



LAB SAFETY MANUAL AND CHEMICAL HYGIENE PLAN

The Citadel, the Military College of South Carolina

2025

LAB-SPECIFIC INFORMATION:

for the Lab Safety Manual and Chemical Hygiene Plan of [NAME of LABORATORY] in [BUILDING] in room [ROOM NO.]

The Citadel Department of Environmental Health and Safety developed a general Lab Safety Manual and Chemical Hygiene Plan (LSM-CHP) that will be provided to Campus Lab Technicians. The OSHA Laboratory Standard requires that every laboratory develop a lab-specific Chemical Hygiene Plan. To satisfy this requirement, the general plan must include lab-specific information on hazards, risks, controls, emergency procedures, and other relevant details.

Complete the templates and forms within this document to include detailed information about your laboratory facility and operations. Once completed, this document must be printed, kept in a binder, signed, and accessible to lab personnel. All lab personnel must review and understand the content of the General LSM-CHP and the Lab-Specific Information for the general plan. A total of 17 sections must be included with your lab-specific LSM-CHP.

Section	Description
1	Contacts for emergencies and other incidents.
2	Laboratory Emergency Procedures in case of a fire, chemical spills, chemical exposure, and personal injury.
3	Hazard and Controls Inventory – list of chemical, biological, radioactive, physical, and other hazards and primary controls identified and implemented.
4	Safety Equipment Inventory and Maintenance Log – a laboratory safety equipment list.
5	Chemical Inventory – list of all chemicals (including gases and cryogens) stored and/or used in the laboratory, with all highly hazardous substances highlighted on the list.
6	Standard Operating Procedures (SOPs) for highly hazardous chemicals, equipment, processes, and other tasks.
7	Safety Data Sheets – location of printed SDS of highly hazardous substances and the primary and backup access SDS of all other chemicals in the laboratory.
8	Safety Manuals, Brochures, operation manuals, information packets, booklets, or brochures from equipment manufacturers, chemicals, PPE, and others.
9	Building Emergency Evacuation and Reentry Plan – procedures for evacuation (and re-entry) in emergencies that require building evacuation.
10	Laboratory shutdown and restart checklist – list of items to be completed when shutting down the laboratory for an extended period, and a list of items to complete when resuming laboratory operations after a shutdown.
11	Training Documentation – certificates of completed training for all laboratory personnel, including chemical and laboratory safety, hazardous waste, lab-specific training, and other training required based on hazardous materials handled.
12	Laboratory Self-Inspections – record of lab safety self-inspections conducted

13	Incident/Accident Reports – record all laboratory accidents, incidents, and near misses.
14	Safety Posters, Signage, Labels, Checklists, others
15	Other Lab Safety Policies on PPE, minors in laboratories, laboratory and equipment decommissioning, waste disposal, and field research safety
16	Resources – references on lab safety standards, regulations, and guidelines.
17	Laboratory Safety Manual and Chemical Hygiene Plan clearance form – signed by all laboratory personnel after reviewing the content of the general LSM-CHP and the Lab-specific Information.

PHONE NUMBERS FOR EMERGENCIES AND OTHER INCIDENTS

Agency/Department/Personnel	Phone Number	Type of Emergency
Public Safety	8-1-1 (on campus phones)	Life-threatening emergencies, such as fire, major spills, injuries, medical events, and others.
	(843) 953-5114	
Environmental Health & Safety (EH&S)	(843) 953-6945 0800 – 1500 M-F jsoares1@citadel.edu	Non-emergency (non-life threatening and does not require immediate attention) chemical spill, chemical exposure, or unsafe conditions.
Facilities and Engineering (F&E)	(843) 953-5304	Emergency and non-emergency facility repair requests.
[Department Dean]	[Contact Phone Number]	All incidents that occur in laboratories within the Department.
[Department Safety Coordinator]	[Contact Phone Number]	All incidents that occur in your laboratory.
[Department Supervisor]	[Contact Phone Number]	All incidents that occur in your laboratory.
[Lab Technician]	[Contact Phone Number]	All incidents that occur in your laboratory.

EMERGENCIES AND BUILDING EVACUATION

When calling 9-1-1, provide the following information

- Your name and phone#
- Incident location: This [ADDRESS, BUILDING NAME, AND ROOM NUMBER].
- Injured person, if any, specific injury and location; request ambulance if needed
- Hazardous materials involved, if known
- What happened? Describe activities that caused the incident and your initial response
- Other relevant information that may help responders evaluate and stabilize the incident
- Other information asked

When you need to evacuate the building

Fire and other emergencies will require you to leave the building. In the event of a fire, always use the stairs, not the elevator.

- Pull the nearest fire alarm in the [LOCATION].
- The building evacuation route is posted in the [LOCATION].
- If this primary route is not safe, the alternative is to use the location.
- All lab staff are to meet at [LOCATION] after exiting the building.
- The Designated Coordinator, [NAME], will take attendance to ensure that everyone has safely evacuated.
- If you can provide information about the incident, proceed to the Fire Department Incident Commander on site.
- Do not re-enter the building until the Incident Commander has declared it safe to return.

SPECIFIC LABORATORY EMERGENCY PROCEDURES

Chemical Hazards

In addition to fire, accidents that lead to the release of chemicals and personnel exposure are the two most common lab emergencies. When incidents like these occur, lab personnel are expected to follow emergency procedures to reduce the potential impact on personnel, property, and the environment.

If 9-1-1 is called, what information do I provide?

- Your name and phone number.
- Incident location: This includes the address, building, and room number.
- Injured person, if any, specific injury and location; request ambulance if needed
- Hazardous materials involved, if known
- What happened? Describe activities that caused the incident and your initial response
- Other relevant information that may help responders evaluate and stabilize the incident
- Other information asked by dispatch

What if I see smoke or suspect a fire? What if my clothing catches fire?

- Pull an emergency fire alarm.
- Evacuate the building using the nearest exit stairway. Warn everyone on your way out.
- Call 9-1-1 and provide information listed above.
- Proceed to the designated evacuation area.
- If your clothing is on fire-
 1. “STOP, DROP, and ROLL”. (If someone is on fire, instruct the person to drop to the ground and roll back and forth.)
 2. Cover your face with your hands.
 3. Never use a fire extinguisher on a person. Use a fire blanket to help smother the flames. A damp towel may be used if the fire does not involve water-reactive chemicals.

What if a chemical spills?

- Determine if it is a “major” or “minor” spill. A minor spill is contained (e.g., inside a fume hood) or small enough that it can be cleaned up safely with the available spill kit, and where special personal protection (i.e., respirator) is not required.
- Assist anyone who may have been contaminated or injured during the spill.
- Clean up a minor chemical spill using your chemical spill kit.
- Call Public Safety (843) 953-5114 and EH&S (843) 953-6945 for major spills and all spills involving mercury and hydrofluoric acid (HF).
- Contain a major spill with an appropriate absorbent, only if it can be done safely (e.g., the spill does not pose an inhalation hazard).
- Post “Hazardous Chemical Spill DO NOT ENTER” on the entrance door and evacuate the area.
- Do not re-enter until Emergency Responders or EH&S have cleaned up the spill and declared the building and laboratory safe for re-entry.

What if my eyes or skin come into contact with chemicals?

1. Pull the safety shower lever to start the water flowing. For eyewashes, push the lever to start the water flowing.
2. Wash off contaminants from your eyes by holding your eyelids open to allow the water to reach under them.
3. Remove all contaminated clothing and shoes to wash off skin contaminants effectively.
4. Stay under the water for at least 15 minutes to wash off the contaminant. If your skin comes into contact with HF, wash the HF off for 5 minutes, then apply a liberal amount of calcium gluconate gel to the affected area. Repeat application every 15 minutes.
5. Proceed to the nearest emergency room (ER) for immediate treatment. Provide the Safety Data Sheet of the chemical involved.
6. Call Public Safety (843) 953-5114 and EH&S (843) 953-6945.

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Procedures for Laboratory Emergencies

Call 9-1-1 for all medical and life-threatening emergencies!

Provide the following information to 9-1-1 dispatch

- Your name and phone number.
- Incident location: **this address, building, and room number.**
- Injured person, *if any*, specific injury and location; request ambulance *if needed*
- Hazardous materials involved, *if known*
- What happened? Describe activities that caused the incident and your initial response
- Other relevant information that may help responders evaluate and stabilize the incident
- Other information asked by dispatch

Laboratory Information

Building & Room:

Lab Phone #:

Contact the following if an incident occurs in this laboratory.

(Laboratory Manager) (Cell Phone #)

(Alternate Person 1) (Cell Phone #)

(Alternate Person 2) (Cell Phone #)

The following emergency equipment is available in this lab:

- Fire extinguisher in **specific location in the room**
- Emergency shower in **specific location in the room**
- Eyewash in **specific location in the room**
- Chemical spill kit in **specific location in the room**
- First aid kit in **specific location in the room**

If you see smoke and suspect a fire:

1. Pull an emergency fire alarm.
2. Evacuate the building using the **nearest exit stairway**. Warn everyone on your way out.
3. Call 9-1-1 and provide information listed above.
4. Proceed to the designated evacuation area.

If your clothing catches on fire:

1. "STOP, DROP, and ROLL". (If someone is on fire, instruct the person to drop to the ground and roll back and forth.)
2. Cover your face with your hands.
3. **Never use a fire extinguisher on a person.** Use a fire blanket to help smother the flames. A damp towel may be used if the fire does not involve water-reactive chemicals.

Evacuation information

Fire and other emergencies will require you to leave the building. In the event of a fire, always use the stairs, not the elevator.

- The nearest fire alarm is in **location**.
- The building evacuation route is posted in **location**.
- If this primary route is not safe, the other way out is **location**.
- All lab staff are to meet at this location after exiting the building.
- The Designated Coordinator, **[person's name]**, will take attendance to ensure that everyone has safely evacuated.
- If you can provide information about the incident, proceed to the Fire Department Incident Commander on site.
- Do not re-enter the building until the Incident Commander has declared that it is safe to return!

If there is a chemical or biological spill:

1. Determine if it is a “major” or “minor” spill. A minor spill is contained (e.g., inside a fume hood or biosafety cabinet) or small enough that it can be cleaned up safely with the available spill kit, and where special personal protection (i.e., respirator) is not required.
2. Assist anyone who may have been contaminated or injured during the spill.
3. Clean up a minor chemical spill using your chemical spill kit and a biological spill with your biological spill kit.
4. Call Public Safety at **(843) 953-5114** and EH&S at **(843) 953-6945** for major spills and spills involving mercury or HF.
5. Contain a major spill with an appropriate absorbent, only if it can be done safely (i.e., the spill does not pose an inhalation hazard).
6. Post “Hazardous Chemical Spill - DO NOT ENTER” on the entrance door and evacuate the area.
7. Do not re-enter until Emergency Responders or EH&S have cleaned up the spill and declared the building and laboratory safe for re-entry.

If your eyes or skin were exposed to chemicals or biological materials:

1. Pull the safety shower lever to start the water flowing. For eyewashes, push the lever to start the water flowing.
2. Wash off contaminants from your eyes by holding your eyelids open to allow the water to reach under them.
3. Remove all contaminated clothing and shoes to wash off skin contaminants effectively.
4. Stay under the water for at least 15 minutes to wash off the contaminant. If your skin comes into contact with HF, wash the HF off for 5 minutes, then apply a liberal amount of calcium gluconate gel to the affected area. Repeat application every 15 minutes.
5. Proceed to the nearest emergency room (ER) for immediate treatment. Provide the Safety Data Sheet of the chemical or biological material involved.

If there is a spill of or exposure to radioactive materials:

- Clean up small spills (<1 ml) by using an appropriate rad decontamination solution. Continue the cleanup until the contamination level is less than three times the background level.
- A spill where liquid is flowing or there is widespread powder contamination is considered a major spill. Contain flowing liquid using an appropriate absorbent. Cover a dry powder spill with a damp cloth.
- Report all incidents and near misses involving radioactive materials, no matter how small, to the Radiation Safety Office.
- Personnel present in the lab at the time of the spill must have their clothing, shoes, hands, and feet surveyed for contamination before leaving the vicinity to avoid spreading contamination beyond the laboratory room.
- If contamination is identified on clothing, immediately remove the clothing and survey the underlying skin. If the skin is contaminated, wash it immediately with soap and water.
- If a laser injury to the eye and/or skin is suspected or known, or if an X-ray exposure is suspected or known, contact 9-1-1 immediately for transport to the nearest Emergency Room. Known or suspected eye injuries from a laser must be evaluated and treated by an ophthalmologist as soon as possible. Notify ER personnel of the type of laser or X-ray that caused the injury.

If fume hood ventilation fails while working with an inhalation hazard:

- Close the fume hood sash.
- Advise lab occupants and neighboring labs to evacuate the area.
- Post “DO NOT ENTER, Contaminated Area” on the entrance door.
- Call EH&S (843) 953-6945 or Public Safety after office hours (843) 953-5114 to have the air contamination evaluated.
- Call Facilities and Engineering (843) 953-5304 to arrange for fume hood repair.
- Call EH&S to have the fume hood re-certified after the repair is completed.

SECTION 1. SAFETY AND COMPLIANCE IN THE LABORATORY

POLICY:

The Citadel is committed to providing a safe laboratory workplace for its students, faculty, staff, and visitors. Safety in the laboratory remains one of the College's top priorities as it endeavors to fulfill its research, education, and outreach missions effectively.

Safety and compliance are necessary goals for every individual who works or visits our laboratories. We strive for zero accidents in our workplace. As much as safety is a goal, it is also a continuous process of identifying hazards, assessing risks, implementing controls, and planning for emergencies. It is a collaborative process involving our College Leaders, Environmental Health and Safety, Academic and Research Departments, Lab Managers, and laboratory personnel. We advocate for collaborative partnerships to fulfill our laboratory safety and compliance goals.

It is the policy of The Citadel to provide a safe laboratory workplace that is also compliant with current laboratory safety regulations, standards, and guidelines, including but not limited to:

- OSHA Standard 1910.1410.
- OSHA's Occupational Exposure to Hazardous Chemicals in Laboratories.
- NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*.
- International Fire Code (Current Approved Cycle).
- ANSI Standard for Emergency Showers and Eyewash Stations.
- ANSI Standard for First-Aid Kits.
- ACS Guidelines for Chemical Laboratory Safety in Academic Institutions.

PURPOSE:

This document constitutes the Laboratory Safety Manual and Chemical Hygiene Plan (the latter required by the OSHA Laboratory Standard). This Plan aims to provide written safety and compliance guidance for all personnel working with hazardous materials, equipment, processes, and other tasks in The Citadel laboratories. It describes roles and responsibilities, policies, guidelines, and practices to ensure safety and compliance in our laboratories.

PERSONNEL AND ACTIVITIES COVERED BY THIS PLAN:

This Laboratory Safety Manual and Chemical Hygiene Plan apply to all work involving hazardous substances, equipment, processes, and tasks performed in Citadel research and teaching laboratories. All personnel, including Faculty, staff, and students working in a Citadel laboratory, must follow the provisions of this Plan.

SECTION 2. ROLES AND RESPONSIBILITIES

DEPARTMENT CHAIR

The Department Chair has the responsibility and authority to implement the College's health and safety policies. The Department Chair has the following specific responsibilities:

- Enforce laboratory safety regulations, standards, and guidelines within the Department.
- Designate a Department Safety Coordinator.
- Review and grant pre-approval for minors to participate in laboratory activities.
- Consult with EH&S to evaluate facility requirements of potential research faculty hires.
- Consult with EH&S to evaluate the suitability of new laboratory construction or renovations for the research work of Faculty assigned to the space.
- Ensure that new Faculty hires communicate and work with EH&S during the start-up of new laboratories.
- Ensure that Faculty leaving the College consult and work with EH&S to close out their assigned laboratory.

DEPARTMENT SAFETY COORDINATOR

Appointed by the Department Chair, the Department Safety Coordinator's responsibilities include those assigned by the Chair and the following:

Serve as liaison between the Department and EH&S by communicating safety policies to Faculty and Staff and reporting to EH&S all Departmental laboratory incidents and safety concerns.

SUPERVISORS

The Supervisors include Teaching Instructors and Facility Managers in charge of laboratory operations. The Supervisors' duties are:

- Develop and maintain a lab-specific Laboratory Safety Manual and Chemical Hygiene Plan, instruct all lab members to conduct work in accordance with the Plan, and ensure the Plan is readily accessible to lab members during work hours.
- Establish and enforce lab-specific safety policies and procedures, following existing College, State, or Federal regulations, standards, and guidelines endorsed by various safety organizations.
- Provide lab-specific and procedure-specific safety training to lab members, ensure they receive EH&S safety training, and document each lab member's completed training.
- Monitor lab members' safety performance and provide guidance and instructions as needed (e.g., correct work practices and conditions that may result in the release of or exposure to hazardous materials, instruct laboratory personnel on proper disposal of unwanted and/or dangerous chemicals).
- Define designated areas and restrict access to areas where work is performed with highly hazardous chemicals, equipment, and processes.
- Collaborate with EH&S to identify hazards, assess risks, and implement controls to mitigate risks in their lab.
- Review and approve Standard Operating Procedures (SOPs) for work with highly hazardous chemicals, equipment, and processes.
- Provide lab members with the required personal protective equipment (PPE) to safely perform all hazardous tasks.
- When potential exposure is suspected, contact EH&S.
- Refer employees who require medical surveillance for potential exposures to Concentra, in accordance with Human Resources requirements.
- Assist EH&S personnel in performing lab safety inspections and submit and implement corrective action plans for deficiencies identified during inspections.
- Report lab incidents to EH&S, participate in incident investigations, and develop and implement corrective action to prevent future incidents.
- Ensure an accurate inventory of all chemicals stored and used in the laboratory is developed and maintained.
- Ensure lab members can access safety data sheets (SDS) for all chemicals used and/or stored in the laboratory.
- Arrange for non-laboratory personnel (e.g., contractors and support personnel) to be informed of hazards they may be exposed to when accessing the laboratory and provide instruction on minimizing the risk of exposure to these materials.
- Collaborate with EH&S to implement lab safety policies and guidelines when establishing a new laboratory, decommissioning an existing laboratory, and/or accepting volunteers to participate in laboratory activities.

LABORATORY TECHNICIAN

Designated by the laboratory Dean, the Laboratory Technician is responsible for evaluating and recommending lab-specific safety issues, as well as all other responsibilities delegated by the Supervisor. Specific responsibilities are:

- Participate in periodic safety inspections and walkthroughs of their laboratory as requested by EH&S.

- Assist their Supervisor in training new lab members.
- Disseminate safety information to lab members.
- Conduct laboratory self-inspections.
- Inspect, maintain, coordinate, and/or request repairs and maintenance of safety equipment, including chemical spill kits, biological spill kits, first-aid kits, fire extinguishers, emergency showers, and eyewash stations.
- Annual review and update of the Laboratory Safety Manual and Chemical Hygiene Plan.
- Maintain an accurate chemical inventory.
- Report to the Supervisor all lab incidents, including those resulting in injury or illness, fire, spills, or releases of hazardous substances, as well as near misses (incidents that could have but did not result in actual injury or property loss).

LABORATORY PERSONNEL

Laboratory personnel include both college employees and non-employees working in a laboratory, such as professors, lecturers, teaching assistants, graduate assistants, undergraduate students, graduate students, postdoctoral associates, visiting scientists, approved minors, and others.

All laboratory personnel must follow the procedures outlined in the Laboratory Safety Manual, Chemical Hygiene Plan, and all Standard Operating Guidelines developed under this plan. One or more of the following responsibilities apply depending on the lab personnel's position or designation in the laboratory group:

- Complete all required safety training before commencing work in the laboratory.
- Understand and follow all safety practices, policies, and regulations of The Citadel and all other governing entities.
- Understand the function, proper use, and maintenance of personal protective equipment, and wear appropriate personal protective equipment at all times when working with hazardous chemicals, equipment, and processes.
- Report in writing to the Supervisor any significant problems arising from the implementation of the written Standard Operating Guidelines.
- Report to the Supervisor and/or EH&S any current or developing conditions or activities that pose an immediate danger to life and health so that they can be addressed promptly.
- Report to the Supervisor, Group Safety Officer, and EH&S all near misses - any action or condition that exists and could result in an accident.
- Report to the EH&S and other investigating authorities all facts surrounding incidents that occur in the laboratory.

ENVIRONMENTAL HEALTH AND SAFETY

Environmental Health and Safety (EH&S) is The Citadel's enforcement and compliance division, which is responsible for monitoring safety and compliance in research and teaching laboratories. EH&S provides guidance and oversight for the safe handling of chemicals, radiological materials, biological agents, equipment, and a wide range of physical hazards that may be present in laboratories. EH&S responsibilities are:

- Review the Standard Operating Procedures for the use of highly hazardous substances, equipment, and processes.
- Review research, building construction, and/or laboratory room renovation plans to ensure they meet current safety regulations, standards, and guidelines.

- Assist lab personnel in identifying hazards, assessing risks, and identifying controls to mitigate risks.
- Conduct periodic safety inspections and facilitate the correction of observed deficiencies.
- Assist new Faculty hires in setting up laboratories that meet current safety regulations, standards, and guidelines.
- Facilitate the disposal of hazardous waste and other unwanted hazardous materials during lab clean-up or when laboratories are closed out.
- Investigate laboratory incidents, identify root causes, and assist lab personnel in developing and implementing corrective action plans.
- Issue “stop operations” order for laboratories where severe conditions are immediately dangerous to life and health.
- Guide various day-to-day safety questions and concerns from laboratory personnel.
- Provide general safety training to handle chemicals, biological agents, and radiological materials safely.
- Monitor and provide support for laboratories in maintaining up-to-date chemical inventories.

SECTION 3. MANAGING A LABORATORY

MULTIPLE LABORATORY ROOMS

The success of maintaining lab workers' health and safety depends on the commitment of all stakeholders in developing, enforcing, and following rules and best practices. The laboratory technician, who has an assigned research space, has the authority and responsibility to manage that space and the personnel who work in it.

Managing a laboratory presents numerous challenges, including the physical size of the space, the diversity of research, and the number and diversity of research personnel. The following recommendations would facilitate personnel safety and compliance in an assigned lab space:

- Demonstrate your commitment to safety. Include safety in your lab meeting agendas, one-on-one discussions, and experiment planning, among other areas. Conduct regular and frequent walks through your lab, using this as an opportunity to reinforce safety as a top priority. Wear proper personal protective equipment (PPE) while in the lab. Enforce rules, updating them when new hazards are introduced.
- Delegate safety responsibilities and authority to enforce rules; communicate this information to the rest of the research group members.
- Formalize onboarding and departure procedures. Develop a system to track all required training, including EH&S and lab-specific training. Ensure new researchers are supervised while learning new procedures until they can work independently. Create a departure checklist for staff and students to ensure that their samples and chemical containers are properly labeled and that all waste and unwanted materials are disposed of in an appropriate manner.
- Monitor lab spaces regularly and frequently. Perform quarterly laboratory self-inspections; rotate self-inspections through all lab members; require a formal lab inspection report that includes deficiencies and corrective actions; require all research group members to implement corrective actions.

SHARED SPACES

Shared research and teaching spaces are typically encouraged to utilize resources efficiently within The Citadel's research and academic departments. Shared spaces include core facilities, equipment rooms, cold rooms, dark rooms, microscopy rooms, animal rooms, and growth chambers. It is often unclear who is primarily responsible for maintaining safety and compliance in the shared space. When hazardous chemicals, biological materials, and radioactive materials are involved, serious safety issues arise, including contaminated work areas, improperly labeled chemical containers, improperly stored waste, clutter, and poor housekeeping. Undetected and uncontrolled contamination can lead to harmful exposures for users of shared rooms and equipment. Improper labelling or waste storage are serious non-compliances with state and federal regulations.

To maintain safety and compliance in shared spaces, a designated competent individual, a laboratory technician, must manage the shared space and/or equipment. An assistant lab manager should be appointed to ensure the space's management continues uninterrupted in the lab manager's absence. The lab manager will develop, implement, and enforce procedures for access and lab safety guidelines to address issues related to housekeeping, contamination, and waste management. Some of the basic guidelines that can be implemented include:

- A mechanism to sign up to use the room or equipment.
- Card access or keys to the shared room are granted only to authorized users; the room is always locked when no one is inside.
- Requirement to complete safety and equipment use training before getting authorization to use the room and equipment.
- Requirement to label all items brought into the space with the owner's name.
- Requirement to follow clean-up and decontamination procedures before leaving the shared space.
- Each user must have a chemical, biological, or radioactive waste container labeled in designated areas.
- When conducting procedures involving radioactive materials, the room must be posted according to the LTs' authorizations, and unsecured material must be under the direct control of the radiation worker.
- Weekly lab clean-up.
- Monthly self-inspections.

SECTION 4. CORE PRINCIPLES OF SAFETY PLANNING

RECOGNIZING HAZARDS IN LABORATORIES

The first critical step in safety planning is recognizing the existence of hazards:

A hazard is any material, condition, or activity that may cause damage or harm to a person's health, college property, and the environment. Examples of hazards include flammable chemicals, a centrifuge, hot surfaces, and the mixing of incompatible chemicals.

Every hazard carries risks that must be assessed and mitigated through control measures. Uncontrolled hazards (risks) can result in personnel injury or illness, loss of property, or environmental damage.

Hazards of chemicals and equipment are communicated through words and pictograms on labels, safety data sheets, equipment operation manuals, and literature. Two central hazard communication systems are used to communicate chemical hazards: the National Fire Protection Association (NFPA) diamond

system (NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*) and the Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

Common hazards in a laboratory can be classified into four main categories: health, physical, environmental, and work conditions.

1. **Health** – chemical, biological, or radioactive agents that affect human health through inhalation, ingestion, the mucous membrane, and skin absorption. i.e., toxic, carcinogenic, teratogenic, mutagenic, reproductive toxins, sensitizing, asphyxiant, pathogenic bacteria, virus, ionizing radiation.
2. **Physical** – chemicals, equipment and process based hazards that can destroy human bones and tissues, i.e., chemicals that are corrosive, pyrophoric, explosive, flammable, oxidizing, self-reactive or unstable; nonionizing radiation, high pressure, low pressure, electrical, uneven surfaces, pinch points, suspended weight, hot surfaces, extreme cold, steam, noise, vibration, falling objects and projectiles, clutter, magnetic fields, simple asphyxiant, oxygen-deficient spaces, ultraviolet radiation, laser light, repetitive pipetting, glassware and other sharp objects, centrifuging.
3. **Environmental**—chemical, biological, or radioactive agents that, when released, negatively impact the soil, groundwater, air, and/or ecological environment, e.g., PCBs, benzene, genetically modified organisms, invasive species, and isotopes.
4. **Work Conditions** – less than ideal conditions that may contribute to increased potential for other hazards to cause injury, i.e., long work hours, counter-intuitive equipment design, unreliable or sudden loss of electricity, water, or ventilation, improperly maintained equipment, limited visibility, improperly selected or improperly fitting personal protective equipment.

ASSESSING RISKS

Once hazards are recognized, the risks associated with them need to be identified. The risks are then rated using the probability of occurrence and severity of consequence scales. The overall risk is calculated as the product of the two ratings, assuming no control measures are in place. Essentially, the risk rating measures the likelihood and severity of damage if no action is taken regarding the hazard. If the risk is high, control measures must be identified to mitigate and reduce it to an acceptable level.

The following is an excerpt from the ACS framework for calculating risks:

The framework enables users to develop a linear scale for the probability of occurrence (the likelihood that the identified risk will occur) and a weighted scale for the severity of consequences (the impact of an identified risk on safety, resources, work performance, property, and/or reputation). Using a weighted scale for the severity of consequences provides a more realistic assessment of the impact of the hazard on personnel safety and property damage, among other criteria. It allows users, for example, to give more weight to the risk of death vs. the risk of skin burn due to exposure to a hazardous chemical. The calculated risk is obtained by multiplying the probability of occurrence and the severity of consequences. The higher the likelihood of occurrence and the more severe the result, the higher the calculated risk. Although ratings are assigned arbitrarily, the framework provides a way to estimate risks associated with various hazardous materials or activities.

Table 1. Risk value is based on the likelihood of an event occurring.

VALUE	PERCENT LIKELY TO OCCUR	DESCRIPTION
0	0	Item/operation not present in the lab
1	1 – 10	Rare
2	10 – 50	Possible
3	50 – 90	Likely
4	90 – 100	Almost Certain

Table 2. Risk value is based on impact on personnel, property, resources, work performance, and reputation.

Severity of Consequences		Impact On				
Value	Rating	Personnel Safety	Resources	Work Performance	Property Damage	Reputation
1	No Risk	No Injuries	No Impact	No Delays	Minor	No Impact
5	Minor	Minor Injuries	Moderate Impact	Modest Delays	Moderate	Potential Damage
10	Moderate	Moderate to Life Impacting Injuries	Additional Resources Required	Significant Delays	Substantial	Damaged
20	High	Life-Threatening Injuries from Single Exposure	Institutional Resources Required	Major Operational Disruptions	Severe	Loss of Confidence

Probability of Occurrence:

The probability of occurrence explores the likelihood that a specified risk will occur. It uses a rating and value scale ranging from Not Present (0) to Almost Certain to Certain (4).

Examples:

- A laboratory measures groundwater's pH and handles hundreds of samples daily. In this case, the likelihood of a container spilling and exposing an employee to groundwater would be high.
- A laboratory is conducting research on electroplating with cyanide baths and only uses the bath monthly. The probability of an occurrence happening would be low.

The following Probability of Occurrence with Standard Linear Scaling chart includes the percent probability that an issue will occur. Note: This chart is arbitrarily scaled from 1 to 4, with 4 being the highest probability.

Probability of Occurrence with Standard Linear Scaling

Severity of Consequences

Severity of consequences assigns a rating based on the impact of an identified risk on safety, resources, work performance, property, and/or reputation. Each rating is then assigned a value. (For example, a "No Risk" rating may be assigned a value of 1; a "High" rating may be assigned a value of 4.) The numerical values from the severity of consequences will contribute to other risk rating tools, such as the hazard risk rating, using standard linear scaling.

Examples:

- The severity of consequence for a laboratory measuring the pH of ground water samples would likely be No Risk (0) if a "failure" caused an employee to be exposed to the ground water.
- The severity of consequence for a laboratory conducting electroplating research with cyanide baths would be High (4) in the event of a "failure" that caused an employee to be exposed to cyanide.

This Severity of Consequences with Standard Linear Scaling chart assesses impacts to personnel safety, resources, work performance, property damage, and institutional reputation associated with each rating. Note: This chart is arbitrarily scaled 1 to 4, with 4 being the highest severity.

The primary goal of risk rating is to differentiate between an institution's high-risk and low-risk activities. Therefore, it may be necessary to weigh the consequences value scale against your institution's priorities and protocols.

For example, using the standard linear scaling, an activity with a certain probability (4) with no risk (1) would produce an overall risk rating of 4. An activity with a rare probability value (1) with potentially lethal consequences (4) would also result in a risk rating of 4. Since any activity with the potential of being lethal would not be considered low risk, regardless of how low the probability, the scale needs to be weighted to reflect the severity of potential consequences.

The Weighted Consequence Value Scale demonstrates how you might assign consequence values to achieve risk ratings that are more reflective of the impact of moderate and high consequences.

Severity of Consequences, Weighted Value Scale

Let's review our previous example. Using this weighted scale, an activity with a certain probability (4) with no risk (1) would still produce an overall risk rating of 4. However, an activity with a rare probability value (1) with potentially lethal consequences (20) would result in an overall risk rating of 20.

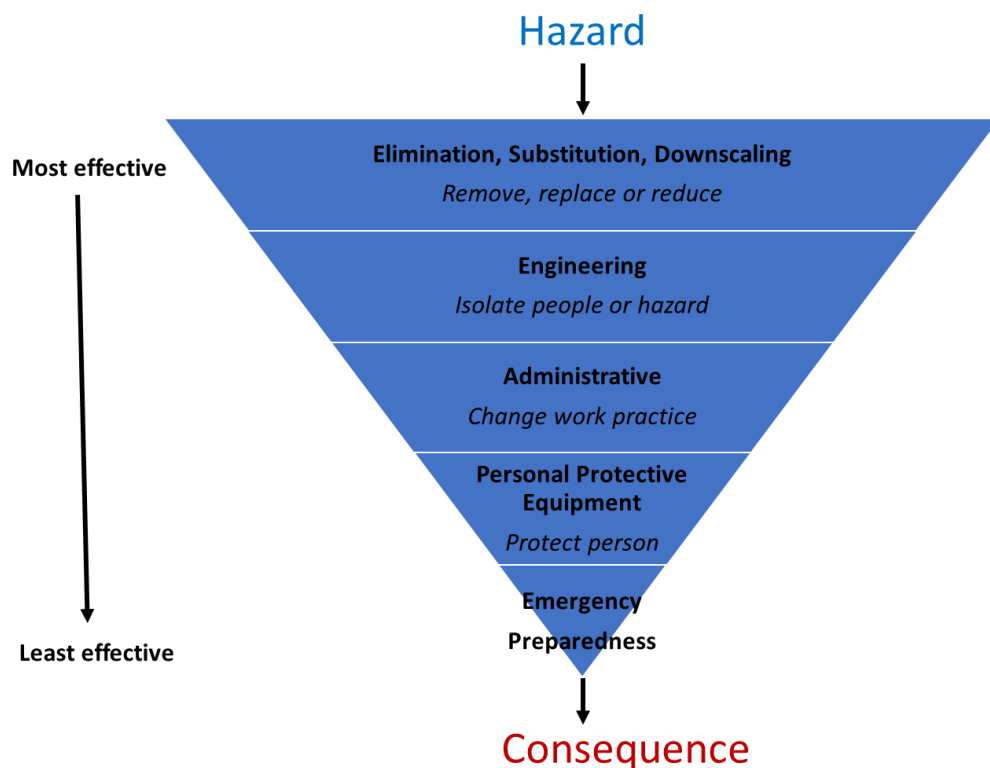
CONTROLLING RISKS

Every institution sets its risk tolerance based on its priorities and resources. This concept trickles down to a lab environment, where the Principal Investigator, in collaboration with safety professionals, plans controls that effectively mitigate risks based on risk ratings for hazards.

There are strategies to address risks. Eliminating the hazard itself is the most obvious but least feasible option. The hazard, being a necessary component of research or instruction, would be difficult to eliminate unless a less hazardous alternative is available. Another possibility is downscaling, where the amount of hazardous material or the intensity or frequency of hazardous activity is significantly reduced.

Controls must be implemented in the order of hierarchy and with redundancy to be most effective (Figure 1). According to the NIOSH pyramid, the most effective control measures are elimination and substitution, followed by engineering controls, administrative controls, and personal protective equipment, which is perceived as the least effective of all controls.

Figure 1. The pyramid of controls illustrates the hierarchy of effectiveness.



Modified from: <http://www.cdc.gov/niosh/topics/hierarchy>

When all controls (Table 3) are planned and implemented, the risk associated with a hazard is significantly reduced. However, residual risk still exists, even if an accident does not happen. Therefore, every laboratory must be prepared for emergencies so that the consequences of an accident can be mitigated.

Table 3. Types and examples of controls.

Order in the Hierarchy	Type of Control	Examples (Not All-Inclusive)
1	Elimination	It is possible not to use the intended hazardous substance, equipment, or process.
	Substitution	A less hazardous chemical, equipment, or process is available.
	Downscaling	It is possible to use less volume, less concentration, and conduct the experiment less frequently.
2	Engineering	Building ventilation. Chemical fume hood. Local exhaust vent/snorkel. Biosafety cabinet. Shielding for radiation. Shielding for explosions. Glove box. Gas cabinet. Closed system. Guards for moving parts. Insulated/guarded electrical connections. Emergency shut-off. Interlocks.
3	Administrative (Rules Requirements, Protocols)	Personnel training before starting work. Prior approval for high-hazard activities. Designate work areas and restrict access. Follow SOPs. Follow safe practices. Comply with College, State, and Federal safety regulations. Conduct a Job Hazard Analysis before starting an experiment or task. Limiting the time a person works with a particular material. Mandating that no one should work in the lab alone (buddy system).
	Administrative (Work Practice and Hygiene)	As a rule, wear proper PPE (including full-coverage shoes and clothing, no dangling accessories, and flame-resistant clothing as needed). Remove PPE (proper removal technique) when leaving the lab area or handling items that you or others typically handle without PPE. Handwashing.

		No eating or drinking in the laboratory. Designate and label appliances and household items. Good housekeeping. Buddy system. Protect unattended operations (i.e., long-term procedures that use flowing gas, pressure, vacuum, running water, heating equipment). Acknowledge personal limitations.
4	Personal Protective Equipment (appropriate for the hazard/task, assigned, always used)	Safety glasses for minimum eye protection. Safety goggles if there is a potential for minimal splash. Face shield for potential moderate splash to the face . Lab coat for general skin protection. Flame-resistant lab coat if using large volumes of flammables and/or open flames. Gloves specifically resistant to or appropriate for the hazard. Nose and Mouth protection. Respiratory protection. Ear protection. Other protection.

PREPARING FOR EMERGENCIES

Being prepared for emergencies is paramount to safety in the laboratory. Even after control measures are well thought out and implemented, residual risk remains due to the hazard. Additionally, controls may fail, and accidents can occur. When accidents happen, everyone must be prepared to respond appropriately. Preparations must occur before an accident, so they must be part of the preparations before starting any experiment or task.

Common laboratory accidents involve fire, exposure to chemicals, and spills or releases of chemicals. Some important considerations when preparing for emergencies:

1. Prepare written procedures.
2. Perform required checks and maintenance on safety equipment, including fire extinguishers, first aid kits, spill kits, emergency showers, and emergency eyewash stations.
3. Ensure lab personnel are trained to execute the emergency procedure, including knowledge of the use and location of safety equipment.
4. Conduct emergency drills.
5. Verify that phone numbers are accurate.

SECTION 5. LAB ACCESS AND SECURITY

AUTHORIZED PERSONNEL ONLY

The laboratory room doors must be locked and accessible only to authorized personnel. Authorized personnel primarily include students, technicians, postdoctoral researchers, and other personnel who are members of the research group under the supervision of the Lab Supervisor or Principal Investigator to whom the research space is assigned. Other personnel may be granted temporary authorized access to conduct short-term activities or utilize shared equipment.

WORKING OUTSIDE OF NORMAL BUSINESS HOURS

Lab personnel working outside regular business hours, Monday through Friday, must seek prior approval from their Lab Technician. The Supervisor must designate a “buddy” for the lab worker, someone who can assist in the event of an emergency.

Researchers should avoid working in the laboratory alone with highly hazardous substances, equipment, and processes. When working alone late at night or over long weekend periods, arrange with Campus Public Safety or workers in other laboratories to check on you periodically. Some experiments are too hazardous to be conducted alone; researchers must consult with their supervisor to identify such hazardous activities.

ANIMALS IN LABORATORIES

Pets, such as dogs, are not permitted in laboratories and other research auxiliary spaces. However, special accommodations may be made for service animals following the Americans with Disabilities Act.

SECTION 6. SAFETY DOCUMENTS AND SIGNAGE

HAZARD NOTICE

A Laboratory Hazard Notice must be posted at the entrance of your laboratory. This notice informs emergency responders, lab personnel, and authorized visitors of all hazardous materials or situations they may encounter upon entering your laboratory. The hazard notice must include all chemical, biological, radioactive, and other hazards in the lab. Emergency contact information and entry requirements must also be listed. Emergency contact numbers should be cell phone numbers that you are likely to answer when not on campus.

Should an incident occur in your lab, Emergency responders will rely on the hazard notice to make timely and effective decisions regarding entry and stabilization of the incident area. If you are your laboratory's designated group Laboratory Technician, you must ensure that the information listed on the hazard notice is always accurate.

This hazard notice template can be modified to create your lab-specific signage. The following instructions describe the information required for each section of the notice:

- **Laboratory Identification** - the laboratory name refers to how you refer to your research group; indicate the Building and room number, and the name of your Laboratory Technician. List the names of all members of your research group. If you need more space than is available, please refer to the lab personnel list in the Laboratory Safety Manual and Chemical Hygiene Plan binder.
- **Research Group**—The Emergency contact should include the Laboratory Technician and two lab personnel who can answer questions about laboratory operations. List phone numbers that can be reached outside of regular office hours, such as a home phone or a cell phone.
- **Emergency and Non-emergency Contact** - Personnel and/or offices who can provide information and/or assistance in emergency and non-emergency situations.
- **Notice**—Include statements and phrases that will inform all personnel of the requirements that need to be met before they can enter your laboratory.
- **Fire Hazards** - Review your lab chemical inventory and safety data sheets to identify the GHS hazard classes and Category ratings of chemicals in your lab. Make a list of hazard classes that have Category 1 or 2 ratings. This section of the template lists all GHS hazard classes of chemicals that may impact the potential for a fire to start or the response during a fire. Remove the pictograms that do not represent the hazard classes in your list. Indicate the total volume of flammable liquids and list individual names of those stored in 5-gallon or larger containers. List the chemical names of all flammable gases and indicate the total volume of all flammable gases in your lab.
- **Health Hazards** - Review your lab chemical inventory and safety data sheets to identify the GHS hazard classes and Category ratings of chemicals in your lab. Make a list of hazard classes that have Category 1 or 2 ratings. This section of the template lists all GHS hazard classes of chemicals that impact a person's short-term and long-term health. Remove the pictograms that do not represent the hazard classes in your list. List all hazardous chemicals by name under each hazard class. For example: Corrosives - HF; Acute toxicity - Arsenic.
- **Physical and Other Hazards** - This refers to equipment, instruments, and other items that pose physical harm, such as cutting, pinching, crushing, burning, electrocution, or exposure to high pressure. Include equipment that generates hazardous chemicals, such as hydrogen, ozone, and mercury. Other hazards refer to items or situations in the lab that are potential safety concerns but are not classified as chemical, biological, physical, or radioactive. Examples include tripping hazards, low beams, noise, confined spaces, and dim lighting.
- **Biological Hazards and Biosafety Level**—List all biological materials (derived from living organisms) present and the biosafety level assigned to your lab. Please note that all BSL-2 labs have specific signage requirements.
- **Radiation Hazards** - List all isotopes, lasers (and classes), and x-rays present in the lab.

LAB SAFETY MANUAL AND CHEMICAL HYGIENE PLAN

Regulatory Reference: 29 CFR 1910.1450(e)(1) Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

- 1910.1450(e)(1)(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and
- 1910.1450(e)(1)(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.

The Occupational Safety and Health Administration (OSHA) regulation 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories", also known as the OSHA Lab Standard, requires that a Chemical Hygiene Plan (CHP) be developed for each laboratory workplace to protect employees from

injury due to chemical exposure in the workplace. Among other required elements, the OSHA Lab Standard specifies that the CHP must include the “criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices”; “particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous” (1910.1450(e)(3)(ii)).

The Citadel Laboratory Safety Manual and Chemical Hygiene Plan (The Citadel LSM-CHP, this document) was developed by the Environmental Health and Safety (EH&S) and Campus Laboratory Technicians. We intend to create a plan to address commonly used hazardous substances, equipment, and processes in our laboratories, resulting in a comprehensive Laboratory Safety Manual that incorporates a Chemical Hygiene Plan. In its current form, this document serves as a foundation for laboratory technicians and lab managers to develop their lab-specific laboratory safety manual and chemical hygiene plan. This template can be customized for a specific lab by completing all forms within the Lab-Specific Information section of The Citadel LSM-CHP document.

CHEMICAL INVENTORY

Regulatory Reference: 29CFR 1910.1200(a)(2) This occupational safety and health standard is intended to address comprehensively the issue of classifying the potential hazards of chemicals, and communicating information concerning hazards and appropriate protective measures to employees, and to preempt any legislative or regulatory enactments of a state, or political subdivision of a state, about this subject. Classifying the potential hazards of chemicals and communicating information concerning hazards and appropriate protective measures to employees, may include, for example, but is not limited to, provisions for: developing and maintaining a written hazard communication program for the workplace, including lists of hazardous chemicals present; labeling of containers of chemicals in the workplace, as well as of containers of chemicals being shipped to other workplaces; preparation and distribution of safety data sheets to employees and downstream employers; and development and implementation of employee training programs regarding hazards of chemicals and protective measures.

The development and maintenance of an accurate chemical inventory facilitates smooth laboratory operations and is required by the Occupational Health and Safety regulation 29 CFR 1910.1200, also known as the OSHA Hazard Communication Standard. Ready access to safety data sheets of each hazardous chemical in the workplace is also an essential requirement of this standard.

To develop and maintain your lab chemical inventory:

- Download the chemical inventory template.
- Using the template, enter the minimum required information: chemical name, CAS# (if available), and amount (quantity and unit).
- Update as new chemicals come in, or as chemicals are used or discarded

SAFETY DATA SHEETS

Regulatory Reference: 29 CFR 1910.1200(b)(3)(ii) Employers shall maintain any safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible during each work shift to laboratory employees when they are in their work areas;

The OSHA Hazard Communication Standard requires chemical manufacturers, distributors, and importers to communicate the hazards of chemical products to users by providing Safety Data Sheets (SDSs), formerly known as Material Safety Data Sheets (MSDSs).

The laboratory technicians are responsible for ensuring that the Safety Data Sheets (SDSs) for all chemicals in the workplace are readily accessible to all personnel at all times. Individual workers are responsible for reading the Safety Data Sheets (SDSs) of chemicals before handling them for the first time. The SDSs contain 16 standard sections providing information not only on the chemical and physical properties but also on essential hazards and protective measures.

Remember that any incident involving a chemical will require an SDS to be provided to Emergency Responders and the attending Physician so that proper treatment can be administered.

The following guidelines describe how to satisfy the requirement for ready access to SDS at all times:

Option 1. Maintain printed copies of SDS for ALL chemicals stored and/or used in the lab in a binder.

- 1.1 Upon receiving a chemical shipment, place the enclosed Safety Data Sheet (SDS) in an SDS binder. If no SDS is enclosed, visit the manufacturer or distributor's website and print the SDS for the chemical received. Arrange SDS alphabetically according to chemical name.
- 1.2 Place tabs for each alphabet letter to facilitate SDS search in the binder. Indicate the location of the SDS binder in the Lab-Specific Information for LSM-CHP.
- 1.3 Place the SDS binder in a work area accessible to all lab personnel.
- 1.4 Provide back-up access to SDS information in case the printed copies are lost or become inaccessible. Examples of back-up access include online databases, PDF files on a CD, or PDF files in a computer folder.

Option 2. Maintain printed SDSs for high-hazard chemicals only. Maintain electronic access to SDSs for all other low—to moderate-hazard chemicals.

In general, high hazard chemicals are classified into Category 1 or 2 based on the Globally Harmonized System for hazard classification and labeling of chemicals for the following hazard classes:

- Acute Toxicity
- Carcinogen
- Mutagenicity
- Reproductive Toxicity
- Respiratory Sensitizer
- Target Organ Toxicity
- Aspiration Toxicity
- Pyrophorics
- Flammables (liquids; if used in large amounts or in combination with heat or open flame)
- Flammables (gases)
- Emits Flammable Gas, Self-Reactive
- Self-heating
- Organic Peroxides
- Skin Corrosion or Burns
- Eye Damage
- Explosives and Oxidizers

If a chemical is classified as Category 3 or 4, consult with EH&S to determine whether it requires a printed Safety Data Sheet (SDS).

- 2.1 See Option 1 to maintain printed copies of SDS of high-hazard chemicals.
- 2.2 For SDS of low to moderate hazard chemicals, describe the procedure for accessing SDS electronically in the Lab Specific Information for the LSM-CHP. Specify the web link(s), how to perform SDS search for a specific chemical, and how to print the SDS if requested (i.e., by

an emergency responder during a release or an attending physician during an exposure incident).

- 2.3. Train all lab personnel on the procedure described in 2.2.
- 2.4. Specify a backup source of the electronic SDS referenced in 2.2 if electricity goes out or the web link becomes unavailable. For example, maintain a CD that contains all the PDF files of SDS in Section 2.2, which can be accessed using a battery-powered laptop.

Online resources for Safety Data Sheets

- Interactive Learning Paradigms, Inc. lists over 85 different online SDS providers
- Sigma-Aldrich
- Fisher Scientific
- VWR
- Airgas, Matheson, Praxair

STANDARD OPERATING PROCEDURES:

Regulatory Reference: 29 CFR 1910.1450(e)(3)(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals.

The following categories of hazardous substances, equipment, and processes pose extreme hazards to personnel and require written Standard Operating Procedures (SOPs), even for a single event where they are used.

- Select human carcinogens
- Reproductive toxins
- Mutagens
- Teratogens
- Compressed gases, especially those that are flammable, reactive, corrosive, and toxic
- Unstable compounds that may explode (i.e., expired peroxide formers, dry picric acid),
- Pyrophoric materials, and
- Highly toxic liquids and solids
- Pressurized systems
- Equipment that poses significant physical hazards (cut, pinch, crush, high voltage, high pressure, others)
- Category 1 or 2 rating for most hazard classes according to GHS classification
- Process that involves the use of any one or a combination of the above

The new safety data sheet format identifies the hazard classes of a substance in Section 2. The hazard classification is based on the Globally Harmonized System of Hazard Classification and Labeling (GHS). If GHS assigns a Category 1 or 2 rating under any hazard class, an SOP must likely be written for this substance. Consult EH&S 777-5269 if in doubt about the high hazard status of a specific substance.

What is an SOP?

(Most text in this section is an excerpt from the American Chemical Society's Hazard Assessment in Research Laboratories.)

- What it is—The SOP method yields a comprehensive document that outlines lab processes and identifies hazards and controls to eliminate or mitigate associated risks.
- Who's involved – Laboratory Technicians and senior lab workers oversee the SOP process, but everyone in the lab should contribute and participate.
- When to use—Scenarios where hazardous materials, equipment, or processes have been identified but could be streamlined for simple experiments, well-tested experiments, or unchanging experiments.

- Training required – Laboratory Technicians and senior lab workers should lead SOP development. All lab workers, regardless of experience level, should participate in SOP development, review, and updates.

Overview:

Standard Operating Procedures (SOPs) are generally effective for designing experimental protocols. They provide an opportunity to identify risks and hazards at each step of an experimental process. An effective SOP analyzes potential hazards associated with several factors, ranging from the types of materials required for the experiment to the personnel working in the lab. By identifying these hazards and risks, SOPs help predict potential problems and assess the impact of a safety failure.

Learn more about the factors to consider when assessing hazards.

The SOP often includes information collected from a checklist, Job Hazard Analysis, What-if Analysis, or control banding.

SOPs are typically developed for repetitive procedures that involve associated hazards, such as injury, property damage, or loss of productivity. The SOP outlines written steps that can be followed to execute the procedure safely. Each step of the experiment can be analyzed separately to identify failure points. After each step is analyzed for potential dangers, the whole experiment process should be examined from beginning to end to determine if combinations of the factors could impact safety.

The lab worker uses the hazard matrix to review the risks associated with using hazardous materials, processes, and equipment. They also measure the impact of conditions, including the adequacy of facilities, worker knowledge and experience, and proposed hazard mitigation measures.

SOP Messages to Remember

- When writing an SOP, ensure that the appropriate research was performed to understand the hazards and identify safety measures, including a review of past incidents.

How to develop and write an SOP

1. Consult with coworkers, vendors, or other experts.

They may point out hazards you hadn't considered or known about. For example, compressed gas vendors can provide guidance on appropriate handling. Include warning or trouble signs and how to prevent a lab accident. Submit the SOP for review by a supervisor and other laboratory workers.

2. Review literature and other guidance materials.
 - Consult the Safety Data Sheet for specific hazards associated with the substances to be used.
 - Consult the National Fire Protection Association codes (available through the safety office) for control requirements for gas storage and use, including tubing and connectors, emergency response equipment, and facility requirements.
 - Review the literature for lessons learned.
 - Review the experiment to see what could go wrong/likely failures.

What failures, even if unlikely, could lead to a catastrophic event?

3. Decide on what approach to take:
 - Process (i.e., distillation, peptide synthesis, hydrogenation, organic synthesis)
 - A specific hazardous substance (i.e., cyanogen bromide, HF, nitric acid)
 - Hazard class – (i.e., organic solvents, peroxide formers, carcinogens, corrosives)
 - By any other reasonable approach that addresses the health and safety concerns of the experiment
4. Use the EH&S SOP template and address the following required elements:
 - Identity of the substance and essential characteristics
 - Material hazards

- Other special considerations, such as extreme reactivity
 - Availability of alternative safer materials
 - Engineering controls
 - Personal protective equipment (PPE) required
 - Proper use and storage
 - Work practices
 - Emergency procedures for spills, exposure to hazardous substances, and/or process or equipment failure
 - Availability of safety equipment
 - Safety information resources
 - SOP-specific training documentation
5. Prepare for the experiment. Perform a dry run.
 - Remove any combustible or unnecessary material from the area around the experiment.
 - Make sure there is a clear emergency egress
 - Ensure you have the appropriate attire and personal protective equipment (PPE).
 - Have a plan to monitor the experiment.
 - Review the hazards and ensure measures are taken to reduce risk.
 - Address other laboratory or facility operations that might affect this experiment or be affected by it.
 - Practice using nonhazardous materials or using a scaled-down process.
 6. Identify unsafe conditions. Revise SOP, incorporate new information.
 - Do not experiment in low humidity, inadequate space, lighting, or cluttered or cramped areas.
 - Do not perform while working alone or without emergency response personnel, if needed.
 - Do not experiment if rushed, fatigued, or ill.
 - Do not proceed if there is evidence of a gas leak, tubing, or equipment failure.
 - Report any incidents or concerns to a supervisor.

TRAINING DOCUMENTATION

See Section 7.

DESIGNATED AREAS

Designated areas should be marked with a conspicuous sign reading: DESIGNATED AREA FOR USE OF (NAME OF HIGHLY HAZARDOUS SUBSTANCE) AUTHORIZED PERSONNEL ONLY. Only authorized and trained personnel should be allowed to work in or have access to such designated areas.

UNATTENDED OPERATIONS

Unattended procedures and operating equipment are strongly discouraged due to the increased risk of developing a hazardous situation or materials release from equipment failure or electricity or water supply interruption. These often result in flooding/, fire, or release of hazardous chemicals. In cases where equipment or procedures require continuous operation over an extended period due to the nature of the experiment, signage must be placed on the equipment.

EMERGENCY PROCEDURES

A written emergency procedure for common laboratory incidents, such as fire, exposure to chemicals, chemical spills, and releases, must be posted by the exit door or on any prominent bulletin board in the laboratory. The procedure must clearly outline the steps to respond appropriately to an incident. The method must include verified emergency phone numbers for personnel and offices who will be able to provide information about laboratory operations or assist during an emergency.

SECTION 7. SAFETY TRAINING

REQUIRED SAFETY TRAININGS

Training is a vital tool for conveying the principles and practices of laboratory safety. The training required for each lab personnel depends on the hazardous materials they will handle. At the time of the initial appointment, the Laboratory Technician and personnel must take time to identify and list all required training. The laboratory technician and lab personnel must ensure that the training identified corresponds with the materials involved in the experiment and that the training is completed before beginning actual work in the laboratory.

The following regulatory agencies require training of employees who work with specific hazardous materials:

- Occupational Safety & Health Administration (OSHA) requires training for all employees who work with hazardous chemicals and human-derived materials (e.g., human blood, body fluids, or tissue specimens).
- RCRA regulation requires employees generating hazardous chemical waste to complete annual hazardous waste generators' training;
- The SC Department of Health and Environmental Control (DHEC) requires personnel generating infectious waste to understand compliance requirements for infectious waste collection, storage, transport, and disposal;
- State and federal regulations require radiation safety training for all personnel using radioactive materials or equipment such as X-rays or lasers;
- National Institutes of Health (NIH) Guidelines require the university to ensure appropriate training for laboratory staff regarding laboratory safety and implementation of the NIH Guidelines;
- Other research funding and accreditation agencies also require grantees to perform their research in compliance with federal safety regulations, standards, and guidelines.

LAB-SPECIFIC TRAINING

It is the Laboratory Technician's responsibility to ensure that their lab members have completed all required training and provide them with laboratory-specific and procedure-specific training on the use of hazardous chemicals, equipment, and processes in their laboratory. This training can be presented during informal group safety meetings or individual discussions with lab personnel.

Laboratory-specific training must include:

- Discussion of all hazards and controls present in the laboratory
- Location of the safety documents (Lab Safety Manual and Chemical Hygiene Plan, Safety Data Sheets, equipment manuals, posters, books, handouts, online resources, others)

- Review the contents of the Lab Safety Manual and Chemical Hygiene Plan. All lab personnel must sign the clearance form after reading the document
- Review of the contents of the safety data sheets and the ways to access them
- Location and use of safety equipment (safety shower, eyewash, fire extinguisher, first-aid kit, others)
- Location, use, limitation, and maintenance of personal protective equipment
- Standard Operating Procedures (SOPs) for handling highly hazardous chemicals, equipment, processes, and tasks. Personnel must be able to demonstrate proficiency in performing all aspects of the SOPs
- Procedures for responding to emergencies (fire, spills, chemical exposure, others), including steps in getting medical care
- Procedures for post-exposure follow-up.

Lab personnel not doing work (access only):

Personnel who will have access to the laboratory but are not performing laboratory work should receive a safety orientation to ensure they are aware of the hazards present in the lab, the emergency procedures to follow in the event of an incident, and the personal protective equipment required to enter the laboratory. The Lab-specific Information for the LSM-CHP clearance form must be signed after the safety orientation.

SECTION 8. LAB VENTILATION AND FUME HOODS

Room exhaust ventilation is the primary method to control inhalation exposure to hazardous substances. Laboratory rooms are designed to change room air with fresh air at a rate of at least eight air changes per hour. The laboratory fume hood is the most common type of ventilated enclosure used in laboratories. Other types of local exhaust include vented enclosures for large pieces of equipment or chemical storage, as well as snorkel-type exhaust systems designed to capture contaminants near the point of release. Local exhaust systems consist of a hood, ductwork, and a fan located on the roof. Some systems feature air-cleaning devices, such as HEPA filters or activated carbon adsorbers. In most cases, individual fans serve each hood.

A chemical fume hood is an essential engineering control designed to contain, capture, and eliminate hazardous chemical vapors, fumes, aerosols, or particulates away from the user's breathing zone. Proper use of a functioning fume hood is required for protection against exposure to many hazardous chemicals used in the laboratory.

The following guidelines should be followed when using chemical fume hoods:

1. Hoods should not be used for work involving hazardous substances unless they have been inspected and certified within the last year.
2. Never put your head inside an operating laboratory hood to check an experiment. The plane of the sash is the barrier between contaminated and uncontaminated air.
3. Always try to keep hazardous chemicals at least six inches behind the plane of the sash.
4. Work with the hood sash in the lowest possible position. The sash will then act as a physical barrier in the event of an accident in the hood. Keep the sash closed when not working in the hood or leaving a long-term experiment.
5. Avoid cluttering your hood with bottles or equipment. Keep it clean and clear. Only materials actively in use should be in the hood. This will provide optimal containment and reduce the risk of extraneous chemicals in the event of a fire or explosion in the hood.
6. The hood must remain "ON" at all times when a chemical is inside it, regardless of whether any work is being done in it.
7. Promptly report power failure or any suspected hood malfunctions to the Laboratory Technician, and submit a work order to F&E.
8. Do not make any modifications to hoods or ductwork.

FUME HOOD CERTIFICATION AND MAINTENANCE

A third party tests new fume hood installations using the ASHRAE 110 standard for laboratory fume hood performance. EH&S performs yearly face velocity testing and certifies fume hoods that meet the required face velocity, usually between 80 and 120 linear feet per minute.

Indications your chemical fume hood is/or may be malfunctioning:

- The fume hood is sounding an alarm.
- There is very low or no draft passing across the area below the sash opening (you can test this by holding a Kimwipe or any thin tissue paper just below the sash).
- You don't hear the motor running.
- There is a power outage in the building.

If you suspect your lab fume hood is malfunctioning, stop using the fume hood immediately, close the sash, and post a notice of "FUME HOOD OUT OF SERVICE UNTIL REPAIRED".

1. Call F&E to request a repair and submit a work order.
2. Once repair is completed, call EH&S (843) 953-6945 to have the fume hood re-certified.

CHAPTER 9. PERSONAL PROTECTIVE EQUIPMENT

EXPOSURE TO CHEMICALS

The OSHA Laboratory standard defines a hazardous substance as "a chemical for which there is statistically significant evidence based on at least one study conducted following established scientific principles that acute or chronic health effects may occur in exposed employees.

The term 'health hazard' includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic systems, and agents that damage the lungs, skin, eyes, or mucous membranes." Highly flammable and explosive substances comprise another category of hazardous compounds.

Most materials have some guidelines for exposure published by various agencies:

- OSHA Permissible Exposure Limits (PEL).
- American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV).
- National Institute for Occupational Safety and Health (NIOSH) Recommended Exposure Limits (RELs).

When such values exist, they will assist the Laboratory Technician and users in identifying and implementing required controls. When TLV or PEL values are not available for a substance, the Lethal Dosage that kills 50% of a population of test animals (LD50), if available, can serve as a guide. If the LD50 is low, the chemical must be used in a fume hood. Sometimes, the Lethal Concentration that kills 50% of a population of test animals by the inhalation route (LC50) is also reported in the scientific literature. The possibility of chemical absorption through the skin should also be considered.

When TLV or PEL values exist and are low, the chemical must be used in an operating fume hood, glove box, or any approved ventilated enclosure. In limited circumstances where a fume hood is not available.

Chemicals with high vapor pressure evaporate quickly at room temperature. Even if they have high PEL, TLV, or LD50, they must be used in a fume hood. These chemicals are likely to reach their exposure limits in the air as quickly as chemicals with low exposure guidelines and low vapor pressure. The Safety Data Sheet of each chemical must be consulted for specific engineering control requirements.

Many substances encountered in the laboratory are known to be toxic, corrosive, or both. Compounds that are explosive and/or highly flammable pose another significant hazard. New and untested substances that may be hazardous are also frequently encountered. Thus, laboratory personnel must understand the types of toxicity, recognize the routes of exposure, and become familiar with the major classes of toxic and corrosive chemicals. The most crucial single generalization regarding toxicity in chemical research is to treat all compounds as potentially harmful, especially new and unfamiliar materials, and work with them under conditions that minimize exposure by skin and mucous membrane contact and inhalation.

When considering potential toxicity hazards while planning an experiment, it is essential to recognize that combining the toxic effects of two substances may result in significantly greater harm than the individual effects. Because most chemical reactions are likely to contain mixtures of substances whose combined toxicities have never been evaluated, it is prudent to assume that mixtures of different substances (e.g., chemical reaction mixtures) will be more toxic than the most harmful ingredient contained in the mix. Furthermore, chemical reactions involving two or more substances may form reaction products that are significantly more toxic than the starting reactants.

Researchers or lab employees with concerns about potential exposure to chemical or physical agents may contact their physician. Any individual experiencing adverse health effects from exposure to hazardous substances or who believes they may have been exposed to a hazardous substance, either through routine exposure or during an accident or spill, should notify their Supervisor immediately to initiate medical treatment. The individual and the supervisor will notify EH&S to report the injury or exposure and get assistance in obtaining medical treatment. Emergency assistance can be obtained by calling 9-1-1.

Any perceived long-term potential exposure to a health-hazardous substance that may require medical surveillance must be referred to EH&S. If required, EH&S will conduct an initial risk assessment and implement environmental measures, such as air monitoring. Subsequent steps involving medical surveillance will be determined if there is significant potential exposure, even with current controls in place.

PERSONAL PROTECTION FROM HAZARDS

Personal protective equipment, commonly referred to as “PPE,” is worn to minimize exposure to chemicals and other hazards that can cause serious injuries and illnesses. PPE creates a barrier between the ports of entry (mouth, skin, mucous membranes, respiratory system) and the hazardous materials in the work environment. Exposure to chemicals occurs through absorption, injection, ingestion, and inhalation.

Examples of commonly used laboratory personal protective equipment (PPE) include safety glasses, safety goggles, a face shield for eye and face protection, various gloves for hand protection, and a lab coat for skin protection. Laboratory room ventilation and the availability of fume hoods make respiratory protection unnecessary in most cases.

The worker protection afforded by PPEs depends on whether the PPE was selected correctly for the hazard and whether the workers use it properly.

To ensure proper use of PPE, laboratory personnel must know:

- When it is necessary.
- What kind is necessary?
- How to properly put it on, adjust, wear, and remove it.
- The limitations of the equipment.
- Proper care, maintenance, useful life, and equipment disposal.

Basic Lab Attire:

The minimum attire for work in our laboratories includes full-coverage shoes and clothing that provides maximum skin coverage, such as long pants and sleeved shirts. Dangling accessories should not be worn, and long hair must be confined, such as tied in a ponytail.

Skin Protection:

Skin contact with any potentially hazardous chemical should be avoided at all times. Any mixture of chemicals should be assumed to be more toxic than its most toxic component, and substances whose hazards have not been evaluated should be treated as hazardous. For this reason, lab coats need to be worn over basic attire that provides maximum skin coverage. Working with concentrated acids and bases requires the use of a chemical-resistant apron for added protection.

Suitable gloves must always be worn when working with hazardous substances. Choose gloves made of material known to be (or tested and found to be) resistant to permeation by the substance. In some cases, two gloves should be worn on each hand to ensure no exposure in the event of damage to the outer glove. Always inspect gloves for small holes or tears before use. To prevent the unintentional spread of hazardous substances, always remove gloves before handling objects such as doorknobs, telephones, pens, etc. Even silicone grease leaves an undesirable sticky residue behind if a door is opened or a phone is answered using a glove contaminated with grease.

Eye and Face Protection:**Regulatory Reference: 29 CFR**

1910.133(a)(1). The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

1910.133(a)(2). The employer shall ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g., clip-on or slide-on side shields) meeting the pertinent requirements of this section are acceptable.

1910.133(a)(3). The employer shall ensure that each affected employee who wears prescription lenses while engaged in operations involving eye hazards wears eye protection that incorporates the prescription into its design, or wears eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.

1910.133(a)(4). Eye and face PPE shall be distinctly marked to facilitate identification of the manufacturer.

1910.133(a)(5). The employer shall ensure that each affected employee uses equipment with filter lenses that have a shade number appropriate for the work being performed to protect against injurious light radiation.

1910.133(b)(1). Protective eye and face protection devices must comply with any of the following consensus standards:

1910.133(b)(1)(i). ANSI/ISEA Z87.1- 2010, Occupational and Educational Personal Eye and Face Protection Devices, incorporated by reference in § 1910.6;

1910.133(b)(1)(ii). ANSI Z87.1-2003, Occupational and Educational Personal Eye and Face Protection Devices, incorporated by reference in § 1910.6; or

1910.133(b)(1)(iii). ANSI Z87.1-1989 (R-1998), Practice for Occupational and Educational Eye and Face Protection, incorporated by reference in § 1910.6;

In general, eye protection must be worn when entering a laboratory. Laboratories that use and/or store chemicals and other potential eye hazards must keep a supply of safety glasses for lab personnel, other University personnel accessing the lab for facility services, and visitors.

Safety glasses must meet the American National Standards Institute (ANSI) standard Z87.1 - 1989, which specifies a minimum lens thickness of 3 mm, specific impact resistance requirements, and other requirements. Ordinary prescription glasses do not provide adequate protection against injury. Safety glasses can protect against injury from flying particles but offer little protection against splashes or sprays of chemicals. Safety goggles are required when a significant splash hazard exists.

Contact Lenses:

No clear evidence indicates that contact lenses increase the risk of eye injury in the laboratory compared with prescription glasses when safety glasses or goggles are worn over them. However, it is essential to remember that when eyes are splashed with chemicals, prescription glasses are much easier to remove than contact lenses when using an emergency eyewash to wash off contaminants.

Additional or Special Protective Glasses:

A face shield must be worn when protection from splashes to the face and neck is needed. Special safety glasses are required for protection against infrared, UV, or laser radiation.

Respiratory Protection:

Regulatory Reference: 29 CFR 1910.134(a)(1)

To control those occupational diseases caused by breathing air contaminated with harmful dusts, fogs, fumes, mists, gases, smokes, sprays, or vapors, the primary objective shall be to prevent atmospheric contamination. This shall be accomplished as feasible by accepted engineering control measures (for example, enclosure or confinement of the operation, general and local ventilation, and substitution of less toxic materials). When adequate engineering controls are not feasible or are not being implemented, appropriate respirators shall be used following the following section.

Respiratory hazards should be controlled at their point of generation by using engineering controls and best work practices. In keeping with this goal, using respirators as the primary means of protecting employees from airborne hazards is considered acceptable only in specific situations and with prior approval from Environmental Health & Safety. The routine use of respirators as primary control is not allowed.

Approval may be granted only on rare occasions, such as a short-term temporary experiment where engineering controls are not feasible, or in situations where respiratory protection is voluntary and supplemental to an existing engineering control. If respirator use is warranted, you will be asked to consult with a physician for medical approval to use a respirator.

Voluntary Use of Respirators (from OSHA training of the same title):

Most workers who wear respirators use them because their employer requires them to do so to protect themselves from airborne hazards. However, there are situations where you may want to wear a respirator, even though your employer or an OSHA standard does not require its use. For example, you might request to wear a respirator to avoid exposure to an airborne hazard, even if the amount of the hazardous substance does not exceed the limits set by OSHA standards. Another example where you might want to use a respirator voluntarily is to reduce exposure and

increase comfort when working in a non-hazardous but dusty environment, such as sweeping a shop floor. If your employer permits you to wear a respirator where it is not required, it is considered voluntary respirator use.

Before you can voluntarily use a respirator, your employer must ensure its use does not pose a health hazard. To do this, your employer must implement certain aspects of a written respiratory protection program to ensure that any worker using a respirator is medically able to do so voluntarily. In addition, your employer must ensure that the respirator is properly cleaned, stored, and maintained so that its use does not present a health hazard to you.

However, employers are not required to develop and implement a written respiratory protection program when workers voluntarily use filtering facepiece respirators.

Suppose you will be voluntarily using a respirator. In that case, your employer must also provide you with a copy of Appendix D of OSHA's Respiratory Protection Standard or the equivalent State OSHA Agency document. This document outlines certain precautions to take when wearing a respirator voluntarily. In general, Appendix D advises you:

- To read and follow the manufacturer's instructions provided with the respirator. These instructions provide information on how to properly use, maintain, and care for the respirator, along with warnings regarding its capabilities and limitations.
- To choose respirators that have been certified by NIOSH for protection against the contaminant of concern.
- To keep track of your respirator so that you do not use someone else's respirator by mistake.
- Do not wear your respirator in areas where it is not designed to protect against contaminants. For example, remember that a particulate respirator does not protect you against gases, vapors, and the non-particulate components of fumes, mists, fogs, smoke, and sprays.

Remember, voluntary use is only permitted when your employer has determined that no airborne hazards require the use of a respirator.

Hearing Protection:

Regulatory Reference: 29 CFR 1910.95(c)(1) The employer shall administer a continuing, effective hearing conservation program, as described in paragraphs (c) through (o) of this section, whenever employee noise exposures equal or exceed an 8-hour time-weighted average sound level (TWA) of 85 decibels measured on the A scale (slow response) or, equivalently, a dose of fifty percent.

Most laboratory equipment and operations do not produce noise levels equal to or exceeding 85 decibels (dBA), the action level that requires the use of hearing protection according to the OSHA Occupational Noise Standard. Noise at this level requires a hearing conservation program. This program includes workplace monitoring, personal exposure monitoring, annual audiometric testing, use of hearing protection, and annual training.

If equipment and operations in your lab require you to yell to be heard by coworkers, call EH&S to have the noise level measured. If the noise level is below 85 dBA, you may use hearing protection, such as earmuffs and earplugs, to enhance comfort in a noisy environment. In such cases, you are not required to enroll in the hearing conservation program.

PPE POLICY:

The Citadel is committed to providing a safe environment for students, staff, faculty, and anyone permitted to work in or visit our laboratories. To support this commitment, the college offers personal protective equipment (PPE). It enforces a comprehensive PPE policy to protect

employees, students, and visitors from exposure to hazardous materials, including chemicals, equipment, and procedures, stored and used in our research laboratories and support facilities.

1. Who must follow this policy: All staff, faculty, students, and volunteers working in The Citadel research laboratory and all visitors permitted to visit The Citadel research laboratories.
2. Areas covered: Research laboratories, equipment rooms, chemical storage areas, and other support facilities where hazardous materials are used and/or stored.
3. Responsibilities: The Laboratory Technician or Instructor in charge of the laboratory or support facility is responsible for enforcing this policy. The Laboratory Technician will provide the required PPE to laboratory employees and authorized visitors.
 - a. All personnel entering and participating in laboratory activities are responsible for wearing the required PPE.
 - b. All non-employee students participating in laboratory activities are responsible for providing and wearing the required PPE.
 - c. All visitors entering the laboratory are responsible for wearing the required PPE provided by the host laboratory.
4. Minimum protection to enter a laboratory includes fully closed shoes and clothing that provides maximum and reasonable skin coverage (e.g., full-length pants or skirt and shirt/tops with sleeves).
5. When working with dilute concentrations of hazardous chemicals, minimum protection plus nitrile gloves, safety glasses, and a lab coat.
6. When working with concentrated hazardous chemicals, use minimum protection plus safety goggles and gloves specifically chosen to resist the chemical being handled.
7. If there is potential for a splash of diluted hazardous chemicals, PPE in #5 plus a face shield over safety goggles.
8. If there is potential for a splash of concentrated hazardous chemicals, wear PPE in #6 plus a face shield over safety goggles and a chemical-resistant apron over a lab coat.
9. When working with flammable and pyrophoric chemicals, all PPEs in #6, #7, or #8, as applicable, and the lab coat must be flame-resistant.
10. For specific, particularly hazardous substances (PHS) and operations, a comprehensive hazard and risk assessment must be conducted to identify specific PPE required. Example:
 - a. Transferring liquid nitrogen or retrieving samples from a liquid-nitrogen-filled dewar: minimum protection plus lab coat, face shield over safety goggles, cryogen gloves over nitrile
 - b. Working with concentrated HF: lab coat, Tyvek suit over lab coat, tightly fitting safety goggles, face shield over safety goggles, chloroprene gloves (at least 0.6 mm thick), acid-resistant booties over shoes.
11. Non-conformity to this policy—The Laboratory Technician, class Instructor, or any of their appointed lab managers or representatives, and The Citadel safety personnel reserve the right to deny access to the laboratory to anyone who does not conform to this policy.
12. Lab-specific PPE policy – The Laboratory Technician or class instructor reserves the right to enforce a more stringent PPE policy than described in this document.

SECTION 10. GENERAL LAB SAFETY

KEEP THE LABORATORY ROOM SECURE

Section 10 of the Prudent Practices in the Laboratory lists the following security risks in laboratories:

1. Theft or diversion of chemicals, biologicals, and radioactive or proprietary materials (such materials could be stolen from the laboratory, diverted or intercepted in transit between supplier and laboratory, at a loading dock, or a stockroom, and then sold or used, directly or as precursors, in weapons or manufacture of illicit substances);
2. Theft or diversion of mission-critical or high-value equipment;
3. Threats from activist groups;
4. Intentional release of, or exposure to, hazardous materials;
5. Sabotage or vandalism of chemicals or high-value equipment;
6. Loss or release of sensitive information; and
7. Rogue work or unauthorized laboratory experimentation.

To mitigate these risks, laboratory personnel are required to implement these control measures:

- control access to the laboratory room (i.e., keep doors locked, restrict access to authorized personnel only, escort approved visitors at all times),
- maintain inventory of hazardous materials, keeping track of their quantities and location,
- report suspicious incidents to the USC Police Department (803) 777-4215 (e.g., samples, chemicals, or equipment that are missing or appearing out of nowhere, tampered locks, unauthorized experiments, etc.),
- and ensure that everyone knows the security risks and all security measures in place.

PRIOR TO WORKING IN THE LAB AND PRIOR TO HANDLING HAZARDOUS MATERIALS

- Conduct a thorough literature search, including a review of Safety Data Sheets, to understand the properties of the chemicals to be handled, their hazards, routes of exposure, symptoms of exposure, potential health and physical injuries from exposure, recommended control measures, and emergency response procedures.
- To assess the overall risk, consider other hazards involved in the task or procedure where the chemical will be used, such as equipment, glassware, reaction with other chemicals, the resulting products, potential pressurization, and others.
- Write a Standard Operating Procedure for safely handling the material you are using. See Section 6.
- Use less hazardous substitutes where possible. Use chemicals on the most minor scale and at the lowest feasible concentration.
- Consult EH&S for an exposure assessment if handling toxicologically significant quantities at any given time or even small amounts for an extended period. In some cases, medical surveillance may be recommended.
- Seek medical consultation for exposures that would likely approach or exceed established occupational limits or result in symptoms of exposure.
- If pregnant or planning to conceive, consult your supervisor and physician before working with known reproductive toxins.
- Prepare detailed Standard Operating Procedures (SOPs) and follow the necessary precautions when administering reproductive or acutely toxic chemicals to animals.

PRUDENT PRACTICES AND UNIVERSAL PRECAUTIONS

- Wear the appropriate Personal Protective Equipment (PPE) as recommended in the Safety Data Sheet (SDS) or your Standard Operating Procedure (SOP). At a minimum, appropriate PPE consists of standard laboratory/work attire (full-coverage shoes and long pants), a

- laboratory coat, gloves resistant to the chemical(s) of concern, and ANSI-certified safety glasses. Wear safety goggles and face shields when there is a risk of splashes to the face.
- Plan for and implement measures to avoid inhaling fumes, vapors, or aerosols. When possible, work with hazardous chemicals in a fume hood. Special containment, such as a glove box, may be necessary for handling highly toxic or highly reactive chemicals. On rare occasions when engineering control is not sufficient to limit inhalation exposure, consult with EH&S to discuss the potential use of appropriate respirators.
 - Keep containers closed when not in use to limit the release of vapors and aerosols.
 - Dispense liquid chemicals using pumps and funnels to limit splashing and mixing with air.
 - Transfer powders and granules using spatulas and spoons instead of pouring them directly from a container to limit dust generation. Clean up dry spills using damp, non-reactive absorbent paper.
 - Never return unused material to the original container. It may contain traces of contamination, which may cause a chemical reaction.
 - Do not reuse empty containers - the residue may react with the added chemical.
 - Remove PPE and wash hands before leaving the work area. Remove gloves without touching the contaminated part with bare fingers.
 - Wash hands immediately after a known or suspected chemical contact.
 - Keep your workspace, including the floor, clean. This will help control the spread of contamination by preventing chemicals from being tracked outside of laboratory areas.
 - Do not eat, drink, chew gum, apply cosmetics, or store such materials in the laboratory.
 - Avoid using sharp objects and breakable glass apparatus if a non-sharp alternative exists.
 - When handling a sharp object or when there is a risk of cuts or sticks, use remote handling devices such as forceps if possible, and use puncture-resistant gloves.
 - Do not recap needles. Dispose of used, uncapped needles in approved sharps containers.
 - Secure highly toxic chemicals in a locked cabinet.
 - If using vacuum pumps with toxic/hazardous materials, ensure exhaust is vented through a fume hood, snorkel, and other duct exhaust systems.
 - Designate workspaces for the use of carcinogens, reproductive toxins, and highly toxic chemicals. Label and restrict access to these workspaces only to authorized users. Clean designated workspaces after a known contamination and at the end of each workday. To facilitate cleaning, it may be advisable to use containment trays or cover workbenches with absorbent paper.
 - Clean chemical contamination of equipment according to the manufacturer's recommendation.
 - Containerize waste solutions/solids, spill residues, related clean-up materials, and grossly contaminated disposable items for pickup by the Environmental Health and Safety (EH&S) department.

UNATTENDED OPERATIONS

Laboratory operations involving hazardous substances are sometimes conducted overnight or for extended periods and left unattended. It is the researcher's responsibility to design these experiments with provisions to prevent the release of hazardous substances in the event of interruptions in utility services, such as electricity, cooling water, and inert gas. Laboratory lights should be left on, and appropriate signs should be posted identifying the nature of the experiment and the hazardous substances in use. In some cases, arrangements should be made for other workers to conduct periodic inspections of the operation. Information should be left indicating how to contact you in an emergency.

HOUSEKEEPING

Good housekeeping practices, which keep work areas clean and clutter-free, contribute significantly to safety in the laboratory. Lab personnel are responsible for cleaning equipment, fume hoods, and workbenches. Should there be a need to request custodial Facilities for floor cleaning, all operations and hazardous materials must be kept out of the way before cleaning can start.

There is a definite relationship between safety and orderliness in the laboratory. The following housekeeping rules should be adhered to in all laboratories:

- Work areas and floors should be cleaned regularly.
- Do not allow trash to accumulate.
- Access to exits and emergency equipment (showers, eyewashes, or fire extinguishers) must not be obstructed.
- Chemical containers should not be stored on the floor where they can be stepped on or tripped over.
- Chemical storage refrigerators should be defrosted periodically and should not be overcrowded.
- Clear all work areas and workbenches of clutter and obstructions. By the end of each workday, all chemicals should be stored in designated areas.
- All spills should be promptly cleaned, and waste properly disposed of.
- All broken glass should be disposed of in a labeled, thick box lined with a heavy-duty trash bag. Do not pick up broken glass with your hands. Use tongs or sweep up with a dustpan and brush. Drop broken glass gently into the box.

SECTION 11. GENERAL GUIDELINES FOR SAFE HANDLING OF CHEMICALS

CONTAINER LABELING

Regulatory Reference: 29 CFR 1910.1200(f)(6)(ii) requires that workplace labeling include “product identifier and words, pictures, symbols, or combination thereof, which provide at least general information regarding the hazards of the chemicals, and which, in conjunction with the other information immediately available to employees under the hazard communication program, will provide employees with the specific information regarding the physical and health hazards of the hazardous chemical.”

Note: Ready access to safety data sheets during all work hours satisfies the requirement for “other information that will provide employees with specific information regarding the physical and health hazards of the chemical.”

Chemical container labels must inform users of the identity of the contents, the hazards associated with the substance, and safety information, including handling precautions and storage or disposal requirements. OSHA has adopted the Globally Harmonized System (GHS) standard for labeling hazardous chemicals. All chemical containers shipped by manufacturers and distributors must have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification.

The user is responsible for ensuring that the original label remains attached to the containers, readable, unaltered, and not defaced. Age and environmental conditions, such as humidity and temperature, or spills on the outside of the container, will cause the original label to deteriorate. At this point, the user may decide to dispose of the chemical or relabel the container, ensuring that the new label contains all

information on the original label. The chemical's safety data sheet will be the best source of this information. Use labels, ink, and markings that are not dissolved by the liquid content of the container.

Suppose the user needs to transfer the contents of an original container to a new one for some reason. In that case, the label of the new container must include all the information on the original label. Consult the safety data sheet for accurate information. Solutions or mixture containers must be labeled with the identity of the solution or mixture (including all components), the main hazard category (e.g., toxic, flammable, oxidizer), the date prepared, and the person who prepared the reagent. Use the common full name of the chemical. If abbreviations, chemical formulas, or alternate names cannot be avoided, post a sign indicating the equivalent full names of the abbreviations, chemical formulas, or alternate names used.

PROPER STORAGE

Proper chemical storage requires five essential considerations: allowable quantities, location, segregation, storage cabinet, and environmental conditions.

Allowable Quantities:

The International Fire Code regulates the amount of flammable, toxic, pyrophoric, and corrosive chemicals that can be used and stored in a research space. Similarly, the CFAT Act regulates specific chemicals. Our university cannot exceed the threshold amount allowed by the CFAT for the listed chemicals. EH&S monitors this information based on chemical inventories submitted by our labs and during safety inspections. It is a prudent practice to maintain the lowest possible quantities of highly hazardous chemicals.

Location:

Store hazardous chemicals at a height of approximately 2 feet off the floor, below shoulder level. If space is limited and floor storage is necessary, place containers in secondary containment such as a closed plastic tote. If users need to reach up to retrieve containers above shoulder level, the potential for containers to be dropped and their contents to spill on the user is very likely. Containers stored directly on the floor may be bumped or come into contact with water in the event of flooding in the lab. Other locations to avoid for storage include fume hoods, cabinets under the sink, and areas near heat sources.

Storage Cabinet:

Hazardous chemicals must be stored in appropriate cabinets (Table 4). Cabinets or shelving should be sturdy and secured to the wall. Shelves should have a barrier or lip at least 1-1/2 inches high to prevent chemicals from falling off the shelves. Corrosives should be stored in wooden or plastic laminate cabinets, if possible. Metal cabinets are not recommended for storing corrosives. Chemicals should not be stored under the sinks in a lab. Secondary containment is recommended for liquids and reactive materials; for liquids, secondary containment may be a dishpan, while for reactives, it may be a Ziplock bag.

If a chemical cabinet or storage area is ventilated, the ventilation system must exhaust through the fume hood exhaust system or be independently ducted to the outside of the building. Cabinets shall not be ventilated through the fume hood work surface. Contact EH&S with questions about ventilation in your chemical storage area.

Segregation:

Chemicals must be segregated according to this order: substance form (liquid or solid), chemical family (organic or inorganic), hazard class, and compatibility within the hazard class. Chemicals that may react violently with each other (Table 5) must be stored in separate, clearly labeled cabinets. Assign separate storage areas for the following general hazard classes. However,

always cross-reference safety data sheets to determine incompatibilities within general hazard classes.

Accidental contact between incompatible chemicals can result in a fire, an explosion, the formation of highly toxic and/or flammable substances, or other potentially harmful reactions. Oxidizers mixed with flammable solvents can cause a fire. Acids mixed with metal dust can produce flammable hydrogen gas. Alphabetical storage can bring incompatibles together. For example, if chromic acid (an oxidizing acid) and chromium powder (a combustible metal) were stored together and an accident broke their containers, the chemicals could mix and react with explosive violence.

Multiple hazard classes. Many chemicals belong to more than one chemical family or hazard class. In such cases, all storage rules must be strictly observed. For example, acetic acid is both a corrosive acid and a combustible liquid. It must be stored away from corrosive bases, such as sodium hydroxide, and from oxidizing acids, such as nitric acid.

Table 4. Compatible storage cabinets for various chemical families.

Substance Form (Phase)	Substance Family	Incompatibilities within the Substance Family	Type of Storage Cabinet
Solid	Dry salts and other substances not belonging to the hazard class below		Open wooden, metal, or plastic shelves
	Dry bases		Open wooden or plastic shelves
	Dry acids		Open wooden or plastic shelves
	Dry poisons		Any closed cabinet equipped with a lock
	Dry oxidizers		Open wooden, metal, or plastic shelves
	Corrosive bases (liquids)		Laminated or epoxy-coated wooden cabinets with plastic-lined shelves or commercial cabinets designed explicitly for corrosives designed for corrosives
	Corrosive inorganic acids	Store away from reactive metals such as sodium, potassium, finely divided magnesium, or zinc. Segregate oxidizing acids, such as nitric, perchloric (heated	Laminated or epoxy-coated wooden cabinets with plastic-lined shelves or commercial cabinets designed explicitly for corrosives

		above room temperature), and chromic, from other mineral acids, organic acids, and combustible/flammable materials and liquids. Segregate acids from cyanides and sulfides, such as sodium cyanide and iron sulfide, that could liberate toxic gases upon contact.	
	Corrosive organic acids	Many organic acids, like glacial acetic acid, are combustible, and consideration should be given to storing combustible organic acids in a flammable liquid storage cabinet	Laminated or epoxy-coated wooden cabinets with plastic-lined shelves or commercial cabinets designed explicitly for corrosives
	Flammable and combustible organic liquids and solvents	If flammable liquids need to be refrigerated, a lab-safe (flammable materials storage) refrigerator, purpose-designed, manufactured, and labeled by the manufacturer for storing flammable liquids, must be used. Do not store flammable liquids in standard, residential-type refrigerators. Safety cans or drums dispensing or receiving flammable liquids must be grounded and bonded when transferring liquids.	Flammable cabinet, not vented
	Flammable solid	These materials react violently in the presence of water, including water vapor as humidity in ambient air. Toxic or flammable gases may be evolved, or the material may catch fire on contact with air.	

		Review SDSs, manufacturer's recommendations, and other references carefully for proper storage conditions. Elemental lithium, potassium, and sodium must be stored under mineral oil.	
	Liquid oxidizers	Segregate oxidizers from reducing agents like hydroxylamine, sulfur dioxide, oxalic acid, alkali metals, and formic acid. Segregate oxidizers from flammable/combustible liquids and solids. Flammable/combustible liquids and solids contribute fuel to the reaction. Oxidizers contribute oxygen to a reaction and can cause the reaction to get out of control rapidly	
	Reactives (water)	The storage area needs to be a moisture-free environment	Closed wooden or plastic cabinets
	Reactives (air)/pyrophorics,		Glove boxes under an inert atmosphere
	Reactives (light/wavelength),		Closed wooden or plastic cabinets away from sources of light
	Odorous substances		Cabinet vented through the fume hood or any cabinets, if containers are double bagged to minimize escape or odor
	Compressed gases		See Section 13

Table 5. Specific chemical incompatibilities.

Chemical	Is Incompatible With
Acetic acid	Chromic acid, nitric acid, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric acid and sulfuric acid mixtures.
Alkali and alkaline earth metals (such as powdered aluminum, magnesium, calcium, lithium, sodium, potassium)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury (in manometers, for example), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrites, sulfur, and finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids
Bromine	See chlorine
Calcium oxide	Water
Chlorates	Ammonium salts, acids, powdered metals, sulfur, and finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, and flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine
Chlorine dioxide	Ammonia, methane, phosphine, and hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Decaborane	Carbon tetrachloride and some other halogenated hydrocarbons
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Everything
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, combustible materials

Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen, flammable liquids, solids, or gases
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium perchlorate (see also chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, and fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric acid	Potassium chlorate, potassium perchlorate, potassium permanganate, (similar compounds of light metals such as sodium, lithium)
Tellurides	Reducing agents

TRANSPORTING CHEMICALS

1. The risk of spills, releases, and exposure is high during chemical transportation. It is essential to follow these guidelines to minimize the potential for spills and releases to the environment, as well as personnel exposure to chemicals.

2. Please note that hazardous chemicals can be transported on a vehicle travelling on a public road only by personnel who have completed the Department of Transportation (DOT) Hazardous Materials training and certification. Anyone needing assistance transporting hazardous chemicals from one building to another via a public road must consult with the Environmental Health and Safety (EH&S) department.
3. When transporting chemicals by walking short distances between labs within the same building or between two adjacent buildings, follow these guidelines:
4. Individuals transporting chemicals must be familiar with the material's hazards and know what to do in the event of a release or spill. Material Safety Data Sheets (MSDSs) are a good source for this information.
5. Materials that are unstable, explosive, or extremely or acutely hazardous should not be moved without first contacting EH&S.
6. Hazardous chemicals must be handled with care at all times during transportation.
7. Use approved secondary containers that are puncture—or break-resistant. Approved secondary containers are commercially available bottle carriers made of rubber, metal, or plastic, with carrying handle(s), resistant to the chemical being transported, and large enough to hold the contents of the chemical container in the event of breakage.
8. Use secondary containment that can contain all materials in the event of a spill. Acceptable secondary containers include plastic bottle carriers with closed tops and handles, as well as liquid-tight carts with lips on all four sides.
9. Label primary containers with the material's chemical name and hazards (e.g., "Acetone Caution—Flammable"). Secondary containment that obscures a primary container's labeling must be labeled with the same information.
10. Never transport incompatible chemicals in the same secondary containment or in any manner that could cause the chemicals to combine or react.
11. Use sturdy carts for transporting multiple, large, or heavy containers. Carts used for secondary containment must have a liquid-tight tray with lips on four sides.
12. Wear appropriate Personal Protective Equipment (PPE). Safety glasses, lab coats, and impermeable gloves are some of the PPE that should be worn if hazardous chemicals might splash onto skin or eyes in the event of a spill during transport.
13. Wear appropriate personal protective equipment (PPE), including eye protection in the form of a face shield or goggles, heavy-duty gloves, a heavy-duty apron, and closed-toe shoes.
14. Transport compressed gas cylinders only with the valve covers screwed on and when securely attached to a compressed gas cart.
15. When transporting compressed gas cylinders, always strap the cylinder in a suitable hand truck and protect the valve with a cover cap.
16. Use freight elevators to move chemicals between floors. If freight elevators are not available, use uncrowded passenger elevators. Only use stairways if elevators are not available.
17. Transport cryogenics only in approved storage vessels (e.g., dewar flasks with pressure relief mechanisms).
18. Immediately update chemical inventories to reflect the relocation of chemicals.

SHIPPING HAZARDOUS CHEMICALS

Regulatory Reference: 49 CFR, Parts 100 to 185

Lab personnel may not ship hazardous materials, including hazardous chemicals, infectious substances, radioactive materials, compressed gases, dry ice, liquid nitrogen, lithium batteries, and more, unless they have received training and certification from the U.S. Department of Transportation.

The U.S. Department of Transportation (US DOT) requires shipping training, which covers packaging and labeling of hazardous materials, the associated documentation, fines for non-compliance, and potential legal action if you are found to have willfully ignored hazardous materials shipping regulations.

International shipments may also be subject to import and export requirements.

For assistance in shipping hazardous chemicals, biohazardous materials, and radioactive materials, contact EH&S at (843) 953-6945.

SECTION 12. MANAGING LAB WASTE

HAZARDOUS WASTE DISPOSAL

Various types of waste are generated in laboratories. Disposal of waste is the responsibility of the waste generator. Researchers must plan purchases and use chemicals while minimizing the waste generated. Please note the university's policy regarding the reduction of high-hazard and unknown waste. The most common laboratory wastes and how to dispose of them are described below:

1. Hazardous chemical waste is collected by Laboratory Technicians, stored in chemical storage rooms, and pick-up requests are sent to EH&S.
 - a. Process-generated waste—Chemical waste generated from experiments and laboratory processes is to be collected and disposed of by Laboratory Technicians. Only compatible chemicals may be combined in a single waste container. Halogenated compounds should be collected in a separate container from other organic compounds.
 - b. Old, expired, and/or unwanted chemicals in their original container may be offered for disposal.
 - c. Unknowns - treat all unknowns as hazardous waste. Label with a hazardous waste tag and write 'UNKNOWN' and its possible identity. Gather information about the unknown from past or present lab group members to determine the likely identity of the material.
 - d. Peroxide formers (Table 6).
 - e. Waste that generates gas—Two common mixtures, aqua regia (a mixture of nitric acid and hydrochloric acid) and piranha (a mixture of sulfuric acid and hydrogen peroxide), tend to produce gas and must be stored carefully to prevent pressurizing or exploding containers. These and similar mixtures must be stored in approved waste containers with special vented caps.
 - f. Mercury-containing items such as thermometers, thermostat switches, and manometers must be collected for proper disposal and not disposed of in the trash.
2. Biohazard waste.
3. Radioactive waste.
4. Mixed waste.
 - a. Mixed wastes are materials contaminated with two or more chemical, biological, or radioactive agents. Avoid generating mixed wastes as much as possible.
5. Empty chemical containers
 - a. Make sure that the container is empty.
 - b. Check if the chemical is p-listed. If the chemical is p-listed, tag it as hazardous waste.
 - c. If the chemical emits strong odors, tag it as hazardous waste.
 - d. If the chemical is not P-listed:
 - i. Remove the label or deface it by crossing it out completely using a marking pen, making it unreadable.
 - ii. If the container is plastic, dispose of it as regular trash.

- iii. If the container is glass, place it in a sturdy cardboard box. Tape the box closed, label it with "EMPTY GLASS BOTTLES," and put it in the dumpster.
6. Broken glass and small glass items (pipettes, stirring rods, sample bottles).
 - a. If biological or radioactive materials are contaminated, see #2 and #3.
 - b. If contaminated with p-listed chemicals, collect in a 5-gallon plastic bucket with a lid.
 - c. If not contaminated with biological and radioactive materials or p-listed chemicals:
 - i. Place it in a 5-gallon plastic bucket with a lid. When the bucket is full, dispose of it in the dumpster.
 - ii. Alternatively, use a small or medium-sized, thick cardboard box lined with a heavy-duty trash bag or a commercially available broken glass box pre-lined with a plastic bag. A thick cardboard and plastic lining is necessary to catch any excess liquid and small glass pieces. This will also keep sharp edges from poking through the box. Do not use large boxes, as they are cumbersome to lift when full of broken glass.
 - iii. Once the box is full, secure the box with tape. Label with "Broken Glass".
 - iv. Place the box in the dumpster.
 - v. NOTE: Broken glass must not be transferred from a transitional container to another due to the increased risk of injury from unnecessary additional handling of broken glass. Once a box is filled with broken glass, the box must be taped up and discarded. If a plastic bucket with a lid is used for collecting broken glass, it must be discarded along with the broken glass. Contents may NOT be transferred to another container to save the bucket.
7. Sharps including syringes and needles, blades, scalpels.
 - a. Collect in a leak-proof, puncture-resistant container and dispose of in a biohazard box.
8. Non-glass, solid wastes.
 - a. Include paper towels, filter paper, weighing boats, plastic pipette tips, and disposable plastic pipettes.
 - b. Check if the chemical contaminant is p-listed. If the chemical is p-listed, collect solid waste in a 5-gallon bucket with a lid and also lined with a plastic bag. Tag as hazardous waste and request EH&S pick-up online.
 - c. If the chemical contaminant is NOT p-listed, collect as regular trash.
9. Gas cylinders.
 - a. Empty gas cylinders must be returned to the vendor. If the cylinder is old and the vendor who owns it cannot be determined, contact EH&S to choose the best way to dispose of the "orphaned" cylinder.
10. Lecture bottles.
 - a. EH&S recommends that researchers purchase lecture bottles from vendors who will accept partially full or empty containers when they are no longer needed in the lab. Disposing of lecture bottles can be costly if the vendor or supplier does not accept unwanted lecture bottles.
11. DEA Controlled Substances and other drugs.
 - a. EH&S does not collect or destroy DEA-controlled substances or other drugs. For information on this subject, consult the South Carolina Department of Health and Environmental Control's Bureau of Drug Control, which enforces the South Carolina Controlled Substances Act, which closely parallels the federal Controlled Substances Act of 1970.
 - b. For more information on the use of DEA substances in animal research, contact the Department of Laboratory Animal Resources (DLAR).

POLICY FOR MINIMIZING HAZARDOUS WASTES AND UNKNOWNNS

Figure 2. Container labels

	 CAUTION  Class A PEROXIDE FORMER Important: <u>Circle earliest discard date.</u> Date Received _____ discard by _____ (12 months after date received) Date Opened _____ discard by _____ (3 months after date opened) Manufacturer's expiration date _____ Call EH&S 953-6945 if chemical is kept past the earliest discard date.	
	 CAUTION  Class B PEROXIDE FORMER Important: <u>Circle earliest discard date.</u> Date Received _____ discard by _____ (12 months after date received) Date Opened _____ discard by _____ (6 months after date opened) Manufacturer's expiration date _____ Call EH&S 953-6945 if chemical is kept past the earliest discard date.	
	 CAUTION  Class C PEROXIDE FORMER Important: <u>Circle earliest discard date.</u> Date Received _____ discard by _____ (12 months after date received) Date Opened _____ discard by _____ (6 months after date opened) Manufacturer's expiration date _____ Call EH&S 953-6945 if chemical is kept past the earliest discard date.	

EMERGENCY PROCEDURES

ALL EMERGENCIES:

1. Call 9-1-1 for all medical and other life-threatening emergencies.
2. Provide the following information to 9-1-1 or Public Safety (843) 953-5114 Dispatch.
 - a. Your name and phone number.
 - b. Incident location: building name, floor, and room number.
 - c. Injured person, if any, specific injury and location; request ambulance if needed.

NOTICE:

You may assist an injured person if your safety is not compromised by doing so and you have instructions from a designated emergency call center or medical personnel over the phone.

- Hazardous materials involved, if known
- What happened? Describe activities that caused the incident and your initial response
- Other relevant information that may help responders evaluate and stabilize the incident

If you see smoke, suspect a fire, or for any emergency requiring building evacuation:

1. Pull an emergency fire alarm.
2. Evacuate the building using the nearest exit stairway. As you exit, please notify your coworkers and everyone else about the emergency. When the fire alarm sounds, all personnel, without exception, must leave the building.
3. Call 9-1-1 or Public Safety (843) 953-5114, Dispatch, and provide the above information.
4. Proceed to the designated assembly point.

EVACUATION INFORMATION:

Fire alarms are activated during emergencies that require you to leave the building. It is best practice to know the location of the nearest fire alarm, the nearest stairway, and the specific assembly point where everyone gathers outside of the building.

1. Proceed to the nearest exit route and use the stairway to exit the building. **DO NOT USE THE ELEVATOR!**
2. Proceed to your assembly point. Your designated Department Head or their designee will take attendance to ensure that everyone has safely evacuated.
3. If you can provide information about the incident, proceed to the Incident Command on site. This is usually an SUV marked "Incident Command".
4. Do not re-enter the building until the Department of Public Safety or its designee declares it safe to return.

IF THERE IS A FIRE IN YOUR LABORATORY:

Lab personnel are not required to extinguish fires. You may attempt to extinguish the fire if ALL of the following are true:

- The fire does not emit overwhelming smoke and other toxic gases.
- You are positioned between the fire and an exit door.
- The fire has just started and is small in size (the size of a regular trash can).
- You have completed the Fire Safety training.

- You know that the type of fire extinguisher is appropriate for the existing fire (ABC fire extinguishers are available in all laboratories; note that fires involving reactive metals need a Class D fire extinguisher).
- You know how to use the fire extinguisher.

If the fire is not extinguished within 10 seconds and is increasing in size, proceed to evacuate the building.

Note that fires in small open containers can usually be suffocated by loosely covering the container.

ABC Fire Extinguishers utilize pale yellow monoammonium phosphate powder, a dry chemical that can quickly extinguish Class A, Class B, and Class C fires by smothering the flames.

- Class A fire involves trash, wood, paper, cloth, rubber, plastic, etc.
- Class B fire involves flammable liquids, solvents, oils, gasoline, paints, etc.
- Class C fire involves energized electrical sources, wiring, motors, appliances, etc.

A Class D fire extinguisher uses dry powder on fires involving combustible metals, such as magnesium, titanium, sodium, etc., which require an extinguishing medium that does not react with the burning metal.

Whenever a fire extinguisher is used, regardless of the duration, it should be inspected and recharged. For recharging and/or replacement of fire extinguishers, call EH&S at (843) 953-6945.

If your clothing catches on fire

- “STOP, DROP, and ROLL” is the best way to extinguish small clothing fires. (If someone is on fire, instruct the person to drop to the ground and roll back and forth.)
- Cover your face with your hands.
- Once the fire is extinguished, wrap the injured person with a blanket to prevent shock.
- Seek immediate medical care by calling 9-1-1.

NOTICE:

- Never use a fire extinguisher on a person.
- Use a fire blanket to help smother the flames on someone lying down. Remember that wrapping the person in a fire blanket can contain the heat and may make the burn injury worse.
- A damp towel may be used if the fire does not involve water-reactive chemicals.
- An emergency shower may extinguish the fire if it is near the person. If the person has to take even a few steps, the fire will likely grow larger before they can reach the shower.

IF THERE IS A CHEMICAL SPILL:

Laboratories must be equipped to respond to spills and chemical releases by developing a spill response procedure, making spill kits readily available, and training lab personnel to recognize the difference between small and large spills, as well as to clean up small-scale spills effectively.

A small spill is contained, controlled, and can be cleaned up by trained personnel using the available spill kit in the lab, and available PPE is sufficient to prevent personnel exposure to the spilled material. A “large” spill is not contained, uncontrolled, and the volume is significant, so the spill kit in the lab is insufficient to contain and clean up the spill; special PPE is required to prevent exposure, or the substance is highly flammable or very toxic.

If a spill presents a risk of exposure (e.g., inhalation) or a risk of fire, assistance from EH&S, Public Safety, and/or 9-1-1 must be obtained as necessary. University custodians are not trained and should not be called upon to clean up chemical spills in the laboratory.

Experiments should always be designed to minimize the possibility of accidentally releasing hazardous substances. Plan your experiments to use the minimal amounts of hazardous substances and transport them properly, using break-resistant bottles or secondary containers. Develop a contingency plan to handle spills when working with hazardous substances. When a spill occurs, the following procedure should be followed:

1. Determine if it is a “major” or “minor” spill. A minor spill is contained (e.g., inside a fume hood) or small enough to be cleaned up safely with the available spill kit, where special personal protection (e.g., respirator) is not required.
2. Assist anyone who may have been contaminated or injured during the spill.
3. Always clean up a spill as soon as possible, depending on the nature of the spill.
4. If a major spill:
 - a. Call Public Safety (843) 953-5114, Dispatch, and EH&S (843) 953-6945 for major spills and spills with mercury or hydrofluoric acid (HF).
 - i. Contain a major spill with an appropriate absorbent, only if it can be done safely (i.e., spilled chemical is not volatile and does not pose an inhalation hazard).
 - ii. Post “Spill in Progress, DO NOT ENTER” on the entrance door and evacuate the area.
 - iii. Do not re-enter until Emergency Responders have cleaned up the spill and declared the building and laboratory safe for re-entry.
5. If a minor spill:
 - a. Wear safety goggles, gloves resistant to spilled chemicals, and a lab coat. Also, wear disposable shoe covers to prevent your shoes from being contaminated.
 - b. Place absorbent or neutralizers around the edge of the spill, moving inwards.
 - c. Let the covered spill sit for 15-30 minutes to ensure that the chemical is fully neutralized and that any aerosols have settled.
 - d. Collect the absorbed/neutralized spill materials in a sealable plastic bag. Seal the plastic and place it inside a solid waste container.
 - e. Label the container as hazardous waste and inform EH&S.
 - f. Spray soapy water on the surface of the spill area and wipe with paper towels. Collect used paper towels as hazardous waste.

NOTE: Cleaning up spills of highly toxic materials should be delegated to personnel who are appropriately trained, such as those from the Fire Department. If the spilled materials are highly volatile and flammable, ignition sources and open flames must be turned off immediately, if safe to do so, and without compromising personal safety.

If your eyes were splashed with chemicals:

1. Proceed to the nearest eyewash. Push the lever to start the water flowing.
2. Ensure your hands are clean and free from contamination. Wash off contaminants from your eyes by holding your eyelids open to allow the water to reach under them. Move your eyes around to ensure all parts of the eyes get decontaminated.
3. Continue washing for at least 15 minutes to remove the contaminant.
4. Proceed to an eye clinic for follow-up medical treatment. During your doctor's visit, bring the safety data sheet of the chemical to which you were exposed.

If your skin is splashed with chemicals:

For spills covering a small area of hands or arms:

1. Immediately wash with running water for 15 minutes. If the burn is not visible, wash with water and soap, removing any jewelry that gets in the way.
2. Proceed to the Center for Health and Well-being or the nearest emergency room for follow-up medical treatment. During your doctor's visit, bring the safety data sheet of the chemical to which you were exposed.

For spills covering a large area of skin and/or clothing:

1. Proceed to the nearest emergency shower. Remove contaminated clothing, shoes, and jewelry to wash off contaminants effectively. (Contaminated clothes should be discarded.)
2. Pull the emergency shower lever to start the water flow. Stay underwater for 15 minutes.

3. Proceed to the nearest emergency room for follow-up medical treatment. During your doctor's visit, bring the safety data sheet of the chemical to which you were exposed.

NOTE: If your skin came into contact with concentrated HF, call 9-1-1 immediately. Wash HF off for 5 minutes. With a gloved hand, apply a liberal amount of calcium gluconate gel to the affected area. Repeat application every 15 minutes until the emergency responders arrive and take you to the Emergency Room.

If fume hood ventilation fails while working with an inhalation hazard:

1. Close the fume hood sash.
2. Advise lab occupants and neighboring labs to evacuate the area.
3. Post "DO NOT ENTER, Contaminated Area" on the entrance door.
4. Call EH&S at (843) 953-6945 and/or Public Safety at (843) 953-5114 to have the air contamination evaluated.
5. Submit a work order to F&E for hood repair.

SAFETY EQUIPMENT AND MAINTENANCE CHECKS

To enable you to respond to minor incidents such as cuts, burns, chemical spills, chemical splashes, or small fires, the following safety equipment must be readily available in your laboratory: a fire extinguisher, an emergency shower and eyewash station, a chemical spill kit, and a first aid kit. This equipment must be visible, labeled, unobstructed, and routinely checked and maintained in functional condition. Monthly checks for fire extinguisher, occasional checks for first aid kit and chemical spill kits, and weekly activation of emergency shower and eyewash need to be conducted according to the following procedures:

Monthly Inspection of Fire Extinguishers:

If you are the lab manager or a designated person, inspecting fire extinguisher units inside your laboratory is one of your essential duties. Fire extinguishers must be checked monthly to ensure that they are charged and in operating condition, ready for use in case a small fire starts in your work area.

Procedure

1. Ensure the extinguisher is located in a designated, visible, unobstructed area and is securely mounted on the wall.
2. Check the pressure on the gauge. The needle must be in the GREEN zone.
3. Verify that the locking pin is in place and the tamper-evident seal is intact.
4. Check that the nozzle and tubing are not pinched, cracked, or clogged.
5. Check that there is no apparent physical damage to the cylinder.
6. Check that the last professional service date on the hangtag is within the last 12 months.
7. Record the inspection date on the hangtag attached to the cylinder.
8. If a fire extinguisher is missing, has expired tags, has been used, or is damaged, report immediately to EH&S (843) 953-6945.

Figure 3. Fire extinguisher parts and hang tag.

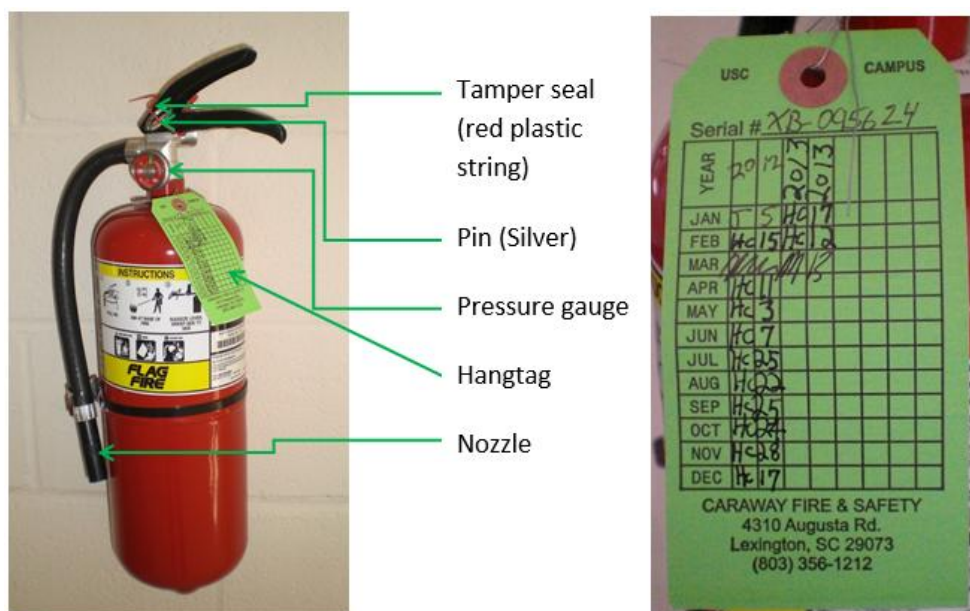


Table 8. Minimum required supplies in first-aid kits

First Aid Supply	Minimum Quantity	Minimum Size
Adhesive bandage	16	1 x 3 in.
Adhesive tape	1	2.5 yd total
Antibiotic application	10	1/57 oz. or 0.5 g
Antiseptic	10	1/57 oz. or 0.5 g
Breathing barrier	1	
Burn dressing (gel soaked)	1	4 x 4 in.
Burn treatment	10	1/32 oz. or 0.9 g
Cold pack	1	4 x 5 in.
Eye covering, with means of attachment	2	2.9 sq. in.
Eye/skin wash	1 fl. oz total	
First aid guide	1	
Hand sanitizer	6	1/32 oz or 0.9 g
Medical exam gloves	2 pair	
Roller bandage	1	2 in. x 4 yd
Scissors	1	
Splint	0	4 x 24 in.
Sterile pad	2	3 x 3 in.
Tourniquet	0	1 in. wide
Trauma pad	2	5 x 9 in.
Triangular bandage	1	40 x 40 x 56 in.

Table 9. Additional supplies for consideration

First Aid Supply	Purpose
Low-dose aspirin	Used to treat a suspected heart attack
Hemostatic agent	For individuals with compromised clotting or uncontrollable bleeding
Electrolyte replacement	Heat-stress related injuries
Glucose replacement	Diabetic or hypoglycemic episodes
Analgesics (oral and/or topical/anti-inflammatory)	Pain management, swelling control
Hydrocortisone	Itchiness and skin-related reactions, including rashes
Antihistamine	Allergic reactions
Foil blanket	Treat shock and/or cold-related injuries.

CONTENTS OF CHEMICAL SPILL KIT:

Absorbents

- Universal Spill Absorbent – universal spill pillow or absorbent pads in commercial spill kits. Alternatively, a 1:1:1 mixture of Flor-Dri (or unscented kitty litter), sodium bicarbonate, and sand. This all-purpose absorbent is suitable for most chemical spills, including solvents, acids (except hydrofluoric acid), and bases.
- Hydrofluoric Acid - HF compatible spill pillow or liquid “HF acid eater”
- Solvents/Organic Liquid Absorbent - Inert absorbents such as vermiculite, clay, sand, Flor-Dri, and Oil-Dri.

Neutralizers

- Acid Spill Neutralizer - sodium bicarbonate, sodium carbonate, or calcium carbonate.
- Alkali (Base) Neutralizer - sodium bisulfate.
- Bromine Neutralizer - 5% solution of sodium thiosulfate and inert absorbent.

Personal Protective Equipment (PPE)

- Goggles and Face Shield
- Heavy Neoprene Gloves
- Disposable Lab Coat and Corrosive Apron
- Plastic Vinyl Booties

Tools for clean-up

- Plastic Dustpan and Scoop
- Plastic Bags (30 Gallon, 3 mm thickness) for contaminated PPE
- One Plastic Bucket (5-gallon polyethylene) with lid for spills and absorbent residues

Others

- For HF: calcium gluconate gel (always check expiration date)
- For mercury: aspirator bulb and mercury decontaminating powder
- For alkali metals: dry sand or a class “D” fire extinguisher
- For acid chlorides - Oil Dri, Zorb-All, or dry sand
- Spill clean-up procedure

Emergency Shower and Eyewash Activation and Flushing

Figure 4. Emergency shower and eyewash maintenance checks and logs

THE CITADEL EMERGENCY EYEWASH/SAFETY SHOWER WEEKLY INSPECTION SHEET

Instructions: Keep this inspection sheet up to date. Emergency eyewash and safety showers shall be inspected weekly to ensure proper operation in an emergency.
Ensure:

1. Equipment is easily accessible, uncluttered, and marked.
2. Equipment is flushed for at least 20 seconds or until stream is clear; and is fully operational (e.g., water comes out of both eye pieces with the same pressure; equipment not clogged; caps are kept on to avoid dust/ debris accumulation; no leaks observed when equipment is tested etc.).
3. The Inspection Sheet is dated and initialed weekly.
4. EH&S is notified of any F&E Work Order for repairs or operational failures.

Month	Week 1 (Date & Initials)	Week 2 (Date & Initials)	Week 3 (Date & Initials)	Week 4 (Date & Initials)	Comments
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
EH&S Annual Inspection	Date:		Signature:		

The American National Standard for Emergency Eyewash and Shower Equipment, ANSI Z358.1- 2014, states, "Plumbed emergency showers and eyewashes shall be activated weekly for a period long enough to verify operation and ensure that flushing fluid is readily available." The intent is to ensure a flushing fluid supply at the head of the device, clear the supply line of any sediment build-up that could prevent fluid from being delivered to the head of the device, and minimize microbial contamination due to standing water.

Procedure for Emergency Eyewash (Perform weekly):

1. Locate the floor drain. If the drainpipe does not extend to the floor drain or connect directly to an outgoing pipe, use a plastic tray to catch the water.
2. Protect nearby objects from getting sprayed. These include electrical objects or personal items you do not wish to become wet.
3. Gently push the lever back to initiate water flow.
4. Allow the water to flow until it is clear.
5. Record the date of emergency eyewash activation and flushing on the log.

Procedure for Emergency Shower (If combined with eyewash unit that is flushed weekly: perform every 3 months for old and every 6 months for new installations. If a standalone safety shower, activate and flush weekly):

1. Locate the safety shower's water shut-off valve and verify that it can be easily opened and closed.
2. Ensure no electrical equipment or other items are near the safety shower.
3. Cover equipment and other items that may potentially be reached by water spray.
4. Pull the lever or chain to activate the safety shower for 15 seconds or until the water is clear.
5. Push the lever back to stop the water flow. For safety showers activated by chains, the safety shower will stop after releasing 5 gallons of water.
1. 6. Record the date on the emergency shower activation and flushing log.

POST-EXPOSURE TREATMENT AND FOLLOW-UP

All exposures involving biological, radioactive, or chemical substances must be referred to a physician immediately following the exposure, even if there are no visible injuries or other symptoms of exposure. Inform the attending physician about the materials to which you were exposed and present the safety data sheet, if available, or retrieve it online.

LAB PREPAREDNESS

Severe weather and other events, such as holiday closings, can interrupt normal business operations at The Citadel. Occasionally, the College declares campus closure, in which case only essential personnel are required to report to work.

During severe weather, lab personnel are expected to stop general operations and safely store and secure all hazardous materials, equipment, and research data to minimize the risk of injury and property losses. When preparing to shut down laboratory operations for an extended period, consider the following questions.

Emergency Plans

- Have 2-3 essential personnel in your laboratory been identified, and have their tasks been clearly defined, in case a lab shutdown is needed?
- Does your laboratory have a specific checklist for shutting down operations?
- Is the information current on the Hazard Information notice posted by the entrance door?
 - Name and contact number for the Laboratory Technician.
 - Name and contact number for the Laboratory Technician.
 - Hazards listed (chemical, biological, radioactive, others).

Hazardous Materials

- Are chemical, radioactive, and biohazard containers securely capped, properly labeled, and safely stored?
- Are containers of hazardous wastes securely capped, properly labeled, and safely stored?
- Have chemicals been removed from laboratory benches and open shelves and stored in appropriate chemical cabinets?
- Are incompatible chemicals stored separately from one another?
- Are chemical containers stored above floor level in case of flooding?
- Are compressed gas cylinders properly secured and stored in an upright position?
- Do compressed gas cylinders that are not in use have their valve caps tightly secured?
- Is proper special storage ensured for air-reactive, water-reactive, or temperature-sensitive chemicals?
- Are glove boxes sufficiently supplied with required gases to ensure an oxygen-free atmosphere for water and/or air-reactive chemicals stored inside?

Equipment

- Are critical equipment plugged into an emergency power outlet?
- Are non-critical equipment safely powered down and unplugged, if possible?
- If equipment needs to be powered, are measures in place to prevent surging?
- Are the equipment stored above floor level in case of flooding?
- Is the equipment covered with a protective tarp or plastic sheets?

Experiments

- Do you have a shutdown procedure for experiments that take more than 24 hours to shut down and secure safely, and what are the contingencies?
- If you are working with animals, have you arranged protective care?
- Are all components of a critical long-term experiment (power, water, gas, equipment, etc.) secured and a sufficient supply ensured to prevent interruption?
- Are non-critical and high-hazard experiments stopped? Is the equipment turned off and unplugged? Are gas supplies turned off? Is the main cylinder valve closed?

Research Data

- Is your intellectual property (lab notebooks, ledgers, CDs, laptops) safely stored and backed up?

SECTION 14. ACCIDENT AND NEAR-MISS REPORTING

The EH&S Office of Research Safety has developed procedures for reporting incidents and near-misses in the laboratory. These procedures are designed to define, record, analyze, and learn from accidents and incidents. Based on the circumstances of the incident, the following guidelines should be followed.

Research Lab Incidents NOT Involving a Hazardous Material

1. Follow the steps outlined in The Citadel Workers' Compensation Guidance for Work-Related Accidents or Injuries.
2. Email Jesse Soares at jsoares1@citadel.edu with a brief incident notification within 24 hours of any lab incident.

Research Lab Incidents Involving a Hazardous Material

1. Follow the steps outlined in The Citadel Workers' Compensation Guidance for Work-Related Accidents or Injuries.
2. Follow the hazard-specific incident response procedures and timelines based on the hazard involved:
 - a. Chemical hazards
 - b. Biological hazards
 - c. Radiation hazards
3. Email Jesse Soares at jsoares1@citadel.edu with a brief incident notification within 24 hours of any lab incident.
4. Healthcare providers must assess all exposures to hazardous materials.

Safety Concerns & Near Miss Reporting

A near miss is considered any incident that did not result in personal injury, property damage, or environmental release but could have resulted in an accident if slightly different circumstances had been present. Examples include laboratory equipment failure, unexpected chemical reactions, non-compliance with safety policies or procedures, and general unsafe laboratory conditions that may result in an accident if not addressed.

It is everyone's responsibility to immediately report and correct potential hazards before they cause injury or illness. Personnel responsible for reporting incidents, safety concerns, and near misses include senior administrators, department chairs, Laboratory Technicians, laboratory personnel, or anyone who becomes aware of a hazardous situation.

Completing a Near Miss Report Form is one meaningful way to document a hazardous situation and any changes made to prevent its recurrence. These reports should be submitted to the Department Head and EH&S. Incidents must be discussed during lab meetings, as they can illustrate lessons learned to prevent future incidents.

Examples of lab incidents and near misses that need to be reported:

- Any fire, especially those that require the use of a fire extinguisher or require sounding a fire alarm.
- Any accident or incident that involved any or a combination of the following emergency responders: Public Safety, Charleston Fire Department, Charleston HazMat, Ambulance, and others.
- An accident that results in an injury requiring medical attention.
- Release or spill of a hazardous substance that takes place outside of a fume hood.
- All releases and spills of high-hazard substance that requires Standard Operating Procedures.

SECTION 15. SELF-INSPECTION SAFETY CHECKLIST

The following checklist summarizes The Citadel's policies and guidelines for working safely in the laboratory, including the proper handling of chemicals and physical hazards.

This document provides a detailed description of these policies and practices. For guidance on handling biological and radiological agents properly, refer to your Biosafety and Radiation Safety Manual.

GENERAL SAFETY

- The lab door is locked when unoccupied and after regular business hours.
- Only authorized personnel can enter and/or perform work in The Citadel laboratories. According to the Policy for Minors in Laboratories, People under 18 who are not currently enrolled at The Citadel must apply and be approved for volunteer work.
- Only service animals are brought into the lab after consultation with and approval by the Supervisor in charge of the lab and the ADA Office.
- Minimum PPE is required to enter the lab. This includes full-coverage shoes, clothing that provides reasonable skin coverage, and additional personal protective equipment (PPE) based on the hazards and risks in the lab.
- A Group safety officer has been identified and his/her delegated responsibilities have been discussed.

FACILITIES

- A floor drain is available to direct the flow of water from the safety shower during testing and actual use. Although there is no requirement for a floor drain, this information is essential to consider when there is potential for flooding in the lab.
- The lab room walls, ceiling, floor, plumbing and electrical utilities, tables, benches, and cabinets are in good working condition.
- Chemical fume hood available for corrosives, volatile flammable, and/or inhalation hazards.
- Room ventilation appears to eliminate chemical fumes and/or odors in the laboratory.

HAZARDS AND CONTROLS

- All hazards (physical, chemical, biological, radiological, environmental) are identified, and control measures are implemented.
- All tasks, experiments, and materials that are highly hazardous are performed or used with prior approval.

DOCUMENTATION AND SIGNAGE

- The following documents are present in the lab and accessible to all personnel during all work hours: Laboratory Safety Manual and Chemical Hygiene Plan, Lab-specific Information for LSM-CHP, Chemical Inventory, Safety Data Sheet, and Standard Operating Procedures for the use of highly hazardous materials, equipment, and processes.
 - The above documents have been updated to reflect changes in research activities.
- The following signage is posted in the lab: Lab Hazard Notice, Emergency procedures for fire, chemical spill, and chemical exposure, designated area for work with highly hazardous chemicals, equipment, and processes, and unattended operations, equipment, and/or procedures.

TRAINING

- All lab personnel have completed all required EH&S trainings (Chemical and Lab Safety, Haz Waste, Biosafety, Rad Safety) and lab-specific trainings before performing independent work in the laboratory and periodically thereafter as required.

EMERGENCY PREPAREDNESS AND RESPONSE

- A written lab emergency procedure for fire, chemical spill, chemical exposure, and other emergencies is posted by the exit door, bulletin boards, and other prominent locations in the laboratory.
- Lab personnel are trained on how to implement the emergency procedures.
- Lab personnel knowledgeable on building emergency procedures, including but not limited to evacuation routes, assembly points, areas of refuge, laboratory shutdown, and responsibilities in case an emergency evacuation occurs.
- Lab personnel are aware of the location and function of safety equipment.

- Accidents and near misses are reported to EH&S.
- The location of personal protective equipment and safety equipment (first aid kit, chemical spill kit, fire extinguisher, emergency shower, emergency eyewash) is conspicuously labeled.

FIRE SAFETY

- Are walkways and egress paths unobstructed, and exits marked in and near the laboratory?
- A portable fire extinguisher is available, mounted by the exit door, unobstructed, and checked monthly, with monthly checks documented on the hangtag.
- Emergency lighting is available and activates to illuminate the egress areas in the event of a power outage.
- Flammable chemicals and other combustible materials (paper, cardboard) are minimized in the laboratory.

BASIC CHEMICAL SAFETY

- Lab workers follow written Standard Operating Procedures for all hazardous tasks, experiments, and/or materials.
- Gloves for hand protection are available, in good condition, and suitable for specific hazardous chemicals and other hazards handled in the lab (e.g., latex, nitrile, leather, cryogen, autoclave)
- Eye and face protection PPE is available, in good condition, and suitable for specific hazardous materials handled in the lab (e.g., safety glasses, safety goggles, face shields, and UV shields).
- Lab coats are available, in good condition, and suitable for handling hazardous materials.
- Chemical-resistant splash apron is available and in good condition for handling corrosives.
- Suitable PPE is used when handling hazardous chemicals and removed before leaving the lab and entering non-laboratory areas in the building.
- Appropriate ear protection is available against unusually loud equipment and/or procedures.
- Chemical spills are promptly and thoroughly cleaned up. The laboratory is free from any signs of chemical release or spill.

WORK PRACTICE AND HYGIENE

- Lab workers do not work alone in the lab as a rule.
- Special permission from the PI is required when working with highly hazardous materials and tasks outside of regular business hours. Special guidelines are followed.
- The laboratory is kept clean and clutter-free. A 28" egress requirement is maintained.
- Food and drink are not stored and/or consumed in the laboratory.
- Home-type appliances such as microwaves, refrigerators, freezers, ice machines, and others designated and labeled "for lab use only".
- Human food items used for research are designated and labeled "for lab use only".
- Personal protective equipment is removed before leaving the lab.
- Designated computer or office workstations are away from hazards.
- Work areas for use and/or storage of highly hazardous materials and procedures are designated and labeled.
- Unattended operations are stable and protected from outside disturbances such as water or power outages?

- Mechanical pipetting devices are available and used as an alternative to mouth pipetting.
- Lab personnel work with a buddy outside of regular office hours.
- Tripping hazards such as electrical cords, gas lines, etc., are adequately covered and/or barricaded.
- Work benches, sinks, other work areas, and walkways are generally clean and clutter-free.

SAFETY EQUIPMENT

- The minimum required safety equipment is present in the lab: a fire extinguisher, emergency shower, emergency eyewash, chemical spill kit, and first aid kit. They are clearly labeled, easy to locate, periodically maintained, and in functional condition.
- Eyewash is available within 50 ft or 10 seconds travel.
- Emergency showers are available within 50 feet or 10 seconds of travel.
- Is the path to the eyewash and safety shower clear and free of obstruction?
- The spill kit is fully stocked and up to date (chemical components have not expired).
- First-aid kit is fully stocked and current (chemical components not expired).

ELECTRICAL

- If an electrical panel box is present in the laboratory, the panel must be locked, and there must be a 3-foot clearance around it.
- Circuit panels, electrical outlets, and receptacles covered.
- GFCI outlets are installed around sinks and other areas where water is used.
- Large appliances and high-amperage equipment are plugged directly into individual wall outlets, rather than using extension cords and power strips.
- Experimental set-ups and all electrical equipment are free of electrocution hazard.
- Electrical wires from extension cords are visible and not run behind ceiling tiles, under carpets, etc.

GENERAL CHEMICAL HANDLING

- Chemicals are segregated based on compatibility.
- Hazardous chemicals are stored below shoulder level but not on the floor.
- Chemicals are stored in appropriate cabinets with secured shelving.
- Flammables are stored in appropriate fire-rated cabinets or a flammable-safe refrigerator or freezer.
- Chemicals are stored in capped, sealed, and leak-proof containers, kept upright.
- Original containers' labels are intact and readable.
- Containers of solutions and mixtures are labeled with the identity of chemicals and associated hazards.
- The amount of each chemical is reasonable for research needs.
- Cabinets used to store hazardous chemicals are labeled.
- Storage areas/cabinets are labeled according to the type of chemical family or hazard classification found there.
- Storage areas are inspected at least every 6 months.
- Storage areas are well-lit, ventilated as needed, and maintained at a consistent, cool temperature.
- Storage areas are away from open flames, heat sources, or direct sunlight.

- Appropriate fire extinguishers for hazardous chemicals are handy and in good working order.
- Storage areas are confined to control leaks or spills.
- Chemical spills and drips are promptly cleaned up.
- Chemicals are not stored in cabinets under the sink.
- Chemicals are not stored in the fume hood except for hazardous gases, which must be stored and used in dedicated hoods.
- Chemicals are not stored on the floor, window ledges, or ceiling. Large bottles/containers are stored no higher than 2 feet from the floor.
- Storage cabinets are designed to contain the hazards associated with the chemicals they store.
- Storage shelves are level, stable, and securely attached to the wall or another stable surface, featuring raised edges or rim guards.
- Containers are not protruding over shelf edges.
- Store corrosives on lower shelves.
- Storage Containers
- Keep containers closed unless you are dispensing a chemical or adding to the container.
- Never store a container with an open funnel.
- Provide secondary containment for liquids in containers larger than 1 gallon in size.
- Dishpans or polyethylene trays are suitable options. Use approved containers for flammable solvents

CHEMICAL FUME HOOD

- All newly installed fume hood was ASHRAE 110 certified by a third party after installation.
- The fume hood is certified by EH&S within the last 12 months or after a recent repair.
- Fume hood airflow is within 80-150 lfm.
- The fume hood is free of stored unnecessary items.
- The fume hood sash is clear and in good condition.
- Fume hood side panels are intact.
- Fume hood airfoil and baffle openings are free of obstruction.
- Fume hood lighting is in good working condition.
- Fume hood alarm, if present, is in good working condition.
- The fume hood sash height is 18" or below when used and closed when not in use.
- The fume hood work surface is clean and free of chemical spills.
- A portable, non-ducted fume hood is third-party certified, used properly, and maintained.

HIGHLY HAZARDOUS CHEMICALS

Hazardous material	Controls implemented
Compressed gases	Is the gas cylinder secured? Is the gas cylinder capped if no regulator is attached? Is the gas cylinder labeled? Are gas valves and connections leak-tested and leak-free?

	Is the gas cylinder transported with a cylinder cart? Is the gas cylinder located away from high-traffic areas, doorways, electrical sources, and heat sources? Does chemical compatibility segregate gas cylinders? Is the cylinder's hydrostatic test current? Are old gas cylinders disposed of properly or returned to the vendor for recycling? Are gas lines clearly labeled from the point of source to the end of use? Are blow guns/gas nozzles used for cleaning and other approved purposes regulated at 30 psi or below? Are gas cabinets labeled? Are cylinders that are not in use (not connected to a system/process) have their regulators removed and the cylinder capped? Are gas lines/tubings visible from the source to the point of use and not hidden behind walls, ceiling tiles, and other obstructions?
Toxic gases	Is the amount of gas reasonable for the procedure so that the IFC's MAQ for highly toxic gases is not exceeded in the control area where the lab is located? Is a highly toxic gas concentration reasonable for a lab procedure? Is the cylinder of highly toxic gas secured, stored, and dispensed in a ventilated, sprinklered gas cabinet or chemical fume hood? Is a gas-specific detector installed at both the point of release and the point of use, and is it calibrated biannually or as recommended by the manufacturer? Is a gas detection system for highly toxic gas attached to a fire alarm system that is monitored 24 hours a day? Is a written Standard Operating Procedure (SOP) for the use of highly toxic gas available, approved by the Principal Investigator (PI), and signed by authorized users?

	Are authorized users of highly toxic gases trained on safe handling of compressed gases, cylinder change-out, and specific SOPs? Are their trainings documented? Is a written SOP for cylinder change-out available and followed?
Flammable gases	Is a written SOP for the use of flammable gas established? Are non-sparking tools available for cylinder change-out? Is the gas cylinder in the appropriate location? Are the tubing used appropriate for the type of gas and rated for the pressure at which the gas is being dispensed from the cylinder?
Corrosive gases	Is a written SOP for the use of corrosive gas established? Is it a corrosive gas stored or used inside a ventilated enclosure, such as a fume hood or gas cabinet? Is a gas sensor and alarm system installed to detect accidental release of corrosive gas? Are gas lines for corrosive gas free of signs of corrosion?
Pyrophorics	Is a written Standard Operating Procedure (SOP) for the use of pyrophoric liquids available, signed, and implemented? Are authorized users of pyrophoric liquids trained on the safe handling of pyrophoric liquids, and is their training documented? Is flame-resistant clothing and a flame-resistant lab coat available and used when handling pyrophoric liquid?
HF	Is calcium gluconate gel and calcium gluconate eyewash (if applicable) available and not expired? Are neoprene gloves, Tyvek suits, acid-resistant aprons, acid-resistant shoe covers, and face shields available? Is HF signage posted in the HF work area? Is the HF SOP written, available, and signed by the Laboratory Technician and authorized users?

	Is the HF-specific procedure and safety training of authorized users performed and documented? Is an HF spill kit available? Is the amount and/or concentration of HF on hand reasonable for research needs? Is HF, when stored with other compatible acids, stored in secondary containment, clearly labeled and separated from other containers in the cabinet as far as possible?
Cryogen	Is the cryogen tank or dewar stored in a well-ventilated area? Is an oxygen monitor available in a room where cryogen tanks are stored, given the unreliable ventilation? Are the required PPE (cryogen gloves, face shield) available and used when handling cryogenics? Are necessary precautions observed so that the potential for oxygen displacement is minimized when transferring liquid nitrogen inside a confined space or a small room?
Peroxide formers	Do containers of peroxide formers indicate the date of receipt and the date opened? Are peroxide formers discarded according to their expected shelf-life and ability to form peroxides? Is the inhibited counterpart of the peroxide former purchased if available and usable? If peroxide testing is performed, are testing results documented in a logbook or on the container?
Flammable liquids in 5 5-gallon or bigger container	Is a solvent pump available and used for dispensing from large flammable liquid containers? Is a 55-gal drum containing flammable liquid properly grounded and bonded? Is the volume of flammable below the maximum allowable quantity within the control area?
Emits flammable gas	Is a class D fire extinguisher available in the lab?

GLOSSARY

ACGIH: American Conference of Government Industrial Hygienists. Publishes "TLVs, Threshold Limit Values for Chemical Substances in Workroom Air Adopted by ACGIH for 1979," ACGIH, Cincinnati, OH, 1979.

Acute: An adverse effect or injury to health that occurs immediately or shortly after a single or short-term exposure to a material or condition.

Cancer: Uncontrolled tissue growth resulting in the formation of malignant tumors.

Carcinogen: A substance capable of causing cancer.

CFR: Code of Federal Regulations.

Chronic: An adverse effect, injury, or illness with symptoms that develop after long-term exposure to a material or condition.

Combustible: Able to catch fire and burn.

Corrosive chemicals: Substances that can cause damage to the skin, eyes, and respiratory epithelium upon contact with the chemicals or their vapors.

Developmental hazard: An agent that interferes with the development of an individual before or after birth.

Embryotoxic: A substance that is poisonous to the unborn organism or fetus.

Environmental monitoring: The measurement of concentrations of airborne hazardous substances.

Flammable: Capable of being easily ignited and of burning.

Highly toxic: A chemical that has an LD50 by ingestion of more than 50 mg/Kg or less; LD50 by contact of more than 200 mg/Kg or less; LC50 by inhalation of 200 ppm or less, or 2 mg/liter or less.

Irritant: A chemical that causes a reversible inflammatory effect on living tissues by chemical action at the site of contact.

Laboratory: A workplace where relatively small quantities of chemicals are used on a non-production basis.

Laboratory Scale: Work with chemicals that one person can easily and safely manipulate.

LC50 (Lethal Concentration 50%): The concentration of a substance that causes death in 50% of the animals exposed.

LD50 (Lethal Dose 50%): The dose that causes death in 50% of the animals exposed.

MSDS: Material Safety Data Sheet

Mutagen: A substance capable of changing cells in such a way that future cells generated are affected.

NEC: National Electrical Code.

NFPA: National Fire Protection Association

OSHA: Occupational Safety and Health Administration, the regulatory branch of the Department of Labor concerned with employee safety and health.

PEL Permissible Exposure Limit: The allowable concentration in the workplace that is considered a safe level of exposure for an eight-hour shift, 40 hours per week.

pH: A measure of how acidic or basic a substance is on a scale of 1 being the most acidic to 14 being the most basic.

Sensitizers: Agents that can cause an allergic reaction with repeated exposure over time.

Sterility: Changes made in male or female reproductive systems resulting in the inability to reproduce.

Teratogen: A substance that causes a deformity in fetal growth if significant exposure exists during pregnancy.

TLV or TWA: Threshold Limit Value or Time Weighted Average. The amount of exposure allowable for an employee in an eight-hour workday.

REFERENCES AND GLOSSARY

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