UMSL

LABORATORY SAFETY PLAN
FOREWARD

Students, Faculty, Staff, Principal Investigators, Researchers, and all laboratory personnel:

This UMSL Laboratory Safety Plan is part of a program designed to make our laboratories safer for everybody. It provides the minimum standards for laboratory personnel using chemicals, potentially infectious or any potentially hazardous materials or equipment. It contains general lab safety practices as well as specific information for the safe handling, storage, and disposal for several types of materials. It also includes first aid, emergency response procedures, training requirements, and responsibilities for laboratory personnel.

The Principal Investigator or Laboratory Manager should fill out the “Lab Safety Plan Owner’s Page,” and keep a printed copy available in their laboratory. They should also have all students and researchers fill out and sign the “Lab Safety Plan Awareness Certification” page after reading the plan.

My expectation is that all laboratory personnel will read the plan and comply with the portions that apply to them, and to their laboratory. Please contact the Environmental, Health & Safety Department with any concerns, suggested changes or additions, or questions.

It is my sincere hope that all UMSL personnel will make safety a high priority and do their utmost to keep our laboratories a safe place to work and learn.

RONALD YASBIN,
DEAN, ARTS AND SCIENCES, PROFESSOR OF BIOLOGY
LAB SAFETY PLAN OWNER’S PAGE

Name of Lab Principal Investigator or Lab Manager

Building and Room Number

Department
EMERGENCY PHONE NUMBERS

All Emergencies
Institutional Safety
911 from an UMSL phone
314-516-5155

Hazardous Materials Support
Environmental, Health & Safety
314-516-6360
314-516-6362
314-516-6367

Major Chemical Spill
911 from a UMSL phone
314-516-5155

Radioactive Spill or Release
314-516-6362
314-516-5155

Building Emergency
Facilities Services
Weekdays 7 am to 4 pm
314-516-6300
314-516-6320
After Hours: 314-516-5155

UMSL Emergency Planning and Preparedness web site:

In case of serious incident needing immediate assistance, your best option is to call 911 from a university (ShoreTel) phone, and you will reach the UMSL Dispatch Center. The UMSL police dispatchers are trained to respond quickly and appropriately to emergency situations. Dialing 911 from an UMSL phone provides Dispatch the capability to know your location, quickly set up a three-way phone connection with you and outside fire, medical or police agencies. This method has several advantages. Both UMSL and the outside agency hear your description of the incident at the same time, which avoids confusion and provides faster response times. This method also automatically notifies UMSL Police, who can provide faster response, help the responder (e.g., fire truck or ambulance) find the correct location faster, and also back up the outside agency when they arrive. This is typically the best and fastest method to obtain emergency services.

If you call 5155 from a university phone, the dispatcher will know your location, but will not have the capability to set up the three-way call.

If you call 314-516-5155 from a cell phone, the dispatcher will not know your location or be able to implement the three-way call.

If you call 911 from your cell phone, you will reach the Saint Louis County Police. They will ask you for your locality and you will need to specifically tell them UMSL. They may not be familiar with our building locations. It is acceptable if you chose to do this in an emergency, especially in a fire or medical emergency, but you need to know that this method may slow the police response by a few minutes. Be sure to follow up with an additional call to UMSL dispatch so the UMSL Police are aware of the situation.
CHEMICAL/HAZARDOUS MATERIAL SPILL/RELEASE NOTIFICATION FORM

Part 1 of this form is provided to aid you in reporting a chemical or hazardous material release to Campus Police at 911 from university phone or 314-516-5155. Part 2 is designed to aid you in documenting additional information you may want later.

Be prepared to give the police dispatcher your name and a phone number where you can be reached, and location of the release.

Provide the name of the material released, hazards of the material (if you know), approximate quantity, state, (gas, liquid or solid) other hazards in the room, (such as hydrogen tanks, open flame, etc.) and any known injuries.

PART 1 - CALL IN INCIDENT TO CAMPUS POLICE

Material Discharged: ________________________________
Container Type: ________________________________
Date and Time of Discharge: ________________________ AM/PM
Approximate Quantity Discharged: ____________________ Grams/Pounds/Gallons
Have you evacuated the area? Yes/No
Was anyone injured? Yes/No
Are there other hazards in the area? ____________________________
Time that you called Campus Police: ____________________________
Type of injury, how many? ____________________________

Your Full Name: ___
Title or Position: ____________________________
Phone Numbers: Day ______________ Evening ______________
Building Name, Floor, & Room #: ____________________________

PART 2 - ADDITIONAL INFORMATION

Source and/or Cause of Incident: ____________________________

RESPONSE ACTION AND IMPACTS
Actions Taken to Correct, Control, or Mitigate Incident: ____________________________

Damage Incurred: (Y/N) Describe: ____________________________

ADDITIONAL INFORMATION: ____________________________

Did Material Reach Water?_____ (Y/N) If so, Approximate Quantity? ______________ Gallons
LAB SAFETY PLAN AWARENESS CERTIFICATION

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PI or Supervisor- building/room-Department

The University of Missouri–St. Louis (UMSL) Lab Safety Plan (LSP) provides the minimum standards for laboratory personnel using chemicals or who may have a reasonably anticipated exposure to blood or other potentially infectious materials. Laboratories with hazards not sufficiently covered in this written manual should generate a laboratory specific safety plan to contain standard operating procedures, emergency procedures, and to identify activities requiring prior approval.

After reading the "University of Missouri–St. Louis Lab Safety Plan," complete and return a copy of this form to your supervisor. By signing below you acknowledge that you are aware of the policies and procedures adopted by the University of Missouri–St. Louis. Your supervisor will provide additional information and training as appropriate.

Please type or print legibly.

Name: ________________________________________________________________

Student or staff ID number: ________________________________________________

UMSL Email address: __________________________________________________________

Signature: ___________________________ Date: ______________

Completed LSP Awareness Certifications are to be filed in a central administrative location within the staff member’s department. These and all safety training records should be organized in a way that allows original records to be retrieved quickly and efficiently on request by a government inspector or an Environmental Health and Safety staff member, and to be retrieved for a single staff member or for an entire work group (identified by supervisor).
# UMSL Laboratory Safety Plan Record of Change

## Record of Changes

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<th>Page</th>
<th>Summary of Change</th>
<th>Entered By</th>
<th>Date Entered</th>
<th>Revision #</th>
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</tbody>
</table>
# Table of Contents

Foreword ................................................................................................................................. i  
Lab Safety Plan Owner’s Page ............................................................................................. ii  
Emergency Phone Numbers ............................................................................................... iii  
Chemical/Hazardous Material Spill/Release Notification Form ........................................ iv  
Lab Safety Plan Awareness Certification ........................................................................... v  
UMSL Laboratory Safety Plan Record of Change ............................................................ vi  

I. Introduction ....................................................................................................................... 1  
   A. Purpose ................................................................................................................... 1  
   B. Scope ....................................................................................................................... 1  
   C. Policy ...................................................................................................................... 1  

II. Responsibilities of Principal Investigators and Laboratory Managers .................. 2  
   A. General Guidelines ................................................................................................ 2  
   B. Additional Responsibilities ................................................................................... 2  
   C. Lab Safety Training .............................................................................................. 4  

III. Emergency Response Procedures .............................................................................. 6  
   A. Introduction ........................................................................................................... 6  
   B. Evacuation ............................................................................................................. 6  
   C. Exposure Incidents And Reporting Requirements ............................................. 6  
      1. Medical Emergencies ...................................................................................... 6  
      2. Bloodborne Pathogen Post-Exposure Evaluation ........................................ 8  
      3. First Aid Kits .................................................................................................. 8  
      4. Reporting ......................................................................................................... 8  
   D. Hazardous Material Spills and Releases ............................................................. 8  
      1. Major Chemical or Biological Spill ............................................................... 8  
      2. Minor Chemical or Biological Spill ............................................................... 9  

IV. General Laboratory Safety Practices ........................................................................ 11  
   A. Permissible Exposure Limits (PEL) ................................................................... 11  
   B. Basic Lab Safety Practices .................................................................................. 11  
   C. Personal Protective Equipment .......................................................................... 12  
      1. Eye Protection .................................................................................................... 12  
      2. Gloves .............................................................................................................. 12
3. Gowns, Aprons, Lab Coats, and Other Protective Clothing ........................................ 13
4. Inhalation Protection ........................................................................................................ 13

D. Engineering Controls ........................................................................................................ 13
   1. Laboratory Fume Hoods ................................................................................................. 13
   2. Biological Safety Cabinets .......................................................................................... 14
   3. Special Ventilation Devices ............................................................................................ 15

E. Specialized Laboratory Equipment ................................................................................ 15
   1. Centrifuges .................................................................................................................... 15
   2. Autoclaves/Sterilizers .................................................................................................. 15

F. Storage Procedures for Hazardous Chemicals ................................................................. 16

G. Housekeeping .................................................................................................................. 17

V. Chemical Handling Procedures ....................................................................................... 19
   A. General Handling ........................................................................................................ 19
   B. Highly Hazardous Materials ......................................................................................... 19
   C. Corrosives ...................................................................................................................... 19
      1. Precautions for Handling Corrosive Materials ........................................................ 20
      2. Storage of Corrosive Materials .................................................................................. 20
   D. Flammables ..................................................................................................................... 21
      1. Precautions for Handling Flammable Materials ....................................................... 21
      2. Definition of Flammable Liquids ............................................................................ 21
      3. Storage Limitations for Flammable Liquids ............................................................. 22
      4. Storage Volume Limits for Flammable Liquids ......................................................... 23
   E. Compressed Gases .......................................................................................................... 24
   F. Toxins ............................................................................................................................. 25
   G. Reactive Chemicals ......................................................................................................... 25

VI. Radiation Safety ............................................................................................................ 28

VII. Lasers .............................................................................................................................. 29

VIII. Biological Hazards ........................................................................................................ 30

IX. Waste Disposal ............................................................................................................... 31
   A. Chemical Waste ............................................................................................................. 31
   B. Sharps and Laboratory Glassware .................................................................................. 31
      1. Sharps ......................................................................................................................... 31
      2. Sharps Containers ...................................................................................................... 32
      3. Contaminated sharps ................................................................................................. 32
4. Laboratory glassware ................................................................. 32

C. Biological Waste ........................................................................ 33
   1. Solid Waste ........................................................................... 33
   2. Liquid Waste .......................................................................... 33
   3. Animal Carcass Disposal .......................................................... 34
   4. Regulated Medical Waste (Non-Sharps) ...................................... 34
   5. Ethidium Bromide Contaminated Waste .................................... 34

X. Medical Consultation ..................................................................... 36

TABLES

Table III-1: Absorbents for Common Laboratory Chemicals

Table V-1: GHS Flammable Liquid Categories

Table V-2: Maximum Quantities of Flammable Liquids in Laboratory Units by Hazard Classification for Laboratory Units Located on the Third Floor or Lower

Table V-3: Maximum Allowable Container Capacity

APPENDICES

Appendix A: SOP for Risk Assessment

Appendix B: SOP for Compressed Gases

Appendix C: SOP for Toxic Chemicals

Appendix D: SOP for Reactives

Appendix E: SOP for Lasers

ATTACHMENTS

Attachment 1: Laboratory Management Plan

Attachment 2: Laboratory Bloodborne Exposure Control

Attachment 3: Autoclave Surveillance

Attachment 4: Rad Handbook Index and Forward
Attachment 5: Biosafety Level Laboratories
Attachment 6: Hepatitis Vaccine Declination

EXHIBITS

Exhibit 1: UCLA Chemical List
Exhibit 2: PHS by CAS
Exhibit 3: Table Z-1 Limits for Air Contaminants
Exhibit 3A: Table Z-2
Exhibit 3B: Table Z-3
Exhibit 4: NIOSH Pocket Guide
I. INTRODUCTION

A. PURPOSE

The purpose of the Laboratory Safety Plan (LSP) is to establish consistent and reasonable expectations, standards, and practices for health and safety in UMSL laboratories. The intent is to protect faculty, staff and students from chemical, physical, and biological hazards present in these laboratories.

B. SCOPE

The UMSL Laboratory Safety Plan applies to all UMSL laboratory personnel who handle or may be exposed to hazardous materials in the laboratory as part of their research, education or employment.

C. POLICY

It is the policy of the University of Missouri to operate in full compliance with all applicable laws and regulations to ensure the health and safety of students, faculty, and staff.

The policy specifically states that “The University of Missouri has an inescapable obligation to furnish facilities and an environment that will provide reasonable protection from injury and property damage for employees, students, and the public and to be a good steward of funds coming into its possession and to preserve it assets.”

“All faculty, staff and students to the University of Missouri have the responsibility and obligation to act in accordance with the rules and regulations of the Centers for Disease Control and Prevention (CDC), U.S. Department of Agriculture (USDA), National Institutes of Health (NIH), U.S. Environmental Protection Agency (EPA), Nuclear Regulatory Commission (NRC), Missouri Department of Natural Resources (DNR), Missouri Department of Health and Senior Services (DHSS), Missouri Department of Labor and Industrial Relations (DOLIR), U.S. Department of Transportation (DOT), National Fire Protection Association (NFPA), Occupational Safety and Health Administration (OSHA), and all other applicable Federal and State regulations.”

“In unusual situations where the University is exempt from regulatory jurisdiction due to its status as a government entity, faculty, staff and students still have an obligation for obtaining knowledge of the risks associated with their activities and exercising judgment to protect against the risks the regulations are intended to protect.”

[SOURCE: University of Missouri System Business Policy Manual Safety and Risk Management section BPM-601, General Policy (revised December 1, 2008)]
II. RESPONSIBILITIES OF PRINCIPAL INVESTIGATORS AND LABORATORY MANAGERS

Every individual working in a laboratory is responsible for his safety. However, the Principal Investigators (PI) and Laboratory Managers still have overall responsibility for the safe operation of their laboratories. Each department with laboratories is responsible for implementing this Laboratory Safety Plan (the Plan, or LSP). It is important for laboratory personnel to be familiar with the health and safety guidelines that apply to their work and to conduct that work in the safest possible manner. The PI and Laboratory Manager are responsible for ensuring compliance with the Plan. The LSP is intended to be a resource to assist laboratory personnel in fulfilling these responsibilities.

A. GENERAL GUIDELINES

Principal Investigators, Lab Supervisors, Professors, and Teaching Assistants are responsible for implementing the LSP in their respective laboratories and should:

- Ensure staff and students receive general laboratory safety training before beginning work in the lab;
- Determine what laboratory specific concerns exist within their laboratory;
- Develop individual laboratory specific standard operating procedures, as necessary;
- Ensure staff and students are trained on laboratory specific concerns before working in laboratory;
- Be familiar with the requirements of the LSP
- Determine required levels of engineering and administrative controls, develop best work practices, and determine personal protective equipment (PPE) for their laboratory; and
- Ensure adequate PPE is available, is in good working order, and is worn within their laboratory.

B. ADDITIONAL RESPONSIBILITIES

The Chemical Safety Board has noted that university lab safety plans typically have ignored physical hazards in laboratories. These include pyrophoric, highly reactive and other materials. UMSL EHS believes it is prudent to address these materials and has decided on three sources. The first was the settlement between UCLA Board of Regents and California OSHA (Cal/OSHA) after a research assistant fatality. The settlement required Standard Operating Procedures (SOP) for 10 categories of chemicals totaling 500 substances. The categories are:

1. Pyrophoric Chemicals
2. Water Reactive Chemicals
3. Potentially Explosive Compounds
4. Acutely Toxic Chemicals
5. Acutely Toxic Gases
6. Peroxide Forming Chemicals
7. Strong Corrosives
8. Strong Oxidizing Agents
9. Strong Reducing Agents
10. Regulated Carcinogens

The list of about 500 “Chemicals of Concern,” from these 10 classes is in Exhibit 1 of this plan and is also provided on the EHS website. The second source is OSHA’s list of “Particularly Hazardous Substances” (PHS). OSHA’s PHS list includes select carcinogens, reproductive toxins, and substances with a high degree of acute toxicity. The OSHA PHS list is in Exhibit 2 of this plan. The third source is the list of reactive, acutely hazardous materials in 40 CFR 261.33(e) and in the Subpart K Laboratory Management Plan (see page 5 of Attachment 1). EHS has adopted the phrase “Highly Hazardous Material” (HHM) to apply to any material that appears on any of the three lists.

The person in charge of the laboratory is also responsible for:

- Completing an inventory of chemicals and hazardous materials in their laboratory;
- Determining if any of these materials fit the EHS criteria for HHM.
- Providing these lists to the Department Chair, EHS, and the UMSL Police Department.
- Conducting a risk assessment for all HHM stored or utilized in the lab. Appendix A provides guidance on conducting a risk assessment. EHS has provided sample risk assessments for common laboratory materials (flammable, corrosive, water reactive, and oxidizers) that may be used or modified by the PI. Sample risk assessments are included with the risk assessment guidance in Appendix A. Risk assessments may be completed by hazard class. It is important to note that some chemicals have multiple hazard classes that must be addressed.
- Generating a Standard Operating Procedure (SOP), protocol, or other work instruction for handling these materials.
- Training (and document the training) all individuals who will work with, or could come in contact with the HHM.

EHS recognizes that generating the inventory lists will be a burden to some laboratories. There are several regulatory requirements for these inventories as well as safety concerns. These include:

- The EPA Emergency Planning and Community Right-to-Know Act (EPCRA) requires hazardous chemical storage reporting.
- The Department of Homeland Security Chemical Facility Anti-Terrorism Standard requires registration if certain “chemicals of interest” exceed a threshold quantity.
- The NFPA Standard on Fire Protection for Laboratories Using Chemicals provides maximum storage limits for flammable materials.
- The International Building Code (IBC) also has maximum storage limits for flammable materials.
The PI or Laboratory Manager should correct any unsafe condition and facilitate repair or replacement of any equipment that is not working properly. All PI, Lab Supervisors, Professors and Teaching Assistants are responsible for following accident and near miss reporting policies as described in the LSP.

**C. LAB SAFETY TRAINING**

The laboratory PI and supervisor are responsible for ensuring laboratory personnel are trained on the safety topics as described in the LSP. This includes, but is not limited to, this list of lab safety topics:

- Physical and health hazards associated with chemicals and or biological agents in the laboratory;
- Safety procedures to protect laboratory workers from chemical exposure and or exposure to biological agents;
- Methods and observations that may be used to detect the presence of or release of a hazardous chemical (i.e., visible appearance, odor, etc.);
- Location of reference materials on hazards, handling, and storage of chemicals in the laboratories. This will include, but not be limited to, safety data sheets; OSHA PELs (see Exhibit 3) for regulated substances, or recommended exposure limits where no OSHA standard exists;
- Signs and symptoms of overexposure to hazardous materials;
- Laboratory specific procedures;
- Response actions for:
  - Minor injury;
  - Major injury;
  - Minor release;
  - Major release;
- Proper use of and location of PPE;
- Container labeling;
- Proper handling and storage for laboratory wastes;
- Where food and drink can and cannot be stored, transported or consumed;
- Use and precautions associated with:
  - Corrosives;
  - Flammable materials;
  - Compressed gases;
  - Reactive materials/oxidizers; and
  - Toxins;
- Work with pathogenic agents;
- List the potential routes of exposure;
- Reporting any exposures or suspicious symptoms to the PI;
- Work with bloodborne pathogens or human cell lines;
- HBV vaccine availability;
- Use of a chemical fume hood;
- Use of a biological safety cabinet;
• Use of specialized lab equipment (centrifuge, autoclaves, etc.);
• Use and testing of safety equipment;
• Thermal hazards (autoclave, cryogenic liquids, etc.);
• Requirements for shipping infectious materials or hazardous chemicals;
• Location of SDS, Lab Safety Plan, and Lab Specific SOPs;
• Location of first aid kit, eye wash station, safety shower, spill kit, and fire extinguisher; and
• Location of Emergency numbers.

Each lab at UMSL must provide lab specific training to all lab members. Lab specific training must be: (1) documented and (2) provided to all lab personnel at the time of initial assignment to the lab and prior to work involving new exposure situations and hazardous operations. All personnel must have annual lab specific training. This training should include specific protocols on how to safely carry out procedures performed in the lab. Each laboratory must complete its own Lab Specific Training document.

EHS provides safety training lectures throughout the year to students, faculty and staff. Training dates will be coordinated with appropriate faculty and posted on the EHS website. In addition to existing online training, EHS has developed online training that will be administered through MyGateway. EHS will give basic lab safety training lectures on a rotating schedule to supplement the information provided in the LSP.

To request a training lecture or to get information about the next scheduled lecture contact EHS.
III. EMERGENCY RESPONSE PROCEDURES

A. INTRODUCTION

In case of serious incident needing immediate assistance, your best option is to call 911 from a university (ShoreTel) phone, and you will reach the UMSL Dispatch Center. The UMSL police dispatchers are trained to respond quickly and appropriately to emergency situations. Dialing 911 from an UMSL phone provides Dispatch the capability to know your location, quickly set up a three-way phone connection with you and outside fire, medical or police agencies. This method has several advantages. Both UMSL and the outside agency hear your description of the incident at the same time, which avoids confusion and provides faster response times. This method also automatically notifies UMSL Police, who can provide faster response, help the responder (e.g., fire truck or ambulance) find the correct location faster, and also back up the outside agency when they arrive. This is typically the best and fastest method to obtain emergency services.

If you call 5155 from a university phone, the dispatcher will know your location, but will not have the capability to set up the three-way call.

If you call 314-516-5155 from a cell phone, the dispatcher will not know your location or be able to implement the three-way call.

If you call 911 from your cell phone, you will reach the Saint Louis County Police. They will ask you for your locality and you will need to specifically tell them UMSL. They may not be familiar with our building locations. It is acceptable if you chose to do this in an emergency, especially in a fire or medical emergency, but you need to know that this method may slow the police response by a few minutes. Be sure to follow up with an additional call to UMSL dispatch so the UMSL Police are aware of the situation.

B. EVACUATION

Each laboratory should have an evacuation plan, including a primary route and a secondary route. EHS will work with Institutional Safety and the laboratories to generate this plan.


C. EXPOSURE INCIDENTS AND REPORTING REQUIREMENTS

1. MEDICAL EMERGENCIES

If the injury requires immediate medical attention, dial 911 and request an ambulance and immediate medical assistance. Have the safety data sheet (SDS) available if chemical exposure. Have lab specific reagent information or Lab Specific Exposure Control plan readily available for Biosafety Level 2 (BSL-2) reagents.
During normal business hours, for all non-emergency work related injuries, contact University Health Services at 314-516-5671. Health Services is located at 131 Millennium Student Center. Outside of normal business hours, contact the UMSL Campus Police at 314-516-5155.

For severe bleeding:
- Elevate the injury above the heart;
- Apply a clean pad or cloth directly to the wound; and
- Call for medical assistance.

For chemical splashes to eyes or body:
- Assist exposed person with use of safety shower and/or eye wash;
- Flush body and/or eyes with copious amounts of water;
- Remove any contaminated clothing while under the safety shower;
- Wash skin with mild soap and water, do not use neutralizing agents, creams, lotions or salve, and
- Call for medical assistance, state the nature of injury, the chemical name, your location and contact information to dispatchers.

For ingestion of a chemical:
- Encourage the victim to drink large amounts of water, and
- Call for medical assistance, state the nature of injury, the chemical name, your location and contact information to dispatchers.

For inhalation of fumes or mists:
- Get medical aid immediately;
- Remove from exposure area to fresh air immediately;
- If not breathing, give artificial respiration, and
- Call for medical assistance, state the nature of injury, the chemical name, your location and contact information to dispatchers.

For minor cuts and punctures:
- Encourage bleeding;
- Wash the area with running water;
- Wrap in a clean cloth until proper treatment can be secured in the Health Services Center; and
- If assisting an injured employee or student that is bleeding, wear PPE if available and timely.
2. **Bloodborne Pathogen Post-Exposure Evaluation**

A confidential medical evaluation and follow-up will be conducted by University Health Services, at 314-516-5671, after first aid (clean the wound, flush eyes or other mucous membrane, etc.) has been provided. See Attachment 2 for details.

3. **First Aid Kits**

Fully stocked first aid kits should be readily available in every lab. Each member of the lab should know where the first aid kit is located and be able to access the kit.

4. **Reporting**

All accidents and incidents are to be reported, per the University of Missouri System Business Policy Manual Section on Reporting Accidents and Incidents.

All injuries and incidents are to be reported to UMSL Campus Police at 314-516-5155 and to Human Resources at 314-516-5639. The PI or supervisor is responsible for taking immediate actions as needed to prevent the occurrence of a similar injury. The PI or supervisor is also responsible for communicating the root cause and corrective actions to other staff and faculty who may have similar risks in their areas. A copy of such incidents and corrective actions should be sent to EHS for incorporation into future training.

**D. Hazardous Material Spills and Releases**

In addition to identifying the spilled chemical, laboratory personnel must know what materials are stored in the lab. A chemical inventory must be on file with the Campus Police Department, the Department of Environmental, Health and Safety, and within the respective department’s central office. Emergency responders will need to know this information to determine PPE and how to properly respond. Without this information, the response will be delayed and the extent of any injury or property damage could worsen.

For all known or suspect releases to the environment (air, water or land), notify EHS at 314-516-6362 or 314-516-6360 during normal business hours, or the Campus Police at 314-516-5155 after normal business hours. **EHS will make any required notifications to regulatory agencies.** Contact EHS to dispose of spilled material after the incident. See Table III-1 for neutralizing agents for different types of chemical spills.

1. **Major Chemical or Biological Spill**

A major spill is one that is spreading rapidly and presents inhalation or fire hazards, has entered the environment, or exceeds the capacity of the laboratory user to respond.

- Secure the area such that no one can enter without proper authorization;
- Notify Campus Police at 911;
- Alert others to leave the area;
• Remove ignition sources, shut down equipment, close fume hood sash, and open windows for chemical spills, if you can do so safely;
• Close the doors to the laboratory;
• Contact others on your lab emergency notification form;
• Assemble at a safe distance; and
• Provide technical assistance to emergency responders.

2. **MINOR CHEMICAL OR BIOLOGICAL SPILL**

A minor spill is one that can easily be managed by laboratory personnel. Response items are as follows:

• Attend to any person who may have been contaminated (See Section III.C above for first aid);
• Notify persons in the immediate area of the spill;
• Secure the area so extraneous personnel do not enter;
• Evacuate non-essential personnel from the area of the spill;
• Notify Campus Police at 911;
• Turn off all ignition sources if the spilled material is flammable;
• Establish exhaust ventilation through the fume hoods or by opening windows for chemical spills;
• Contact EHS for assistance in disposing of the collected materials;
• Never attempt to handle broken glass or sharps with your hands; and
• Use the appropriate spill kit according to lab specific SOPs.
  o A typical spill kit will contain three types of equipment:
    ▪ Personal protective equipment (PPE);
    ▪ Equipment and materials to clean-up small spills; and
    ▪ Equipment to contain larger spills.
  o The type and amount of equipment compiled for each kit should be sufficient to address any minor spill that employees can safely respond to; and
  o Kits should include appropriate container for debris.

Below are some examples of types of chemicals and the materials used to neutralize, absorb or contain a spill. This is not an exhaustive list and individual labs will need to review best practices for their lab:
### Table III-1: Absorbents for Common Laboratory Chemicals

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Neutralizer, Absorbent, or Spill Containment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acids</td>
<td>Sodium bicarbonate, sodium carbonate, or calcium carbonate</td>
</tr>
<tr>
<td>Acid Chlorides</td>
<td>Dry sand or other inert absorbent. Do not use water or sodium bicarbonate</td>
</tr>
<tr>
<td>Alkali Metals (Lithium, Sodium, Magnesium, Potassium)</td>
<td>Dry sand or contents from a Class &quot;D&quot; fire extinguisher. Do not use water</td>
</tr>
<tr>
<td>Bases</td>
<td>Sodium bisulfate</td>
</tr>
<tr>
<td>Bromine</td>
<td>5% solution of sodium thiosulfate or other inert material</td>
</tr>
<tr>
<td>Flammables</td>
<td>Activated charcoal, sand or non-combustible absorbent pads</td>
</tr>
<tr>
<td>Hydrofluoric Acid</td>
<td>Neutralize with soda ash or lime (or absorb with special HF spill pillow - standard spill pads will NOT work)</td>
</tr>
<tr>
<td>Mercury</td>
<td>Mercury amalgamate powder, such as Merc-sorb</td>
</tr>
<tr>
<td>Oil</td>
<td>Granular absorbent or oil-specific absorbent pads (especially important if a spill is on water; oil-specific absorbents will only absorb the oil)</td>
</tr>
<tr>
<td>Oxidizers</td>
<td>non-combustible absorbent pads</td>
</tr>
<tr>
<td>Solvents (organic)</td>
<td>Inert absorbent material</td>
</tr>
<tr>
<td>Thiols/Mercaptans</td>
<td>The odor of thiols and mercaptans may be removed with activated charcoal</td>
</tr>
<tr>
<td>White or Yellow Phosphorus</td>
<td>Cover with wet sand or wet absorbent</td>
</tr>
</tbody>
</table>

Source: [http://www.anr.state.vt.us/dec/wastediv/rcra/SpillKitFAQ.htm](http://www.anr.state.vt.us/dec/wastediv/rcra/SpillKitFAQ.htm)
IV. **GENERAL LABORATORY SAFETY PRACTICES**

A. **PERMISSIBLE EXPOSURE LIMITS (PEL)**

Permissible Exposure Limits (PEL) have been established for numerous chemicals and are listed in the OSHA standard at 29 CFR 1910.1000 Table Z-1 (See Exhibit 3). For chemicals that OSHA has not identified a PEL, refer to the National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards (See Exhibit 4). Links to this information can be found on the EHS website.

Potential chemical exposure should be maintained at the lowest practical level and must not exceed posted exposure levels. Labs may perform risk assessment to determine if monitoring is warranted. Contact EHS for assistance if PEL monitoring is indicated by the risk assessment.

B. **BASIC LAB SAFETY PRACTICES**

*Prudent Practices for Handling Hazardous Chemicals in Laboratories* may be used as a supplemental reference.

- Post emergency contact information at each entrance;
- Maintain an inventory of hazardous materials used or stored;
- Provide a copy of the inventory to Department Chair, UMSL Police, and EHS;
- Be aware of the location and operation of laboratory safety equipment such as eye wash stations, showers, fire extinguishers and spill kits;
- Be aware of emergency evacuation routes and gathering points once exiting the building;
- Dress appropriately for the laboratory setting. This should include close toed shoes and clothing that covers the skin. Open toed shoes and sandals should not be worn. Loose or torn clothing should not be worn. Hair should be secured to prevent accidental exposure to reagents or ignitions sources;
- Wear lab coats and gloves in the laboratory area only. Do not wear lab coats or gloves in the halls or public areas;
- Do not eat or drink, apply cosmetics, chew gum or apply contact lenses in the laboratory;
- Do not store food for human consumption anywhere in the lab or in laboratory prep areas;
- Wash hands with soap and water after de-gloving and before exiting the lab;
- Label cabinets and drawers and keep closed;
- Keep lab doors closed for fire safety and for HVAC control;
- Use mechanical means for pipetting. Never mouth pipette; and
- Secure compressed gas cylinders from tipping over and position in such a way that the label can be read.
C. PERSONAL PROTECTIVE EQUIPMENT

Personal Protective Equipment (PPE) is specialized clothing or equipment worn by an employee for protection against a hazard. General work clothes (e.g., uniforms, pants, shirts or blouses) not intended to function as protection against a hazard are not considered to be personal protective equipment. PPE may be needed to supplement available engineering controls, but PPE should never be used as a substitute for engineering controls. Proper use of PPE can minimize exposure to hazards associated with many laboratory operations. PPE should satisfy performance requirements such as strength, chemical resistance and thermal resistance without inhibiting flexibility and manual dexterity. PPE is intended to be worn in the laboratory only, and should be left in the laboratory upon exit.

Eye and face protection shall be required where there is a reasonable probability that injury could be prevented by such protection. Safety glasses shall always be worn when working with chemicals. This requirement may be waived by the Principal Investigator for specific labs while working at a desk or on a computer performing clerical duties. Eye and face protection can be obtained from the Chemistry Stock Room and from safety catalogs.

1. EYE PROTECTION

- Chemical splash goggles are required in chemical handling operations where protection is needed against mists, aerosols and sprays. Splash proof goggles provide superior protection against dust, splash, spray and mist hazards and should be the first choice for primary eye protection;
- Masks, that cover the nose and mouth, in combination with eye protection devices, such as goggles or glasses with solid side shields, or chin-length face shields, shall be worn whenever splashes, spray, spatter, or droplets of blood or other potentially infectious materials may be generated and eye, nose, or mouth contamination can be reasonably anticipated; and
- Face shields are required where facial skin protection is needed for chemical or physical agents. Where both eye and face protection is needed, the face shield is used in addition to the safety glasses or goggles.

2. GLOVES

- Gloves should be worn whenever there is potential for contact with corrosive or toxic materials, or materials of unknown toxicity, blood, or other potentially infectious material;
- Gloves should be selected based on chemical resistance data from the glove manufacturer (See Exhibit 5 for an example). EHS maintains links to additional glove selection resources on its website;
- Chemicals can eventually permeate gloves; however, they can be used safely for limited time periods if specific use and glove characteristics, i.e., thickness, permeation rate and time, are known;
- Disposable gloves are not to be washed or re-worn; and
- Gloves should be replaced immediately if punctured or torn.
Gloves should be replaced periodically depending on frequency of use and permeability to the substance(s) handled. Be sure to dispose of gloves according to the type of agent being handled.

Gloves are not to be worn outside of the laboratory. If a small container must be carried between labs, wear one clean glove to carry the container. The other hand should be ungloved to open doors or elevators. It is preferred to transport all chemicals in secondary containers to eliminate the need for a gloved hand.

3. **GOWNS, APRONS, LAB COATS, AND OTHER PROTECTIVE CLOTHING**

Skin contact is a potential source of exposure to hazardous materials. Check the Safety Data Sheet for substances that can create exposure routes by skin absorption. Even when there is minimal danger of skin contact with a hazardous substance, clean lab coats or aprons should be worn. Garments contaminated with hazardous substances should not be taken home for laundering. Garments should be replaced as needed. Disposable gowns and lab coats may be used where appropriate.

Lab garments, such as lab coats and aprons, are not to be worn outside of the laboratory.

4. **INHALATION PROTECTION**

Departments or laboratories that issue, recommend, or provide respirators for employee protection are required to comply with a respiratory protection program in accordance with OSHA Standard 1910.134. EHS currently has a compliant program and is available to assist departments in determining their need to utilize respirators. Respiratory protection program components include hazard evaluations, medical evaluations, fit testing and training for individuals required to use respirators, and written programs including record keeping and annual reviews. Contact EHS if you need to use a respirator.

Types of respiratory protective equipment include:

- Air purifying respirators: have filters, cartridges or canisters that remove contaminants from the air before it reaches the user; and
- Atmosphere supplying respirators: supply clean air directly to the user.

D. **ENGINEERING CONTROLS**

1. **LABORATORY FUME HOODS**

- Laboratory fume hoods shall be operated according to manufacturer specifications;
- The fume hood should be used at the approved sash height indicated on the front of the hood;
- All work should be conducted at least six inches back from the face of the fume hood;
- Large objects should be placed on shelves or risers 2 to 3 inches above the work surface to insure proper air flow;
• Keep rear baffle openings clear;
• Keep nearby windows and doors closed and pedestrian traffic to a minimum when working in the hood;
• Fully close the sash when the hood is not in use;
• Fume hoods are not to be used for permanent storage, except for toxic or other highly hazardous gases;
• If the fume hood is equipped with an on/off switch it should be left on at all times, even when not in use;
• All fume hood modifications shall be approved by EHS; i.e., those that do not detract from the hood performance;
• The fume hood should be appropriate for the material used within (e.g., perchloric acid requires a specific hood);
• Airflow shall be such that contaminants within do not escape the fume hood. A smoke tube test, or other approved test, may be performed by EHS to ensure airflow is adequate;
• Each laboratory fume hood at UMSL is inspected annually. PI and lab supervisors must allow EHS access to any university fume hood for annual testing and inspection. Where performance parameters fall outside specifications, work orders are initiated to repair the hoods. When appropriate, a notice is placed on the hood indicating that it is not to be used until its performance is within the specified performance parameters;
• All work with volatile hazardous chemicals shall be performed in hoods that vent outdoors and;
• Fume hoods should be used for operations which might result in release of toxic chemical, vapors, or dust.

Confirm adequate fume hood performance before use and verify the inspection sticker is current; keep fume hood closed at all times except when adjustments within the fume hood are being made. Contact EHS and the Facilities Department immediately if you suspect fume hood performance has been compromised. Keep materials stored in fume hoods to a minimum and do not allow them to block vents or air flow.

Conventional fume hoods are not designed to protect against an explosion. If there is the potential for an explosion, appropriate shielding should be provided.

2. **Biological Safety Cabinets**

• Biological safety cabinets (BSC) shall be certified when installed, whenever they are moved, and at least annually. Each Department or PI is responsible for BSC certification and maintenance;
• Properly maintained class II biological safety cabinets are used whenever:
  o Procedures with a potential for creating infectious aerosols or splashes are conducted. These may include centrifuging, grinding, blending, vigorous shaking or mixing, sonic disruption and opening containers of infectious materials whose internal pressures may be different from ambient pressures;
  or
  o High concentrations of large volumes of infectious agents are used. Such materials may be centrifuged in the open laboratory if sealed rotor heads or
centrifuge safety cups are used, and if these rotors or safety cups are opened only in a biological safety cabinet.

- Biological safety cabinets shall not be used in settings, such as a cold room, where the room air is recirculated.

3. **Special Ventilation Devices**

Procedures involving radioactive aerosols, powders or gaseous products, or procedures that could produce volatile radioactive effluents shall be conducted in an approved fume hood, glove box or other suitable closed system. Such fume hoods shall be designed with smooth, non-porous materials and possess adequate lighting to facilitate work within. Contact EHS for further information on fume hood use for radioactive materials.

E. **Specialized Laboratory Equipment**

1. **Centrifuges**

Centrifuges, due to the high speed at which they operate, have great potential for injuring users if not operated properly. Unbalanced/damaged/worn centrifuge rotors can result in injury, even death. Sample container breakage can generate aerosols that may be harmful if inhaled. Use safety cups or a sealed rotor when centrifuging infectious materials and whenever possible, centrifuge rotors should be loaded and unloaded within a biosafety cabinet for infectious material. Use appropriate decontamination and cleanup procedures for the materials being centrifuged if a spill occurs and report all accidents to your supervisor immediately. Follow the manufacturer’s recommendations regarding preventive maintenance. A proper maintenance program/service contract, including periodic rotor inspections, with the manufacturer or authorized service company is strongly recommended.

2. **Autoclaves/Sterilizers**

Autoclaves and sterilizers are such a familiar feature within laboratories it is often easy to overlook the hazards which they present. In order to render a material sterile, the autoclave utilizes hot pressurized steam (270°F at 30 lbs/in²), which presents serious burn hazards. Because the conditions within autoclaves are so extreme, the chance for malfunction is high if not properly operated and maintained. Each autoclave has unique characteristics, so it is important for users to review and understand the operator’s manual or receive training prior to use.

Autoclave maintenance is an important aspect of autoclave safety. A properly working autoclave will help ensure safety measures are in place to protect workers from injury or exposure. Follow the manufacturer’s recommendations for a preventive maintenance schedule and ensure maintenance personnel are approved to work on your autoclave.

An effective preventive maintenance program may include efficacy testing to ensure the autoclave is functioning properly. A typical efficacy test is the use of a biological indicator (e.g., Bacillus spore test). If an autoclave fails a maintenance inspection/validation, it should
be placed out of service immediately and users should be verbally and visually informed through communication and signage. See Attachment 3 for details.

Since any unsafe practice could result in injury to laboratory staff, the following safety precaution should be enforced when using autoclaves:

- Never attempt to autoclave items which contain hazardous chemicals or other hazardous materials (other than potentially infectious materials);
- Firmly lock autoclave doors prior to operation. Most autoclaves are equipped with an interlock system, which does not allow operation without the door being completely closed. Determine if your autoclave is equipped with an interlock system. If it does not, be sure all users are aware of this feature and advise them to utilize extra caution when operating the autoclave;
- Post signs to warn users or passers-by of the hazards present (e.g.“Hot Surfaces, Keep Away”). Older autoclaves may not provide efficient heat shielding around the unit;
- Do not store combustible materials near autoclaves;
- Always utilize the appropriate PPE when handling items being placed into or removed from an autoclave. This includes heat resistant gloves, safety goggles, and if handling large amounts of liquid, rubber boots and rubber apron to protect against splash/spill hazards;
- Be sure autoclave is OFF and pressure is low before opening doors. Open autoclave doors slowly, keeping the head, face, and hands away from the opening to prevent direct contact with steam. Wait at least 30 seconds after opening the door before reaching into the autoclave to remove sterilized items. Wearing appropriate gloves and protective equipment, remove items slowly;
- Before loading the autoclave, check the inside for items left by previous users;
- Load autoclaves as per the manufacturer’s recommendations. Not following these recommendations may result in incomplete sterilization of items;
- Loosen the caps of containers with liquids before loading to prevent bottles from shattering during pressurization;
- Use a tray with a solid bottom and walls to contain the contents and catch spills, should they occur. Add ¼ to ½ inch of water in the bottom of the tray to ensure bottles heat evenly;
- Check plastic materials to ensure they are compatible with the autoclave;
- Allow glassware to cool for at least 15 minutes prior to touching with ungloved hands for non-liquid loads;
- Allow liquids to stand for at least 1 hour prior to touching with ungloved hands; and
- Ensure all manufacturer safety recommendations are in place and effectively enforced. If injury occurs from exposure to autoclave steam or autoclaved materials, follow procedures for treatment of a burn and seek immediate medical attention.

F. STORAGE PROCEDURES FOR HAZARDOUS CHEMICALS

To prevent chemical reactions that may result in fire, produce dangerous vapors, or produce uncontrolled explosions, the laboratory should select a storage scheme that achieves segregation of incompatible materials. Storage guidance may be found in laboratory and safety catalogs,
safety data sheets, container labels, *Prudent Practices in the Laboratory* and the EHS website. Only store the minimum amount of chemicals necessary in the laboratory.

- Ensure all containers are in good condition and labeled with the chemical name, concentration and hazards;
- Review stored items at least yearly, more frequently for age sensitive materials;
- Ensure containers and caps are in good condition:
- Ensure materials are stable;
- Store chemicals by hazard class, not alphabetical order, to keep incompatible chemicals separate;
- Do not store flammable solvents in refrigerators or freezers not engineered for storage of flammable solvents;
- Avoid floor chemical storage and never store chemicals in glass containers on the floor;
- Provide shelving that can be cleaned, sanitized and won't soak up spilled chemicals. Do not use bare wood shelving. Provide a suitable barrier or secondary container;
- Store chemicals at or below eye level;
- Do not store chemicals on top of shelving units or on top of flammable storage cabinets;
- Avoid use of shelves with adjustable supports with clips;
- Store severe poisons in a dedicated cabinet;
- Store corrosive materials in corrosion-resistant cabinets;
- Store acids in a secondary container. Store bases in a separate secondary container;
- Label storage areas by chemical hazard;
- Label refrigerators and freezers used for storage of chemicals or other laboratory supplies with “No flammables” unless they have been designed and approved for these materials;
- Avoid storing chemicals on bench tops;
- Do not store chemicals under the sink;
- Avoid exposure of chemicals to heat or direct sunlight;
- Dispose of old chemicals promptly; EHS will pick up unwanted material; and
- Store flammable liquids that are not in use in laboratory safety cans or approved storage cabinets.

**G. HOUSEKEEPING**

The following practices shall be followed in the laboratories:

- Keep access to emergency equipment, showers, eyewashes, and exits free of obstructions;
- Keep aisles, hallways and stairs clear of chemicals and clutter;
- Keep counter tops free of clutter;
- Keep all lab areas clean and uncluttered to help prevent unnecessary contact or injury due to breakage or spills;
- Clean up small, low hazard spills and dispose of the spilled chemical and cleanup materials properly. Contact EHS for assistance; and
• Place all chemicals in their assigned storage area at the end of the operation or at least by the end of the day.

In restricted areas where radioactive materials, BSL-2 agents, or other extremely hazardous agents are used and stored, housekeeping staff may be allowed into these areas only if supervised by the lab supervisor or PI.
V. **CHEMICAL HANDLING PROCEDURES**

A. **GENERAL HANDLING**

- Obtain and review the SDS before ordering and using chemicals;
- Ensure that the material can be safely procured, stored, used, and disposed;
- Conduct a risk assessment for highly hazardous materials;
- Develop lab specific SOPs and training for highly hazardous materials;
- Do not work alone in the laboratory if you are working with highly hazardous materials;
- Purchase the minimum amount of materials necessary to accomplish the work and dispense only amounts necessary for immediate use;
- Avoid direct contact with any chemical. Use protective equipment to avoid exposure and review SDS for specific recommendations;
- Ensure all containers are labeled with chemical name, concentration and hazard information;
- Keep all bottles and containers closed except when in use;
- Ensure ventilation is adequate for the materials you are using. Where possible, handle all chemicals in a chemical fume hood;
- Electrically ground and bond conductive containers using approved methods before transferring or dispensing a flammable liquid from a large container; and
- Use bottle carriers for glass containers and use carts with edges to prevent containers from falling when transporting chemicals outside the lab.

B. **HIGHLY HAZARDOUS MATERIALS**

EHS has adopted the phrase “Highly Hazardous Materials” (HHM) to include the chemicals listed in the settlement agreement between the UCLA Board of Regents and Cal/OSHA, OSHA’s list of Particularly Hazardous Substances, and the 6 reactive, acutely hazardous materials in 40 CFR 261.33(e). HHMs will exhibit one or more of the hazards identified in this section of the LSP. It is important to identify all HHMs and the special handling associated with the HHM. PIs are required to conduct a risk assessment for each HHM stored or used in the lab.

C. **CORROSIVES**

A corrosive chemical, such as a strong acid or base, is one that causes visible destruction or irreversible alterations of living tissue by chemical action at the site of contact. They can be in liquid, solid or gaseous form and act on the body tissues by direct contact, inhalation or ingestion. Corrosive liquids are responsible for most corrosive based injuries. Corrosive gases are the most serious because they can be readily absorbed into the body by dissolution with skin moisture and by inhalation.
1. **Precautions for Handling Corrosive Materials**

   - Wear eye protection and gloves when handling corrosive materials. A faceshield, rubber apron, and rubber boots may also be appropriate; depending upon work performed (check SDS for personal protective equipment requirements);
   - Handling processes should be designed to minimize the potential for splash, splatter, or other likely scenarios for accidental contact;
   - Avoid violent reactions that may cause injury: for example, never add water to acid;
   - Never empty carboys or drums by means of air pressure. Use a tilting rack, a safety siphon, or a liquid pump;
   - Open bottles or carboys slowly and carefully;
   - Wipe drips from containers and bench tops. Be careful to avoid skin contact as burns may result;
   - Ensure an eyewash and safety shower is readily accessible to areas where corrosives are used and stored;
   - Reactions involving acids and bases are often exothermic;
     - Use on heat resistant, dry labware;
     - Allow for extra volume in reaction vessels to account for potential expansion and/or foaming;
     - Pre-cool solutions when mixing/reacting may be required;
   - Have SDS readily available; and
   - Use safety rubber bottle carriers or non-breakable bottles (PVC-coated) for the transport of strong acids and bases from one location to another, even within the lab.

2. **Storage of Corrosive Materials**

   - Storage cabinets, containers, and equipment should be made of corrosion resistant materials;
   - Specially designed corrosion-resistant cabinets should be used to store large quantities of corrosive materials.
   - Corrosive materials should not be stored under sinks or near wiring of any kind;
   - Acids and bases should be stored in secondary containers to prevent damaging spills if primary container should fail;
   - Do not store corrosive materials above eye level;
   - Store strong oxidizing agents such as chromic and perchloric acids in glass or other inert containers (preferably unbreakable); corks and rubber stoppers should not be used;
   - Acids and bases should be stored separately. Strong oxidizers should be stored separately from other acids and bases;
   - Separate organic acids from mineral acids; and
   - Separate liquids from solids;
D. FLAMMABLES

Flammable materials can generate sufficient vapors to cause a fire in the presence of an ignition source. They are categorized based on flash point, the minimum temperature at which a substance gives off vapor in sufficient concentrations to allow the substance to ignite.

1. PRECAUTIONS FOR HANDLING FLAMMABLE MATERIALS

- Review SDS for proper PPE and storage;
- When handling flammable materials or contacting potentially contaminated surfaces, protective gloves are to be worn;
- Goggles (rather than safety glasses) are appropriate in processes where splash or spray is foreseeable;
- 100% cotton or natural fiber lab coats and clothing are appropriate when handling flammable liquids. Avoid synthetic fibers;
- Eliminate ignition sources such as open flames, smoking materials, hot surfaces, sparks from welding or cutting, operation of electrical equipment, and static electricity;
- Minimize the quantity maintained in the work area;
- Transfer flammable liquids from containers of five gallons or less inside a fume hood to prevent accumulation of vapors;
- Store in approved flammable liquid containers (safety cans) and storage cabinets;
- Store away from oxidizers;
- Refrigerators and freezers used for storage of flammables shall be explosion safe and labeled as such;
- Domestic refrigerators shall not be used to store flammable liquids with a flash point of less than 37.8°C (100°F);
- Ensure laboratory personnel know the locations of fire alarm pull stations, fire extinguishers, safety showers, and other emergency equipment; and
- Ensure appropriate fire extinguishers are in the area. Using the wrong type of fire extinguisher can make a fire worse.

2. DEFINITION OF FLAMMABLE LIQUIDS

The Global Harmonization System (GHS) defines flammable liquids based on flash point and initial boiling point. The GHS flammable categories are shown in Table V-1.
Table V-1: GHS Flammable Liquid Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flash Point &lt; 23°C (73°F) and initial boiling point ≤ 35°C (95°F)</td>
<td>Diethyl ether</td>
</tr>
<tr>
<td>2</td>
<td>Flash Point &lt; 23°C (73°F) and initial boiling point ≥ 35°C (95°F)</td>
<td>Acetone, toluene, methyl ethyl ketone, dioxane Xylene</td>
</tr>
<tr>
<td>3</td>
<td>Flash Point ≥ 23°C (73°F) and ≤ 60°C (140°F)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Flash Point ≥ 60°C</td>
<td>Phenol, Ethylene glycol</td>
</tr>
</tbody>
</table>

3. **Storage Limitations for Flammable Liquids**

NFPA laboratory classifications are based on the quantities of flammable and combustible liquids (a) used, and (b) used and stored, in the laboratory. Teaching laboratories are considered instructional laboratories and are limited to Class C or Class D. Research laboratories are not considered instructional laboratories and can be classified anywhere from Class A to Class D.

Per NFPA 45, laboratories shall be classified as:

- **Class A**: High fire hazard;
- **Class B**: Moderate fire hazard;
- **Class C**: Low fire hazard; or
- **Class D**: Minimal fire hazard.

For the LSP, EHS will use the GHS definition of flammable liquid and apply the NFPA usage and storage standards. The equivalent GHS flammable category will replace the NFPA flammable and combustible class. The laboratory hazard classification and their respective maximum storage amounts of flammable liquids that may be kept in a laboratory unit are provided in Table V-2.
TABLE V-2 Maximum Quantities of Flammable Liquids in Laboratory Units by Hazard Classification for Laboratory Units Located on the Third Floor or Lower

<table>
<thead>
<tr>
<th>Laboratory Hazard Class</th>
<th>Flammable Liquid Category</th>
<th>Quantities in Use</th>
<th>Quantities in Use and Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Maximum Quantity per 100 ft² of Laboratory Unit</strong></td>
<td><strong>Maximum Quantity per Laboratory Unit</strong></td>
<td><strong>Maximum Quantity per 100 ft² of Laboratory Unit</strong></td>
</tr>
<tr>
<td>Class A</td>
<td>1, 2 and 3 1, 2, 3 and 4</td>
<td>10 gal 20 gal</td>
<td>480 gal 800 gal</td>
</tr>
<tr>
<td>Class B</td>
<td>1, 2 and 3 1, 2, 3 and 4</td>
<td>5 gal 10 gal</td>
<td>300 gal 400 gal</td>
</tr>
<tr>
<td>Class C</td>
<td>1, 2 and 3 1, 2, 3 and 4</td>
<td>2 gal 4 gal</td>
<td>150 gal 200 gal</td>
</tr>
<tr>
<td>Class D</td>
<td>1, 2 and 3 1, 2, 3 and 4</td>
<td>1 gal 1 gal</td>
<td>75 gal 75 gal</td>
</tr>
</tbody>
</table>


For Class B laboratories above the 3rd floor, reduce quantities by 50%. For Class C and D laboratories, reduce quantities by 25% for laboratories located on the 4th through 6th floors and reduce quantities by 50% for laboratories above the 6th floor. Contact EHS if you need assistance calculating flammable storage volumes.

4. **Storage Volume Limits for Flammable Liquids**

Individual containers holding flammable liquids are limited as shown in Table V-3.
### TABLE V-3 Maximum Allowable Container Capacity

<table>
<thead>
<tr>
<th>Container Type</th>
<th>Flammable Liquids</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Glass</td>
<td>500 ml</td>
</tr>
<tr>
<td>Metal or approved plastic</td>
<td>4 L</td>
</tr>
<tr>
<td>Safety Cans</td>
<td>10 L*</td>
</tr>
<tr>
<td>Metal Container (DOT)</td>
<td>4 L</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>4 L</td>
</tr>
<tr>
<td>Pressurized liquid dispensing container</td>
<td>20 L</td>
</tr>
</tbody>
</table>


NOTE: *In instructional laboratories, Class 1, 2 and 3 liquid containers shall not exceed 8 L for safety cans, or 4 L for other containers.

### E. COMPRESSED GASES

By definition, a compressed gas is:

- A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 pounds per square inch (psi) at 70° F;
- A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 F regardless of the pressure at 70° F; or
- A liquid having a vapor pressure exceeding 40 psi at 100° F as determined by ASTM D-323-72.

Compressed gases may be grouped into different hazard categories based upon their physical or health properties, or both. Any gas could be placed into more than one category. A gas could be corrosive, flammable, toxic, an oxidizer, or act as an asphyxiant by displacing oxygen. The fact that gases are stored under high pressure creates an additional hazard.

Cryogens create unique hazards including fire, pressure, embrittlement of materials, and skin or eye burns upon contact with the liquid. Cryogens condense oxygen from air creating an oxygen rich atmosphere and increasing potential for fire if flammable or combustible materials and an ignition source are present. Pressure is a hazard because of the large expansion ratio from liquid to gas, causing pressure build up in containers. Many materials become brittle at extremely low temperatures. Brief bodily contact with materials at extremely low temperatures can cause burns similar to thermal burns.

See Appendix B for more information on handling and storage of compressed gases.
F. TOXINS

Any chemical can result in some toxic effect if a high enough amount (dose) of the substance comes in contact with a living system. The dose-response relationship for the chemical determines the chemical's level of toxicity. This is often expressed as the chemical’s Median Lethal Dose (LD50). Toxic effects of chemicals can occur after single (acute), intermittent (repeated), or long-term, repeated (chronic) exposure. An acutely toxic substance can cause damage as the result of a single, short-duration exposure. In contrast, a chronically toxic substance causes damage after repeated or long-duration exposure or causes damage that becomes evident only after a long latency period.

Minimizing or eliminating exposure is the simplest way to provide protection from toxic hazards. To minimize exposure, it is necessary to determine the route by which exposure may occur, (i.e., inhalation, contact through skin or mucus membranes, ingestion, and injection or puncture) and take precautionary measures.

See Appendix C for more information on handling and storage for toxic materials.

G. REACTIVE CHEMICALS

The category "reactive" is a term given to a chemical class that displays a broad range of reactions. These substances are capable of producing toxic, corrosive, or flammable gases, reacting with water violently, forming explosive or auto-igniting mixtures, or being explosive. Reactive chemicals exhibit moderate to extremely rapid reaction rates and include materials capable of rapid release of energy by themselves (self-reaction or polymerization), and/or rates of reaction that may be increased by heat or pressure or by contact with incompatible substances. Examples of reactive chemicals may include the following:

Explosives are solid or liquid substances (or mixtures) which are capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gas.

Oxidizing gas is any gas which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does.

Oxidizing liquid is a liquid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.

Oxidizing solid is a solid which, while in itself not necessarily combustible, may, general by yielding oxygen, cause, or contribute to, the combustion of other material.

Self-reactive substances or mixtures are thermally unstable liquid or solid substances or mixtures liable to undergo a strongly exothermic decomposition even without participation of oxygen (air). This definition excludes substances or mixtures classified under the GHS as explosives, organic peroxides, or as oxidizing.
Self-heating substance or mixture is a solid or liquid substance or mixture, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat, this substance or mixture differs from a pyrophoric liquid or solid in that it will ignite only when in large amounts (kg) and after long periods of time (hours or days).

Pyrophoric liquid is a liquid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.

Pyrophoric solid is a solid which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.

Substances or mixtures which, in contact with water, emit flammable gases are solids or liquid substances or mixtures which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.

Organic peroxides are liquid or solid organic substances which contain the bivalent –O-O-structure and may be considered derivatives of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals. The term also includes organic peroxide formulations (mixtures). Organic peroxides are thermally unstable substances or mixtures, which may undergo exothermic self-accelerating decomposition. In addition they may have one or more of the following properties:

- Be liable to explosive decomposition;
- Burn rapidly;
- Be sensitive to impact or friction; and
- React dangerously with other substances.

Peroxide formers, or peroxidizables, are materials which react with oxygen to form peroxides which can explode with impact, heat, or friction.

Peroxide-forming compounds can be divided into three hazard categories. Storage times are based on time after opening container.

1. **Compounds and metals forming peroxides that can spontaneously decompose during storage. Maximum storage time is 3 months.** Examples include:

<table>
<thead>
<tr>
<th>butadiene</th>
<th>potassium amide</th>
</tr>
</thead>
<tbody>
<tr>
<td>chloroprene</td>
<td>potassium metal</td>
</tr>
<tr>
<td>divinyl</td>
<td>sodium amide</td>
</tr>
<tr>
<td>acetylene</td>
<td></td>
</tr>
<tr>
<td>divinyl ether</td>
<td>tetrafluoroethylene</td>
</tr>
<tr>
<td>isopropyl ether</td>
<td>vinylidene chloride</td>
</tr>
</tbody>
</table>

2. **Compounds forming peroxides that require the addition of a certain amount of energy (evaporation/distillation, shock) to explosively decompose. Maximum storage time is 12 months.** Examples include:
<table>
<thead>
<tr>
<th>Compound</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetyl</td>
<td>ethylene glycol dimethyl ether (glyme)</td>
</tr>
<tr>
<td>acetaldehyde</td>
<td>ethylene glycol ether acetates</td>
</tr>
<tr>
<td>benzyl alcohol</td>
<td>4-heptanol</td>
</tr>
<tr>
<td>bis (2-methoxyethyl) ether</td>
<td>2-hexanol</td>
</tr>
<tr>
<td>2-butanol</td>
<td>methyl acetylene</td>
</tr>
<tr>
<td>cumene</td>
<td>3-methyl-1-butanol</td>
</tr>
<tr>
<td>cyclohexanol</td>
<td>methyl cyclopentane</td>
</tr>
<tr>
<td>cyclohexene</td>
<td>methyl isobutylketone</td>
</tr>
<tr>
<td>2-cyclohexen-1-ol</td>
<td>4-methyl-2-pentanol</td>
</tr>
<tr>
<td>cyclopentene</td>
<td>2-pentanol</td>
</tr>
<tr>
<td>decahydronaphthalene</td>
<td>4-penten-1-ol</td>
</tr>
<tr>
<td>decalin</td>
<td>1-phenylethanol</td>
</tr>
<tr>
<td>diacetylene</td>
<td>2-phenylenethanol</td>
</tr>
<tr>
<td>dicyclopentadiene</td>
<td>2-propanol (IPA)</td>
</tr>
<tr>
<td>diethyl ether</td>
<td>tetrahydrofuran (THF)</td>
</tr>
<tr>
<td>diethylene glycol dimethyl ether</td>
<td>vinyl ethers</td>
</tr>
<tr>
<td>dioxane</td>
<td>tetrahydronaphthalene</td>
</tr>
<tr>
<td>1,4-dioxane</td>
<td></td>
</tr>
</tbody>
</table>

3. **Compounds that have the potential to form peroxide polymers, a highly dangerous form of peroxide which precipitate from solution easily and are extremely heat and shock-sensitive. Maximum storage time is 12 months.** Examples include:

<table>
<thead>
<tr>
<th>Compound</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>acrylic acid</td>
<td>styrene</td>
</tr>
<tr>
<td>acrylonitrile</td>
<td>tetrafluoroethylene</td>
</tr>
<tr>
<td>butadiene</td>
<td>vinyl acetate</td>
</tr>
<tr>
<td>chlorobutadiene</td>
<td>vinyl acetylene</td>
</tr>
<tr>
<td>chloroprene</td>
<td>vinyl chloride</td>
</tr>
<tr>
<td>chlorotrifluoroethylene</td>
<td>vinyl pyridine</td>
</tr>
<tr>
<td>methyl methacrylate</td>
<td>vinylidene chloride</td>
</tr>
</tbody>
</table>

Precautions for handling peroxide forming materials include the following:

- Date all peroxidizables upon receipt and opening. Unless the manufacturer has added an inhibitor, materials should be disposed of in a timely manner; and
- Do not open any container that has obvious crystal formation around the lid.
- Stored materials kept after the recommended storage period must be tested monthly for peroxides.

See Appendix D for more information on storage and handling of reactive materials.
VI. RADIATION SAFETY

Personnel working with radioactive materials must adhere to the general safety precautions for the chemical laboratory. In addition, special procedures and requirements apply when working with radioactive materials.

Licensed authorized users are faculty members who have been authorized through the Radiation Safety Officer (RSO) and approved by the Nuclear Regulatory Commission (NRC) to possess and use certain radioisotopes in designated laboratories. Laboratories that have been designated as containing radioactive materials will be labeled with all the elements as shown below:

The laboratory will identify through clear and conspicuous signage

- The Authorized User contact information;
- The RSO contact information;
- Department;
- Room number and building information; and
- Wording “This is a restricted area authorized for the use and storage of radioactive materials”;

Attachment 4 contains the Handbook of Operations Involving the Use of Radiation Sources index and forward. A complete copy of the Handbook may be obtained from the RSO.
VII. LASERS

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. A laser produces an intense, coherent, directional beam of monochromatic radiation in the ultraviolet, visible, or infrared regions of the electromagnetic spectrum. There is a high concentration of energy per unit area both at the laser end and at the far end of the beam.

Overexposure and possibly permanent damage of the eye and skin are the principal hazards of improper laser use. Other hazards include fires or vaporization of hazardous materials that may be caused by the laser beam or electrical shock that may result from accidental contact with the laser’s power supply.

See Appendix E for additional information on laser safety.
VIII. BIOLOGICAL HAZARDS

A biohazard is a biological agent or material which is potentially hazardous to humans, animals, and/or plants. Biohazardous agents may include certain bacteria, fungi, viruses, rickettsiae, chlamydiae, parasites, recombinant products, allergens, cultured human or animal cells and the potentially infectious agents these cells may contain.

Currently, UMSL operates Biosafety Level (BSL) 1 and 2 laboratories only. BSL-1 agents are defined organisms and are not known to cause disease in healthy adults. Examples include Bacillus subtilis, Escherichia coli strain K12, and Klebsiella oxytoca. BSL-2 agents pose a moderate risk to personnel and the environment. If exposure occurs in a laboratory situation, the risk of spread is limited and rarely would cause infection that would lead to serious disease. Effective treatment and preventive measures are available in the event that an infection occurs. Examples of BSL-2 organisms are: Streptococcus pneumonia, and Salmonella. See Attachment 5 for more information on Biosafety Levels.

Human and NHP Cell Line Policy

The guidance that has directed the UMSL policy on cell lines of human origin and nonhuman primate (NHP) cell lines is;

- The Centers for Disease Control and Prevention (CDC)/National Institutes of Health (NIH) Biosafety in Microbiological and Biomedical Laboratories (BMBL): 5th edition, Appendix H
  - “Human and other primate cells should be handled using BSL-2 practices and containment. All work should be performed in a BSC (biological safety cabinet), and all material decontaminated by autoclaving or disinfection before discarding.”
  - “Potential laboratory hazards associated with human cells and tissues include the bloodborne pathogens HBV, HIV, HCV, HTLV, EBV, HPV and CMV as well as agents such as Mycobacterium tuberculosis that may be present in human lung tissue. Other primate cells and tissues also present risks to laboratory workers.”

Based on the recommendation provided, it is the university’s policy that all cell lines of human origin and NHP cell lines be handled under BSL-2 conditions and fall under the BBP exposure control plan (See Attachment 2). When there is the potential for exposure to bloodborne pathogens, the PI will ensure availability of appropriate PPE and engineering controls.
IX. WASTE DISPOSAL

A. CHEMICAL WASTE

In November, 2013, UMSL notified the Missouri Department of Natural Resources (MDNR) and the Environmental Protection Agency (EPA) Region VII that it was opting into the provisions of 40 CFR 262 Subpart K, Alternative Requirements for Hazardous Waste Determination and Accumulation of Unwanted Material for Laboratories Owned by Eligible Academic Entities. A Laboratory Management Plan is required per 40 CFR 262.214.

Refer to the Subpart K Laboratory Management Plan (Attachment 1) for more detail on handling chemical wastes generated in UMSL laboratories.

B. SHARPS AND LABORATORY GLASSWARE

All sharps must be collected and disposed of in safe, puncture resistant containers. Sharps include non-contaminated lab glassware and pipettes as well as contaminated sharps.

1. SHARPS

Sharps are any object with corners, edges, or projections that when inappropriately handled or disposed are capable of cutting or piercing skin or regular trash bags or waste containers. Examples of sharps include:

- Hypodermic needles, syringes, tubing;
- Blades (scalpels, razors);
- Sharp dental wires and appliances;
- Microscope slides and covers;
- Glass capillary tubes;
- Pasteur pipettes;
- Glass slides or cover slips;
- Laboratory glassware or plastic pipette tips contaminated with an infectious agent;
- ‘Plastic ware’ made from plastic polymers which shatter on breakage (culture flasks, Petri dishes).

Sharps are to be disposed of in safe puncture resistant containers only. Make sure that sharps contaminated with biological, chemical or radioactive materials go into the corresponding sharps container. Never autoclave chemical or radioactive sharps containers.

- Never bend, shear, break or recap disposable needles or remove them from disposable syringes;
- Place used sharps into the sharps disposal container;
- Never reach into the sharps disposal container;
- Never empty the contents of the sharps disposal container into another container;
- Never remove the lid from the sharps container;
• Never overfill a sharps disposal container; no materials should be sticking out the top;
• Never force materials into a sharps disposal container; and
• Contact EHS for pickup when a sharps disposal container is full.

2. SHARPS CONTAINERS

There are a variety of containers that can be used to contain used sharps. For example, a used plastic laundry detergent bottle with a screw on cap could be used to contain sharps. It is important that the container meets the following minimum requirements.

• Rigid construction;
• Non-breakable and puncture resistant;
• Leak proof;
• Closable to minimize exposure to hands; and
• Properly labeled.

3. CONTAMINATED SHARPS

Any object contaminated by human blood, body fluids, or other potentially infectious material that can penetrate the skin including, but not limited to, needles, scalpels, broken glass, broken capillary tubes, and exposed ends of dental wires must be managed appropriately. In addition, all syringes, needles, scalpels and blades, whether contaminated or not, will be treated as if they are contaminated and will be disposed of as such.

• Dispose of immediately into sharps container labeled with the biohazard symbol and the word “Biohazard”;
• Store containers for contaminated sharps disposal upright and easily accessible;
• Close the primary container and place in a labeled secondary container if leakage may occur when transporting contaminated sharps; and
• Do not store sharps in a manner that requires employees to reach into the container where the sharps have been placed.

4. LABORATORY GLASSWARE

Laboratory glassware is any item that could puncture regular trash bags and potentially cause injuries to someone handling the trash bag. Laboratory glassware includes clean and empty broken glassware, bottles, flasks, vials and glass pipettes not used for biohazard or infectious waste. Waste laboratory glassware may be disposed of as regular trash after it has been safely cleaned, packaged and labeled. Laboratory glassware may be disposed of in a cardboard broken glass container obtained from the Chemical Storeroom. The glassware should not be contaminated with hazardous waste or with biohazard waste. Empty chemical bottles, for many chemicals, can be triple rinsed before disposal and the label blackened out or removed. Contact EHS if you have empty chemical bottles contaminated with Highly Hazardous Materials.

• Never handle broken glass directly. Use tongs or a dust pan to gather material;
• Collect laboratory glassware in a sturdy cardboard box that has been lined with a regular trash bag. Never use a “red bag” to line the box. Red or bright orange trash bags are the universal symbols for infectious waste;
• Label the outside of the box “Broken Glass Only.” Ensure that the label is in a location that is readily visible to laboratory occupants. It is acceptable to use a plastic bucket with a lid in lieu of the trash bag-lined cardboard box. Regardless of the type of container used, always ensure you place a “Broken Glass Only” label on the outside. This label communicates the potential hazard to anyone who may handle the container;
• Twist and tape closed the bag top once full, and tape the box top shut. For plastic pails, replace the container lid and ensure a tight seal;
• Ensure that the label remains visible after the box/container has been sealed; and
• Carry the sealed, labeled container directly to the trash dumpster outside of your building. Containers are not to be placed in the recycle dumpsters. Housekeeping may remove these containers if they are properly labeled.

C. BIOLOGICAL WASTE

Biological waste is any material that contains or has been contaminated by a biohazardous agent. A biohazardous agent is biological in nature and has the capacity to adversely affect biological organisms. Biohazardous agents may include bacteria, fungi, viruses, rickettsiae, parasites, and cultured human and animal cells. Biological waste, therefore, may include petri dishes, culture tubes, syringes, blood vials, absorbent material, PPE and pipette tips. Types of biological waste include solid, liquid, animal carcasses, and regulated medical waste. Handling of biological wastes is as follows:

1. SOLID WASTE:

Biological solid wastes are solids that contain biohazardous materials or lab waste that has come in contact with biohazardous materials. These include:

• Culture media;
• Personal Protective Equipment (contaminated);
• Plasticware, including pipette tips; and
• Transgenic plants, including soil.

Disposal Methods: Place material in an autoclave bag, close bag loosely to allow steam into the bag. Place bag in secondary autoclavable bin to catch any liquid. Attach a strip of autoclave tape. Steam sterilize in a validated autoclave using standard operating procedures for solids. Wait until cool. Apply “decontaminated” label and place in black garbage bag for disposal in trash.

2. LIQUID WASTE:

Biological liquid wastes are liquids containing biohazardous waste. These include:

• Liquid culture broths;
- Cell culture media; and
- Animal Blood.

**Disposal Method:** Decontaminate by treating with a solution that is 1 part household bleach diluted with 9 parts water for 30 minutes or steam sterilize in a validated autoclave using standard operating procedures for liquids. If other chemical methods are used for decontamination, the product has to state specifically that it is approved for use on the exact agent to be inactivated.

3. **ANIMAL CARCASS DISPOSAL:**

EHS will provide 55 gallon drums or other containers to the labs for the disposal of non-infectious animal carcasses.

4. **REGULATED MEDICAL WASTE (NON-SHARPS)**

Infectious waste is waste capable of producing an infectious disease and may include sharps (see section IX.B.3), cultures and stocks, and other wastes. Place in Medical Waste containers provided by EHS, which are:

- Closable;
- Constructed to contain all contents and prevent leakage of fluids during handling, storage, transport or shipping;
- Labeled or color-coded and shall include the legend “Biohazard” and/or display the biohazard symbol. These labels shall be fluorescent orange or orange-red or predominantly so, with lettering and symbols in a contrasting color; and
- Closed prior to removal to prevent spillage or protrusion of contents during handling, storage, transport, or shipping. If contamination of the regulated waste container exterior occurs, it shall be placed in a second container. The second container shall be:
  - Closable;
  - Constructed to contain all contents and prevent leakage of fluids during handling, storage, transport or shipping;
  - Labeled or color-coded and shall include the legend “Biohazard” and/or display the biohazard symbol. These labels shall be fluorescent orange or orange-red or predominantly so, with lettering and symbols in a contrasting color;
  - Compliant with DOT regulations for shipping hazardous waste; and
  - Closed prior to removal to prevent spillage or protrusion of contents during handling, storage, transport, or shipping.

Contact EHS for pickup when the container is full.

5. **ETHIDIUM BROMIDE-CONTAMINATED WASTE**

Ethidium Bromide is not regulated by the EPA as a hazardous waste. However, due to its mutagenic properties, its disposal must be managed. Use an EHS “Unwanted Material Pickup Request And Container Filling Log” if you want EHS to pick up and dispose of this material. If
you use the EHS Unwanted Material Pickup Request Form, the container must be kept closed unless you are adding or removing material, and the container must be picked up by EHS within six months.

- Aqueous solutions of Ethidium Bromide may be poured down the sewer after proper treatment. Treatment methods may include
  - Activated Charcoal Filtration using a Green Bag Kit (tea bags).
  - Powdered Activated Charcoal Filtration
  - Funnel Kit with packaged charcoal disk.
  - Lunn and Sansone Method of chemical neutralization
  **NOTE:** Any solid (i.e. charcoal) contaminated with Ethidium Bromide should be managed with the debris in Item 6 below.
  **NOTE:** Do not use an Unwanted Material Pickup Request Form for material you intend to treat. Label the container “TO BE TREATED” or similar verbiage.
- Aqueous solutions of Ethidium Bromide may be managed through EHS as other chemical wastes. If EHS is to manage the aqueous Ethidium Bromide solution, the lab should follow the container labeling and disposal requirements for Unwanted Material.
- If the Ethidium Bromide solution has been contaminated with heavy metals or other hazardous chemicals, it must be managed through EHS as an Unwanted Material.
- Gels containing Ethidium Bromide should be placed in a sturdy plastic bag and placed in a sturdy container. The container should be labeled as “Ethidium Bromide Gels.” The container should be kept closed except when adding waste gels. EHS should be contacted for pickup when the container is full.
- Sharps contaminated with Ethidium Bromide should be placed in a sharps container and managed with other laboratory sharps.
- Gloves, pipette tips and other debris that is visibly contaminated with Ethidium Bromide should be placed in a sturdy plastic bag and then placed in a sturdy container. The container should be labeled as “Ethidium Bromide Debris.” The container should be kept closed except when adding debris. EHS should be contacted for pickup when the container is full.
X. MEDICAL CONSULTATION

University Health Services
University of Missouri-St. Louis
131 Millennium Student Center
One University Blvd.
St. Louis, MO 63121
To make an appointment call: (314) 516-5671

UMSL shall provide laboratory personnel who work with hazardous substances an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

- Whenever a laboratory person develops symptoms associated with a hazardous substance to which they may have been exposed in the laboratory;
- Where exposure monitoring reveals an exposure level routinely above the action level for an OSHA regulated substance. In the absence of an action level, the PEL shall be used; and
- Whenever an event takes place in the laboratory such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure.

UMSL makes the hepatitis B vaccine and vaccination series available to all students and employees who have occupational exposure. Post-exposure evaluation (Section III. C.) and follow-up are also available for personnel who have had an exposure incident. UMSL provides all medical evaluations and procedures including the hepatitis B vaccine and vaccination series and post-exposure evaluation and follow-up:

- At no cost;
- At a reasonable time and place;
- Performed by or under the supervision of a licensed physician or by or under the supervision of another licensed healthcare professional; and
- Confirmed by antibody testing.

If the hepatitis B vaccine series was completed previously and antibody testing has confirmed that the employee is immune, or the vaccine is contraindicated for medical reasons, then no further action is needed.

If the student or employee does not wish to receive the vaccine series, a Hepatitis B Vaccine Declination form must be signed. If the employee initially declines hepatitis B vaccination but at a later date, while still covered under the standard, decides to accept the vaccination, UMSL will provide the hepatitis B vaccination. See Attachment 6 for a sample Hepatitis Vaccine Declination form.
APPENDICES
SOP: HOW TO CONDUCT A RISK ASSESSMENT

PURPOSE
The purpose of this document is to provide assistance for Principal Investigators (PI) and Laboratory Managers in generating risk assessments for any “Highly Hazardous Material” in their laboratories.

The main purpose of any risk assessment is to minimize the risk associated with identified hazards in order to prevent injuries from occurring. Other benefits include improved training and employee education, greater compliance with regulations, increased efficiency, higher quality experiments, and enhanced experimental design.

Completing a risk assessment can be accomplished in 3 steps.

1. Identify the hazards;
2. Assess the hazard and associated risk; and
3. Control the risk.

IDENTIFY THE HAZARDS

In order to manage identifying hazards in the laboratory, the PI needs to define the scope of the process. A scope of work can be defined very narrow, or broader. For example;

- A detailed review of an individual task.
- A given experiment.
- All of the activities within the walls of a laboratory.

One of the primary sources for identifying hazards in the laboratory is the Safety Data Sheet (SDS). Following the Global Harmonization System, the SDS will identify physical hazards, health hazards, and environmental hazards for a chemical. When identifying hazards, it is important to consider the following:

- The material – Carcinogen, corrosive, pyrophoric, toxic, flammable, etc.
- The conditions – Temperature, pressure, noise, clutter, pinch points, etc.
- The activities – Lifting, mixing, repetitive actions, pipetting, handling glassware, heating, etc.

ASSESS THE HAZARDS

There are a number of techniques that can be used to evaluate the hazards identified in Step 1. Depending on the experience of the team, different techniques may be appropriate. Possible assessment techniques include Job Hazard Analyses (JHA), What-If Analyses, and Failure Mode and Effects Analyses (FMEA). Each of the following questions must be considered.
• What can go wrong?
• Why would the failure occur?
• What are the consequences if something does go wrong?
• What conditions could enable something to go wrong?
• Are there other contributing factors?
• How likely is it that a hazardous situation will occur?
• What should be done if something goes wrong?

CONTROL THE RISK

The most effective control is to eliminate the hazard all together. Eliminating the hazard could require removing a piece of equipment or not handling a specific chemical. Similarly, a PI may substitute a highly hazardous chemical or procedure for a chemical or procedure with lower associated hazards.

The next most effective control is engineering controls. Engineering controls are those that involve making changes to the work environment to reduce work related hazards. These types of controls are preferred over all others because they make permanent changes that reduce exposure to hazards and do not rely on worker behavior. Fume hoods or biological safety cabinets are commonly used laboratory engineering controls used to keep hazards physically away from personnel.

Administrative controls and work practices are those that modify workers’ work schedules and tasks in ways that minimize their exposure to workplace hazards, such as a written Standard Operating Procedure (SOP), exposure time limits, and training.

The last line of defense is Personal Protective Equipment (PPE). PPE is protective gear needed to keep workers safe while performing their jobs. Sometimes, all three types of controls will be required to keep workers safe. PPE should be implemented when engineering controls do not provide sufficient protection or are not feasible. It is important that PPE be:

• Selected based upon the hazard to the worker;
• Properly fitted and in some cases periodically refitted;
• Conscientiously and properly worn;
• Regularly maintained and replaced in accord with the manufacturer’s specifications;
• Properly removed and disposed of to avoid contamination of self, others or the environment; and
• If reusable, properly removed, cleaned, disinfected and stored.

REVIEW THE RESULTS OF THE RISK ASSESSMENT

It is important to periodically review procedures, especially if an injury or illness occurs. Even if the tasks involved in an experiment have not changed, a review can identify hazards not recognized in the initial assessment. Keep track of and review close calls or near misses that
occur in the lab. This may indicate that an SOP needs to be revised, or personnel may require additional training.

**General risk assessments** for oxidizers and for corrosive, flammable, and water reactive materials are included in this document.

These general risk assessments may be used “as is,” used with modification, or completely rewritten by PIs and Lab Managers in generating risk assessment documents for the highly hazardous materials in their laboratories.
GENERAL RISK ASSESSMENT: CORROSIVE CHEMICALS

I. IDENTIFY THE HAZARD

The primary hazards associated with corrosive chemicals are skin damage and irritation, eye damage, damage due to inhalation, and metal corrosion. In addition, some corrosive chemicals may also be flammable. Refer to the General Risk Assessment: Flammable Chemicals when working with flammable and corrosive chemicals.

In order to better understand corrosive chemicals, it is important to understand strength and concentration.

- Strength relates to the percentage of ionization that occurs when an acid or base is mixed with water. A strong acid or base will almost totally ionized in water. The extent of ionization will drive the reaction since it is the ions that are reacting. A stronger acid or base will produce damage sooner than a weaker acid, in general.
- Concentration is the amount of acid or base mixed with a certain amount of water. The concentration will affect the pH of the solution.

Acids will generally damage proteins and will be noticeable upon exposure. Bases damage proteins and fats and the damage may not be noticeable for some time. Since bases affect proteins and fats, base exposure can cause more damage than acid exposure.

Corrosive gases and vapors can be an inhalation hazard. Lung tissue can be damaged due to inhalation of corrosive vapors. Safety Data Sheets (SDS) will provide OSHA Permissible Exposure Limits (PEL) data above which respiratory protection is required.

II. ASSESS THE HAZARD

Exposures can result from:
- Chemical spills.
- Poor laboratory technique.
- Poor ventilation in the lab.
- Reaction that generates vapors not being conducted in the fume hood.

In case of a corrosive chemical spill, follow the steps outlined in Section III, Emergency Response Procedures in the UMSL Laboratory Safety Plan. See also Table III-1, Absorbents for Common Laboratory Chemicals in the Laboratory Safety Plan.

Use of certain acids, such as hydrofluoric acid and trifluoroacetic acid, should have a risk assessment completed specific to that acid and its hazards. The general risk assessment will not provide adequate protection from exposure to these acids.
III. CONTROL THE RISK

Eliminate the hazards: Whenever possible, replace the corrosive chemical with a non-corrosive chemical. If a non-corrosive chemical substitute is not available, replace the corrosive chemical with a less corrosive chemical, or use a more dilute solution. Due to the nature of research and teaching laboratories, it may not be possible to eliminate the use of corrosive chemicals.

Engineering Controls:
- Storage
  - Store corrosive chemicals in glass shatterproof bottles.
  - Store corrosive chemicals in corrosive storage cabinets.
- Fume hoods
  - Ensure proper ventilation (measured as face velocity).
  - Ensure sash is kept closed.
- Safety shower / Eyewash
  - Access must be unobstructed.
  - Shower is tested and tagged every six months.
  - Eyewash is tested and tagged every six months.
  - If eyewash bottles are used, verify expiration date.
- Lab ware should be heat resistant due to possibility of exothermic reactions.

Administrative Controls:
- Storage
  - Only store the minimal amount of corrosive chemicals necessary in the lab.
  - Segregate acids and bases.
  - Segregate corrosive chemicals from oxidizers and other incompatible materials.
  - Store corrosive chemicals in secondary containment.
  - All secondary containers must be labeled with contents and hazard.
  - Minimize storage in the fume hood.
  - Do not store corrosive chemicals above eye level.
- Operations
  - Always transport corrosive chemicals in a secondary container.
  - Always add acid or base to water, not the other way.
  - Since reactions may be exothermic, allow for extra volume in reaction vessel.
  - Ensure all laboratory personnel know evacuation routes in the case of an emergency.
  - Ensure laboratory personnel do not work alone when working with corrosive chemicals.
  - Generate lab specific standard operating procedures (SOPs), as needed, for handling.
  - Ensure SDSs are readily available.
  - Ensure all laboratory personnel know the symptoms of exposure and cease work immediately if they develop any of the symptoms.
When a large amount of vapor may be released, the chemical must be managed in the fume hood.

Immediately cleanup any corrosive chemical spill using appropriate absorbent.

Personal Protective Equipment:
- Eye protection must be worn in the lab.
- Goggles are more appropriate if there is potential for splash or spray.
- Gloves should be chosen based on their resistance to the chemicals being handled.
- A face shield, rubber apron and rubber boots may be appropriate depending upon chemicals and work being performed.
GENERAL RISK ASSESSMENT: FLAMMABLE CHEMICALS

I. IDENTIFY THE HAZARD

Fire and explosion are the primary hazards associated with the use, transport and storage of flammable chemicals. For a fire to start, the following conditions are required:

- Fuel source with a concentration in the flammable range
- Oxygen
- Ignition source

Additional oxygen may not be needed if an oxidizer is present. An ignition source may not be needed if the flammable chemical is heated above its auto-ignition temperature.

Flammable chemicals burn when the vapors released from the liquid ignite. Some of the physical properties of the chemical will provide information that may be used to assess the potential fire hazard.

- Flash Point – the lowest temperature at which the chemical will give off sufficient vapors to ignite.
- Flammable Range – the range of a concentration for an ignition point for a chemical.
- Vapor Pressure – measure of the chemical’s tendency to vaporize.
- Vapor Density – weight of a vapor compared to an equal volume of air. If greater than 1.0, the vapor is heavier than air and may concentrate in low places.
- Boiling Point – temperature at which the vapor pressure is equal to the pressure of the gas above it.
- Viscosity – a chemical’s resistance to flow. A chemical with a low viscosity may spread quickly if spilled, allowing more surface area for evaporation.
- Auto-ignition Temperature – the lowest temperature at which a chemical will auto-ignite in normal conditions without an external ignition source.

Ignition sources can include:

- Thermal sources: Flames from pilot lights, burners, hot plates, electric heaters, electric lamps.
- Electrical sources: Electric motors, cable breaks, electrostatic discharge.
- Mechanical sources: Friction heat.
- Chemical sources: Exothermic reactions.

The physical environment needs to be considered when assessing the hazards associated with flammable chemicals. Vapors may build up in poorly ventilated areas.
Other hazards may result when flammable chemicals burn.

- Potential production of toxic substances (carbon monoxide).
- Potential production of irritating gases.
- Potential oxygen deficiency as oxygen is consumed.

II. ASSESS THE HAZARD

Research and teaching laboratories manage all of the components necessary to support a fire. There are flammable chemicals, oxidizing chemicals, sources of ignition or heat, and oxygen. Each lab will need to review its practices for managing chemicals.

A flammable condition can result from:
- Chemical spills.
- Open containers, including containers not properly closed.
- Handling flammable materials outside of a fume hood.
- Poor ventilation in the laboratory.
- Poor laboratory technique.
- Inappropriate storage (i.e., storing flammable liquids in non-rated refrigerator).

Ignition can result from:
- Static charge from transferring materials.
- Open flames.
- Overheated electrical equipment.
- Hot plates.
- Exposed electrical.

Consequences of a laboratory fire could include personal injury, property damage, loss of use of facilities, and lost research.

In case of a flammable chemical spill, follow the steps outlined in Section III, Emergency Response Procedures in the UMSL Laboratory Safety Plan.

In the event of a fire:
- Sound the fire alarm.
- If trained to fight an incipient fire, use the appropriate fire extinguisher. Make sure to keep your back to an unblocked exit.
- Evacuate the building and assist handicapped personnel.
- Notify the Police Dispatch at 911 from a university phone or at 314-516-5155.
- Do not let unauthorized personnel enter the building.
III. CONTROL THE RISK

Eliminate the hazards: Whenever possible, replace the flammable chemical with a non-flammable chemical. If a non-flammable chemical substitute is not available, replace the flammable chemical with a less flammable chemical (one with a higher flash point). Due to the nature of research and teaching laboratories, it may not be possible to eliminate the use of flammable chemicals. Wherever possible, eliminate ignition sources such as hot plates, open flames, and static electricity.

Engineering Controls:
- Storage
  - Store flammable chemicals in flammable storage cabinets and safety cans.
  - Refrigerators and freezers storing flammable chemicals shall be explosion proof.
- Fume hoods
  - Ensure proper ventilation (measured as face velocity).
  - Ensure sash is kept closed.
- Safety shower
  - Access must be unobstructed.
  - Shower is tested and tagged every six months.
- Equipment
  - Electrical equipment should be explosion proof.
  - Unattended heating equipment should have an over-temperature shutoff switch.
  - Electrically heated temperature baths should have an over-temperature shutoff switch.
  - Ensure the appropriate type of fire extinguisher is available with current inspections.

Administrative Controls:
- Storage
  - Only store the minimal amount of flammable chemicals necessary in the lab.
  - Segregate flammable chemicals from oxidizing chemicals.
  - Limit flammable liquid storage to quantities in Table V-3 of the UMSL Laboratory Safety Plan.
  - All secondary containers must be labeled with contents and hazard.
  - Minimize storage in the fume hood.
- Operations
  - Ensure all laboratory personnel know locations of fire alarm pull stations, safety showers and other emergency equipment.
  - Ensure all laboratory personnel know evacuation routes in the case of an emergency.
  - Ensure laboratory personnel do not work alone when working with flammable chemicals.
 Generate lab specific standard operating procedures (SOPs), as needed, for handling.

- Ensure safety data sheets (SDS) are readily available.
- Ensure all laboratory personnel know the symptoms of solvent vapor exposure and cease work immediately if they develop any of the symptoms.
- When a large amount of vapor may be released, the chemical must be managed in the fume hood.
- Immediately cleanup any flammable chemical spill using appropriate absorbent.

**Personal Protective Equipment:**

- Typical laboratory PPE
  - Closed toe shoes
  - Safety glasses
- Goggles are more appropriate if there is potential for splash or spray.
- Chemically resistant gloves should be worn.
- Fire retardant lab coat is recommended. Avoid synthetic fibers. Wear 100% cotton or natural fiber clothing.
GENERAL RISK ASSESSMENT: OXIDIZING CHEMICALS

I. IDENTIFY THE HAZARD

Oxidizing chemicals may include peroxides, chlorates, perchlorates, nitrates and permanganates. Oxidizing chemicals evolve oxygen at room temperatures or slightly elevated temperatures. The presence of an oxidizing chemical may cause or intensify a fire. Explosive mixtures may be formed when oxidizing chemicals are mixed with flammable, organic or other easily oxidized materials.

Fire and explosion are the primary hazards associated with the use, transport and storage of oxidizing chemicals. For a fire to start, the following conditions are required:

- Fuel source with a concentration in the flammable range
- Oxygen
- Ignition source

Ignition sources can include:

- Thermal sources: Flames from pilot lights, burners, hot plates, electric heaters, electric lamps.
- Electrical sources: Electric motors, cable breaks, electrostatic discharge.
- Mechanical sources: Friction heat.
- Chemical sources: Exothermic reactions.

Please refer to the General Risk Assessment: Flammable Chemicals for information specific to flammable chemical hazards.

II. ASSESS THE HAZARD

Research and teaching laboratories manage all of the components necessary to support a fire. There are flammable chemicals, oxidizing chemicals, sources of ignition or heat, and oxygen. Each lab will need to review its practices for managing chemicals.

An oxidizing chemical can increase the risk of a fire through:

- Chemical spills.
- Open containers, including containers not properly closed.
- Not handling oxidizing materials in a fume hood.
- Improper storage.
- Poor ventilation in the laboratory.
- Poor laboratory technique.
Ignition can result from:
- Static charge from transferring materials.
- Open flames.
- Overheated electrical equipment.
- Hot plates.

III. CONTROL THE RISK

Eliminate the hazards: Whenever possible, replace the oxidizing chemical with a non-oxidizing chemical. Due to the nature of research and teaching laboratories, it may not be possible to eliminate the use of oxidizing chemicals. Wherever possible, eliminate ignition sources such as hot plates, open flames, and static electricity.

Engineering Controls:
- Fume hoods
  - Ensure proper ventilation (measured as face velocity).
  - Ensure sash is kept closed.
  - Only use perchloric acid in a fume hood designed and labeled for perchloric acid use.
- Safety shower and eye wash
  - Access must be unobstructed.
  - Shower is tested and tagged every six months.
  - Eye wash is tested and tagged every six months.
  - If eye wash bottles are used, they are changed out based on expiration date.
- Equipment
  - Electrical equipment should be explosion proof.
  - Unattended heating equipment should have an over-temperature shutoff switch.
  - Electrically heated temperature baths should have an over-temperature shutoff switch.
  - Ensure the appropriate type of fire extinguisher is available with current inspections.

Administrative Controls:
- Storage
  - Only store the minimal amount of oxidizing chemicals necessary in the lab.
  - Segregate oxidizing chemicals from other chemicals.
  - Store nitric acid away from other acids.
  - All secondary containers must be labeled with contents and hazard.
  - Minimize storage in the fume hood.
- Operations
  - Ensure all laboratory personnel know locations of fire alarm pull stations, safety showers and other emergency equipment.
o Ensure all laboratory personnel know evacuation routes in the case of an emergency.
o Ensure laboratory personnel do not work alone when working with oxidizing chemicals.
o Generate lab specific standard operating procedures (SOPs), as needed, for handling.
o Ensure safety data sheets (SDS) are readily available.
o Ensure all laboratory personnel know the symptoms of exposure and cease work immediately if they develop any of the symptoms.
o When a large amount of vapor may be released, the chemical must be managed in the fume hood.
o Immediately cleanup any chemical spill using appropriate absorbent.

Personal Protective Equipment:
• Typical laboratory PPE
  o Closed toe shoes
  o Safety glasses
• Goggles are more appropriate if there is potential for splash or spray.
• Chemically resistant gloves should be worn.
• Avoid synthetic fibers. Wear 100% cotton or natural fiber clothing.
• A lab coat, or long sleeves, should be worn when handling oxidizing chemicals.
GENERAL RISK ASSESSMENT: WATER REACTIVE CHEMICALS

I. IDENTIFY THE HAZARD

Water reactive chemicals will react violently with water releasing large amounts of heat and potentially explosive by-products. Alkali metals react with water to produce the hydroxide and hydrogen gas. The heat generated by the reaction may be enough to ignite the hydrogen gas. Please refer to the General Risk Assessment: Corrosive Chemicals for handling the hydroxide. Please refer to the General Risk Assessment: Flammable Chemicals for managing the flammable hazard.

Water reactive potassium metal may also form peroxides during storage. It is important to note date received, date opened, and expiration when storing peroxide forming chemicals in the laboratory.

The hazards associated with water reactive materials are related to the formation of hydroxides (corrosive materials), generation of hydrogen gas (flammable gas), and formation of peroxides.

II. ASSESS THE HAZARD

Research and teaching laboratories will handle water reactive chemicals. Hazardous conditions can result from:

- Improper storage.
- Conducting experiments outside of a glove box with an inert atmosphere.
- Not using clean, dry and rust free tools.
- Exposed ignition sources.
- Prolonged storage of peroxide forming chemicals. Peroxide formation may be indicated by crystallization, discoloration or stratification.

III. CONTROL THE RISK

Eliminate the hazards: Whenever possible, replace the water reactive chemical with one that is not water reactive. Due to the nature of research and teaching laboratories, it may not be possible to eliminate use of water reactive chemicals.

Engineering Controls:

- Handling
  - Handle materials in a glove box with an inert atmosphere.
  - All tools used should be compatible with the chemicals used.
- Safety shower
  - Access must be unobstructed.
o Shower is tested and tagged every six months.

- Fire extinguisher
  o Proper type of fire extinguisher is readily available.
  o Personnel who may use fire extinguisher have been trained on use and hazards associated with incipient fire fighting.
  o Inspections are current.

Administrative Controls:
- Storage
  o Only store the minimal amount of water reactive chemicals necessary in the lab.
  o Segregate water reactive from incompatibles, such as acids and halogenated hydrocarbons.
  o Store away from combustible materials, such as paper towels and Kimwipes.
  o Store under inert atmosphere or under mineral oil.
  o Store in a stable location where the material is protected from tipping or falling.
  o If you notice any signs of peroxide formation, do not move the container. Contact EHS.

- Operations
  o Ensure all laboratory personnel know locations of fire alarm pull stations, fire extinguishers, and other emergency equipment.
  o Ensure all laboratory personnel know evacuation routes in case of an emergency.
  o Ensure laboratory personnel do not work alone when working with water reactive chemicals.
  o Generate lab specific standard operating procedures (SOPs), as needed.
  o Ensure safety data sheets (SDS) are readily available.
  o Ensure laboratory personnel know the symptoms of exposure and cease work immediately if they develop any of the symptoms.

Personal Protective Equipment:
- Avoid skin contact
  o Wear appropriate gloves.
  o Wear apron or appropriate clothing to prevent skin contact.
  o A fire retardant lab coat is recommended.
  o Clothing should be cotton or wool. Synthetic fiber materials are strongly discouraged.

- Avoid eye contact
  o Wear safety goggles.
  o Wear faceshield.
GENERAL SOP FOR WORKING WITH COMPRESSED GASES

PROCESS OR EXPERIMENT DESCRIPTION

This standard operating procedure (SOP) is intended to provide general guidance on how to safely work with compressed gases. This SOP is generic in nature, and only addresses safety issues specific to compressed gases. In some instances, several general use SOPs may be applicable for a specific chemical (i.e., for flammable gases, both this general use SOP and the general use SOP for flammables would apply). If you have questions concerning the applicability of any item listed in this procedure contact the Principal Investigator/Laboratory Supervisor of your laboratory or Environmental Health and Safety. Specific written procedures are the responsibility of the Principal Investigator.

Globally Harmonized System of Classification

Compressed gases have inherent pressure hazards and can also create hazardous and/or flammable atmospheres. Common hazard characteristics of gases include flammability, toxicity, and corrosivity. A few gases (i.e., silane, diborane, phosphine) are considered pyrophoric (will ignite spontaneously in air). One additional hazard property common to all compressed gases is the substantial volume expansion when released to air. Gas release in an inadequately ventilated room can create an oxygen-deficient environment. The GHS includes compressed gases as part of gases under pressure.

Control of Hazards—General

- Secure cylinders using wall straps, stands, or carts designed for this purpose.
- Minimize the quantity of compressed gasses stored in an area to the smallest amount needed.
- Check connections and hoses regularly for leaks using a specific monitoring instrument or soapy water (or equivalent).
- When using highly flammable or toxic gas, check the delivery system using an inert gas prior to introducing the hazardous gas.
- When using compressed acetylene: (i) do not exceed a working pressure of 15 psig, and (ii) do not use vessels, piping, or other materials that contain a significant amount of copper (usually considered to be more than 50% copper).
- Replace valve caps when cylinders are not in use or before moving.
- Remove damaged or defective cylinders from service (contact the cylinder vendor for assistance).

Engineering/Ventilation Controls

Manipulation of compressed gases should typically be carried out in a fume hood, with the sash as far down as feasible, if the compressed gas is an irritant, oxidizer, asphyxiant, or has other associated hazards. If the process does not permit gas use and/or storage in well-ventilated areas (i.e., lab ventilation having a minimum of 6 air changes per hour), contact Environmental Health and Safety to determine necessity of an oxygen-deficiency monitor or other alarm devices.
Certain compressed gasses are also considered highly hazardous substances (e.g., hydrogen cyanide) and may require use of a fume hood (due to toxicity potential) in any quantity.

**PERSONAL PROTECTIVE EQUIPMENT**

At minimum, lab coats, safety glasses, and closed toed shoes should be worn when handling compressed gases. Depending on the hazard characteristics, additional protective equipment may be necessary.

**STORAGE REQUIREMENTS**

Safe Handling:

- Compressed gas cylinders must be transported using hand-trucks or other appropriate means. NEVER TRANSPORT UNSECURED COMPRESSED GAS CYLINDERS!
- Cylinders should be transported upright whenever possible (always transport acetylene in an upright (vertical) position).
- Never drop cylinders or permit them to strike each other violently.
- Do not drag, roll, or slide cylinders, even for a short distance. Use a cylinder hand truck to move them.
- Never tamper with safety devices in valves or cylinders.
- Use the correct regulator and pressure gauge for the type of gas cylinder in use. Beware extended use of some regulators may cause them to freeze up. Use of an "adapter" or cross-threading of a valve fitting should not be attempted. The threads on cylinder valves, regulators, and other fittings should be examined to ensure that they correspond to one another and are undamaged.
- Use compressed gases only in well-ventilated areas. Toxic, flammable, and corrosive gases should be handled in a hood. Only small cylinders of toxic gases should be used.
- Use a trap or suitable check valve when discharging gas into a liquid to prevent liquid from getting back into the cylinder or regulator.
- Close the valve before shipment, leaving some positive pressure in the cylinder. Replace any valve outlet and protective caps originally shipped with cylinder.
- Read all label information and SDS before using cylinders. Check the SDS for required personal protective equipment and hazard Information before use.
- Follow the precautions detailed in Flammables when working with a flammable gas.
- Wear safety goggles when handling cryogens. If there is a splash or spray hazard, personnel protective clothing should also include a face shield, impervious apron or coat, trousers without cuffs, and shoes that cover the foot.
- Wear gloves designed for use with liquid cryogens to protect hands from burns and excessive cold.
- Ensure pressure relief mechanisms are on containers and systems containing cryogens.
- Make sure identifying labels are legible.
Safe Storage:

- Cylinders should be stored in an upright position and secured to a wall or lab bench through the use of chains or straps.
- Do not subject any part of a cylinder to temperatures higher than 125° F. A flame should never be permitted to come in contact with any part of a compressed gas cylinder.
- Do not store full and empty cylinders together unless they are part of a regulated tank farm that will not allow empty tanks to be opened to a pressurized system. Serious suck-back can occur when an empty cylinder is attached to a pressurized system.
- Bond and ground all cylinder, lines, and equipment used with flammable compressed gases.
- Label cylinders “Full”, “In Use” or "Empty." Place a start date on the cylinder once use begins and an end date when empty. Store empty cylinders in a designated area for return.
- Cylinder caps should remain on the cylinder at all times unless a regulator is in place/use.
- Segregate and clearly mark full and empty ("MT") cylinders.
- Store compressed gas cylinders away from heat sources, and flammable and highly combustible materials (such as oil and greases).
- Segregate according to hazard class and chemical compatibility. Ensure to separate flammable and oxidizing gases.
- Store flammable gases away from flammable solvents, combustible material, ignition sources (including unprotected electrical connections), and oxygen gas cylinders and liquid oxygen (at least 20 feet if possible).
- Follow all substance-specific storage guidance provided in SDS documentation.

**LABELING**

All compressed gases must be clearly labeled with the correct chemical name in English. All compressed gases should have the appropriate hazard class(es) on the label. The label should be facing forward and legible.

**SPILL PROCEDURES**

For all known or suspect releases to the environment, notify EHS at 314-516-6363, 314-516-6362, or 314-516-6360 during normal business hours, or the Campus Police at 314-516-5155 after normal business hours. EHS will make any required notifications to regulatory agencies.

For a release of a compressed gas,

- Secure the area such that no one can enter without proper authorization;
- Notify Campus Police at 911;
- Alert others to leave the area;
- Remove ignition sources, shut down equipment, close fume hood sash, and open windows, if you can do so safely;
- Close the doors to the laboratory;
- Contact others on your lab emergency notification form;
• Assemble at a safe distance; and
• Provide technical assistance to emergency responders.

DISPOSAL OF UNWANTED MATERIALS

Compressed gasses must be recycled or returned to their vendor.

MINIMUM TRAINING REQUIREMENTS

Each lab should document lab specific training provided by the Principal Investigator or Lab Supervisor.

APPROVAL REQUIRED

Principal Investigators must be consulted and give personnel and students approval prior to obtaining compressed gases for the laboratory, particularly for new chemicals and those listed as HHM in the LSP.

DECONTAMINATION PROCEDURES

Refer to the specific hazard category (i.e.; toxin or corrosive) for decontamination requirements.
GENERAL SOP FOR WORKING WITH TOXIC CHEMICALS

PROCESS OR EXPERIMENT DESCRIPTION

This standard operating procedure (SOP) is intended to provide general guidance on how to safely work with materials having high acute toxicity, also referred to as highly toxic materials. This SOP is generic in nature and only addresses safety issues specific to the high acute toxicity of chemicals. In some instances, several general use SOPs may be applicable for a specific chemical (i.e., for carbon monoxide gas, general use SOPs for highly toxics, flammables, and compressed gases could apply). If you have questions concerning the applicability of any item listed in this procedure contact the Principal Investigator/Laboratory Supervisor of your laboratory or Environmental Health and Safety. Specific written procedures are the responsibility of the Principal Investigator.

GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION

The GHS divides toxic chemicals by health effect. The categories are; Acute Toxicity, Reproductive Toxicity, Target Organ System Toxicity, Aspiration Hazard Toxicity, Sensitizers, Mutagens, and Carcinogens.

ACUTE TOXICITY

Substances are assigned to one of the five toxicity categories on the basis of LD$_{50}$ (oral, dermal) or LC$_{50}$ (inhalation). The LC$_{50}$ values are based on 4-hour tests in animals. The GHS provides guidance on converting 1-hour inhalation test results to a 4-hour equivalent. The five categories are shown below.

<table>
<thead>
<tr>
<th>Acute toxicity</th>
<th>Cat. 1</th>
<th>Cat. 2</th>
<th>Cat. 3</th>
<th>Cat. 4</th>
<th>Category 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral (mg/kg)</td>
<td>≤ 5</td>
<td>&gt; 5 ≤ 50</td>
<td>&gt; 50 ≤ 300</td>
<td>&gt; 300 ≤ 2000</td>
<td>Criteria:</td>
</tr>
<tr>
<td>Dermal (mg/kg)</td>
<td>≤ 50</td>
<td>&gt; 50 ≤ 200</td>
<td>&gt; 200 ≤ 1000</td>
<td>&gt; 1000 ≤ 2000</td>
<td>• Anticipated oral LD50 between 2000 and 5000 mg/kg;</td>
</tr>
<tr>
<td>Gases (ppm)</td>
<td>≤ 100</td>
<td>&gt; 100 ≤ 500</td>
<td>&gt; 500 ≤ 2500</td>
<td>&gt; 2500 ≤ 5000</td>
<td>• Indication of significant effect in humans;*</td>
</tr>
<tr>
<td>Vapors (mg/l)</td>
<td>≤ 0.5</td>
<td>&gt; 0.5 ≤ 2.0</td>
<td>&gt; 2.0 ≤ 10</td>
<td>&gt; 10 ≤ 20</td>
<td>• Any mortality at category 4;*</td>
</tr>
<tr>
<td>Dust &amp; mists (mg/l)</td>
<td>≤ 0.05</td>
<td>&gt; 0.05 ≤ 0.5</td>
<td>&gt; 0.5 ≤ 1.0</td>
<td>&gt; 1.0 ≤ 5</td>
<td>• Significant clinical signs at category 4;*</td>
</tr>
</tbody>
</table>
*Indications from other studies.* |
*If assignment to more hazardous class is not warranted.

Category 5 has been included to identify substances that are of a relatively low acute toxicity hazard, but which may present a hazard to vulnerable populations.
**Reproductive Toxicity**

Reproductive toxicity includes adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in offspring. Substances and mixtures with reproductive and/or developmental effects are assigned to one of two hazard categories, 'known or presumed' and 'suspected'. Category 1 has two subcategories for reproductive and developmental effects. Materials which cause concern for the health of breastfed children have a separate category, Effects on or Via Lactation.

<table>
<thead>
<tr>
<th>Category 1</th>
<th>Category 2 Suspected</th>
<th>Additional Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Known or presumed to cause effects on human reproduction or on development</td>
<td>Human or animal evidence possibly with other information</td>
<td>Effects on or via lactation</td>
</tr>
<tr>
<td>Category 1A Known</td>
<td>Category 1B Presumed Based on experimental animals</td>
<td></td>
</tr>
<tr>
<td>Based on human evidence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Target Organ Systemic Toxicity (TOST): Single Exposure & Repeated Exposure**

The GHS distinguishes between single and repeat exposure for Target Organ Effects. Some existing systems distinguish between single and repeat exposure for these effects and some do not. All significant health effects, not otherwise specifically included in the GHS, that can impair function, both reversible and irreversible, immediate and/or delayed are included in the non-lethal target organ/systemic toxicity class (TOST). Narcotic effects and respiratory tract irritation are considered to be target organ systemic effects following a single exposure.

Substances and mixtures of the single exposure target organ toxicity hazard class are assigned to one of three hazard categories as shown below.

<table>
<thead>
<tr>
<th>Category 1</th>
<th>Category 2</th>
<th>Category 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant toxicity in humans&lt;br&gt;- Reliable, good quality human case studies or epidemiological studies&lt;br&gt;Presumed significant toxicity in humans&lt;br&gt;- Animal studies with significant and/or severe toxic effects relevant to humans at generally low exposure (guidance)</td>
<td>Presumed to be harmful to human health&lt;br&gt;- Animal studies with significant toxic effects relevant to humans at generally moderate exposure (guidance)&lt;br&gt;- Human evidence in exceptional cases</td>
<td>Transient target organ effects&lt;br&gt;- Narcotic effects&lt;br&gt;- Respiratory tract irritation</td>
</tr>
</tbody>
</table>

Substances and mixtures of the repeated exposure target organ toxicity hazard class are assigned to one of two hazard categories shown below.
ASPIRATION HAZARD

Aspiration toxicity includes severe acute effects such as chemical pneumonia, varying degrees of pulmonary injury or death following aspiration. Aspiration is the entry of a liquid or solid directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system. Some hydrocarbons (petroleum distillates) and certain chlorinated hydrocarbons have been shown to pose an aspiration hazard in humans. Primary alcohols and ketones have been shown to pose an aspiration hazard only in animal studies.

<table>
<thead>
<tr>
<th>CATEGORY 1</th>
<th>CATEGORY 2</th>
</tr>
</thead>
</table>
| Significant toxicity in humans  
- Reliable, good quality human case studies or epidemiological studies  
- Presumed significant toxicity in humans  
- Animal studies with significant and/or severe toxic effects relevant to humans at generally low exposure (guidance)  | Presumed to be harmful to human health  
- Animal studies with significant toxic effects relevant to humans at generally moderate exposure (guidance)  
- Human evidence in exceptional cases |

SENSITIZERS

A respiratory sensitizer is a substance that induces hypersensitivity following inhalation of the substance. A skin sensitizer is a substance that will induce an allergic response following skin contact.

MUTAGENS

Mutagen means an agent giving rise to an increased occurrence of mutations in populations of cells and/or organisms. Substances and mixtures are assigned to one of two hazard categories, as shown below.
A carcinogen is a substance or a mixture of substances which induce cancer or increase its incidence. Substances and mixtures are assigned to one of two hazard categories. Category 1, known or presumed carcinogens has two subcategories.

1. Subcategory 1A: known human carcinogen based on human evidence
2. Subcategory 1B: presumed human carcinogen based on demonstrated animal carcinogenicity.

Category 2 is suspected carcinogens.

**CONTROL OF HAZARDS—GENERAL**

Although the specific SOPs will vary according to the material used, the following guidelines are generally applicable for projects involving toxic materials:

1. Use the smallest amount of chemical that is consistent with the requirements of the work to be performed.
2. Use containment devices (such as lab fume hoods or glove boxes) when: (i) volatilizing these substances, (ii) manipulating substances that may generate aerosols, and (iii) performing laboratory procedures that may result in uncontrolled release of the substance.
3. Use high efficiency particulate air (HEPA) filters, carbon filters, or scrubber systems with containment devices to protect effluent and vacuum lines, pumps, and the environment whenever feasible.
4. Use ventilated containment to weigh out solid chemicals. Alternatively, the tare method can be used to prevent inhalation of the chemical. While working in a laboratory hood, the chemical is added to a pre-weighed container. The container is then sealed and can be re-weighed outside of the hood. If chemical needs to be added or removed, this manipulation is carried out in the hood. In this manner, all open chemical handling is conducted in the laboratory hood.
5. Conduct a risk assessment and develop safe lab specific standard operating procedures before undertaking laboratory operations with toxins.
6. Review SDS and do additional research if necessary.
7. Use less toxic materials if possible.
8. Be aware that combining two chemicals may produce a product with a much higher toxic effect.
9. Be aware that heating substances may increase the airborne concentration of toxic substances.
10. Use appropriate protective equipment.
11. Be prepared for spills and know how and when to take emergency action.
12. Wash hands and arms immediately after working with toxic chemicals.
13. Store toxins in sealed, labeled and secured containers to restrict access.
14. Transport toxic chemicals in shatter resistant secondary containment containers.
15. Refrigerators and other storage containers should be clearly labeled and provide contact information for trained, responsible laboratory staff.

**ENGINEERING/VENTILATION CONTROLS**

Use a properly functioning, certified lab fume hood when handling toxic materials. If the process does not permit the handling of such materials in a fume hood, contact Environmental Health and Safety for reviewing the adequacy of ventilation measures.

**PERSONAL PROTECTIVE EQUIPMENT**

At minimum, safety glasses, lab coat, long pants, and closed toed shoes are to be worn when entering laboratories having hazardous chemicals

Additionally:

- When handling hazardous chemicals or contacting potentially contaminated surfaces, protective gloves are to be worn. Disposable nitrile gloves provide adequate protection against accidental hand contact with small quantities of most laboratory chemicals, but for proper selection of glove material where direct or prolonged contact with hazardous chemicals is anticipated, review the chemical’s safety data sheet, a glove selection guide or contact the glove manufacturer.
- Goggles (not safety glasses) are appropriate for processes where splash or spray is foreseeable.
- For hazardous chemicals that are toxic via skin contact/ absorption, additional protective clothing (i.e., facemask, apron, oversleeves) is appropriate where chemical contact w/ body/ skin is foreseeable.

**SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS**

Ensure secondary containment and segregation of incompatible chemicals per guidance in the LSP. Also, follow any substance-specific storage guidance provided in the substances’ safety data sheets.
LABELING

All materials must be clearly labeled with the correct chemical name in English. Handwritten labels are acceptable; chemical formulas and structural formulas are not acceptable. Appropriate hazard class(es) should be listed on the label.

SPILL PROCEDURES

For all known or suspect releases to the environment (air, water or land), notify EHS at 314-516-6363, 314-516-6362, or 314-516-6360 during normal business hours, or the Campus Police at 314-516-5155 after normal business hours. EHS will make any required notifications to regulatory agencies.

MAJOR SPILL

A major spill is one that is spreading rapidly and presents inhalation or fire hazards, has entered the environment, or exceeds the capacity of the laboratory user to respond.

- Secure the area such that no one can enter without proper authorization;
- Notify Campus Police at 911;
- Alert others to leave the area;
- Remove ignition sources, shut down equipment, close fume hood sash, and open windows, if you can do so safely;
- Close the doors to the laboratory;
- Contact others on your lab emergency notification form;
- Assemble at a safe distance; and
- Provide technical assistance to emergency responders.

MINOR SPILL

A minor spill is one that can easily be managed by laboratory personnel. Response items are as follows:

- Attend to any person who may have been contaminated;
- Notify persons in the immediate area of the spill;
- Secure the area so extraneous personnel do not enter;
- Evacuate non-essential personnel from the area of the spill;
- Notify Campus Police at 911;
- Turn off all ignition sources;
- Establish exhaust ventilation through the fume hoods or by opening windows;
- Contact EHS for assistance in disposing of the collected materials;
- Never attempt to handle broken glass or sharps with your hands; and
- Use the appropriate spill kit according to lab specific SOPs.
  - A typical spill kit will contain:
    - Personal protective equipment (PPE);
Material to safely absorb and neutralize the specific chemical; and
Equipment and materials to clean-up small and large spills.
  o The type and amount of equipment compiled for each kit should be sufficient to address any minor spill that employees can safely respond to; and
  o Kits should include appropriate container for debris.

DISPOSAL OF UNWANTED MATERIALS

Toxic materials must be disposed of through EHS. For general guidance regarding disposal of unwanted materials, refer to the EHS web site.

MINIMUM TRAINING REQUIREMENTS

Each lab should document lab specific training provided by the Principal Investigator or Lab Supervisor.

APPROVAL REQUIRED

Principal Investigators must be consulted and give personnel and students approval prior to obtaining toxic materials for the laboratory, particularly for new chemicals and those listed as HHM in the LSP.

DECONTAMINATION PROCEDURES

If the injury requires immediate medical attention, dial 911 and request an ambulance and immediate medical assistance. Have the safety data sheet (SDS) available. Have lab specific reagent information readily available.

During normal business hours, for all non-emergency work related injuries, contact University Health Services at 314-516-5671. Health Services is located at 131 Millennium Student Center. Outside of normal business hours, contact the UMSL Campus Police at 314-516-5155.

For splashes to eyes or body:

- Assist exposed person with use of safety shower and/or eye wash;
- Flush body and/or eyes with copious amounts of water;
- Remove any contaminated clothing while under the safety shower;
- Wash skin with mild soap and water, do not use neutralizing agents, creams, lotions or salve, and
- Call for medical assistance, list the nature of injury, the chemical name, your location and contact information to dispatchers.

For ingestion of a chemical:

- Encourage the victim to drink large amounts of water, and
• Call for medical assistance, list the nature of injury, the chemical name, your location and contact information to dispatchers.

For inhalation of fumes or mists:

• Get medical aid immediately;
• Remove from exposure area to fresh air immediately;
• If not breathing, give artificial respiration, and
• Call for medical assistance, list the nature of injury, the chemical name, your location and contact information to dispatchers.

Decontamination procedures vary depending on the material being handled. The toxicity of some materials can be neutralized with other reagents. All surfaces should be wiped with the appropriate cleaning agent following dispensing or handling. Materials generated as the result of decontamination should be disposed of through EHS.
GENERAL SOP FOR WORKING WITH HIGHLY REACTIVE/UNSTABLE MATERIALS

PROCESS OR EXPERIMENT DESCRIPTION

This standard operating procedure (SOP) is intended to provide general guidance on how to safely work with highly reactive/unstable materials. This SOP is generic in nature and only addresses safety issues pertaining to reactivity/stability hazards of chemicals. In some instances, several general use SOPs may be applicable for a specific chemical (i.e., for perchloric acid, both general use SOPs for highly reactive/unstable materials and corrosives would apply). If you have questions concerning the applicability of any item listed in this procedure contact the Principal Investigator/Laboratory Supervisor of your laboratory or Environmental Health and Safety. Specific written procedures are the responsibility of the Principal Investigator.

Highly reactive or unstable materials are those that have the potential to vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, temperature, light, or contact with another material.

CONTROL OF HAZARDS—GENERAL

- Minimize the quantity of highly reactive/unstable chemicals used or synthesized to the smallest amount needed.
- Handle highly reactive/unstable chemicals with caution. Appropriate chemical-specific precautions must be taken for mixing even small quantities with other chemicals.
- Chemical reactions conducted at temperatures or pressures above or below ambient conditions must be performed in a manner that minimizes risk of explosion or vigorous reaction.
- Provide a mechanism for adequate temperature control and heat dissipation.
- Utilize shields and barricades, and personal protective equipment (such as face shields with throat protectors and heavy gloves) whenever there is a possibility of explosion or vigorous chemical reaction.
- Glass equipment operated under vacuum or pressure must be shielded, wrapped with tape, or otherwise protected from shattering.

ENGINEERING/VENTILATION CONTROLS

As many highly reactive/unstable materials liberate combustible and/or toxic gas when exposed to water vapor or air, they should be used in a lab hood to prevent hazardous buildup of gases. If the process does not permit the handling of such materials in a fume hood, contact Environmental Health and Safety to review the adequacy of alternative ventilation measures. Certain reactive materials are may require the use of a chemical fume hood due to other associated hazards regardless of quantity.
PERSONAL PROTECTIVE EQUIPMENT

At minimum, safety glasses, lab coat, long pants, and closed toed shoes are to be worn when entering areas where hazardous chemicals are used. Additionally:

- Utilize shields and barricades, and personal protective equipment (such as face shields with throat protectors and heavy gloves) whenever there is a possibility of explosion or vigorous chemical reaction.
- When handling hazardous chemicals or contacting potentially contaminated surfaces, protective gloves are to be worn. Disposable nitrile gloves provide adequate protection against accidental hand contact with small quantities of most laboratory chemicals, but for proper selection of glove material where direct or prolonged contact with hazardous chemicals is anticipated, review the chemical’s safety data sheet, a glove selection guide, or contact the glove manufacturer.
- Goggles (not safety glasses) are appropriate for processes where splash or spray is foreseeable.
- For hazardous chemicals that are toxic via skin contact/absorption, additional protective clothing (i.e., faceshield, apron, oversleeves) is appropriate where chemical contact with body/skin is foreseeable.

SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Ensure careful handling of materials that may be sensitive to shock, heat, friction, or light. Label all chemicals with date received and date opened. Observe all manufacturer specified storage requirements such as temperature controls or storage under inert atmosphere.

Any chemicals with crystallization, visible discoloration, or liquid stratification potentially have undergone peroxidation and must not be used or otherwise disturbed. Test known peroxide forming compounds regularly with commercial peroxide test strips. Fire extinguishers appropriate for the fire hazards present must be available in all laboratories and storage areas. In particular, Class D fire extinguishers must be available in the immediate work area when working with flammable metals such as magnesium, sodium, and potassium.

Ensure secondary containment and segregation of incompatible chemicals per guidance in the LSP. Also, follow any substance-specific storage guidance provided in the substances’ safety data sheets.

LABELING

All materials must be clearly labeled with the correct chemical name in English. Handwritten labels are acceptable; chemical formulas and structural formulas are not acceptable. Appropriate hazard class(es) should be listed on the label.

SPILL AND ACCIDENT PROCEDURES
For all known or suspect releases to the environment (air, water or land), notify EHS at 314-516-6363, 314-516-6362, or 314-516-6360 during normal business hours, or the Campus Police at 314-516-5155 after normal business hours. EHS will make any required notifications to regulatory agencies.

**MAJOR SPILL**

A major spill is one that is spreading rapidly and presents inhalation or fire hazards, has entered the environment, or exceeds the capacity of the laboratory user to respond.

- Secure the area such that no one can enter without proper authorization;
- Notify Campus Police at 911;
- Alert others to leave the area;
- Remove ignition sources, shut down equipment, close fume hood sash, and open windows, if you can do so safely;
- Close the doors to the laboratory;
- Contact others on your lab emergency notification form;
- Assemble at a safe distance; and
- Provide technical assistance to emergency responders.

**MINOR SPILL**

A minor spill is one that can easily be managed by laboratory personnel. Response items are as follows:

- Attend to any person who may have been contaminated;
- Notify persons in the immediate area of the spill;
- Secure the area so extraneous personnel do not enter;
- Evacuate non-essential personnel from the area of the spill;
- Notify Campus Police at 911;
- Turn off all ignition sources;
- Establish exhaust ventilation through the fume hoods or by opening windows;
- Contact EHS for assistance in disposing of the collected materials;
- Never attempt to handle broken glass or sharps with your hands; and
- Use the appropriate spill kit according to lab specific SOPs.
  - A typical spill kit will contain:
    - Personal protective equipment (PPE);
    - Material to safely absorb and neutralize the specific chemical; and
    - Equipment and materials to clean-up small and large spills.
  - The type and amount of equipment compiled for each kit should be sufficient to address any minor spill that employees can safely respond to; and
  - Kits should include appropriate container for debris.

**DISPOSAL OF UNWANTED MATERIALS**
Highly reactive/unstable chemicals must be disposed of through EHS. For general guidance regarding disposal of unwanted materials, refer to the EHS web site.

**MINIMUM TRAINING REQUIREMENTS**

Each lab should document lab specific training provided by the Principal Investigator or Lab Supervisor.

**APPROVAL REQUIRED**

Principal Investigators must be consulted and give personnel and students approval prior to obtaining highly reactive/unstable chemicals for the laboratory, particularly for new chemicals and those listed as Highly Hazardous in the University Lab Safety Plan.

**DECONTAMINATION PROCEDURES**

If the injury requires immediate medical attention, dial 911 and request an ambulance and immediate medical assistance. Have the safety data sheet (SDS) available. Have lab specific reagent information readily available.

During normal business hours, for all non-emergency work related injuries, contact University Health Services at 314-516-5671. Health Services is located at 131 Millennium Student Center. Outside of normal business hours, contact the UMSL Campus Police at 314-516-5155.

For splashes to eyes or body:

- Assist exposed person with use of safety shower and/or eye wash;
- Flush body and/or eyes with copious amounts of water;
- Remove any contaminated clothing while under the safety shower;
- Wash skin with mild soap and water, do not use neutralizing agents, creams, lotions or salve, and
- Call for medical assistance, list the nature of injury, the chemical name, your location and contact information to dispatchers.

For ingestion of a chemical:

- Encourage the victim to drink large amounts of water, and
- Call for medical assistance, list the nature of injury, the chemical name, your location and contact information to dispatchers.

For inhalation of fumes or mists:

- Get medical aid immediately;
- Remove from exposure area to fresh air immediately;
- If not breathing, give artificial respiration, and
• Call for medical assistance, list the nature of injury, the chemical name, your location and contact information to dispatchers.

Decontamination procedures vary depending on the material being handled. The toxicity of some materials can be neutralized with other reagents. All surfaces should be wiped with the appropriate cleaning agent following dispensing or handling. Materials generated as the result of decontamination should be disposed of through EHS.
GENERAL SOP FOR WORKING WITH LASERS

PROCESS OR EXPERIMENT DESCRIPTION

This standard operating procedure (SOP) is intended to provide general guidance on how to safely work with lasers. This SOP is generic in nature, and only addresses safety issues specific to lasers. If you have questions concerning the applicability of any item listed in this procedure contact the Principal Investigator/Laboratory Supervisor of your laboratory or Environmental Health and Safety. Specific written procedures are the responsibility of the Principal Investigator.

CLASSIFICATIONS

A. Class 1 lasers are not considered hazardous, even if the direct beam is concentrated into the eye. Users of Class 1 lasers are generally exempt from radiation hazard controls during operation and maintenance.

B. Class 1M lasers are not considered hazardous unless the beam is viewed with an optical instrument such as an eye-loupe or a telescope. Users of Class 1M lasers are exempt from radiation hazard controls other than preventing hazardous optically aided viewing.

C. Class 2 lasers are low power and emit in the visible portion of the electromagnetic spectrum. The aversion reaction to bright light will provide protection.

D. Class 2M lasers emit in the visible portion of the electromagnetic spectrum. Class 2M lasers are potentially hazardous if viewed with certain optical aids. For unaided viewing, the aversion reaction to bright light will provide protection.

E. Class 3R lasers are medium power and are potentially hazardous under some direct and specular reflection if the eye is focused and stable. The laser does not pose a fire or diffuse reflection hazard.

F. Class 3B lasers are moderate power and may be hazardous under direct and specular reflection. The laser is not normally a fire hazard or a diffuse reflection hazard.

G. Class 4 lasers are high powered and are hazardous to the eye and skin from direct beam. Class 4 lasers may pose a diffuse reflection hazard and a fire hazard.

HAZARDS

A. Radiation hazards to the eye and skin. Effects from laser radiation will depend on exposure, wavelength, source size, duration, environmental conditions, and individual susceptibility. The eye is the most important organ to protect from the effects of laser radiation. The focusing effect of the cornea and lens can concentrate radiation upon the retina on the order of 100,000 times. For the high powered lasers, skin and the eye are equally vulnerable to injury. Skin burns are usually associated with exposure times greater than 10 microseconds and in the wavelength from the near ultraviolet to far infrared.

B. Electrical hazards exist since the power supplies have the potential of causing electrical shock. Maintenance should be performed by knowledgeable personnel only.

C. Chemical hazards exist in the lab where the laser could vaporize a chemical and create an airborne hazard. Liquid nitrogen or other cryogenic fluids may be used as a coolant.
When these cryogenic fluids evaporate, they replace atmospheric oxygen. It is important that the laser laboratory is properly ventilated.

D. Trip hazards need to be identified and eliminated to keep laboratory personnel from falling into the beam.

CONTROL OF HAZARDS

General:
- The laser beam path should not be at eye level.
- The laboratory entry should allow rapid egress or emergency admittance.
- Windows and doors should be covered.
- Entry to area should be controlled.

Class 1:
- Do not look directly into the laser beam.

Class 1M:
- Only trained personnel should operate the laser.
- Avoid optically enhanced viewing of the laser beam.

Class 2:
- Only trained personnel should operate the laser.
- Never direct the beam into a person’s eye.
- Never look directly into the laser.

Class 2M:
- Only trained personnel should operate the laser.
- Never direct the beam into a person’s eye.
- Never look directly into the laser.
- Avoid optically enhanced viewing of the laser beam.

Class 3R:
- Only trained personnel should operate the laser.
- Never direct the beam into a person’s eye.
- Never look directly into the laser.
- Avoid optically enhanced viewing of the laser beam.
- The lab should be posted with a Laser Warning Sign.
- The laser beam path should be enclosed as much as possible to prevent a person or object from blocking the path.
- The laser should only be used under the direct supervision of the PI.

Class 3B:
- Only trained personnel should operate the laser.
- Never direct the beam into a person’s eye.
- Never look directly into the laser.
- Avoid optically enhanced viewing of the laser beam.
- The lab should be posted with a Laser Warning Sign.
- The laser beam path should be enclosed as much as possible to prevent a person or object from blocking the path.
- The laser should only be used under the direct supervision of the PI.
- Protective housing which encloses the laser shall be provided with an interlock which is activated when the housing is opened or removed. Interlocks shall be provided for any portion of the protective housing that can be removed.
- The laser system will be provided with a master switch operated by key or coded access.
- Laser beam path shall be controlled.
- The laser should be provided with a beam stop or attenuator.
- SOPs should be written for Class 3B lasers.
- A warning light or audible alarm should indicate laser operation.
- Class 3B lasers shall be operated only in a controlled area unless the beam is completely enclosed.

Class 4:
- Only trained personnel should operate the laser.
- Never direct the beam into a person’s eye.
- Never look directly into the laser.
- Avoid optically enhanced viewing of the laser beam.
- The lab should be posted with a Laser Warning Sign.
- The laser beam path should be enclosed as much as possible to prevent a person or object from blocking the path.
- The laser should only be used under the direct supervision of the PI.
- Protective housing which encloses the laser shall be provided with an interlock which is activated when the housing is opened or removed. Interlocks shall be provided for any portion of the protective housing that can be removed.
- The laser system will be provided with a master switch operated by key or coded access.
- Laser beam path shall be controlled.
- The laser shall be provided with a beam stop or attenuator.
- SOPs shall be written for Class 4 lasers.
- A warning light or audible alarm shall indicate laser operation.
- Class 4 lasers should be controlled from a position as distant as possible from the emission portal of the laser.
- Class 4 lasers shall be operated only in controlled areas.

**PERSONAL PROTECTIVE EQUIPMENT**

Eye protection devices are specifically designed for protection against radiation from Class 3B and Class 4 lasers. It is important to verify that eye protection is appropriate for the laser class, energy and wavelength.

Other protective equipment should include beam stops, shields, safety interlocks and warning lights.
MINIMUM TRAINING REQUIREMENTS

Each lab should document lab specific training provided by the Principal Investigator or Lab Supervisor.

APPROVAL REQUIRED

Principal Investigators must be consulted and give personnel and students approval prior to using lasers.