nurse Practitioner Physician	Health Services-assigned by adloc
Lab Coordinators: Biology, Biomedical, Chemistry, ESCI Faculty in the Biomedical Sciences Program	College of Science and Engineering-assigned to the BBP Group
Facilities Assistant I & II	Art Museum of South Texas- assigned to the BBP Group
Chief Captain Lieutenant Sergeant Police Officer- I, II, III	University Police: assigned by title codes and Chief assigned to the BBP Group
Associate Professor Assistant Professor Clinical Assistant Professor Clinical Associate Professor Lab Coordinators Graduate Research Assistant	College of Nursing & Health Sciences-assigned to the BBP Group
Director, Recreational Sports Assistant Director Coordinator Operations Technician Lifeguard Building Supervisor Momentum Field Supervisor	Recreational Sports assigned to the BBP Group
Assistant Director Facilities & Operations Manager Operations Coordinator	University Center- assigned to the BBP Group

- Annual refresher training is provided within one year of the employee's previous training. Employees have 30 days to complete the annual refresher. The employee's supervisor will ensure that an employee completes the BBP refresher in TrainTraq.
- Within the training, the employee has the option to complete the TAMUS Hepatitis B form if they chose to be vaccinated. This form is automatically sent to Environmental, Health & Safety.
- If an employee accepts the vaccination, they will be provided with the information needed to receive the vaccinations.
- The cost of the vaccinations is the responsibility of the employing department or as applicable to the Occupational Health Program (OHP).
- It is the responsibility of the supervisor to ensure the employee completes all training assigned by the scheduled due date.
- E,H&S receives a monthly report from TrainTraq and performs a monthly spot check to verify that the training has been completed.

1.4 Working in the Laboratory

Every person who works in a laboratory, whether an employee or a student, is responsible for being aware of the hazards in that laboratory and for working in a safe manner. This includes:

a. Know where emergency contact information is posted.
b. Know and follow emergency response procedures (including spill response, first aid response, evacuation routes, etc.).
c. Ensure you have received laboratory safety training *before* working with hazardous materials or equipment.
d. Wear appropriate Personal Protective Equipment; and
e. Report unsafe conditions to your supervisor and/or to E,H&S.

Laboratory personnel should avoid working alone. If procedures require a person to work at a time when others may not be present (such as after hours or on weekends) the person shall:

a. Obtain written permission to work alone in the laboratory (e.g., e-mail or letter from the Principal Investigator or Laboratory Supervisor).
b. Ensure that a means to contact emergency response personnel is available when working alone in the laboratory; and
c. Inform UPD so they are aware of building occupants in the case of an emergency and so they can perform building sweeps at regular intervals.

NOTE: *According to the National Safety Council, the term* ***alone*** *means that a person is beyond the visual or auditory range of any other individual for more than a few minutes at a time.*

1.5 Housekeeping

Maintain a neat and clean laboratory work area to minimize accidents in the laboratory. The following steps should be taken:

a. Keep aisles clear of clutter to eliminate tripping hazards and to maintain a clear exit path in the event of an emergency, such as a fire in the laboratory or building.
b. Dispose of empty boxes and other unneeded items that take up space.
c. Keep bench tops clear of clutter. Properly store chemicals and sharps when they are not in use or at the end of the workday. A clear workspace will reduce the likelihood of accidental contact with hazardous items.
d. Clean up spills, even minor ones, promptly.
e. Replace bench liners regularly or when they become dirty or contaminated.

1.6 Signage and Contact Information

Contact information should be posted at the entrance to every laboratory. This information should at minimum include the principal investigator (PI) or other person primarily responsible for the laboratory, the PI's office and laboratory phone numbers, and after-hours emergency contact information.

Depending upon the hazards located in the laboratory, such as biological or radiological, additional signage may be required. This information is critical for emergency personnel responding to an incident in the laboratory. Consult the appropriate section or authority for more information on signage requirements.

SECTION 2: Physical Safety

There are a variety of physical hazards that can be found in a laboratory environment. Many of these hazards are like those found in every home, and if common sense is applied, risks can be minimized. This section will focus on common physical hazards and how to reduce the risk associated with them.

2.1 Aerosol Production

Liquid or solid particles suspended in air are referred to as "aerosols." Aerosols containing infectious agents and hazardous materials can pose a serious health risk. If inhaled, small

aerosol particles can readily penetrate and remain deep in the respiratory tract. Also, aerosol particles can easily contaminate equipment, ventilation systems, and human skin. Because they may remain suspended in the air for long periods of time after they are initially discharged, steps should be taken to minimize the production of and exposure to aerosols.

The following may produce aerosols:

- Centrifuge
- Blender
- Shaker
- Magnetic stirrer
- Sonicator
- Pipette
- Vortex mixer
- Syringe and needle
- Vacuum-sealed ampoule
- Grinder, mortar, and pestle
- Test tubes and culture tubes
- Heated inoculating loop
- Separatory funnel
- Animals
- Hot plate (if chemicals are spilled onto the hot surface)
- Chemical or biological spills

Follow these guidelines to eliminate or reduce the hazards associated with aerosols:

a. Conduct procedures that may produce aerosols in a certified biological safety cabinet or a chemical fume hood.
b. Keep tubes stoppered when vortexing or centrifuging.
c. Allow aerosols to settle for five to ten minutes before opening a centrifuge, blender, or tube.
d. Place a cloth soaked with disinfectant over the work surface to kill any biohazardous agents.
e. Slowly reconstitute or dilute the contents of an ampoule.
f. When combining liquids, discharge the secondary material down the side of the container or as close to the surface of the primary liquid as possible to avoid splattering the material.
g. Avoid splattering by allowing inoculating loops or needles to cool before touching biological specimens.
h. Use a mechanical pipetting device.

2.2 Electrical Safety

Electrical safety is an important component of laboratory safety. When using electrical equipment in a laboratory, the guidelines below should be followed:

a. Check electrical cords and switches for damage prior to using equipment or appliances. Damaged cords (cords with frayed or exposed wires or with damaged or missing plug prongs) should be repaired promptly or the equipment should be locked/tagged out until the cord can be repaired.
b. Use extension cords only when necessary and only on a temporary basis (less than eight hours). Do not use extension cords in place of permanent wiring. Contact Facilities Services to request new outlets if your work requires equipment in an area without an outlet.
c. Use extension cords that are the correct size or rating for the equipment in use. The diameter of the extension cord should be the same or greater than the cord of the equipment in use.
d. Do not run electrical cords above ceiling tiles, through walls or across thresholds.
e. Keep electrical cords away from areas where they may be pinched and areas where they may pose a tripping or fire hazard (e.g., doorways, walkways, under carpet, etc.)
f. Appliances must be plugged directly into the wall. NFPA 1, 11.1.6 and 11.1.7.
g. Avoid "daisy-chaining" or "bird-nesting." Connecting power strips and/or extension cords in a series or cluster is against fire and electrical codes.
h. Use ground fault circuit interrupters when using electrical equipment near water sources.
i. Keep access to electrical panels clear of obstructions.

2.3 Mechanical/Equipment Safety

There are four fundamental elements of equipment safety:

1) Use the correct equipment for the job.
   Equipment should be used for its intended purpose only. **Never** modify or adapt equipment without guidance from the equipment manufacturer. Do **NOT** circumvent, remove, or override equipment safety devices! Doing so can result in injury or even death. (Example: Defeating a fume hood sash lock.)

2) Know how to properly operate equipment.
   This may require documented, specific training. Also, the user must be familiar with applicable safeguards and maintenance requirements.

3) Inspect equipment for damage and for required safety features prior to use.
   Ensure that equipment meets the following requirements:
   - Controls and safeguards are adequate and functional (e.g., interlocks that shut-off equipment automatically and guards that protect moving parts and belts).
   - The location is safe (and well-ventilated, if necessary).
   - Equipment works properly.

IMPORTANT: *Disconnect any equipment that is unsafe or does not work properly and remove it from service (lock out/tag out). Notify other users of the problem*.

4) Use equipment properly.
   Do **NOT** use the equipment in ways it was not designed or intended to be used. Strictly adhere to the manufactures operating instructions.

Refer to other sections in this chapter and manual for specific information on operating laboratory equipment, such as fume hoods, heating devices, vacuums, etc.

2.4 Noise/Auditory Safety

Many laboratory environments are noisy due to the number and type of equipment used in them. While some equipment is inherently noisy, others only become noisy when there is a problem, such as a loose belt. In noisy environments, precautions should be taken to protect personnel from hearing loss. Ear plugs or other hearing protection may be necessary. If equipment is operating at a louder than normal noise level, maintenance may need to be scheduled. E,H&S has instruments to measure noise levels in the work area. These measurements may be used to determine if noise attenuating materials or hearing protection needs to be implemented. Refer to the TAMU-CC Safety Manual at http://safety.tamucc.edu for details on hearing protection.

2.5 Glass & Metal Sharps

Accidents involving glassware are a leading cause of laboratory injuries. Careful handling and disposal of metal and glass sharps can minimize the risk of cuts and puncture wounds, not only for laboratory personnel, but for other university employees as well.

Laboratory Glassware

Follow these practices for using laboratory glassware safely:

- Prevent damage to glassware during handling and storage.
- Inspect glassware before and after each use. Discard any cracked, broken, or damaged glassware into the broken glass box, never in the trash can.
- Thoroughly clean and decontaminate glassware after each use.
- When inserting glass tubing into rubber stoppers, cores, or tubing follow these guidelines:
  - Use adequate hand protection, such as a glass tubing insertion tool.
  - Lubricate the tubing.
  - Hold hands close together to minimize movement if the glass breaks.
  - When possible, use plastic or metal connectors instead of glass connectors
- Heat and cool large glass containers slowly to reduce the risk of thermal shock.
- Use Pyrex or heat-treated glass for heating operations.
- Never use laboratory glassware to serve food or drinks.
- Do not wash laboratory glassware in the same sink in which food and beverage utensils are washed.
- Use thick-walled and/or round-bottomed glassware for vacuum operation. Flat-bottomed glassware is not as strong as round-bottomed glassware.
- Use a mesh glass sleeve around glassware or tape glassware that is under pressure. This will contain the glass in one place should it break.
- Use a standard laboratory detergent to clean glassware.

IMPORTANT: *<u>Avoid use of chromic acid</u> to clean glassware. Use a standard laboratory detergent. Chromic acid is extremely corrosive and expensive to dispose. Chromic acid must not be disposed in the sanitary sewer system.*

When handling glassware, follow these safety guidelines:

a. When handling cool flasks, grasp the neck with one hand and support the bottom with the other hand.

b. Lift cool beakers by grasping the sides just below the rim. For large beakers, use two hands: one on the side and one supporting the bottom.

c. Never carry bottles by their necks.

d. Use a cart or specially designed secondary container to transport large and/or heavy bottles.

e. Do not pick up broken glass with bare or unprotected hands. Use a brush and dustpan to clean up broken glass. Remove broken glass in sinks by using tongs for large pieces and cotton held by tongs for small pieces and slivers.

Metal Sharps

Metal sharps should be carefully stored and handled properly. Follow these guidelines:

a. Do not uncap a needle by placing the cap in your mouth.
b. Never re-cap a used syringe needle by hand or mouth, and never manipulate (bend, break, shear, remove from syringe, etc.) a needle. Immediately place used/contaminated sharps in a sharp's disposal container.
c. Do not leave sharps, including razor and scalpel blades, lying unprotected on bench tops. Place in a secondary container when not in use or when being transported.
d. If a needle/syringe must be reused,
    i. Use self-sheathing syringes or other safety devices for re-capping sharps whenever possible. The one-handed scoop method may be used as a last resort.
    ii. Place the uncapped syringe/needle in cork or foam. Place needles a tray or other type of secondary container when not in use and when being transported.

For information on glass waste and sharps disposal procedures, see Chapter 4 – Laboratory Waste Disposal.

2.6 TEMPERATURE

Equipment that produces extreme temperatures are often used in laboratories. Whether the equipment is a -80 freezer, a walk-in cooler or freezer, cryogenic liquids, a hotplate, an oven, or an autoclave, caution should be taken whenever extreme temperatures may be encountered. Not using appropriate protective equipment, such as temperature resistant gloves, when using this equipment can lead to painful injuries.

Before using temperature generating equipment, become familiar with proper procedures and handling techniques. Pay special attention to the personal protective equipment required for that equipment. Posting signs that warn of the hazard may help reduce the likelihood of someone accidentally touching an extremely hot or cold surface – such as a hot plate - especially if it is not obvious that the equipment is on.

2.7 PRESSURIZED SYSTEMS

Pressurized systems have the potential to cause extensive damage and injury if extreme caution is not taken. Pressurized systems include compressed gases, liquid cryogenic cylinders, and vacuum systems, among others. When working with pressurized systems, remember:

a. Do not conduct a reaction in, or apply heat to, a closed system apparatus unless the equipment is designed and tested to withstand pressure. See American Society of Mechanical Engineers (ASME) Code, Section VIII for more information about maximum allowable working pressure (MAWP).
b. Pressurized systems should have an appropriate relief valve set at the MAWP.
c. Pressurized systems must be fully shielded and should not be utilized in an occupied space until safe operation has been assured. Until safe operation is assured, remote operation is mandatory.

Safety points to remember:

a. Limit exposure to pressurized systems to minimize risk.
b. Identify and assess all hazards and consequences prior to beginning operations.
c. Use remote manipulations whenever possible.
d. Minimize pressure, volume, and temperature.
e. Design pressurized systems conservatively relative to the operating temperature and pressure.
f. Use material with a predictable safe failure mode.
g. Ensure that the components of the pressurized system will maintain structural integrity at the maximum allowable working pressure.

IMPORTANT: Do not use glass containers for pressurization unless the glass item is designed to be pressurized and is rated for pressurization by the manufacturer.

h. Only use equipment designed for use under pressure. Avoid material that may become brittle at extreme temperatures.
i. Operate within the original design parameters.
j. Ensure safety mechanisms (e.g., pressure relief valves, fail-safe devices) are in place.
k. Use quality hardware.
l. Use protective shield or enclosures.

m. Use tie-downs to secure tubing and other equipment.

n. Do not leave a pressurized system unattended.

SECTION 3: EQUIPMENT SAFETY

3.1 COMPRESSED GASES

Compressed gases in the laboratory present chemical and physical hazards. The gases may be toxic, corrosive, flammable, or explosive (reactive). If compressed gases are accidentally released, they may cause the following:

- Depleted oxygen atmosphere, potentially resulting in asphyxiation (includes inert gases)
- Fire or explosion
- Adverse health effects from chemical exposure
- Physical damage to facilities or injuries to personnel as a result of the sudden release of potential energy

Cylinders that fall, are knocked over or dropped can be very dangerous and can cause serious injuries. If a valve is knocked off a compressed gas cylinder, the cylinder can become a high speed, potentially lethal projectile.

IMPORTANT: Cylinders can travel through walls much like a torpedo travel through water. They can cause structural damage, severe injury, and even death.

Because disposal of compressed gas cylinders is difficult and expensive, be sure to arrange a return agreement with suppliers prior to purchase.

Guidelines to ensure safe storage of gas cylinders:

a. Check the label. The cylinder must be clearly marked with its contents and with any hazard warnings. Do not rely on color to identify container contents.

b. Secure all cylinders to a wall or bench using brackets or clamping devices designed for such. Cylinders may also be stored in gas cylinder racks or floor stands. (A cylinder dolly should not be used for storage.)

   i. Fasten cylinders individually (not ganged or grouped).

   ii. Fasten cylinders with a sturdy chain. A strap, bungee cord and rope are not acceptable as a means of securing compressed gas cylinders.

c. Store cylinders in a well-ventilated area that is cool and dry. Ignition sources such as heat, sparks, flames, and electrical circuits should be kept away from gas cylinders.

d. When not in use (i.e., the regulator has been removed), gas cylinders should be stored with a safety cap attached.
e. Minimize the number of hazardous gas cylinders in a laboratory. Do not exceed the following:
    i. Three 10" x 50" flammable gas and/or oxygen cylinders, and
    ii. Two 9" x 30" liquefied flammable gas cylinders, and
    iii. Three 4" x 15" cylinders of severely toxic gases (e.g., arsine, chlorine, diborane, fluorine, hydrogen cyanide, methyl bromide, nitric oxide, phosgene).
f. Store cylinders of flammables and oxidizing agents at least 20 feet apart or separate these items with a fire wall.
g. Do not store cylinders with corrosive materials.
h. Do not store cylinders on the tops of shelves or cabinets.
i. Keep flammable gases away from doorways or exit routes.
j. Separate full cylinders from empty cylinders. Label empty cylinders as "Full", "In-Use", or "Empty" as appropriate with a hangar tag or similar label.
k. Do not store gas cylinders in hallways or public areas. Cylinders should be stored in a secure area.
l. Close valves, and release pressure on the regulators when cylinders are not in use.
m. Dispose of old lecture bottles. Return lecture bottles to the supplier or dispose of them as hazardous waste.

Handling and working with compressed gas cylinders:

a. Never move a gas cylinder unless the cylinder safety cap is in place.
b. When working with particularly hazardous gases use special procedures and work in approved gas storage cabinets.
c. The gas cylinder should be chained or otherwise secured to an approved cylinder cart or dolly when being transported. Do not move a cylinder by rolling it on its base.
d. Only use regulators approved for the type of gas in the cylinder. Do not use adapters to interchange regulators. Also, never try to repair or modify a gas regulator or its pressure gauges.
e. Do not use Teflon tape when attaching the regulator.
f. When opening a cylinder valve, follow these guidelines:
    i. Direct the cylinder opening away from people.

ii. Open the valve slowly. Never open a cylinder valve without a regulator.

g. For a leaking cylinder:
   i. Close the valve if it is open and contact the supplier to pick it up
   ii. If the valve is already closed, leave the laboratory, and shut the door behind you. Contact E,H&S immediately.

h. Do not use oil or other lubricant on valves and fittings.

i. Do not use oxygen as a substitute for compressed air.

j. Do not lift cylinders by the safety cap.

k. Do not tamper with the safety devices on a cylinder. Have the manufacturer or supplier handle cylinder repairs.

l. Do not change a cylinder's label or color. Do not refill cylinders yourself.

m. Do not heat cylinders to raise internal pressure.

n. Do not use compressed gas to clean your skin or clothing.

o. Do not completely empty cylinders. Maintain at least 30 psi pressure.

p. Use only brass connectors or tubing with acetylene. Acetylene can form explosive compounds with silver, copper, and mercury.

q. Do not store acetylene cylinders on their side.

r. Always wear impact resistant glasses or goggles when working with compressed gases.

s. Do not subject compressed gas cylinders to cryogenic temperatures.

3.2 CRYOGENIC LIQUIDS

Cryogenic fluids are extremely cold liquefied gases, such as liquid nitrogen or liquid oxygen, and are used to obtain extremely cold temperatures. Most cryogenic liquids are odorless, colorless, and tasteless. When cryogenic liquids are exposed to the atmosphere, however, they create a highly visible and dense fog.

Cryogens pose numerous hazards. A person who is exposed to cryogens can have significant health consequences. All cryogens, except for oxygen, can displace breathable air and can cause asphyxiation. Cryogens can also cause frostbite on exposed skin and eye tissue.

IMPORTANT: *Be aware of the tremendous expansion and threat of asphyxiation when a cryogenic liquid vaporizes at room temperature.*

There is also an increased risk of fire in areas where liquid cryogens are stored and used. For example, cryogenic vapors from liquid oxygen, liquid hydrogen or other flammable

cryogens may cause a fire or explosion if ignited. Materials that are normally noncombustible (e.g., carbon steel) may ignite if coated with an oxygen-rich condensate. Liquefied inert gases, such as liquid nitrogen or liquid helium, are capable of condensing atmospheric oxygen and causing oxygen entrapment or enrichment in unsuspected areas. Extremely cold metal surfaces are also capable of entrapping atmospheric oxygen.

Because the low temperatures of cryogenic liquids may affect physical properties of materials such as stainless steel or aluminum, take care to select equipment materials accordingly.

Follow these guidelines when working with cryogenic liquids:

a. Before working with cryogenic liquids, acquire a thorough knowledge of cryogenic procedures, equipment operation, safety devices, and material properties. Cryogenic training should be documented.
b. Reject delivery of unsafe cylinders.
c. Keep equipment and systems extremely clean.
d. Avoid skin and eye contact with cryogenic liquids. Wear appropriate personal protective equipment, such as a laboratory coat, temperature resistant gloves, and chemical splash goggles. Also, do not inhale cryogenic vapors.
e. Pre-cool receiving vessels to avoid thermal shock and splashing.
f. Use tongs to place and remove items in cryogenic liquid.
g. When discharging cryogenic liquids, purge the line slowly. Only use transfer lines specifically designed for cryogenic liquids.
h. Rubber and plastic may become very brittle in extreme cold. Handle these items carefully when removing them from cryogenic liquid.
i. Store cryogenic liquids in double-walled, insulated containers (e.g., Dewar flasks) which are designed for this use.
j. Do not plug relief valves on cryogenic tanks and Dewar flasks.
k. Tape exposed glass on cryogenic containers. In the event the container breaks or implodes, the tape will reduce fragmentation and violent dispersal of glass shards.
l. Do not store cylinders of cryogenic liquids in hallways or other public areas.

3.3 Vacuum Systems

All vacuum equipment is subject to possible implosion. Take precautions to minimize damage and injuries that can result from an implosion. When using a vacuum system, follow these guidelines and requirements to ensure system safety:

a. Ensure that pumps have belt guards in place during operation.
b. Ensure that service cords and switches are free from defects.
c. Always use a trap on vacuum lines to prevent liquids from being drawn into the pump, vacuum line, or water drain. An in-line High Efficiency Particulate Air (HEPA) filter is required whenever biohazardous or recombinant DNA materials are used in a vacuum system.
d. Replace and properly dispose of vacuum pump oil that is contaminated with condensate. Used pump oil must be disposed of as hazardous waste.
e. Place a pan under pumps to temporarily catch oil drips.
f. Do not operate pumps near containers of flammable chemicals.
g. Do not place pumps in an enclosed, unventilated cabinet. Dangerous carbon monoxide gas and heat can build up in enclosed spaces.
h. Conduct all vacuum operations behind a table shield or in a fume hood. Also, glassware may be wrapped with tape to minimize the effects of an implosion.
i. Use only heavy-walled round-bottomed glassware for vacuum operations. The only exception to this rule is glassware specifically designed for vacuum operations, such as an Erlenmeyer filtration flask.
j. Wrap exposed glass with tape to prevent flying glass if an implosion occurs.
k. Carefully inspect vacuum glassware before and after each use. Discard any glass that is chipped, scratched, broken, or otherwise stressed.
l. Wear appropriate PPE, including safety glasses or goggles and a face shield when approaching a system under pressure.
m. Glass desiccators often have a slight vacuum due to contents cooling. When possible, use molded plastic desiccators with high tensile strength. For glass desiccators, use a perforated metal desiccator guard.

CAUTION: *Do not underestimate the pressure differential across the walls of glassware that can be created by a water aspirator.*

Cold Trap

A cold trap is a condensing device used to prevent moisture contamination in a vacuum line. Follow these guidelines for using a cold trap:

a. Locate the cold trap between the system and vacuum pump.
b. Ensure that the cold trap is of appropriate size and temperature to condense vapors present in the system.
c. Check frequently for blockages in the cold trap.

d. Use isopropanol/dry ice or ethanol/dry ice instead of acetone/dry ice to create a cold trap. Isopropanol and ethanol are cheaper, less toxic, and less prone to foam.

e. Do not use dry ice or a liquefied gas refrigerant bath as a closed system. These can create uncontrolled and dangerously high pressures.

3.4 CENTRIFUGES

A centrifuge is a common piece of laboratory equipment, and using a centrifuge properly is essential to preventing accidents which could result in serious injury or destruction of the equipment. The hazards associated with centrifuges can be related to the equipment itself, the materials used in the centrifuge, or improper use of the centrifuge. It is vital that the centrifuge operator has been thoroughly trained on how to safely use the centrifuge and on how to properly maintain it.

Guidelines for Centrifuge Use

a. Centrifuge operators must be trained in the proper use, handling, storage, and maintenance of the equipment.

b. Use a centrifuge only if it has a disconnect switch that deactivates the rotor when the lid is open. Replace older models that do not have this safety feature.

c. Always keep the lid closed and locked during operation and shut down. Do not open the lid until the rotor is completely stopped or attempt to stop the head rotation by hand.

IMPORTANT: *Attempting to defeat safety mechanisms and/or to stop the rotor by hand could result in severe injury!*

d. Use the centrifuge in a well-ventilated area.

e. Low-speed and small portable centrifuges that do not have aerosol-tight chambers may allow aerosols to escape. Use a safety bucket to prevent aerosols from escaping or use the centrifuge in a biological safety cabinet or fume hood.

Safe Operating Techniques

The following safe operating techniques should be followed for proper centrifuge operation:

a. Inspect the inside of each tube cavity or bucket prior to using the centrifuge. The rotor and tubes should be clean and dry. Remove any glass or other debris from the rubber cushion.

b. Before loading the rotor, examine the tubes for signs of stress, and discard any tubes that are damaged.

c. Ensure that centrifuge tubes are not filled more than three-fourths full. Overfilling can result in leaks or spills. Also, do not fill tubes to the point where the rim, cap, or cotton plug becomes wet.

d. When balancing the rotors, match the tubes, buckets, adapters, and inserts against each other, and consider any added solution. Tubes, etc. should be spaced or distributed evenly around the rotor, and the density of the contents of the tubes should also be similar.

e. Whenever possible, use safety cups and centrifuge caps on all tubes.

f. Do not use aluminum foil to cap a centrifuge tube. Foil may rupture or detach.

g. Ensure that the centrifuge has adequate shielding to guard against accidental ejection.

h. Stop the rotor and discontinue operation if you notice anything abnormal such as a noise or vibration.

High Speed Centrifuges

High-speed centrifuges pose additional hazards due to the higher stress and force applied to their rotors and tubes. It is necessary to understand the basic mechanics of the equipment and to know how to maintain it properly to ensure overall safety and reduce risk. In addition to the safety guidelines outlined above, follow these guidelines for high-speed centrifuges:

- Be sure the centrifuge rotor and tubes are clean and dry prior to use.
- The centrifuge should be cleaned periodically to help prevent corrosion or other damage. Routinely wash rotors with a mild dish soap to prolong rotor life. Rinse and let air dry.
- Clean any spills in the centrifuge immediately, especially if the materials are corrosive.
- Frequently inspect the rotor and other parts for corrosion, wear, or other damage; turn the spindle by hand. Rotors or parts exhibiting corrosion or other damage should be removed from use and evaluated by a service technician.
- Check the expiration date of both the rotor and centrifuge. Always follow the manufacturer's retirement date for rotors and other centrifuge parts.
- Do not exceed manufacturer recommendations for safe operating speeds.
- Keep a record of rotor usage and follow the manufacturer's recommendations on when to replace the rotor.
- For centrifuges that have been refrigerated, wipe away any excess moisture and allow the open unit to dry.
- Filter the air exhausted from the vacuum lines.

3.5 ELECTROPHORESIS

Electrophoresis equipment may be a major source of electrical hazard in the laboratory. The presence of high voltage and conductive fluid in this apparatus presents a potentially lethal combination.

Many people are unaware of the hazards associated with this apparatus; even a standard electrophoresis operating at 100 volts can deliver a lethal shock at 25 milliamps. In addition, even a slight leak in the device tank can result in a serious shock.

Protect yourself from the hazards of electrophoresis and electrical shock by taking these precautions:

- Use physical barriers to prevent inadvertent contact with the apparatus.
- Use electrical interlocks.
- Frequently check the physical integrity of the electrophoresis equipment.
- Use warning signs to alert others of the potential electrical hazard.
- Use only insulated lead connectors.
- Turn the power off before connecting the electrical leads.
- Connect one lead at a time using one hand only.
- Ensure that your hands are dry when connecting the leads.
- Keep the apparatus away from water and water sources.
- Turn the power off before opening the lid or reaching into the chamber.
- Do not disable safety devices.
- Follow the equipment operating instructions.

3.6 HEATING SYSTEMS

Common hazards associated with laboratory heating devices include electrical hazards, fire hazards, and hot surfaces. Devices that supply heat for reactions or separations include the following:

- Open flame burners
- Hot plates
- Heating mantles
- Oil and air baths
- Hot air guns
- Ovens
- Furnaces
- Ashing systems

Follow these guidelines when using heating devices:

a. Before using any electrical heating device:
    i. Ensure that heating units have an automatic shutoff to protect against overheating.
    ii. Ensure that heating devices and all connecting components are in good working condition.
b. Use caution when heating chemicals, as heated chemicals can cause more damage more quickly than would the same chemicals at a lower temperature.

RULE OF THUMB: *Generally, reaction rates double for each 10° C increase in temperature.*

c. Use heating baths equipped with timers to ensure that they turn on and off at appropriate times.
d. Use a chemical fume hood when heating flammable or combustible solvents. Arrange the equipment so that escaping vapors do not contact heated or sparking surfaces.
e. Use non-asbestos thermal-heat resistant gloves to handle heated materials and equipment.
f. Perchloric acid digestions must be conducted in a perchloric fume hood.

IMPORTANT: *See Chapter 3 - Chemical Safety for more information on using perchloric acid.*

g. Minimize the use of open flames. *Never* leave an open flame unattended.
h. Follow manufacturer's instructions when operating any heating system or equipment.

3.7 REFRIGERATORS/FREEZERS

Using a household refrigerator to store laboratory chemicals is extremely hazardous for several reasons. Many flammables' solvents are still volatile at refrigerator temperatures. Refrigerator temperatures are typically higher than the flashpoint of most flammable liquids. In addition, the storage compartment of a household refrigerator contains numerous ignition sources including thermostats, light switches, heater strips, and light bulbs. Furthermore, the compressor and electrical circuits, located at the bottom of the unit where chemical vapors are likely to accumulate, are not sealed.

Laboratory-safe and explosion-proof refrigerators typically provide adequate protection for chemical storage in the laboratory. Laboratory-safe refrigerators, for example, are specifically designed for use with flammables since the sparking components are located on the exterior of the refrigerator. Explosion-proof refrigerators are required in areas that may contain high levels of flammable vapors (e.g., chemical storage rooms with large quantities of flammables).

Follow these rules for using refrigerators and freezers in the laboratory:

a. Never store flammable chemicals in a household refrigerator.
b. Do not store food or drink in a laboratory refrigerator/freezer.
c. Ensure that all refrigerators are clearly labeled to indicate suitable usage.
    i. Laboratory-safe and explosion-proof refrigerators should be identified by a manufacturer label.
    ii. Refrigerators used to hold food should be labeled "For Food Only" and should be located outside of the laboratory.

SECTION 4: BIOLOGICAL AND ANIMAL SAFETY

Many laboratories on campus use biological materials, including biological pathogens, toxins and allergens derived from biological agents. Some laboratories work with animals in their research or in clinical settings. In these laboratories, Biological and/or Animal Safety is integral to overall laboratory safety.

For research involving biological materials or animals, oversight by Research Compliance Office (RCO) may be required. Three committees within the RCO oversee and grant approval for conducting such research.

- The Institutional Review Board (IRB) manages research involving human subjects.
- The Institutional Animal Care and Use Committee (IACUC) oversees any research involving the use of animals.
- The Institutional Biosafety Committee (IBC) manages research involving recombinant DNA materials, biological pathogens, and biological toxins (including those on the Select Agent List). Specific information on Biological Safety may be obtained from the Institutional Biosafety Committee.

4.1 BIOSAFETY LEVEL 1

Biosafety Level 1 is suitable for work involving well-characterized agents not known to consistently cause disease in immunocompetent adult humans, and present minimal potential hazard to laboratory personnel and the environment. BSL-1 laboratories are not necessarily separated from the general traffic patterns and work is conducted on open bench tops using stand microbiological practices.

The following standard practices, safety equipment, and facility requirements apply to BSL-1 laboratories:

Standard Microbiological Practices

1. The laboratory supervisor must enforce the institutional policies that control access to the laboratory.

2. Persons must wash their hands after working with potentially hazardous materials and before leaving the laboratory.
3. Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human consumptions must not be permitted in laboratory areas. Food must be stored outside the laboratory area in cabinets or refrigerators designated and used for this purpose.
4. Mouth pipetting is prohibited; mechanical pipetting devices must be used.
5. Policies for the safe handling of sharps, such as needles, scalpels, pipettes, and broken glassware must be developed and implemented. Whenever practical, laboratory supervisors should adopt improved engineering and work practice controls that reduce risk of sharps injuries. Precautions, including those listed below must always be taken with sharp items. These include:
    a. Careful management of needles and other sharps are of primary importance. Needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal.
    b. Used disposable needles and syringes must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal.
    c. Non-disposable sharps must be placed in a hard-walled container for transport to a processing area for decontamination, preferably by autoclaving.
    d. Broken glassware must not be handled directly. Instead, it must be removed using a brush and dustpan, tongs, or forceps. Plastic ware should be substituted for glassware whenever possible.
6. Perform all procedures to minimize the creation of splashes and/or aerosols.
7. Decontaminate work surfaces after completion of work and after any spill or splash of potentially infectious material with appropriate disinfectant.
8. Decontaminate all cultures, stocks, and other potentially infectious materials before disposal using an effective method. Depending on where the decontamination will be performed, the following methods should be used prior to transport.
    a. Materials to be decontaminated outside of the immediate laboratory must be placed in a durable, leak proof container and secured for transport.
    b. Materials to be removed from the facility for decontamination must be packed in accordance with applicable local, state, and federal regulations.
9. A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents are present. The sign may include the name of the agent(s) in use, and the name and phone number of the laboratory supervisor or other responsible personnel. Agent information should be posted in accordance with the institutional policy.
10. An effective integrated pest management program is required.

11. The laboratory supervisor must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures. Personnel must receive annual updates or additional training when procedural or policy changes occur. Personal health status may impact an individual's susceptibility to infection, ability to receive immunizations or prophylactic interventions. Therefore, all laboratory personnel and particularly women of childbearing age should be provided with information regarding immune competence and conditions that may predispose them to infection. Individuals having these conditions should be encouraged to self-identify to the institution's healthcare provider for appropriate counseling and guidance.

Special Practices

1. None required.

Safety Equipment (Primary Barriers and Personal Protective Equipment)

1. Special containment devices or equipment, such as BSCs, are not generally required.
2. Protective laboratory coats, gowns, or uniforms are recommended to prevent contamination of personal clothing.
3. Wear protective eyewear when conducting procedures that have the potential to create splashes of microorganisms or other hazardous materials. Persons who wear contact lenses in laboratories should also wear eye protection.
4. Gloves must be 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. Wash hands prior to leaving the laboratory. In addition, BSL-1 workers should:
    a. Change gloves when contaminated, glove integrity is compromised, or when otherwise necessary.
    b. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory.
    c. Do not wash or reuse disposable gloves. Dispose of used gloves with laboratory waste. Hand washing protocols must be rigorously followed.

Laboratory Facilities

1. Laboratories should have doors for access control.
2. Laboratories must have a sink for hand washing.
3. The laboratory should be designed so that it can be easily cleaned. Carpets and rugs in laboratories are not appropriate.

4. Laboratory furniture must be capable of supporting anticipated loads and uses. Spaces between benches, cabinets, and equipment should be accessible for cleaning.
    a. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals
    b. Chairs used in laboratory work must be covered with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.
5. Laboratory windows that open to the exterior should be fitted with screens.

4.2 BIOSAFETY LEVEL 2

Biosafety Level 2 builds upon BSL-1. BSL-2 is suitable for work involving agents that pose moderate hazards to personnel and the environment. It differs from BSL-1 in that: 1) laboratory personnel have specific training in handling pathogenic agents and are supervised by scientists competent in handling infectious agents and associated procedures; 2) access to the laboratory is restricted when work is being conducted; and 3) all procedures in which infectious aerosols or splashes may be created are conducted in BSCs or other physical containment equipment.

The following standard and special practices, safety equipment, and facility requirements apply to BSL-2.

Standard Microbiological Practices

1. The laboratory supervisor must enforce the institutional policies that control access to the laboratory.
2. Persons must wash their hands after working with potentially hazardous materials and before leaving the laboratory.
3. Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human consumption must not be permitted in laboratory areas. Food must be stored outside the laboratory area in cabinets or refrigerators designated and used for this purpose.
4. Mouth pipetting is prohibited; mechanical pipetting devices must be used.
5. Polices for handling of sharps, such as needles, scalpels, pipettes, and broken glassware must be developed and implemented. Whenever practical, laboratory supervisors should adopt improved engineering and work practice controls that reduce risk of sharps injuries. Precautions, including those listed below, must always be taken with sharp items. These include:
    a. Careful management of needles and other sharps are of primary importance. Needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal.

b. Used disposable needles and syringes must be carefully placed in conveniently located puncture resistant containers used for sharps disposal.

c. Non-disposable sharps must be placed in a hard-walled container for transport to a processing area for decontamination, preferable autoclaving.

d. Broken glassware must not be handled directly. Instead, it must be removed using a brush and dustpan, tongs, or forceps. Plastic ware should be substituted for glassware whenever possible.

6. Perform all procedures to minimize the creation of splashes and/or aerosols.
7. Decontaminate work surfaces after completion of work and after any spill or splash of potentially infectious material with appropriate disinfectant.
8. Decontaminate all cultures, stocks, and other potentially infectious materials before disposal suing an effective method. Depending on where the decontamination will be performed, the following methods should be used prior to transport:
   a. Materials to be decontaminated outside the immediate laboratory must be placed in a durable, leak proof container and secured for transport.
   b. Materials to be removed from the facility for decontamination must be packed in accordance with applicable local, state, and federal regulations.
9. A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents are present. Posted information must include the laboratory's biosafety level, the supervisor's name (or other responsible personnel), telephone number, and required procedures for entering and exiting the laboratory. Agent information should be posted in accordance with the institutional policy.
10. An effective integrated pest management program is required.
11. The laboratory supervisor must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures. Personnel must receive annual updates or additional training when procedural or policy changes occur. Personal health status may impact an individual's susceptibility to infection, ability to receive immunizations or prophylactic interventions. Therefore, all laboratory personnel and particularly women of childbearing age should be provided with information regarding immune competence and conditions that may predispose them to infection. Individuals having these conditions should be encouraged to self-identify to the institution's healthcare provider for appropriate counseling and guidance.

Special Practices

1. All persons entering the laboratory must be advised of the potential hazards and meet specific entry/exit requirements.

2. Laboratory personnel must be provided medical surveillance, as appropriate, and offered available immunizations for agents handled or potentially present in the laboratory.
3. Each institution should consider the need for collection and storage of serum samples from at-risk personnel.
4. A laboratory-specific biosafety manual must be prepared and adopted as policy. The biosafety manual must be available and accessible.
5. The laboratory supervisor must ensure that laboratory personnel demonstrate proficiency in stand and special microbiological practice before working with BSL-2 agents.
6. Potentially infectious materials must be placed in a durable, leak proof container during collection, handling, processing, storage, or transport within a facility.
7. Laboratory equipment should be routinely decontaminated, as well as, after spills, splashes, or other potential contamination.
    a. Spills involving infectious materials must be contained, decontaminated, and cleaned up by staff properly trained and equipped.
    b. Equipment must be decontaminated before repair, maintenance, or removal from the laboratory.
8. Incidents that may result in exposure to infectious materials must be immediately evaluated and treated according to procedures described in the laboratory biosafety manual. All such incidents must be reported to the laboratory supervisor. Medical evaluation, surveillance, and treatment should be provided, and appropriate records maintained.
9. Animal and plants not associated with the work being performed must not be permitted in the laboratory.
10. All procedures involving the manipulation of infectious materials that may generate an aerosol should be conducted within a BSC or other physical containment devices.

Safety Equipment (Primary Barriers and Personal Protective Equipment)

1. Properly maintained Biosafety cabinets (BSC), other appropriate personal protective equipment, or other physical containment devices must be used whenever:
    a. Procedures with a potential for creating infectious aerosols or splashes are conducted. These may include pipetting, centrifuging, grinding, blending, shaking, mixing, sonicating, opening containers of infectious materials, inoculating animals intranasally, and harvesting infected tissues from animals or eggs.
    b. High concentrations or large volumes of infectious agents are used. Such materials may be centrifuged in the open laboratory using sealed rotor heads or centrifuge safety cups.

2. Protective laboratory coats or uniforms designated for laboratory use must be worn while working with hazardous materials. Remove protective clothing before leaving for non-laboratory areas (e.g., cafeteria, library, and administrative offices). Dispose of protective clothing appropriately, or deposit it for laundering by the institution. It is recommended that laboratory clothing not be taken home.
3. Eye and face protection (goggles, mask, face shield or other splatter guard) is used for anticipated splashes or sprays of infectious or other hazardous materials when the microorganisms must be handled outside the BSC or containment device. Eye and face protection must be disposed of with laboratory waste or decontaminated before reuse. Persons who wear contact lenses in laboratories should also wear eye protection.
4. Gloves must be 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. Gloves must not be worn outside the laboratory. In addition, BSL-2 laboratory workers should:
    a. Change gloves when contaminate, glove integrity is compromised, or when otherwise necessary.
    b. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory.
    c. Do not wash or reuse disposable gloves. Dispose of used gloves with laboratory waste. Hand washing protocols must be rigorously followed.
5. Eye, face, and respiratory protection should be used in rooms containing infected animals as determined by the risk assessment.

Laboratory Facilities (Secondary Barriers)

1. Laboratory doors must be self-closing and have locks in accordance with the institutional policies.
2. Laboratories must have a sink for hand washing. The sink may be manually, hands-free, or automatically operated. It should be located near the exit door.
3. The laboratory should be designed so that it can be easily cleaned and decontaminated. Carpets and rugs in laboratories are not permitted.
4. Laboratory furniture must be capable of supporting anticipated loads and uses. Spaces between benches, cabinets, and equipment should be accessible for cleaning.
    a. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemical.
    b. Chairs used in laboratory work must be covered with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.
5. Laboratory windows that open to the exterior are not recommended. However, if a laboratory does have windows that open to the exterior, they must be fitted with screens.
6. BSCs must be installed so that fluctuations of the room air supply and exhaust do not interfere with proper operations. BSCs should be located away from doors,

windows that can be opened, heavily traveled laboratory areas, and other possible airflow disruptions.
7. Vacuum lines should be protected with liquid disinfectant traps.
8. An eyewash station must be readily available.
9. There are no specific requirements for ventilation systems. However, planning of new facilities should consider mechanical ventilation systems that provide an inward flow of air without recirculation to spaces outside of the laboratory.
10. HEPA filtered exhaust air from a Class II BSC can be safely recirculated 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) connection or directly exhausted outside through a hard connection. Provisions to assure proper safety cabinet performance and air system operation must be verified.
11. A method for decontaminating all laboratory wastes should be available in the facility (e.g., autoclave, chemical disinfection, incineration, or other validated decontamination method).

4.3 AUTOCLAVES

Safe and Effective Use of Autoclaves

Autoclaves use high pressure and high temperature steam to sterilize media, glassware, instruments, waste, etc. To accomplish the desired end goal and to protect the user and the environment from hazardous materials, the autoclave must be used correctly. Additionally, wastes must be managed in compliance with state and local regulations. The physical hazards that are involved with steam autoclaves are heat, steam, and pressure. The biological hazards involve potential exposure to viable pathogens.

Due to the high heat and pressure created in autoclaves during operation, proper loading, use, and unloading procedures must be followed to prevent burns and other accidents. Burns can result from physical contact with the structure of the autoclave and steam burns can occur from contact with steam leaving the apparatus. Burns can also result from careless handling of vessels containing hot liquids. Explosive breakage of glass vessels during opening and unloading because of temperature stresses can lead to mechanical injury, cuts, and burns. Autoclave performance for the purpose of sterilization is dependent on proper use.

General Procedures

It is the supervisor's responsibility to ensure his/her employees are trained before operating any autoclave unit and that procedural and instructional documents are followed. Personnel who use an autoclave must be trained to understand proper packaging, loading, labeling, and operation procedures.

1. All potentially infectious materials must be autoclaved before being washed and stored or disposed.

2. Personnel who use an autoclave must be trained to understand proper packaging, loading, labeling, and operation procedures.
3. Biohazardous materials must be labeled as such and must be sterilized by the end of each workday or must be secured appropriately. Do not leave biohazardous materials in an autoclave overnight in anticipation of autoclaving the next day.
4. Do not autoclave materials that also contain toxic or volatile chemical or radiological agents.

Packaging

1. Use bags or other containers labeled "Biohazard" for items that contain or may be contaminated with potentially infectious agents.
2. Use plain, unmarked containers for items that are not hazardous.
3. Do not double bag waste or tightly seal containers as this will impede steam penetration.
4. Do not put sharp objects such as broken glassware into an autoclave bag.
5. Open, shallow metal pans are more effective in conducting heat and allowing air removal than tall, plastic tubs.
6. Vessels with liquid should not be plugged or tightly capped.
7. It is advisable to add some water to bags of solid wastes (the water will vaporize into steam that will drive out residual air once sterilization temperature has been reached inside the bag).
8. When using an autoclave bag with a 'Biohazard' symbol on it, place a strip of tape that produces the word "autoclaved" across the symbol. This must be done for any autoclave bag that has a Biohazard symbol.

Loading

1. Place containers of liquid, bags of agar plates, or other items that may boil over or leak inside a secondary pan in the autoclave.
2. Never place autoclave bags or glassware in direct contact with the bottom of the autoclave.
3. Do not overload the autoclave; leave sufficient room for thorough steam circulation.
4. Make sure the plug screen in the bottom of the autoclave is clean.
5. Do not mix loads of liquids with solids.

Operating Parameters

1. The parameters for the sterilization cycle will depend upon the amount and type of material. Usually, 121 C° at 15 psi for a minimum of 30 minutes is recommended. However, the temperature and cycle time should be determined using a worst-case

load and using a biological indicator as verification that sterilization was achieved (e.g., ampoule of *B. stearothermophilus* spores placed in the middle of the full load). A biological indicator should be used frequently enough (e.g., once per month) to ensure that the sterilization parameters are effective in treating biohazardous waste.

2. Make sure chart paper or printer paper is in place to document the cycle parameters for the load. If a recording system is not available, it is critical to verify that sterilization parameters were achieved by another means such as spore strips, an autoclave thermometer, etc.
3. The exact operating procedure for each model of autoclave will differ. The user should develop an SOP to describe proper steps to operate the autoclave.

Removing Sterilized Items

1. Open the sterilizer door no more than 0.5 inch; wait 10 minutes before unloading items.
2. Wear heat resistant gloves to unload items.
3. Be very careful of liquids, molten agar, etc. to avoid getting splashed with scalding liquid. Do not agitate containers of super-heated liquid or remove caps before unloading.
4. Unload hot items onto a cart for transport.
5. Take bags of autoclaved disposable waste to the dumpster.
6. NOTE: If a faulty condition exists (e.g., sterilizer did not finish the cycle, or water leaks out when the door is unlocked), contact a service technician.

Recordkeeping

1. Document the treatment of each load of biohazardous waste in a log which lists: the date of treatment; the amount of waste treated; the method/conditions of treatment; and the printed name and initials of the person performing the treatment. Keep charts or printout strips with the logbook as documentation of the autoclave operation.
2. Document the date and results of each verification test using biological indicators.

Non-Sterilization Procedures

For procedures where an autoclave treatment is used for purposes other than acquiring sterilization, the time and temperature parameters will vary as needed to accomplish the intended goal of the user.

Repairs / Maintenance

When maintenance work or repairs are needed, the user must provide a safe work environment for the service technician. Remove all items from the sterilizer chamber, clean any spills or leaks inside the chamber, remove untreated biohazardous materials from the vicinity, etc.

SECTION 5: RADIOLOGICAL AND LASER SAFETY

Light Amplification by the Stimulated Emission of Radiation (Laser) is:

- Monochromatic- one color/wavelength
- Directional light emitted in a narrow beam in a specific direction
- Coherent- all light waves are in phase.

These three properties of laser light are what make it more hazardous than ordinary light. Laser light can focus a lot of energy within a small area. Lasers operate in the ultraviolet, visible, near infrared, and far infrared regions.

Laser Hazard Classifications

- Class 1- "safe" if not disassembled. Cd Rom players/drives
- Class 2- eye hazard if you stare into the beam. A supermarket point-of sale scanner
- Class 3a- (3R) eye hazard if collected or focused into the eyes. If operated with care Class 3a- lasers pose a low risk of injury. Most laser pointers are 3R lasers.
- Class 3b- eye hazard if direct or reflected beam is viewed. Most 3B lasers do not produce diffuse reflection hazards.
- Class 4- eye hazard if direct, reflected or diffusely reflected beam is viewed, possible skin and fire hazard.

Types of Laser Hazards

a. Eye: Acute exposure of the eye to lasers of certain wavelengths and power can cause corneal or retinal burns (or both).
    i. Chronic exposure to excessive levels may cause corneal or lenticular opacities (cataracts) or retinal injury.
    ii. Damage to the retina resulting in scotoma (blind spot in the fovea).
    iii. Photoacoustic retinal damage may be associated with an audible "pop" at the time of exposure. Damage may not be apparent to the operator until considerable thermal damage has occurred.

b. Skin: Acute exposure to high levels of optical radiation may cause skin burns, while carcinogenesis may occur for ultraviolet wavelengths (290-320 nm).

c. Chemical: Some lasers require hazardous or toxic substances to operate (i.e., chemical dye, Excimer lasers).

d. Electrical: Most lasers utilize high voltages that can be lethal.

e. Fire: The solvents used in dye lasers are flammable. High voltage pulse or flash lamps may cause ignition. Flammable materials may be ignited by direct beams or specular reflections from high power continuous wave (CW) infrared lasers.

Control Measures

a. Administrative controls are policies that limit exposure to laser hazards.
    i. Authorized personnel operate the laser
    ii. Standard Operating Procedures
    iii. Training

b. Engineering controls built into the equipment or facility that protect personnel automatically without the need of protective action by the worker
    i. Interlocks
    ii. Enclosed beams

c. Personnel Protective Equipment (PPE)
    i. Eye Protection is required for Class 3B and Class 4 lasers.
        - Laser protective eyewear is to be available and worn by all personnel within the Nominal Hazard Zone (NHZ) of Class 3B and Class 4 lasers where the exposures above the Maximum Permissible Exposure (MPE) can occur
        - The attenuation factor (optical density) of the laser protective eyewear at a specific wavelength shall be specified.
        - All laser protective eyewear shall be clearly labeled with the optical density and the wavelength for which protection is afforded. This is especially important in areas where multiple lasers are housed.
        - Inspect all laser protective eyewear for damage prior to use.
    ii. Skin protection can best be achieved through engineering controls.
        - If the potential exits for damaging skin exposure, particularly for ultraviolet lasers (0.200-0.400 m), then skin covers and or sunscreen creams are recommended.

- For the hands, gloves will provide some protection against laser radiation. Tightly woven fabrics and opaque gloves provide the best protection.
- A laboratory jacket or coat can provide protection for the arms. For Class 4 lasers, flame-resistant materials may be best.

Chapter 3

CHEMICAL SAFETY

SECTION 1: OVERVIEW

Almost everyone works with or around chemicals and chemical products every day. Chemical safety is inherently linked to other safety issues including engineering controls, laboratory procedures, personal protective equipment, electrical safety, fire safety, and hazardous waste disposal. Many chemicals have properties that make them hazardous: they can create physical hazards (fire, explosion) and/or health hazards (toxicity, chemical burns, and dangerous fumes). However, there are many ways to work with chemicals which can both reduce the probability of an accident to a negligible level and minimize the consequences should an accident occur.

Risk minimization depends on safe practices, appropriate engineering controls for chemical containment, the proper use of personal protective equipment, the use of the least quantity of material necessary, and substitution of less hazardous chemicals. Before beginning an operation, one should ask "What would happen if . . .?" The answer to this question requires an understanding of the hazards associated with the chemicals, equipment and procedures involved. The hazardous properties of the material and intended use will dictate the precautions to be taken.

It is important to distinguish the difference between *hazard* and *risk*. The two terms are sometimes used as synonyms. In fact, the term “hazard” is a much more complex concept because it includes conditions of use. The hazard presented by a chemical has two components: (1) its inherent capacity to do harm by virtue of its toxicity, flammability, explosiveness, corrosiveness, etc.; and (2) the ease with which the chemical can come into contact with a person or other object of concern. The two components together determine “risk” – the likelihood or probability that a harmful consequence will occur. Thus, an extremely toxic chemical such as strychnine cannot cause poisoning if it is in a sealed container and does not contact the handler. In contrast, a chemical that is not highly toxic can be lethal if a large amount is ingested.

It should be noted that not all chemicals are considered *hazardous*. Examples of nonhazardous chemicals include pH neutral buffers, sugars, starches, agar, and naturally occurring amino acids. This chapter will focus on hazardous chemicals.

SECTION 2: HAZARD COMMUNICATION PROGRAM

TAMU-CC has a written program, the TAMU-CC Hazard Communication Program, for hazardous chemicals that complies with the Texas Hazard Communication Act (THCA). This program is available from Environmental, Health & Safety. It requires the following:

a. Employee training (including recognition of signs of exposure)
    i. General – Assigned to new or newly relocated employees by their administrative location (adloc) in TAMU-CC TrainTraq before they work with or handle hazardous chemicals.
    ii. Work Area Specific – Provided by individual's supervisor (PI, laboratory manager, etc.)

b. Availability of SDSs

c. Work Area Chemical Inventory (WACI)
    i. Recordkeeping requirements
    ii. Emergency response requirements
    Exemptions-Research laboratories are exempt from the WACI requirements under THCA, however, TAMU-CC requires that all laboratories submit a chemical inventory.

d. Labeling requirements
    i. Primary container labels – Must have the original manufacturer's label, which includes the chemical name, hazards, and manufacturer's-information.
    ii. Secondary container labels – Must identify the chemical as it is on the Safety Data Sheet (SDS) and the hazards.
    EXEMPTIONS – Research laboratories are exempt from the secondary container labeling requirements under THCA. However, TAMUCC requires that all containers be labeled to somehow identify the contents.

SECTION 3: HAZARD IDENTIFICATION

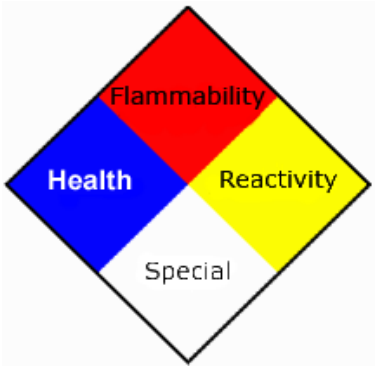
An integral part of hazard communication is hazard identification. Everyone who works with hazardous chemicals should know how to read and interpret hazard information. Signs, labels, placards, and symbols alert employees to the known hazards in a location.

The National Fire Protection Association (NFPA) 704 Diamond in the illustration below is one method of identifying chemical hazards. NFPA uses a scale of 0 – 4 to rate each hazard, with 0 indicating "no hazard" and 4 indicating the most extreme hazard. The following is a detailed explanation of the NFPA hazard classification codes:

a. Health (Blue):

4 - Can cause death or major injury despite medical treatment
3 - Can cause serious injury despite medical treatment
2 - Can cause injury. Requires prompt medical treatment
1 - Can cause irritation if not treated
0 - No hazard

b. Flammability (Red):



4 - Very flammable gases or liquids
3 - Can ignite at normal temperatures
2 - Ignites with moderate heat
1 - Ignites with considerable preheating
0 - Will not burn

c. Reactivity (Yellow):

4 - Readily detonates or explodes
3 - May detonate or explode with strong initiating force or heat under confinement
2 - Normally unstable, but will not detonate
1 - Normally stable. Unstable at high temperature and pressure.
0 - Normally stable and not reactive with water.

d. Specific Hazard (White):

Oxidizer - OX
Acid - ACID
Alkali - ALK
Corrosive - COR
Use No Water - ~~W~~
Radioactive – (see image at right)

Many chemicals fall under more than one hazard class. Extra care should be taken when handling or storing chemicals with multiple hazards.

Other labeling systems may also be used. For instance, the Department of Transportation (DOT) has a labeling system for the shipment of hazardous materials. Examples of DOT placards are shown within the text of this chapter.

SECTION 4: CHEMICAL SAFETY GUIDELINES

Always follow these guidelines when working with chemicals:

a. Assume that any unfamiliar chemical is hazardous and treat it as such.
b. Know all the hazards of the chemicals with which you work. For example, perchloric acid is a corrosive, an oxidizer, and a reactive. Benzene is an irritant that is also flammable, toxic, and carcinogenic.
c. Never underestimate the potential hazard of any chemical or combination of chemicals. Consider any mixture or reaction product to be at least as hazardous as – if not *more* hazardous than – its most hazardous component.
d. Never use any substance that is not properly labeled. It may not be what you think it is!
e. Date all chemicals when they are received and again when they are opened.
f. Follow all chemical safety instructions, such as those listed in Safety Data Sheets or on chemical container labels, precisely.
g. Minimize your exposure to any chemical, regardless of its hazard rating, and avoid repeated exposure.
h. Use personal protective equipment (PPE), as appropriate for that chemical.
i. Use the buddy system when working with hazardous chemicals. Don't work in the laboratory alone.

SECTION 5: SAFETY DATA SHEETS

Before using any chemical, read the appropriate Safety Data Sheet (SDS). An SDS is a document that details information about chemicals and with the container label is a good source of information for chemical safety. The SDS provides the following information:

Section 1- Identification:
includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.

Section 2- Hazard(s) identification:
includes all hazards regarding the chemical; required label elements.

Section 3- Compositions/information on ingredients:
includes information on chemical ingredients, trade secret claims.

Section 4- First-aid measures:
includes important symptoms/effects, acute, delayed; required treatment.

Section 5- Fire-fighting measures:
lists suitable extinguishing techniques, equipment, chemical hazards from fire.

Section 6- Accidental release measures:
lists emergency procedures; protective equipment; proper methods of containment and cleanup.

Section 7- Handling and storage:
lists precautions for safe handling and storage, including incompatibilities.

Section 8- Exposure controls/personal protection:
lists OSHA's Permissible Exposure Limits (PELs); ACGIH Threshold Limit Values (TLVs); and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the SDS where available as well as appropriate engineering controls; personal protective equipment (PPE).

I. Permissible Exposure Limit (PEL) or Recommended Exposure Limit (REL) – This is the amount of a chemical that a person can be exposed to, averaged over an eight-hour period, before it causes him/her harm.
II. Short Term Exposure Limit (STEL) – This is the amount of a chemical that a person can be exposed to, averaged over a 15-minute period, before it causes him/her harm.
III. Immediately Dangerous to Life and Health (IDLH) – This is the amount of chemical that immediately puts a person a risk of serious injury or death. If this level is reach or exceeded, the area should be evacuated immediately!

Section 9- Physical and chemical properties:
lists the chemical's characteristics.

Section 10- Stability and reactivity:
lists chemical stability and possibility of hazardous reactions.

Section 11- Toxicological information:
includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.

Section 12- Ecological Information (not mandatory):
provides information to evaluate the environmental impact of the chemical(s) if it were released to the environment.

Section 13- Disposal consideration (not mandatory): provides guidance on proper disposal practices, recycling or reclamation of the chemical(s) or its container, and safe handling practices.

Section 14- Transport information (not mandatory):
guidance on classification information for shipping and transporting of hazardous chemical(s) by road, air, rail, or sea.

Section 15- Regulatory information (not mandatory):
identifies the safety, health, and environmental regulations specific for the product that is not indicated anywhere else on the SDS.

Section 16- Other information:
indicates when the SDS was prepared or when the last know revision was made. The SDS may also state where the changes have been made to the previous version. Other useful information also may be included here.

Each person working with chemicals should have access to the SDS for all chemicals they use. "Access" may be:

- A current hard copy kept in a work area file or binder.
- An electronic copy.

SECTION 6: SAFE HANDLING GUIDELINES

Employees should treat all chemicals and equipment with caution and respect. When working with chemicals, remember to do the following:

a. Wear appropriate personal protective equipment (PPE) for the chemical hazard.
b. Remove and use only the amount of chemicals needed for the immediate job at hand.
c. Properly seal, label, and store chemicals in appropriate containers. Keep the containers clearly marked and in a well-ventilated area.

d. Segregate and store chemicals by their hazard class.

e. Check stored chemicals for deterioration and for damage to the containers.

f. Learn how to dispose of chemicals safely and legally. Follow TAMU-CC waste disposal requirements. (See Chapter 4 – Laboratory Waste Disposal.)

g. Clean up spills and leaks immediately.

h. Develop a Plan of Action for how to respond in an emergency. Review this plan regularly to be familiar with it.

i. Do not store chemicals near heat, in sunlight, or near substances which might initiate a dangerous reaction.

j. When transporting chemicals between the work area and other areas, use secondary containment (such as a tray, rack, cart, or rubber carrier) to protect against spills, leaks, or container breakage. Always use a secondary container when transporting hazardous or highly odorous chemicals on an elevator.

k. Never pour any chemicals down the sink. Use proper hazardous waste disposal procedures for all excess or unused chemicals.

SECTION 7: CHEMICAL STORAGE GUIDELINES

Proper chemical storage is as important to safety as proper chemical handling. Often, seemingly logical storage ideas, such as placing chemicals in alphabetical order, may cause incompatible chemicals to be stored together.

7.1 GENERAL STORAGE GUIDELINES

Follow these guidelines for safe chemical storage:

a. Read chemical labels and the SDS for specific storage instructions.

b. Store chemicals in a well-ventilated area; however, *do not* store chemicals in a fume hood.

c. Date all chemicals when they are received and again when they are opened.

d. Maintain an inventory of all chemicals in storage. An electronic copy of the inventory should be maintained at a location other than the laboratory.

e. Return chemical containers to their proper storage location after use.

f. Store glass chemical containers so that they are unlikely to be broken. Glass containers should never be stored directly on the floor.

g. Store all hazardous liquid chemicals below eye level of the shortest person working in the laboratory.

h. Never store hazardous chemicals in a public area or corridor. Hazardous chemicals must be kept in a secured area.

7.2 Separating and Storing Hazardous Chemicals

In addition to the guidelines above, there are storage requirements for separating hazardous chemicals. Follow these guidelines to ensure that hazardous chemicals are stored safely:

a. Group chemicals according to their hazard category (i.e., corrosives, flammables, toxins, etc.), not alphabetically, and separated by some sort of physical barrier. An alphabetical storage system may place incompatible chemicals next to each other.

b. Separate acids from bases and inorganic acids or bases from organic acids or bases. Store these chemicals near floor level.

c. Isolate perchloric acid from all other chemicals and from organic materials. Do not store perchloric acid on a wooden shelf or spill paper.

d. Separate highly toxic chemicals and carcinogens from all other chemicals. This storage location should have a warning label and should be locked.

e. Time-sensitive chemicals, such as those that form peroxides, should not be kept longer than twelve months from purchase or six months after opening. If stratification of liquids, precipitate formation, and/or change in color or texture is noted, do not touch the container, a hazard exists, contact E,H&S immediately.

f. Picric acid *must* be stored under a layer of liquid, as picric crystals are highly explosive. If picric acid dries out (forming yellow crystals), do not touch the container! Contact the Principal Investigator and E,H&S immediately!

g. If flammables need to be chilled, store them in an explosion proof laboratory-safe refrigerator, not in a standard (household style) refrigerator.

h. Chemicals may be stored in the cabinets underneath a chemical fume hood provided the cabinetry is designed for that use.

   i. Cabinetry designed for flammable storage vents into the fume hood exhaust duct.

   ii. Cabinetry designed for corrosives storage vents directly into the fume hood. Flammable chemicals should *never* be stored in this type of cabinets!

iii. Some cabinetry is only designed for general storage or with a drying rack. These cabinets are not meant to be used for hazardous chemical storage.

i. Flammables should be stored in a well-ventilated area and large quantities in a flammable storage cabinet. Contact E,H&S for more information on allowable storage of flammable liquids per NFPA Code.

The following table provides examples of incompatible chemicals:

CHEMICAL	INCOMPATIBLE WITH . . .
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric and sulfuric acid mixtures
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine
Cyanide	Acids
Fluorine	Most other chemicals
Nitrates	Sulfuric acid
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils,
Sodium	Carbon tetrachloride, carbon dioxide, water
Sulfides	Acids

SECTION 8: HYGIENE AND CHEMICAL SAFETY

Good personal hygiene will help minimize exposure to hazardous chemicals. When working with chemicals, follow these guidelines:

a. Wash hands frequently and before leaving the laboratory. Also, wash hands before eating, drinking, smoking, or applying makeup.

b. Wear appropriate personal protective equipment (PPE). Always wear protective gloves when handling any hazardous chemicals.

c. Remove PPE before leaving the laboratory and before washing hands.

d. Remove contaminated clothing immediately. Do not use the clothing again until it has been properly decontaminated.

e. Follow any special precautions for the chemicals in use.

f. Do not eat, drink, smoke or apply makeup around chemicals.

g. Tie back long hair when working in a laboratory or around hazardous chemicals.

h. Do not keep food, beverages, or food and beverage containers anywhere near chemicals or in laboratories where chemicals are in use.

i. Do not use laboratory equipment, including laboratory refrigerators/freezers, to store or serve food or drinks.

j. Do not wash food and beverage utensils in a laboratory sink.

k. Do not sniff or taste chemicals.

l. Do not touch doorknobs, telephones, computer keyboards, etc. with contaminated gloves.

SECTION 9: TYPES OF CHEMICAL HAZARDS

9.1 CORROSIVES

Corrosive chemicals destroy or damage living tissue by direct contact. Some acids, bases, dehydrating agents, oxidizing agents, and organics are corrosives. Examples of the different types of corrosive chemicals are listed below:

- Acidic corrosives:
  - Inorganic Acids
    - Hydrochloric acid
    - Nitric Acid
    - Sulfuric acid
  - Organic Acids
    - Acetic Acid
    - Propionic acid
- Alkaline, or basic, corrosives:
  - Sodium hydroxide
  - Potassium hydroxide
- Corrosive dehydrating agents:
  - Phosphorous pentoxide
  - Calcium oxide
- Corrosive oxidizing agents:
  - Halogen gases
  - Hydrogen peroxide (concentrated)
  - Perchloric acid
- Organic corrosive:
  - Butylamine

Health Consequences

Extreme caution should be taken when handling corrosive chemicals, or severe injury may result.

a. Concentrated acids can cause painful and sometimes severe burns.
b. Inorganic hydroxides can cause serious damage to skin tissues because a protective protein layer does not form. Even a dilute solution such as sodium or potassium hydroxide can saponify fat and attack skin.
c. At first, skin contact with phenol may not be painful, but the exposed area may turn white due to the severe burn. Systemic poisoning may also result from dermal exposure.
d. Skin contact with low concentrations of hydrofluoric acid (HF) may not cause pain immediately but can still cause tissue damage if not treated properly. Higher concentrations of HF (50% or greater) can cause immediate, painful damage to tissues.

Safe Handling Guidelines for Corrosives

To ensure safe handling of corrosives, the following special handling procedures should be used:

a. Always store corrosives properly. Segregate acids from bases and inorganics from organics.
b. Always wear a laboratory coat, gloves and chemical splash goggles when working with corrosives. Wear other personal protective equipment, as appropriate.
c. To dilute acids, carefully add the acid to the water, not the water to the acid. This will minimize any reaction.
d. Corrosives, especially inorganic bases (e.g., sodium hydroxide), may be very slippery; handle these chemicals with care and clean any spills, leaks, splashes, or dribbles immediately.
e. Work in a chemical fume hood when handling fuming acids or volatile irritants (e.g., ammonium hydroxide).
f. A continuous flow eye wash station should be in every work area where corrosives are present. An emergency shower should also be within 55 feet of the area.

Corrosive Example: Perchloric Acid

Perchloric acid is a corrosive oxidizer that can be dangerously reactive. At elevated temperatures, it is a strong oxidizing agent and a strong dehydrating reagent. Perchloric acid reacts violently with organic materials. When combined with combustible material, heated perchloric acid may cause a fire or explosion. Cold perchloric acid at less than 70% concentration is not a very strong oxidizer, but its oxidizing strength increases significantly at concentrations higher than 70%. Anhydrous perchloric acid (>85%) is very unstable and can decompose spontaneously and violently.

When using perchloric acid, remember the following:

a. Be thoroughly familiar with the special hazards associated with perchloric acid before using it.
b. If possible, purchase 60% perchloric acid instead of a more concentrated grade.
c. Always wear rubber gloves and chemical splash goggles while using perchloric acid. Consider also wearing a face shield and rubber apron if splashing is likely.
d. Store perchloric acid inside secondary containment (such as a Pyrex dish) and segregated from all other chemicals and organic materials. Do not store bottles of perchloric acid in wooden cabinets or on spill paper.

IMPORTANT: *Heated digestions with perchloric acid require a special fume hood with a wash-down system. A perchloric acid fume hood should also be used when handling highly concentrated (greater than 70%) perchloric acid. Refer to the "Laboratory Ventilation Equipment" section of Chapter 5 – How to Protect Yourself for more information on these hoods.*

9.2 FLAMMABLES

A flammable chemical is any solid, liquid, vapor, or gas that ignites easily and burns rapidly in air. Consult the appropriate SDS before beginning work with flammables.

Flashpoint, Boiling Point, Ignition Temperature, and Class

Flammable chemicals are classified according to flashpoint, boiling point, fire point, and auto-ignition temperature.

a. Flash Point (FP) is the lowest temperature at which a flammable liquid's vapor burns when ignited.
b. Boiling Point (BP) is the temperature at which the vapor pressure of a liquid is equal to the atmospheric pressure under which the liquid vaporizes. Flammable liquids with low BPs generally present special fire hazards.
c. Fire Point is the temperature at which the flammable liquid will burn.
d. Auto-ignition Temperature is the lowest temperature at which a substance will ignite without an ignition source.

Flammable liquids are classified according to how easily they burn. The following table illustrates flammable class characteristics as defined by NFPA 45:

FLAMMABLE CLASS	FLASHPOINT (°F)	BOILING POINT (°F)	EXAMPLES
1A	<73	<100	Ethyl ether "Flammable" aerosols
1B	<73	≥100	Acetone Gasoline Toluene
1C	≥73	<100	Butyl alcohol Methyl isobutyl ketone Turpentine
2	100 - 140	---	Cyclohexane Kerosene Mineral spirits
3A	140 - 199	---	Butyl cellosolve
3B	>200	---	Cellosolve Ethylene glycol Hexylene glycol

The following table provides examples of common flammables and their flashpoint and class.

CHEMICAL	FLASHPOINT (°F)	FLAMMABLE CLASS
Acetone	0	1B
Benzene	12	1B
Butyl Acetate	>72	1C
Carbon Disulfide	-22	1B
Cyclohexane	-4	1B
Diethylene Glycol	225	3B
Diethyl ether	-49	1A
Ethanol	55	1B
Heptane	25	1B
Isopropyl Alcohol	53	1B
Methanol	52	1B
Pentane	<-40	1A
Toluene	40	1B

Conditions for a Fire

Improper use of flammable liquids can cause a fire. The following conditions must exist for a fire to occur:

- Flammable material (i.e., fuel) must be present in a concentration to support a fire.
- Oxygen or an oxidizer must be present.
- An ignition source (i.e., heat, spark, etc.) must be present.

When working with flammables, always take care to minimize vapors which act as fuel.

Safe Handling Guidelines for Flammables

a. Handle flammable chemicals in areas free from ignition sources.
b. Never heat flammable chemicals with an open flame. Use a water bath, oil bath, heating mantle, hot air bath, hot plate, etc. Such equipment should be intrinsically safe, with no open sparking mechanisms.

   NOTE: *When using an oil bath, make sure the temperature is kept below the oil flash point.*

c. Use ground straps when transferring flammable chemicals between metal containers to avoid generating static sparks.

d. Work in an area with good general ventilation and use a fume hood when there is a possibility of dangerous vapors. Ventilation will help reduce dangerous vapor concentrations, thus minimizing this fire hazard.
e. Restrict the quantity of stored flammables in the laboratory and minimize the volume of flammables present in a work area.

   NOTE: *The NFPA has established formal limits on the total amounts of flammable liquids that may be stored or used in laboratories. (NFPA 30 and 45)*

f. Only remove from storage the amount of chemical needed for an experiment or task.

9.3 SOLVENTS

Organic solvents are often the most hazardous chemicals in the workplace. Solvents such as ether, alcohols, and toluene, for example, are highly volatile and flammable. Perchlorinated solvents, such as carbon tetrachloride (CCl_4), are non-flammable. But most hydrogen-containing chlorinated solvents, such as chloroform, are flammable. When exposed to heat or flame, chlorinated solvents may produce carbon monoxide, chlorine, phosgene, or other highly toxic gases.

Always use volatile and flammable solvents in an area with good ventilation or preferably in a fume hood. Never use ether or other highly flammable solvents in a room with open flames or other ignition sources present, including non-intrinsically safe fixtures.

Solvent Exposure Hazards

Health hazards associated with solvents include exposure by the following routes:

- Inhalation of a solvent may cause bronchial irritation, dizziness, central nervous system depression, nausea, headache, coma, or death. Prolonged exposure to excessive concentrations of solvent vapors may cause liver or kidney damage. The consumption of alcoholic beverages can enhance these effects.
- Skin contact with solvents may lead to defatting, drying, and skin irritation.
- Ingestion of a solvent may cause sever toxicological effects. Seek medical attention immediately.

The odor threshold for the following chemicals exceeds acceptable exposure limits. Therefore, if you can smell it, you may be overexposed — *increase ventilation immediately!* Examples of such solvents are:

- Chloroform
- Benzene
- Carbon tetrachloride
- Methylene chloride

NOTE: *Do not depend on your sense of smell alone to know when hazardous vapors are present. The odor of some chemicals is so strong that they can be detected at levels far below hazardous concentrations (e.g., xylene).*

Some solvents (e.g., benzene) are known or suspected carcinogens.

Reducing Solvent Exposure

To decrease the effects of solvent exposure, substitute hazardous solvents with less toxic or hazardous solvents whenever possible. For example, use hexane instead of diethyl ether, benzene, or a chlorinated solvent.

Solvent Example: DMSO

Dimethyl sulfoxide (DMSO) is unique because it is a good solvent with many water-soluble as well as lipid-soluble materials. Due to these properties, dimethyl sulfoxide is rapidly absorbed and distributed throughout the body.

DMSO can facilitate absorption of other chemicals – such as grease, oils, cosmetics – that may contact the skin.

- While DMSO alone has low toxicity, when combined with other, more toxic chemicals it can cause the more toxic chemical to be absorbed more readily through the skin.
- Some medications, such as liniment, also contain DMSO.

While relatively stable at room temperature, DMSO can react violently to other chemicals when heated.

Wear impervious clothing and personal protective equipment (laboratory coat, gloves, etc.) to prevent skin exposure. Use chemical splash goggles and/or a face shield if splashing may occur.

9.4 TOXINS AND IRRITANTS

The toxicity of a chemical refers to its ability to damage an organ system (kidneys, liver), disrupt a biochemical process (e.g., the blood-forming process) or disrupt cell function at some site remote from the site of contact. Any substance, even water, can be harmful to living things under the right conditions.

The **biological effects** – whether beneficial, indifferent, or toxic – of all chemicals are dependent on several factors, including:

- Dose (the amount of chemical to which one is exposed)
- Duration of exposure (both length of time and frequency)
- Route of entry:
  - Ingestion
  - Absorption through the skin
  - Inhalation
  - Injection

NOTE: *Inhalation and dermal absorption are the most common methods of chemical exposure in the workplace.*

- Individual response and history
- One's exposure to other chemicals
- Mixing the toxin with other chemicals

The most important factor in toxicity is the dose-time relationship. In general, the more toxin to which an individual is exposed, and the longer they are exposed to it, the stronger their physiological response will be. However, an individual's response can also depend on several other factors, including:

- Health
- Gender
- Genetic predisposition
- An individual's exposure to other chemicals
- Previous sensitization

NOTE: *When a person becomes sensitized to a chemical, each subsequent exposure may often produce a stronger response than the previous exposure.*

- Chemical mixtures

NOTE: *Combining a toxic chemical with another chemical can increase the toxicity of either or both chemicals.*

IMPORTANT: *Minimize exposure to any toxic chemical.*

General Safe Handling Guidelines

a. Read the appropriate SDS.
b. Be familiar with the chemical's exposure limits.
c. Use a chemical fume hood.
d. *Always* wear appropriate PPE.
e. *Never* eat, drink, or use tobacco products around toxins or store them near any hazardous chemicals.
f. Avoid touching your face or other exposed skin with contaminated gloves or other contaminated materials.
g. Store toxic gases in a gas exhaust cabinet.

Acute Toxins vs. Chronic Toxins

The dose-time relationship forms the basis for distinguishing between acute toxicity and chronic toxicity.

The **acute toxicity** of a chemical is its ability to inflict bodily damage from a single exposure. A sudden, high-level exposure to an acute toxin can result in an emergency, such as a severe injury or even death. Examples of acute toxins include the following:

- Hydrogen cyanide
- Hydrogen sulfide
- Nitrogen dioxide
- Ricin
- Organophosphate pesticides
- Arsenic

IMPORTANT: *Do not work alone when handling acute toxins. Use a fume hood to ensure proper ventilation or wear appropriate respiratory protection if a fume hood is not available*.

Chronic toxicity refers to a chemical's ability to inflict systemic damage as a result of repeated exposures, over a prolonged time period, to relatively low levels of the chemical. Such prolonged exposure may cause severe injury. Examples of chronic toxins include the following:

- Mercury
- Lead
- Formaldehyde

Some chemicals are extremely toxic and are known primarily as acute toxins. Some are known primarily as chronic toxins. Others can cause either acute or chronic effects.

The toxic effects of chemicals can range from mild and reversible (e.g.,) a headache from a single episode of inhaling the vapors of petroleum naphtha that disappears when the victim gets fresh air) to serious and irreversible (liver or kidney damage from excessive exposures to chlorinated solvents). The toxic effects from chemical exposure depend on the severity of the exposures. Greater exposure and repeated exposure generally lead to more severe effects.

Types of Toxins

Carcinogens are materials that can cause cancer in humans or animals. Several agencies including OSHA (Occupational Safety & Health Administration), NIOSH (The National Institute for Occupational Safety and Health), and IARC (International Agency for Research on Cancer) are responsible for identifying carcinogens. There are very few chemicals known to cause cancer in humans, but there are many suspected carcinogens and many substances with properties similar to known carcinogens.

Examples of known carcinogens include the following:

- Asbestos
- Benzene
- Tobacco smoke
- Hexavalent Chromium
- Aflatoxins

Zero exposure should be the goal when working with known or suspected carcinogens. Workers who are routinely exposed to carcinogens should undergo periodic medical examinations.

Reproductive toxins are chemicals that can adversely affect a person's ability to reproduce. **Teratogens** are chemicals that adversely affect a developing embryo or fetus. Heavy metals, some aromatic solvents (benzene, toluene, xylenes, etc.), and some therapeutic drugs are among the chemicals that can cause these effects. In addition, the adverse effects produced by ionizing radiation, consuming alcohol, using nicotine, and using illicit drugs are recognized.

While some factors are known to affect human reproduction, knowledge in this field (especially related to the male) is not as broadly developed as other areas of toxicology. In addition, the developing embryo is most vulnerable during the time before the mother knows she is pregnant. Therefore, it is prudent for all persons with reproductive potential to minimize chemical exposure.

Sensitizers may cause little or no reaction upon first exposure. Repeated exposures may result in severe allergic reactions.

Examples of sensitizers include the following:

- Isocyanates
- Nickel salts
- Beryllium compounds
- Formaldehyde
- Diazomethane
- Latex

NOTE: *Some people who often use latex-containing products may develop sensitivity to the latex. A sensitized individual's reaction to latex exposure can eventually include anaphylactic shock, which can result in death. To minimize exposure to latex, use non-latex containing gloves, such as nitrile gloves.*

Irritants cause reversible inflammation or irritation to the eyes, respiratory tract, skin, and mucous membranes. Irritants cause inflammation through long-term exposure or high concentration exposure. For the purpose of this section, irritants do not include corrosives.

Examples of irritants include the following:

- Ammonia
- Formaldehyde
- Halogens
- Sulfur dioxide
- Poison ivy
- Phosgene
- Dust
- Pollen
- Mold

Mutagens can alter DNA structure. Some mutagens are also carcinogens. Examples of mutagens are:

- Ethidium bromide
- Nitrous acid
- Radiation

Neurotoxins are chemicals that affect the nervous system. Examples of neurotoxins include:

- Methanol
- Many snake and insect venoms
- Botulinum toxin

9.5 REACTIVES AND EXPLOSIVES

Reactive chemicals may be sensitive to either friction or shock, or they may react in the presence of air, water, light, heat, or other chemicals. Some reactive chemicals are inherently unstable and may quickly decompose on their own, releasing energy in the process. Others form toxic gases when reacting.

Explosive chemicals decompose or burn very rapidly when subjected to shock or ignition. Reactive and explosive chemicals produce large amounts of heat and gas when triggered, and thus are extremely dangerous.

Follow these guidelines when handling and storing reactive and explosive chemicals:

a. Read the appropriate SDS and other pertinent fact sheets on the chemical. Be familiar with chemical specific handling and storage requirements.
    i. Store reactives separate from other chemicals.
    ii. Store reactives in a cool/dry area.
    iii. Keep reactive chemicals out of sunlight and away from heat sources.
b. Follow Operating Procedures and have a plan for emergency situations.
c. Know where emergency equipment is located and how to use it.

Examples of reactive compounds include the following:

REACTIVE CLASSIFICATION	CHEMICAL EXAMPLES
Acetylenic compounds	Acetylene Copper(I) acetylide
Azides	Benzenesulfonyl azide Lead (II) azide
Azo compounds	Azomethane Diazomethane
Chloro/perchloro compounds	Lead perchlorate Potassium chlorite Silver chlorate Perchloric Acid (Anhydrous)
Fulminates	Copper (II) fulminate Silver fulminate
Nitro compounds	Nitromethane Trinitrotoluene (TNT)
Nitrogen-containing compounds	Silver amide Silver nitride
Organic peroxide formers	Diethyl ether Isopropyl ether
Picrates	Picric acid (dry) Lead picrate
Peroxides	Diacetyl peroxide Zinc peroxide
Strained ring compounds	Benzvalene Prismane
Polymerizable compounds	Butadiene Vinyl chloride

9.6 CONTROLLED SUBSTANCES, CONTROLLED SUBSTANCE ANALOGUES, CHEMICAL PRECURSORS AND CERTAIN CHEMICAL LABORATORY APPARATUS USED IN NON-CLINICAL EDUCATIONAL TRAINING AND RESEARCH ACTIVITIES

General

This internal policy regulates the use of controlled substances, controlled substance analogues, chemical precursors and certain chemical laboratory apparatus used in non-clinical educational training and research activities in the Texas A&M University-Corpus Christi Research, Physical and Environmental Science (PENS), and Life Sciences (LSCI) Departments.

The Texas Department of Public Safety (DPS) and the Texas Higher Education Coordinating Board (THECB) signed a Memorandum of Understanding (MOU) that establishes responsibilities on institutions of higher education for implementing and maintaining a program for reporting information concerning controlled substances, controlled substance analogues, chemical precursors and chemical laboratory apparatus used in educational training and research activities. This document defines the requirements and procedures necessary for compliance with the MOU by the E,H&S.

Controlled Substances Definition

Controlled Substance is defined as a substance listed in the United States Drug Enforcement Administration (DEA) Schedules I through V[1] or Penalty Group 1 through 4 of the Health and Safety Code (HSC), Chapter 481, the Texas Controlled Substance Act2. This definition also includes controlled substance analogues with a chemical structure similar to that of a listed controlled substance and chemical precursors that may be used as a primary component in manufacturing a controlled substance. The Controlled Substance Acts also cover "Chemical Laboratory Apparatus" which is defined as "…any equipment designed, mad or adapted to manufacture a controlled substance or a controlled substance analogue."

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[1]Code of Federal Regulations Title 21-Food and Drugs Chapter 13-Drug Abuse Prevention and Control: https://uscode.house.gov/view.xhtml?path=/prelim@title21/chapter13&edition=prelim ; DEA, Controlled Substances Act 811 & 812

[2]Texas Health and Safety code Subtitle C. Substance Abuse Regulation and Crimes Chapter 481. Texas Controlled Substance Act: https://statutes.capitol.texas.gov/Docs/HS/htm/HS.481.htm

Responsible Party

Individual faculty members are responsible for aspects of ordering, storing, recording, and using controlled substances in their research program. If the controlled substances are to be used in conjunction with the activities of an organized research unit (e.g., centers) outside the operation of a specific sponsored project, the Director of the units is responsible. If the controlled substances are to be used in a teaching activity, the Head of the department through which the academic course is offered is the responsible party. The responsible party individual must obtain and keep current federal Drug Enforcement Administration (DEA) and Texas Department of Public Safety (DPS) registration, unless exempted by law. Registrants are responsible for procuring, maintaining security, keeping records, and disposing of controlled substance in accordance with federal and state regulations and rules.

The Environmental, Health & Safety Department (E,H&S) office shall maintain an updated list of all controlled substances license holders and the types of controlled substances each responsible party utilizes.

Site Operational Security

A. Specific locations (e.g., laboratory or locked storage area assigned to the responsible party) should be established where controlled substances are utilized and stored. They must be stored behind a minimum of three (3) locks: in a locked cabinet, in a room that is locked after normal business hours, and in a building that is locked after hours.
B. Access to rooms and locked storage areas containing controlled substances must be restricted to authorized personnel.
C. Positions for personnel having access to controlled substances should be designated as security sensitive and appropriate pre-employment criminal history checks must be performed.
D. When controlled substances are received, they should be immediately checked for completeness with the shipping invoice, logged in an inventory record book and placed in the proper storage site.

Inventory and Reporting of Loss

A. Procedures must be established by each responsible party that holds a controlled substance license to monitor their use of controlled substances used along with a running inventory of their usage. Purchase records are maintained according to State and Federal requirements and are subject to DPS audit.
B. Authorized personnel must be alert and attentive to the disappearance of any controlled substances. Any loses must reported to the appropriate Principal Investigator, TAMU-CC's Police Department, Center or Research Department Director and the Environmental, Health & Safety Office upon the discovery of the loss.

C. A fully and complete inventory of the controlled substances must be completed every year by the responsible party and a list of the substances used that year reported to the E,H&S Office.

Disposal

Disposal of controlled substances must be in accordance with Federal and State regulations.

Notification

The Environmental, Health & Safety Department (E,H&S) will notify each controlled substance license holder of the controlled substance policy on an annual basis. Each license holder will also be required to annually submit to the office a list of controlled substances they used that year and an update list of all personnel authorized to use controlled substances.

The following is a list of the controlled items including precursor chemicals, laboratory apparatus and glassware whose purchase, use, transfer, and disposal must be monitored.

Chemical Precursors and Chemical Laboratory Apparatus

Precursor Chemicals		**Laboratory Apparatus**	
1. Methylamine 2. Ethylamine 3. D-Lysergic acid 4. Ergotamine tartrate 5. Diethyl malonate 6. Malonic acid 7. Ethyl malonate 8. Barbituric acid 9. Piperidine	10. N-Acetyl anthranilic acid 11. Pyrrolidine 12. Phenylacetic acid 13. Anthranilic acid 14. Hypophosphorus acid 15. Ephedrine 16. Pseudoephedrine 17. Norpseudoephedrine 18. Phenylpropanolamine 19. Red phosphorus Controlled Substance Analogue†	A. Condensers B. Distilling apparatus C. Vacuum dryers D. Three-necked flasks E. Distilling flasks F. Tableting machines G. Encapsulating machines H. Filter funnels, Buchner funnels, and separatory funnels	I. Erlenmeyer flasks, two-necked flasks, single-necked flasks, round-bottom flasks, Florence flasks, thermometer flasks, and filtering flasks J. Soxhlet extractors K. Transformers L. Flask heaters M. Heating mantles N. Adapter tubes
† Substantially similar to a controlled substance or acts on the central nervous system to a similar or greater extent. Prescription and non-prescription medicines are exempted.			

Based on review by the A&M System Office of General Council, it has been determined that inventory requirements listed in the MOU pertain to chemical substances but *not* to apparatus.

Note: The MOU does not establish any de minimis quantities of precursor chemicals nor size of glassware or equipment.

Prescription and non-prescription medicinal formulation are exempted.

E,H&S Controlled Substances Information Sheet

The following procedures and requirements are necessary for E,H&S to comply with the Health Safety Code.

1. Maintain Purchase Order Records according to Federal and State requirements.
2. Do Not Sell, Furnish or Transfer any controlled items (including surplus property) to a person or entity not holding a DPS permit or waiver, unless the recipient is specifically exempted by law or rule. Every sale, furnishing or transferring of a controlled item leaving the immediate campus (where the specific controlled item is stored and inventoried) should be reported (by the 15th day of the next month) to the DPS on a Nar-22 Form.
3. Report to TAMU-CC's Police Department promptly upon discovery of a readily unacceptable discrepancy, pilferage, or theft of a controlled item. The Police Department is responsible for forwarding the report to DPS.
4. Security
    a. The Vice President for Finance & Administration, The Chief of Police and E,H&S Director has primary responsibility for all matters associated with safety, security, and law enforcement at TAMU-CC.
    b. Maintain locked storage for precursor chemicals and controlled substance analogues. Strictly limit access to these chemicals.
    c. Limit access to storerooms containing listed items to authorized personnel only. Lock storage areas when unattended.
    d. All doors into any room in which controlled items are used must be locked when authorized personnel are not present.
5. Notification and Awareness.
    a. Departments and units affected by this Policy should post notices (this page) in prominent location(s), to inform personnel of the Policy and of the steps necessary for compliance.
    b. Encourage personnel to be alert and attentive to the disappearance of controlled items and to report such losses as appropriate.
    c. Assistance from the Texas Department of Public Safety: Upon request, the DPS will provide technical advice to the institution and will assist in investigating losses, etc. covered by the Controlled Substance Act.

Regulated Laboratory Apparatus

Laboratory Apparatus	Picture	Number Present	Location (Room#)
1. Adapter Tubes			
1. Buchner Funnel 2. Seperatory Funnel	 		
1. Condenser 2. Soxhlet extractors	 		
1. Distiller 2. Distilling Flask	 		
Flasks 1. Erlenmeyer 2. Filtering	 		
1. Vacuum Filters			
1. Flask Heaters 2. Heating Mantles	 		
1. Round Bottom Flask 2. Three Neck Flask			
Transformer			

SECTION 10: PROTECTING ONESELF WHEN WORKING WITH CHEMICALS

For information on ways to protect oneself when working with chemicals, including information on personal protective equipment, engineering controls, and how to respond to chemical spills and exposures, see Chapter 5 of this manual, which is titled, "How to Protect Yourself."

SECTION 11: CHEMICAL WASTE DISPOSAL

Chemical waste must be disposed of as hazardous waste. For information on chemical waste disposal, see refer to the Hazardous Waste Management Program document at http://safety.tamucc.edu .

SECTION 12: TRANSPORTING HAZARDOUS MATERIALS

The U.S. Department of Transportation regulates the shipment of hazardous materials. Anyone who packages, receives, unpacks, signs for, or transports hazardous chemicals must be trained and certified in Hazardous Materials Transportation. Warehouse personnel, shipping and receiving clerks, truck drivers, and other employees who pack or unpack hazardous materials must receive this training as well.

Chapter 4

LABORATORY WASTE DISPOSAL

Disposal of hazardous materials is regulated by various federal and state agencies. Laboratory waste very often includes hazardous chemical, biological, or radiological materials. Thus, proper disposal of laboratory waste is not only prudent, but also mandatory. Environmentally sound disposal methods prevent harm to the water, land, and air and by extension, to people as well. Proper disposal techniques also protect waste handlers from harm.

Laboratory waste disposal can be broken down into five categories – hazardous (chemical) waste, biological waste, radioactive waste, glass waste, and metal (sharps) waste – which are discussed below.

SECTION 1: HAZARDOUS CHEMICAL WASTE

The term "hazardous waste" refers to hazardous *chemical* waste. If waste chemicals contain infectious materials or biological hazards, label the waste "biological waste" for handling by the disposal company. Once the biological hazard has been eliminated, then the waste can be managed as hazardous waste. Any waste containing radioactive materials must be managed as radiological waste.

Disposal of hazardous waste is governed by the Environmental Protection Agency (EPA) and by the Texas Commission on Environmental Quality (TCEQ) through Federal and State regulations. TAMU-CC complies with hazardous waste disposal regulations by following the TAMU-CC Hazardous Waste Management Program. For more information on hazardous waste disposal regulations and definitions, refer to the Hazardous Waste Management Program.

Laboratory personnel can ensure compliance with the Hazardous Waste Management Program by following a few simple steps:

1) *Never* dispose of chemicals improperly. Improper disposal includes
    a. Pouring chemicals down the drain.
    b. Leaving uncapped chemical containers in the fume hood to evaporate off the chemical; *and*
    c. Disposing of chemicals in the regular trash.
2) Collect waste in a leak proof container that is in good condition, that can be securely closed, and that is appropriate and compatible for the given chemical.

NOTE: *If a large waste container (>10 gallons) is warranted, contact E,H&S for assistance.*

3) When reusing a container to collect chemical waste, completely deface or remove the original label.
4) Label the container:
    a. The words "Hazardous Waste" must be written on the container, or a preprinted Hazardous Waste label can be affixed to the container. (See "Hazardous Waste Disposal and Waste Collection" section below.)
    b. Identify the contents of the waste container on the container label itself and on a Hazardous Waste Inventory. Use the full name of the chemical, not use an abbreviation or chemical formula.
5) Do *not* mix incompatible waste chemicals in a single container. Use separate waste containers for different waste streams.
6) Do *not* overfill the waste container.
    a. For liquid hazardous waste:
        i. Do not fill jugs and bottles past the shoulder of the container.
        ii. Fill closed head cans (5 gallons or less), leaving approximately two inches of space between the liquid level and the top of the container.
        iii. Fill closed head drums (larger than 5 gallons), leaving approximately four inches of space.

Do not fill past shoulder

    b. For solid hazardous waste materials, do not fill beyond the weight capacity of the container, and leave at least a two-inch head space for closure.
7) Keep waste containers closed. Waste containers should only be open when adding or removing material.

1.1 Hazardous Waste Disposal and Waste Collection

When the waste container is ready for disposal, it should be labeled as Hazardous Waste. These labels may be affixed or attached to the container. Fill out the label following the guidelines below:

1) The words "Hazardous Waste" must be used for chemicals requiring disposal.
2) List all chemical components, including water, with an approximate percentage of the materials in the container.
3) Use full chemical names or common names. Chemical formulas or abbreviations are not acceptable.
4) Indicate the percent concentration of potentially explosive materials such as picric acid and nitro compounds.
5) Place additional hazard information on the label
6) Attach the label to the container.

To schedule waste to be removed from a laboratory, send an inventory of all waste containers ready for disposal to E, H&S by email at ehs@tamucc.edu.

NOTE: *Some departments have Laboratory Coordinators that may remove the waste containers from the lab and accumulate them for pick-up. If waste is taken by the Laboratory Coordinator, the waste inventory should remain with the coordinator. For more information, contact E,H&S.*

1.2 Disposing of Empty Chemical Containers

Empty chemical containers may be disposed of in the regular trash provided the following EPA requirements are met:

1) Containers must not contain free liquid or solid residue.
2) Containers must be triple rinsed.
3) Product labels must be defaced or removed.
4) Container lids or caps must be removed.
5) Render metal containers and plastic jugs unusable by punching holes in the bottom of the containers before disposing of them in the regular trash. (It is not necessary to break empty glass containers.)

IMPORTANT: *Containers that do not meet the requirements mentioned here must be treated as hazardous waste.*

Refer to the Hazardous Waste Management Manual at https://www.tamucc.edu/finance-and-administration/facility-administration/ehs/environmental/lab-and-waste.php for more information on hazardous waste disposal procedures and regulations as well as information on waste reduction and minimization.

SECTION 2: Biological Waste

The Texas Department of State Health Services (TDSHS) and the Texas Commission on Environmental Quality (TCEQ) regulate the disposal of biohazardous materials. Biohazardous materials include organisms or substances derived from biological materials or organisms that may be harmful to humans, animals, plants, or the environment. *Biohazardous waste* includes any waste materials that contain biohazardous materials, such as

- Waste (including blood) from *and* bedding or litter used by infectious animals
- Bulk human blood or blood products and waste materials contaminated with human blood
- Microbiological waste (including pathogen-contaminated disposable culture dishes and disposable devices used to transfer, inoculate, and mix pathogenic cultures)
- Biological pathogens
- Sharps
- Any recombinant (rDNA) materials and products of genetic manipulation

IMPORTANT: *All biohazardous material must be decontaminated prior to disposal.*

Biohazardous waste mixed with hazardous chemical or radioactive waste must be labeled prior to disposal.

There are strict safety requirements regarding segregation, labeling, packaging, treatment (including documentation), and transportation of biohazardous waste. The guidelines below should be followed:

1) Do not mix biological waste with chemical waste or laboratory trash.
2) Segregate hazardous biological waste from nonhazardous biological waste.
3) Clearly label each container of untreated biohazardous waste and mark it with the Biohazard Symbol.
4) It is recommended to label nonhazardous biological waste as "NONHAZARDOUS BIOLOGICAL WASTE."

Refer to the Biological Waste Disposal Manual at http://safety.tamucc.edu for more information on biowaste disposal.

SECTION 3: GLASS WASTE

Glassware should never be disposed of in the regular trash. Pasteur pipettes and broken glass can break through trash bags and cut individuals who handle trash. Follow these guidelines when disposing of broken glass:

- Do not pick up broken glass with bare or unprotected hands. Use a brush and dustpan to clean up broken glass. Remove broken glass in sinks by using tongs for large pieces and cotton held by tongs for small pieces and slivers.
- Glass contaminated with biological agents must be decontaminated by thermal or chemical treatment before disposal.
- Glassware contaminated with chemical or radiological materials must also be decontaminated prior to disposal. If decontamination is not possible, the glass should be disposed of as hazardous or radioactive waste. Place non-contaminated broken glass in a rigid, puncture resistant container such as a sturdy cardboard box. Mark the box "Non-contaminated Broken Glass." Once the box is three-quarters full, seal it shut. The box should then be placed in the dumpster by laboratory personnel. *Custodial staff are not responsible for disposing of glass waste containers.*

NOTE: *If broken glass is commingled with metal sharps, it must be treated as sharps waste and encapsulated before for disposal.*

SECTION 4: METAL SHARPS

All materials that could cause cuts or punctures, must be contained, encapsulated, and disposed of in a manner that does not endanger other workers. Needles, blades, etc. are considered biohazardous even if they are sterile, capped, and in the original container. The following guidelines apply to handling and disposing of sharps:

1) Metal sharps must be segregated from all other waste.
2) Sharps that have been used with chemical or biological materials should be decontaminated prior to disposal whenever possible.
3) Sharps that have radiological contamination must be disposed of as radiological waste.
4) Dispose of sharps in a rigid container, such as a sturdy plastic jar or a metal can.
5) When the container is three-quarters full, encapsulate the sharps with Plaster of Paris or some other solidifying medium.
6) Once the contents are encapsulated, seal the sharps container, label it "Encapsulated Sharps," and take it to the dumpster.

NOTE: *Laboratory personnel are responsible for sharps disposal. Custodial staff are not responsible for encapsulating and/or disposing of metal sharps waste.*

SECTION 5: RADIOACTIVE WASTE

Radioactive materials, depending upon the license, are regulated by the State of Texas or the Nuclear Regulatory Commission, and these regulations/rules are enforced by E,H&S's Radiological Safety Program. All radioactive wastes shall be disposed through E,H&S or via written procedures approved by E,H&S. Contact E,H&S for more information on proper disposal of radiological waste.

Chapter 5

HOW TO PROTECT YOURSELF

SECTION 1: ADMINISTRATIVE CONTROLS

Protecting oneself when working in a hazardous environment begins with Administrative Controls, which includes administrative actions, documented training, and pre-planning.

1.1 ADMINISTRATIVE ACTIONS

Departments are expected to enforce safety standards through administrative actions in a variety of ways. For instance, employee performance evaluations should reflect that laboratory personnel are following TAMU-CC safety standards and protocols in their work areas. Also, it is each department's responsibility to establish whether safety performance should be included in the grading criteria for laboratory courses.

Appropriate safety signage is another way departments can promote safety in laboratories. Signs indicating the hazards present in the laboratory can be posted on laboratory doors. Signs pointing to the location of safety equipment in or near the laboratory can minimize the consequences of an incident by enabling employees to quickly locate needed equipment. Emergency contact information should be posted outside each laboratory door to make it easier for emergency responders to obtain needed information quickly.
And finally, departments should ensure that all laboratory employees receive proper training for the hazards in their work areas and that such training is properly documented and filed.

1.2 EMPLOYEE SAFETY TRAININGS

Before entering a laboratory, all new laboratory employees, including teaching assistants, must receive training on the hazards they will encounter in their work area. This training includes both general and work area specific Hazard Communication and Bloodborne pathogen training. Bloodborne Pathogen training is required by the TAC title 25. Hazard communication training is required by the Texas Hazard Communication Act (THCA).

General Training

Hazard Communication, Bloodborne Pathogens and Texas Precursor Chemical trainings are provided in TrainTraq. Students receive general safety training by completing a course in the Blackboard Learning Management System or in person by the instructor.

Work Area Specific Training

Work area specific training is provided by the principal investigator, laboratory manager and/or laboratory supervisor. These training should focus on the specific hazards in the employee's work area, such as chemical hazards, equipment hazards, biological hazards, bloodborne pathogens, etc. Work area specific training should also include the location of SDSs, the proper use of personal protective equipment, the location and proper use of safety equipment (fume hoods, biological safety cabinets, etc.), the location and use of emergency equipment (showers, eyewashes, fire extinguishers, spill kits, etc.), and the proper response to emergency situations (fires, chemical spills, etc.).

Training should also be provided for new hazards that are introduced into the work area. If new information becomes available for an existing hazard, additional training on that information should be provided.

Training Documentation

Employee safety training must be documented, and records maintained for at least five years per the THCA. Completion of Hazard Communication, Bloodborne Pathogens and Texas Chemical Precursor Trainings are documented in TrainTraq.

1.3 Additional Training Options

In addition to Hazard Communication Training, E,H&S provides a variety of other training opportunities for TAMU-CC laboratory employees. Some training may be required, such as training for employees who will be working with radioactive materials. A list of training courses provided by E,H&S is available on the E,H&S website http://safety.tamucc.edu/.

1.4 Student Safety

Student Training

As required by the Texas A&M University System, "Students enrolled in Laboratory, Studio or Clinic courses will receive appropriate safety information and instruction if class work involves hazardous chemicals, biohazards, and/or the use of specialized equipment."

Students complete an online safety course presented in the Blackboard Learning Management System. The course presents the potential hazards associated with the laboratory and a list of rules the student is to follow. A quiz completed with 100% is acknowledgement that they have received the appropriate information.

Instruction on safe and proper use of laboratory equipment should also be provided to students as needed. Student training is documented in Blackboard.

Departmental Oversight of Student Safety

Departments with teaching laboratories should periodically conduct self-evaluations to ensure teaching assistants are enforcing safety rules and students are complying with them. These evaluations should be documented, as should any discrepancies found, and steps taken to correct them.

1.5 Pre-planning

Many laboratory hazards can be minimized by pre-planning. Before beginning work on a new project, the associated hazards should be considered carefully. What are the sources of danger? Are there chemical, equipment, or electrical hazards? Also consider the risk of an accident or exposure occurring, and what the impact of that incident would be. Also, conduct a thorough safety review of new apparatus.

Once the hazards have been identified, steps to minimize risk should be implemented. This includes utilizing engineering controls (such as fume hoods) and personal protective equipment. If the hazard is chemical, another option would be to substitute a less hazardous chemical. Or perhaps the project can be designed in such a way as to separate incompatibles, such as electrical equipment and water.

Careful planning is essential to a safe working environment.

SECTION 2: Laboratory Ventilation Equipment

Ventilation in a laboratory is a very important aspect of laboratory safety. General room exhaust is not enough to protect the laboratory worker who uses hazardous chemicals, works with biological agents, or uses equipment that generates excess heat. Additional engineering controls are required. This chapter discusses different types of laboratory ventilation.

2.1 Chemical Fume Hoods

Chemical fume hoods provide primary containment in a chemical laboratory. They exhaust toxic, flammable, noxious, or hazardous fumes and vapors by capturing, diluting, and removing these materials. Fume hoods also provide physical protection against fire, spills, and explosions.

For optimum performance and most effective protection, chemical fume hoods should be located away from doorways, supply air vents, and high-traffic areas. Air currents created by passers-by can cause turbulence in a fume hood, which can result in contaminated air being drawn back out of the hood and into the room. Similarly, a supply air vent located directly above a fume hood can also cause turbulence in the hood.

TAMU-CC requires that all chemical fume hoods be ducted to the outside of the building and operate with an average face velocity that is consistent with industry standards. The acceptable range for the average face velocity of a general-purpose chemical hood is 95 – 120 feet per minute (fpm). The minimum face velocity at anyone measuring point should be at least 80 fpm. (The *face* of the hood is the opening created when the hood sash – the movable glass window at the front of the hood – is in the open position.)

Types of Fume Hoods

<u>*Standard Fume Hoods*</u> (aka Constant Air Volume (CAV) fume hoods)

These hoods exhaust a constant volume of air. The velocity of the air passing through the face of a standard fume hood is inversely related to the open face area. Thus, if the sash is lowered, the inflow air velocity increases.

IMPORTANT: *Face velocity that is too high may cause turbulence, disturb sensitive apparatus, or extinguish Bunsen burners.*

Fume Hood Diagram of a Standard

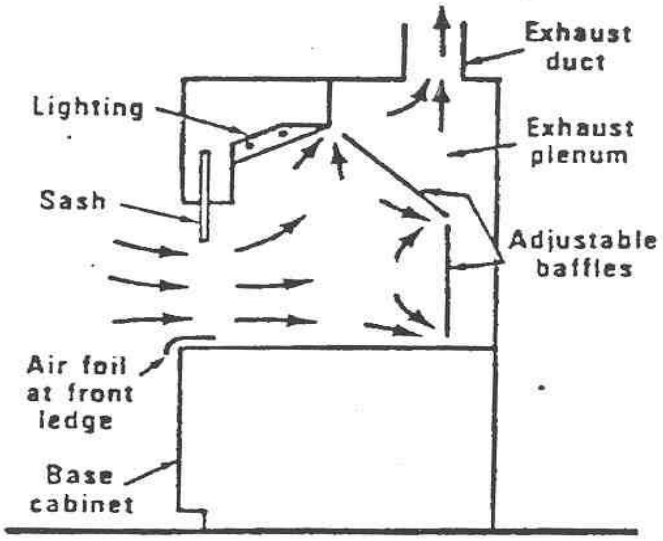


Figure 2

Bypass Fume Hoods

Bypass fume hoods are also constant air volume hoods, but with an improved design. These hoods are designed with a grille-covered opening above the sash. When opened, the sash blocks the grille and does not allow air through. However, as the sash is lowered, air is drawn through the grille, allowing a constant exhaust volume without increasing the velocity of air at the face of the hood. This design helps keep the room ventilation system balanced and helps eliminate the problems with turbulence that high face velocity can cause.

Auxiliary Air Fume Hoods

Auxiliary air fume hoods are also known as "supplied air" or “make-up air” hoods. They use an outside air supply for 50% to 70% of the hood's exhaust requirements. This type of hood is designed to reduce utility costs and conserve energy by reducing the amount of conditioned room air that is pulled through the hood. One disadvantage, however, is that additional ductwork and fans increase the overall cost of these hoods. Also, if the supplied air is tempered, the energy savings is negated, while if it is not tempered, the user may be working under hot or cold air, depending on the season. Untempered air may also cause condensation in the hood, which can lead to rusting of the hood. The face velocity of an auxiliary air fume hood may vary.

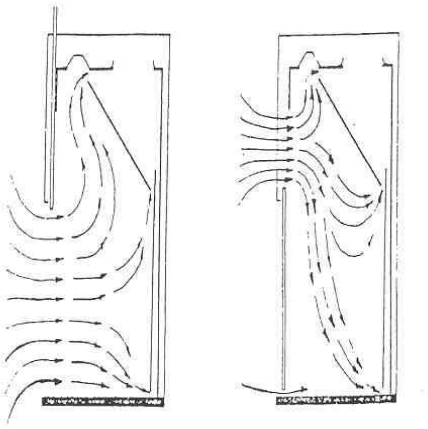


Diagram of a Bypass Fume Hood
(Left – with sash open; Right – with sash

Variable Air Volume Fume Hoods

Just as their name suggests, variable air volume (VAV) hoods are designed to vary the amount of air being exhausted from the fume hood based on the sash position. By varying the exhausted air, these hoods can maintain a constant face velocity, no matter where the sash is positioned. VAV hoods are often equipped with an audio/visual alarm to notify the user if the hood is not operating properly.

Special Fume Hoods

Special fume hoods are necessary when working with certain chemicals and operations. Examples of special fume hoods include the following:

Perchloric acid fume hoods: Anyone working with perchloric acid must use a perchloric acid fume hood. These special fume hoods are equipped with a water spray system to wash down the entire length of the exhaust duct, the baffle, and the wall of the hood. Perchloric acid vapors can condense on the hood ductwork, forming dangerous, explosive metal perchlorates. Also, perchloric acid can react with organic materials to form organic perchlorates, which are also explosive. For this reason, organic solvents should *never* be used or stored in a perchloric acid fume hood, and the hood should be labeled "Perchloric Acid Use Only; No Organic Chemicals". The water wash-down system, used periodically or after each use of the hood, removes any perchlorates or organic materials that may have accumulated in the hood exhaust system. The wash down system should be activated *only* when the exhaust fan has been turned off, so that complete coverage can be achieved.

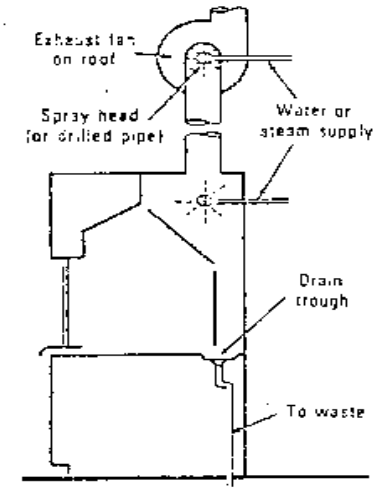
Walk-in hoods: These fume hoods have single vertical sashes or double vertical sashes and an opening that extends to the floor. These hoods are typically used to accommodate large pieces of equipment.

Radioisotope hoods: These hoods are labeled for use with radioactive materials. The interiors of these hoods are resistant to decontamination chemicals. These hoods are also often equipped with High Efficiency Particulate Air (HEPA) filtration. For more information on using radioisotopes in fume hoods, contact EHS.

Ductless hoods: Ductless hoods are designed with a filtration system. Generally, however the filters are not appropriate for use with all chemicals. Also, it is difficult to know when the filters need to be replaced, even if a strict change-out schedule is followed.

Fume Hood Safety Considerations

The potential for glass breakage, spills, fires, and explosions is great within a fume hood. To ensure safety and proper fume hood performance, follow these guidelines:



a. Know how to properly operate a fume hood before beginning work.
b. Fume hoods provide the best protection when the fume hood sash is in the closed position.
c. Inspect the fume hood before starting each operation, including any airflow monitors. Do not use the hood if it is not functioning properly; call Facilities Services to have it checked.
d. Keep traffic in front of the fume hood to a minimum and walk slowly when passing by the hood, especially when work is being conducted in the hood. This will reduce the likelihood of creating turbulence in the hood.

e. Use the appropriate type of hood for the work being conducted. For example, when using perchloric acid, use a perchloric acid fume hood.
f. Keep the area in front of the hood clear of obstructions. This will allow room for laboratory workers to move about and will allow enough airflow to the hood.
g. Place equipment and chemicals at least six inches behind the fume hood sash. This practice reduces the chance of exposure to hazardous vapors.
h. Do not allow equipment and chemicals to block baffle openings. Blocking these openings will prevent the hood from operating properly.
i. Keep loose paper out of the fume hood. Paper or other debris that enter the exhaust duct of the hood can interfere with the hood's ventilation.
j. Do not store excess chemicals or equipment in fume hoods.
k. Elevate any large equipment within the hood at least three inches to allow proper ventilation under the equipment.
l. When working in a fume hood, set the sash at the lowest working height, about 12 – 15 inches from the base of the hood opening. Close the sash completely when no one is standing at the hood working in it. The only time the sash should be completely open is while setting up equipment.

IMPORTANT: *A fume hood's sash is designed to protect the user from dangerous chemical gases and vapors, chemical splashes, and potentially flying debris. The sash should be positioned to protect the user's face, neck, and upper body. The lower the sash position, the more area of the user's body will be protected.*

m. Do not defeat sash stops by removing them or altering their design or function.
n. Wear personal protective equipment, including protective eyewear, as appropriate. The hood does not replace PPE.
o. Keep laboratory doors closed. Laboratory ventilation systems are designed to operate with the doors closed.
p. Do not alter/modify the fume hood or associated duct work. If additional equipment needs to be ventilated, contact E,H&S for an evaluation.
q. Clean up spills in the hood immediately.

IMPORTANT: *If a power failure or other emergency occurs (e.g., building fire or fire within the fume hood), close the fume hood sash and ensure safe shutdown of the lab, paying special attention to equipment that may be reenergized when power is restored.*

Fume Hood Inspections

Fume hoods should and will be tested at least annually. Fume hoods should also be tested in the following circumstances:

- When an employee requests an inspection.
- After major repair work.

- After a fume hood is moved.

Fume hood testing includes measuring the velocity of airflow through the face of the hood as well as a general inspection of the hood's condition (sash, lighting, noise level, etc.). If you suspect a problem with your fume hood, contact Facilities Services.

2.2 Other Laboratory Ventilation Systems

Biological Safety Cabinets (BSCs)

BSCs provide containment for pathogenic materials and are not intended for use as a chemical fume hood. When used and maintained correctly, Class II biosafety cabinets protect the user from exposure to harmful biological agents and protect the product from contamination by filtering the air inside the cabinet through High Efficiency Particulate Air (HEPA) filters. Before using a biological safety cabinet, laboratory personnel should be thoroughly trained on how to properly use and maintain the cabinet.
Follow these instructions for safe use of a biological safety cabinet:

a. Only biosafety cabinets that are certified according to National Sanitation Foundation (NSF) Standard # 49 may be used with pathogenic or recombinant DNA materials. BSCs must be certified upon installation, upon being moved, after major repair, and at least annually.
    i. Annual service and certification of BSCs are contacted by an outside company.
    ii. BSCs that are not certified annually or that fail certification will be tagged "Not Safe For Use With Pathogens."
b. Locate biosafety cabinets away from doorways and high traffic areas. As with chemical fume hoods, rapid movement in or near the cabinet can create turbulence, causing contaminants to be drawn out of the cabinet and into the general laboratory area.
c. Restrict entry into the laboratory when work is being conducted in the BSC.
d. Turn off UV light before beginning work in a BSC.
e. Disinfect the biosafety cabinet prior to beginning and after completing work in the cabinet.
f. Allow cabinet to operate without activity at least 15-20 minutes before and after use. This will allow all the air in the cabinet to circulate through the HEPA filters, removing any contaminants that may be present.

g. Keep the BSC clear of clutter and loose paper. Only place items that are needed in the cabinet.
h. Keep clean items and dirty items segregated in the BSC.
i. Provide a waste container inside of the cabinet and keep it covered.
j. Always wear appropriate personal protective equipment.
k. Keep face away from the BSC opening.
l. Never use a Bunsen burner in a biosafety cabinet. Dangerous levels of gas can build up in the cabinet. Also, heat from the open flame can damage the HEPA filters.
m. Clean up spills in the BSC immediately.

Canopy Hoods

These hoods capture upward moving contaminants and are good for heat- producing operations only. Canopy hoods should not be used as chemical fume hoods, as workers may be exposed to contaminants if they work under the hood.

Glove Boxes

Glove boxes are designed to be leak-tight and can be used with highly toxic or air-reactive chemicals and materials. Some glove boxes may also be appropriate for use with some radioactive materials. The leak-tight design provides a controlled atmosphere, protecting both the product and the worker by preventing vapors/moisture, gases, and particulates from entering or leaving the box.

Laminar Flow Hoods

Also known as clean benches, laminar flow hoods provide a continuous flow of HEPA filtered air across the work surface. This design helps prevent contamination of the product but does not offer any protection to the worker. Laminar flow hoods should only be used with non-hazardous materials.

Snorkel Hoods

Snorkel hoods are small fume exhaust duct connections. They are designed with flexible ducts and can be positioned directly over a work area at the bench. For best performance, the snorkel hood should be placed within six inches of the item needing ventilation. Snorkel hoods should *only* be used to exhaust heat and nuisance odors. They should never be used with highly toxic or flammable chemicals.

SECTION 3: PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) includes all clothing and work accessories designed to protect employees from workplace hazards. Protective equipment should not replace engineering, administrative, or procedural controls for safety — it should be used in conjunction with these controls. Employees *must* wear protective equipment as required and when instructed by a supervisor.

IMPORTANT: *Personal protective equipment is used to prevent exposure or contamination. PPE should always be removed before encountering other individuals or before going in or near elevators, break rooms, classrooms, bathrooms, etc. Do not launder personal protective equipment at home.*

3.1 ARM AND HAND PROTECTION

Arms and hands are vulnerable to cuts, punctures, burns, bruises, electrical shock, chemical spills, and amputation. Forms of hand protection available to employees include but are not limited to:

- Disposable exam gloves
- Chemical resistant gloves (rubber, nitrile, neoprene, etc.)
- Non-asbestos heat-resistant gloves
- Metal-mesh gloves for meat cutters
- Kevlar or Dynema gloves for cut resistance
- Bite-resistant gloves

Always wear the appropriate hand and arm protection. Double your hand protection by wearing multiple gloves when necessary (e.g., two pairs of disposable gloves for work involving biological hazards). For arm protection, wear a long-sleeved shirt, a laboratory coat, chemical-resistant sleeves, or gauntlet-length gloves.

Follow these guidelines to ensure arm and hand safety:

a. Inspect and test new gloves for defects.
b. Always wash your hands before and after using gloves.
c. Wash reusable chemical-protective gloves with soap and water before removing them.
d. Do not reuse disposable gloves. Turn disposable gloves inside-out as you remove them to avoid contaminating your hands.
e. Do not wear gloves near moving machinery; the gloves may become caught.
f. Do not wear gloves with metal parts near electrical equipment.

IMPORTANT: *Gloves are easily contaminated. Avoid touching surfaces such as telephones, doorknobs, etc. when wearing gloves.*

3.2 Body Protection

Hazards that threaten the torso tend to threaten the entire body. A variety of protective clothing, including laboratory coats, long pants, rubber aprons, coveralls, and disposable body suits are available for specific work conditions, including the following:

- Rubber, neoprene, and plastic clothing protect employees from most acids and chemical splashes.
- Laboratory coats, coveralls, and disposable body suits protect employees and everyday clothing from contamination by chemicals, biological materials, dirt, and grime, etc.
- Welding aprons provide protection from sparks.
- Chain mail aprons provide protection for meat cutters.

Launder reusable protective clothing separate from other clothing. Do not launder protective clothing at home or in any public facilities outside of the university. A laundry service that specializes in biological or chemical contaminants may be used.

3.3 Hearing Conservation

If you work in a high noise area, preventing hearing loss is of utmost importance. Whenever possible, attempts should be made to control noise levels through engineering controls or operational changes before resorting to hearing protection. Equipment that is operating more loudly than usual may just need maintenance. Also, installing noise attenuating devices in an inherently noisy environment may alleviate noise levels. If, however, the noise level cannot be controlled sufficiently, hearing protection should be employed.

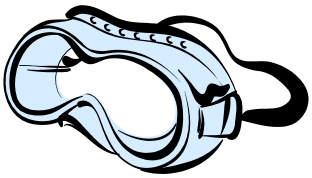
If you suspect that your laboratory environment exceeds acceptable noise levels, contact E,H&S for help. E,H&S has instruments for measuring decibel levels and can make recommendations on possible ways to reduce the noise level or on types of hearing protection that would be appropriate for the situation.

3.4 Eye and Face Protection

Employees must wear protection if hazards exist that could cause eye or face injury. Eye and face protection should be used in conjunction with equipment guards, engineering controls, and safe practices.

NOTE: *Unless it is documented that there is no potential for eye injury to occur, safety glasses are <u>required</u> in laboratories. Chemical splash goggles should be worn when handling chemical materials.*

Always wear adequate eye and face protection when performing tasks such as grinding, buffing, welding, chipping, cutting, pouring chemicals or pipetting. Safety glasses or goggles should be worn in case of impact hazard. Chemical splash goggles provide the most effective eye protection against chemical splashes as well as protection against impact.
Follow the information below regarding eye protection:



a. If you wear prescription glasses, goggles or other safety protection should be worn over the glasses.
b. Safety glasses with side-shields provide protection to eyes and are four times as resistant as prescription glasses to impact injuries.
c. Goggles protect against impacts, sparks, chemical splashes, dust, etc., but not all goggles provide the same type of protection. There are specific goggles for:
    i. Wood-working or other impact hazards
    ii. Chemical splash hazards
    iii. Laser hazards
    iv. UV hazards
    v. Welding hazards
d. A face shield is designed to protect the face from some splashes or projectiles but does not eliminate exposure to vapors.

NOTE: *Goggles or safety glasses with side shields <u>must</u> be worn under a face shield.*

<u>3.5 FOOT PROTECTION</u>

To protect feet and legs from falling objects, moving machinery, sharp objects, hot materials, chemicals, or slippery surfaces, employees should wear closed-toed shoes, boots, foot-guards, leggings, or safety shoes as appropriate. Safety shoes are designed to protect people from the most common causes of foot injuries — impact, compression, and puncture. Foot protection is particularly important in laboratory work.

IMPORTANT: *Do not wear sandals, open-toed shoes, open-backed shoes, or Crocs in laboratories, shops, or other potentially hazardous areas.*

Chemically resistant shoes may be necessary when working with certain materials, such as corrosives. Special foot protection is also available for protection against static electricity, sparks, live electricity, and slipping. For more information on specialty foot protection, consult the TAMU-CC Safety Manual.

3.6 Head Protection

Accidents that cause head injuries are difficult to anticipate or control. With some exceptions, head protection is generally not needed in a laboratory environment. However, if hazards exist in the laboratory that could cause head injury, employees should try to eliminate the hazards, but they should also wear head protection. Refer to the TAMU-CC Safety Manual for more information on head protection.

3.7 Respiratory Protection Program

TAMU-CC uses engineering, administrative, and procedural controls to protect people from dangerous atmospheres, including harmful mists, smoke, vapors, oxygen deficient environments, and animal dander. When these controls cannot provide adequate protection, respiratory protection is necessary.

People who use respiratory protection must be physically capable of using and wearing the equipment. In some cases, a physician must determine if an employee is healthy enough to use a respirator. In addition, *all* people required to wear respirators must be formally trained and instructed in proper equipment usage.

Choosing the right respirator for the job is equally important to knowing how to use it. There are many types of respirators, and each type protects against different hazards.

IMPORTANT: *Respirators are available in different sizes. Always fit test a respirator to select the correct size.*