CHEMICAL HYGIENE PLAN
Central Michigan University

Updated: April 2024

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Appendices

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I. INTRODUCTION

The purpose of this Chemical Hygiene Plan (CHP) is to offer guidance on maintaining a strong chemical safety program at Central Michigan University (CMU). This plan will ensure adequate control methods are implemented to protect lab workers from hazardous chemicals in laboratories. This plan has been developed to comply with the U.S. Occupational Safety and Health Administration (OSHA) Laboratory Standard (29 CFR 1910.1450) and the Michigan OSHA Hazardous Work in Laboratories Standard (Part 431). A copy of each of these Standards can be found in Appendix H. The intention of this plan is to serve as an employee reference for safe work practices in the laboratory.

A CHP is required in any laboratory area where hazardous materials are used or stored; however, the Standards apply only to areas where hazardous materials are used and when **ALL** the following criteria are met:

1. chemical operations are carried out on a laboratory scale, i.e., the containers used in the operation are of a size that can be easily and safely manipulated by one person;
2. multiple chemical procedures or chemicals are used;
3. the procedures involved are not part of a production process nor simulate a production process; and
4. “protective laboratory practices and equipment” are available and commonly used to prevent employee exposure.

The MIOSHA Laboratory Standard defines a hazardous chemical as any chemical which is classified as a health hazard or simple asphyxiant in accordance with the Hazard Communication Standard (§1910.1200). At Central Michigan University, the definition of a hazardous chemical is expanded to include physical hazard chemicals, as defined by the Hazard Communication Standard.

Health hazard means a chemical that is classified as posing one of the following hazardous effects:

(a) Acute toxicity, any route of exposure
(b) Skin corrosion or irritation
(c) Serious eye damage or eye irritation
(d) Respiratory or skin sensitization
(e) Germ cell mutagenicity
(f) Carcinogenicity
(g) Reproductive toxicity
(h) Specific target organ toxicity, single or repeated exposure
(i) Aspiration hazard

The definition of a **simple asphyxiant** is "A substance or mixture that displaces oxygen in the ambient atmosphere and can thus cause oxygen deprivation in those who are exposed, leading to unconsciousness and death."

Physical hazard means a chemical that is classified as posing one of the following hazardous effects:

(a) Explosive
(b) flammable (gases, aerosols, liquids, or solids)
(c) oxidizer (liquid, solid or gas)
(d) self-reactive
(e) pyrophoric (liquid or solid)
(f) self-heating
(g) organic peroxide
(h) corrosive to metal
(i) gas under pressure
(j) in contact with water emits flammable gas

Laboratory means any lab, studio, classroom, or shop area used for academic or research purposes, in which hazardous chemicals are used and meets the four criteria listed above. Non-academic and non-research oriented spaces where hazardous chemicals are used by Facilities Management or other operational departments will not be considered laboratories.

The primary emphasis of this plan is to protect laboratory workers from overexposure to hazardous substances by appropriate administrative procedures or engineering controls; however, this plan applies to clerical, custodial, maintenance and contract personnel who, as part of their assigned duties, spend working time within the laboratory environment.

The CHP will be updated annually by the Office of Laboratory and Field Safety (OLFS) with review by the Lab Safety Committee. The CHP can be found at the following locations:

108 Foust Hall

-or-

Online- Office of Laboratory and Field Safety | Central Michigan University (cmich.edu)

II. RESPONSIBLE PERSONS

Persons responsible for the employment of the Chemical Hygiene Plan (CHP) along with respective duties are as follows:

A. Chemical Hygiene Officer (Director, Office of Laboratory and Field Safety)

- Prepare/implement/maintain the CHP
- Coordinate safety and training programs
- Conduct safety inspections and provide guidance on fixing deficiencies
- Maintain records of all safety training and inspections
- Promote laboratory safety
- Provide consultation, training, exposure monitoring, record maintenance, and inspections as needed
- Serve as contact person for hazardous material emergencies
- Serve as liaison with outside regulatory agencies

B. Vice President for Research and Innovation

- Oversees compliance with the CHP

C. Deans

- Provide the leadership and necessary resources to ensure and maintain safe working conditions in the Colleges
- Assist with disciplinary actions for employees violating safety rules (see Section III)

D. Department Chairs

- Provide the leadership and necessary resources for the maintenance of safe working conditions in the department (e.g., working with the chemical hygiene officer and safety committee to implement safety programs)
- Motivate and assist employees with CHP compliance
- Communicate to department employees that they are required by federal and state law to attend all applicable training sessions
- Refer to the dean's office employees violating safety rules (see Section III)

E. Lab Safety Committee

- Members serve as Safety Representatives for respective departments within the Colleges
- Update the CHP annually and as needed
- Meet regularly to review CHP compliance
- Oversee the direction of the chemical hygiene program
- Develop enforcement policies

F. Supervisors/Principal Investigators

- Arrange for appropriate repairs to maintain a safe environment
- Make lab spaces safe for maintenance personnel who perform work in the lab space. See Appendix C.

- Clean and decontaminate lab equipment and items prior to removal from the lab. See Appendix O.
- Develop written standard operating procedures (SOPs) for each laboratory
- Enforce the requirements of the CHP
- Ensure appropriate training is provided to all laboratory employees prior to assigning them work with chemicals (see Appendix I)
- Provide appropriate personal protective equipment (PPE)
- Maintain chemical inventories
- Ensure environmental and medical monitoring are provided as needed (see Section VI)
- Conduct safety inspections (see Appendix B)
- Correct safety deficiencies in a timely manner
- Ensure Safety Data Sheets (SDS) are available for their particular chemical inventory

G. Employees

- Follow the established CHP, SOPs, and safety rules
- Use appropriate PPE
- Report safety hazards to supervisor
- Report signs and symptoms of possible exposures, known exposures, accidents, and near misses to supervisor
- Complete all required safety training

H. Human Resources

- Assist employees and student employees who feel they have experienced an injury or illness related to performing their assigned tasks here at CMU
- Fill out employee accidental personal injury reports
- Provide timely, appropriate, and quality medical care for work-related injury/illness
- Provide timely wage loss benefits when appropriate
- Facilitate communication between employee, physician, and supervisor
- Facilitate timely return to work
- Identify and eliminate fraud and abuse of Worker's Disability Compensation system

III. ENFORCEMENT

If a supervisor or principal investigator shows disregard for the contents of this plan, the following steps will be taken to correct the situation:

1. The individual will be notified of the problem and given the opportunity to comply in a timely manner.
2. If there is still a problem following step 1, then the Department Chair and/or direct supervisor will be notified of the problem. The Department Chair and/or direct supervisor will meet with the individual and reinforce the need to fix the problem. The individual will be given the opportunity to comply in a timely manner.
3. If there is still a problem following step 2, then the Director of the Office of Laboratory and Field Safety will meet with both the individual and Department Chair and/or direct supervisor to again reinforce the need to fix the problem. The individual will be given the opportunity to comply in a timely manner.
4. If there is still a problem following step 3, then the Department Chair must take the problem to the Dean to consider further action.
5. Note: For College of Medicine, Department Chair does not apply.

IV. GENERAL SAFETY RULES

1. Avoid working alone. Working alone in a chemical storage area or in an area where hazardous materials are used is never a good idea and should be avoided if possible. If the employee and supervisor of the laboratory determine that work must be done under these conditions, the hazards should be carefully assessed, contingencies thought out, and the work approved only if the chances of injury are minimal. An effort should be made to keep in contact with the employee who is working alone.
2. Wear the appropriate eye protection when in an area where hazardous materials are used or stored, or hazardous operations are underway.
3. When working with flammable chemicals, be certain that there are no sources of ignition near enough to cause a fire or explosion in the event of a vapor release or liquid spill.
4. Use a tip-resistant shield for protection whenever there is the potential that an explosion or implosion might occur.
5. When working with chemicals, be aware of:
    - The hazards of the chemicals, as determined from the SDS or other appropriate documented references
    - Appropriate safeguards that need to be taken when using the chemical, including personal protective equipment
    - The location and proper use of all emergency equipment
    - How and where to properly store the chemical when not in use, as well as how to properly dispose of the chemical once the task is complete
    - The proper methods of transporting chemicals within the facility
    - Appropriate procedures for emergencies, including evacuation routes, spill cleanup procedures and proper waste disposal methods
6. Do not ride in the elevator with containers of cryogenic materials or poison inhalation hazards. DOT Class 4 flammable solids and pyrophoric/water-reactive chemicals should also be hand-carried using the stairs.
7. Promptly notify the appropriate personnel in the event of an accident, injury, or chemical release.
8. Do not participate in horseplay, practical jokes or any behavior that may startle, distract, or disorient another worker in an area where hazardous materials are used or where potentially dangerous operations are in place.
9. Be alert to any unsafe condition. If an unsafe condition exists, either remediate the problem or notify the appropriate supervisor to ensure the unsafe condition is corrected.
10. Do not block access to emergency equipment, safety showers, eyewashes, fire extinguishers, electrical panels, or exits, even with temporary equipment or parked carts.
11. Label all containers of chemicals with the full chemical name, the hazard warnings, and the concentration.
12. Keep all work areas, workbenches, and hoods free of clutter.
13. Keep all aisles, hallways, and stairways clear of all obstructions.

14. Return all chemicals to their assigned storage areas at the end of each day. Return flammable materials to flammable storage cabinets.
15. Label and store waste containers properly.
16. Clean all working surfaces and floors regularly. Keep floors free of all slip and trip hazards.
17. Do not store chemicals in hallways or stairwells, in aisles or on the floor, or on desktops or workbenches. Return materials requiring long-term storage to the appropriate storage area.
18. Make sure that all chemical containers are closed when not in use.
19. Make sure that fume hoods are working properly before working with chemicals inside of them.
20. Maintain a chemical inventory for each laboratory and indicate the location of SDS.
21. Dispose of glass, sharps, and waste according to section VIII of the chemical hygiene plan.
22. Secure compressed gas cylinders at all times. Keep cylinder caps in place when cylinders are not in use.
23. Make sure that service/maintenance workers and visitors are not exposed to hazardous materials when they are in the lab.
24. Prohibit children in laboratories unless an employee from that specific laboratory area accompanies them.
25. DO NOT HAVE FOOD OR BEVERAGES IN A LABORATORY WHERE HAZARDOUS MATERIALS ARE PRESENT!!! Food and beverages are only allowed in the hallways, office areas, and conference rooms.
26. Wear appropriate clothing in the laboratory and animal rooms. Long pants, shirts with sleeves (long or short) that completely cover the torso, socks and full coverage heel and toe shoes are required when working in any laboratory on campus. Clothing made from natural materials, such as cotton or wool, is recommended rather than synthetic fibers, which may melt on the skin during a fire. Tie back long hair and loose clothing and remove dangling jewelry prior to working in the laboratory.
27. Synthetic and acrylic nails are not recommended for certain types of lab work. Acrylic nails are very flammable and, once ignited, can burn to completion. Ensure synthetic nails do not damage protective gloves or affect glove removal.

V. UNDERSTANDING AND RECOGNIZING CHEMICAL HAZARDS

To ensure that employees of Central Michigan University (CMU) are not overexposed to chemicals, each employee must be knowledgeable of the chemical hazards in his/her work environment. Each employee must be able to identify chemical hazards and understand what measures can be taken to eliminate chemical hazards. This section addresses how to understand and recognize chemical hazards.

A. Employee Training

Before lab workers are granted unescorted access to laboratory areas, they shall successfully complete Lab Safety Training as offered/managed by OLFS. The Lab Safety Training requirement does not apply to students enrolled in laboratory courses, unless the student is considered a lab worker (Note: A lab worker is an individual who works with hazardous materials in a laboratory. A lab worker may be faculty, staff, graduate student, postdoctoral scholar, undergraduate student researcher, volunteer, or visitor/visiting scholar. Lab worker excludes individuals who only passively participate in tours, lectures, conferences, etc.). However, the teaching laboratory instructor, teaching assistant, and/or classroom laboratory manager is still responsible for conveying the necessary information for students to work safely. Lab Safety Training is required annually.

Supervisors shall provide a safety orientation specific to their lab and operation to new lab workers. The lab specific safety training form (located in Appendix I) shall be completed before the worker is granted unescorted access to or assigned work activities in the lab. The form documents the safety orientation for lab workers. The supervisor shall keep a copy of this form for each active worker. It must be available upon request, such as during inspections.

Lab Safety Training will include the following:

1. The content and requirements of the Laboratory Standard.
2. The content, location, and availability of the chemical hygiene plan.
3. The Permissible Exposure Limit (PEL), action levels, and other recommended exposure limits for hazardous chemicals used in CMU's laboratories.
4. Signs and symptoms associated with exposures to the hazardous chemicals used in the laboratory.
5. The location and availability of SDS and other reference materials.
6. The methods and observations that may be used to detect the presence or release of a hazardous chemical.
7. The hazards associated with the chemicals used in CMU's laboratories.
8. The measures employees can use to protect themselves from these hazards, including specific procedures such as appropriate work practices, personal protective equipment to be used, and emergency procedures.
9. The proper disposal of hazardous waste.

If there are any questions about training (to whom it applies, etc.), contact the principal investigator, the supervisor, or the Office of Laboratory and Field Safety.

B. Identification of Hazardous Chemicals

Before starting any procedure that requires the use of a chemical, you must identify the hazards associated with the chemical. Reading and understanding the warning or hazard labels on the

chemical containers and the Safety Data Sheet (SDS) for each of the chemicals used can help achieve this. Other references available through the Office of Laboratory and Field Safety (including Internet sites) are listed in Appendix A. See Section VII for more detail on the different classifications of hazardous chemicals.

C. Signs

At a minimum, you should post the following signs in each laboratory:

1. OLFS Lab Door Sign, which includes telephone numbers for CMU Police (911), the Office of Laboratory and Field Safety, and supervisory personnel, should be posted on the outside of the lab door.
2. Location signs for safety equipment, such as safety showers, eyewash stations, fire extinguishers, emergency cut-off switches, and first aid equipment.
3. MIOSHA Right to Know signs designating the location of SDS information.
4. Warning signs where dangerous equipment is in use or where potentially dangerous operations are taking place.
5. Unattended Lab Operations sign should be completed and posted next to lab operations running unattended.
6. See Appendix T for sign templates and requirements.

D. Chemical Labeling

At a minimum, each new chemical container must be labeled with the following:

1. Name of chemical (no abbreviations).
2. Hazard warnings.
3. Name and address of supplier.
4. Chemical concentration.

At a minimum, you must label each transfer chemical container with the following:

1. Name of chemical (no abbreviations).
2. Hazard warnings.
3. Chemical concentration.

For small chemical containers that are too small for a legible complete label, such as sample vials, it is appropriate to label them with a letter or numbering system and place them in a secondary container that is labeled with the chemical name, hazard warning, and chemical concentration.

You must also properly label containers of non-hazardous materials. (Example: distilled water). Dispose of unlabeled containers as unknown hazardous waste.

E. Safety Data Sheet (SDS)

Departments shall ensure access to copies of Safety Data Sheets (SDS) for each hazardous chemical used in their department. SDS must be readily accessible during each work shift to employees in their work area. When a new SDS arrives, date it and send a copy to RMEHS.

RMEHS maintains a searchable SDS database for campus chemical inventories. All chemicals on campus must have an SDS on file with RMEHS in this database for regulatory and emergency response purposes. Go to:

https://www2.cmich.edu/office_provost/ORGS/Lab_Safety/Pages/Safety-Data-Sheets-.aspx to access the database. SDS must be maintained for thirty years because they serve as exposure records. Send all discontinued SDS to RMEHS for archiving and cross referencing with the database.

F. Chemical Inventory

Each laboratory shall maintain a hazardous chemical inventory. Update the inventory at least biannually within Laboratory Registration Manager/Office of Laboratory and Field Safety so it is available for emergency response, inspections, and regulatory reporting. The inventory template can be found in Appendix J. Directions for completing the hazard warning column on the inventory can be found in Appendix L.

Store all chemicals safely and properly. Store by chemical classification and hazard, and separate incompatible materials. Do not store chemicals alphabetically. See Appendix A for references.

G. Inspections

Principal Investigators/Supervisors are responsible for conducting periodic inspections of laboratories. Quarterly inspections are strongly recommended. A sample laboratory inspection checklist can be found in Appendix B. Include personal protective equipment (PPE), safety equipment, electrical cords, laboratory equipment, and general laboratory conditions during the inspection. If you discover any defective equipment during the safety inspection, tag it, take it out of service, and have it repaired. If the equipment is not going to be repaired, then it is recommended that the item is either disposed of or removed to a storage location. Maintain a file of inspection checklists and logs.

Facilities Management will be responsible for inspecting/flushing safety showers and plumbed eyewash stations biannually. Any safety shower or eyewash not passing the inspection will be immediately tagged and taken out of service until it is repaired. The Departments will be responsible for inspecting non-plumbed eyewash stations according to the manufacturer's specifications.

Facilities Management will be responsible for inspecting the performance of chemical fume hoods biannually. If any hood does not pass the inspection, it will be immediately tagged and taken out of service until it is repaired.

Facilities Management will be responsible for inspecting fire extinguishers monthly.

H. Laboratory Entry, Access, and Lab Hazard Area Preparation Forms for Repair Work

Appendix C contains the CMU Laboratory Entry and Access Policy, Laboratory Entry and Access Standard Operating Procedure, and the Lab Hazard Area Preparation Form. Together, these documents establish rules and procedures for laboratory and non-laboratory personnel to permit safe and secure access to laboratories. When non-laboratory workers are required to perform work in laboratory spaces, both lab and non-lab employees shall adhere to the procedure described in this appendix.

VI. REDUCING EXPOSURE TO CHEMICALS

Chemical safety is achieved through continual awareness of chemical hazards and by minimizing chemical exposures using the hierarchy of controls – elimination, substitution, engineering (i.e., ventilation), administrative controls (good lab practices), and personal protective equipment. Always attempt to substitute a less hazardous chemical when feasible.

A. Ventilation

General room ventilation is not usually sufficient to prevent the accumulation of chemical vapors; therefore, chemicals must be used in an operating fume hood, glove box, vacuum line, or similar device, which is equipped with appropriate traps and/or scrubbers. If this equipment is not available, then no work shall be performed using that chemical. There are many different types and sizes of hoods as well as other forms of local exhaust ventilation such as snorkels and vented chemical storage cabinets on campus. Become familiar with the local exhaust ventilation units in your work area. NOTE: Most biological safety cabinets are not designed for chemical ventilation! Check the cabinet rating before using chemicals.

When laboratory handling of a chemical will be likely to exceed exposure limits, see section D, Environmental Monitoring, for further guidance.

1. Ventilation Failure

Fume hoods and other ventilation controls should provide enough ventilation to adequately remove the chemical hazard from the work area. Be alert to detect any malfunction in the ventilation equipment. In the event that a ventilation system fails, shut down all operations within that system promptly and safely. Close or seal any open containers or equipment containing hazardous materials to prevent a release of vapors into the room. If the ventilation equipment is a hood or a snorkel, post a sign on the item stating the hood or snorkel is not working properly. Phone the FM Service Center (774-6547) and follow the procedures listed in section V part H. Do not use chemicals in the hood or beneath the snorkel until further notice is given that the system has been repaired. If the ventilation shut down creates an emergency situation (i.e., hazardous chemical vapors are not controlled), then evacuate personnel from the area, dial 911, and give as much detail as possible to the CMU Police Dispatcher (i.e., location, name of chemical, etc.).

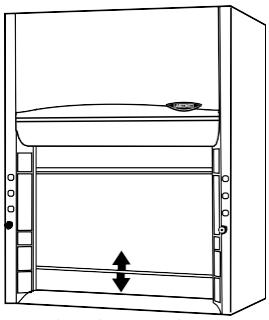
2. Ventilation Testing

The chemical fume hoods will be tested biannually by Facilities Management. If any hood is not working properly, then it will be tagged out of service until the repairs are made. While the hood is out of service, it cannot be used for chemical applications.

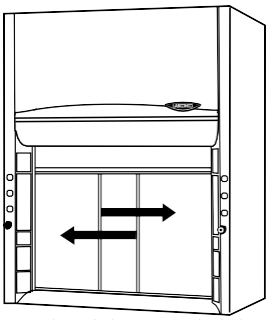
3. Use of a Chemical Fume Hood

Chemical fume hoods are protective equipment and must be used correctly to offer protection from chemical exposure. The sash is the moveable barrier on the front of the chemical fume hood. The illustrations below show the different sash types that you may encounter while working in CMU laboratories. The following is a list of procedures that must be followed to ensure that the ventilation is properly working at all times.

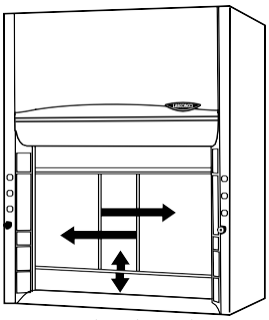
1. Keep all laboratory doors to the hallway closed. This will aid in keeping the hallways at a positive pressure and the laboratories at a negative pressure so chemical odors will not migrate out of the lab.
2. Keep windows closed in the laboratory. Drafts and eddy currents can cause turbulence at the face of the hood that may allow chemical vapors to escape from the hood.
3. For hoods with a vertical-rising sash, keep the hood sash in a lowered position with a maximum opening of 18 inches at all times except when actively positioning equipment. For your reference, the hoods have been marked at 18 inches. Chemical fume hoods with sliding horizontal sash panels are used with one panel placed in front of the face and arms reaching around the sides to perform manipulations. Do not slide the panels laterally exposing the face to the interior of the hood with chemicals present and keep the vertical-rising sash fully lowered if your hood is a combination type sash. The primary reason for this is safety. The hoods are designed to eliminate chemical inhalation exposure. When the sashes are wide open, the hood does not trap as much of the chemical vapor. When the hood is not in use or unattended, close the sash completely.
4. For hoods with manual flow controls, place the face velocity setting at 100 ft/min before using the hood. Allow 3-5 minutes for the hood to stabilize and reach the new face velocity setting prior to beginning work. A safe working range for a hood is 80-120 ft/min. When the hood is not being used, the setting should be turned to minimum for standby mode. To obtain a quick flush of the hood following a chemical spill in the hood, lower the sash to about an 8-inch open height, set the controller to 200 ft/min for a couple minutes, and then return the controller to 100 ft/min for regular use. Hoods that do not contain manual flow controls will be adjusted to maintain a face velocity of around 100 ft/min when turned on with the sash raised to 18 inches.
5. Keep storage of chemicals and equipment in the hood to a minimum (i.e., only those materials in use). If the hoods become cluttered, then airflow is blocked. A spacious work area inside the hood will also allow the researcher more elbowroom to work more efficiently.
6. Place items at least six inches away from the front edge for better capture of vapors.



Hood with vertical-rising sash



Hood with horizontal-sliding sashes



Hood with combination sash

Reference: Labconco, Inc.

B. Personal Protective Equipment (PPE)

1. Responsible Parties

Supervisors and Principal Investigators are responsible for the Personal Protective Equipment (PPE) program in their laboratories. This includes enforcement of the program and maintenance of the equipment. Appropriate disciplinary action must be taken for repeated violation of this program. Each Department must provide the necessary PPE for their employees. To assist with PPE determinations, a PPE guide to hazard sources can be found in Appendix D. **NOTE: If there are any questions on how to select PPE, contact OLFS.**

2. Workplace Assessments

Perform a workplace assessment in each laboratory to determine if hazards requiring the use of PPE are present. This is often a complex task; therefore, sample copies of the workplace assessment forms can be found in Appendix D. If potential hazards are present in the laboratory, do the following:

- Identify each hazard and the source
- Determine which body parts are affected
- Select appropriate PPE against the hazard
- Train each employee on the hazards present and when PPE should be worn
- Train employees on the proper use, maintenance and limitations of each PPE device used
- Maintain training records within the department
- Complete and maintain a workplace assessment form for each task or process performed in the laboratory that requires PPE

Do not rely upon PPE alone to completely protect against hazards. Rather, use it in conjunction with effective engineering controls and workplace practices to minimize hazards in the workplace.

3. Eye Protection

All safety eyewear and face protection must meet the ANSI Z87.1 standard for minimum allowable protection. All eye and face protection supplied by Central Michigan University Departments must meet this standard, to provide impact protection. Side shields are required, under Michigan law, on all safety glasses. It is recommended that each individual be issued their own eye protection. MIOSHA regulations state that shared eyewear must be cleaned and disinfected between uses by different wearers.

Safety glasses do not give adequate protection from chemical splashes. If the potential for liquids to be splashed or sprayed is present, wear safety goggles. When liquids are under extreme, high pressure, wear a face shield. Never wear a face shield without wearing eye protection underneath.

Contact lenses do not provide eye protection! Wearing contact lenses is discouraged when working with materials or procedures that give off gases, vapors, welding fumes, smoke or dust. If you choose to wear contacts, be aware of the hazards of wearing contacts in a lab.

Eye Protection is Required:

- When working with or in the vicinity of solvents or corrosive chemicals, or with any chemical that could produce an eye injury

- When working near equipment or apparatus under high pressure or vacuum, or when around equipment that could produce projectiles
- When near laboratory benches where chemical reactions are being run or when around a radiation hazard
- When transporting flammable, corrosive or toxic chemicals
- During routine or maintenance activities involving chemicals, hand/power or machine tools, welding, cutting, grinding, or abrasive blasting
- When working behind hood doors or blast shields

4. Gloves

Gloves provide protection against chemical, radiological and biological agents. Selection of proper gloves for the work task is critical in maintaining protection against hazardous agents. OLFS can assist employees in the selection of proper gloves. A glove selection table can be found in Appendix E.

Note the Following for Safe Glove Usage:

- When working with corrosive liquids, solvents, or other potentially hazardous materials, wear proper gloves. One type of glove will not protect against all chemicals; therefore, proper glove selection is critical. Consult with the glove manufacturer(s) as the primary source for glove selection and compatibility with intended procedures.
- Remove gloves prior to answering phones, using computers, opening doors, or any other situation that might cause the spread of hazardous materials.
- Remove gloves prior to leaving the laboratory area.
- Wash hands anytime gloves are removed.
- Be careful not to touch other parts of your body or apparel while wearing gloves (i.e., pushing up your glasses, etc.).
- Dispose of gloves as hazardous waste if they meet the characteristics of a hazardous waste (see section VIII part H).

Note: Flame-resistant gloves shall be worn whenever possible where pyrophoric reagents are used outside the inert atmosphere of a glovebox.

5. Respiratory Protection

Respirators are designed to keep the wearer from inhaling toxic chemicals or other contaminants in the air during accidents, emergencies or when engineering controls are not sufficient to maintain exposures below the Permissible Exposure Limit (PEL). **If you plan to use a respirator, see OLFS prior to use.** Respirators have inherent hazards, should be considered the last line of defense, and should not be used during routine laboratory operation. When required, respirators are available to employees at no cost.

Departments shall make every effort to use engineering and workplace controls to minimize exposures. Respirators shall only be used when engineering controls and workplace practices fail to reduce the exposures below the PEL. Departments are responsible for ensuring compliance with the Respiratory Protection Program. Responsibilities include:

- Inform OLFS of potential health hazards that may require the use of respirators.
- Ensure employees receive a respirator fit test prior to respirator usage.

- Ensure employees have received proper medical and training clearance before they start using respirators.
- Ensure employees use and store the respirator in compliance with the Respiratory Protection Program.
- Ensure respirators are stored in a closed container, shelf, or cabinet.
- Ensure respirators are kept clean and dust-free and washed when necessary.
- Ensure respirator cartridges are changed on a regular basis according to specifications or use limitations. NOTE: Cartridges may be a hazardous waste (see section VIII part H).
- Require training for all employees using respirators. Make sure training is recorded and on file with OLFS.
- Monitor the respirator program for compliance and report deficiencies to OLFS.

6. Laboratory Coats

Laboratory coats are worn to protect lab workers from exposure, prevent the spread of hazardous materials outside the laboratory, and prevent damage to employees' personal clothing. Protective clothing is only to be worn on site or for external activities relating to laboratory requirements where protective clothing is needed. Remove contaminated clothing before leaving the laboratory area.

OLFS offers a lab coat rental program with different lab coat options, including flame resistance and chemical resistance. Lab coats are selected based on the hazards present in the lab. The program allows for routine washing of lab coats with replacement as needed.

Note: Flame-resistant lab coats shall be worn where pyrophoric reagents are used outside the inert atmosphere of a glovebox.

7. Laboratory Attire

Wear appropriate clothing in the laboratory and animal rooms. Long pants, shirts with sleeves (long or short), socks and full coverage heel and toe shoes are required when working in any laboratory on campus. Clothing made from natural materials, such as cotton or wool, is recommended rather than synthetic fibers, which may melt on the skin during a fire. Tie back long hair and loose clothing and remove dangling jewelry prior to working in the laboratory.

Note: Natural-fiber clothing shall be worn under flame-resistant lab coats and on the legs and feet where pyrophoric reagents are used outside the inert atmosphere of a glovebox.

8. Hearing Protection

If in the laboratory setting, a process is conducted with a high noise output, contact OLFS to conduct a noise survey. From this survey, the following items can be addressed:

- Sources of noise output
- Whether the action levels are exceeded
- Types of hearing protection devices needed and when they should be worn
- Who is affected by the problem and whether the affected employee needs to participate in the Hearing Conservation Program

Generally speaking, if you have to raise your voice to have a conversation with the person standing next to you, then the noise may be at a level that requires a noise survey and assessment.

C. Laboratory Practices

Proper lab practice can greatly reduce exposure to chemicals. If a chemical is highly hazardous, then substituting a less hazardous chemical that will accomplish the same procedure is strongly recommended. Observe the following practices at all times:

- Plan work ahead of time. Be prepared for spills and emergencies.
- Be familiar with the chemicals being used and the associated signs and symptoms of exposures.
- Do not eat or drink in a laboratory area.
- Wash hands prior to leaving the laboratory.
- Label unattended operations (sign located in Appendix T).

D. Environmental Monitoring

The recommended exposure limits or OSHA-mandated limits for toxic chemicals can be found in the SDS for most of the chemicals used in the laboratory. These limits may be expressed as threshold limit values (TLV), permissible exposure limits (PEL), short-term exposure limits (STEL), ceilings (C), and action levels. These limits help to serve as guidelines for determining the appropriate safety precautions to be taken when handling specific chemicals. In laboratories, instrumental monitoring for airborne contaminants is usually not practical or required. However, OLFS will conduct monitoring for any substance regulated by a standard that requires monitoring or if it is suspected that exposure levels routinely exceed the action level or PEL/STEL.

- Employees may request a determination of their exposure to a chemical by contacting OLFS.
- Employees must be notified within 15 business days after receipt of monitoring results. OLFS provides the Department and employees with a monitoring report.
- OLFS will maintain records pertaining to work-related exposure to chemicals or harmful physical agents for at least 30 years after an employee's termination of employment.

E. Medical Surveillance Criteria

All employees working with chemicals have the option to receive medical consultation and examination under any of the following conditions:

- The employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
- If exposure monitoring suggests that there could have been an exposure above the action level (or PEL if there is no action level) for a chemical for which a substance-specific standard has been established.
- An event occurs (spill, leak, explosion) resulting in a hazardous chemical exposure.

The examining health care physician will provide a written opinion for examinations or consultations performed. The opinion shall include:

- Any recommendations for further medical follow-up.
- The results of the medical examination and any associated tests.
- Conclusions concerning any other medical condition noted that could put the employee at increased risk.
- A statement that the employee has been informed of the previous items.

Note: These statements shall not reveal findings that do not relate to the chemical exposure. The written opinion shall remain confidential.

F. Medical Records

All employees have the right to examine and obtain a copy of their own medical and chemical exposure records. No one shall have access to this information, except the employee and his or her physician.

- All memos, notes, and reports related to a complaint of actual or possible exposure must be maintained as part of the medical record.
- The health care provider shall maintain all medical records for at least 30 years after termination of employment.
- These records shall include the results of biological monitoring and any blood tests performed for work-related monitoring programs.

VII. SPECIFIC CHEMICAL HAZARDS

Each hazardous chemical container label includes the product identifier used on the SDS. Additionally, the label contains a signal word, hazard statement(s), pictograms(s) and precautionary statements(s) for each hazard class. Pictograms have been standardized with the Global Harmonization Standard. These pictograms are shown below.

Flame	Flame Over Circle	Exclamation Mark	Exploding Bomb
			
Flammables Self-reactives Pyrophorics Self-heating Emits Flammable Gas Organic Peroxides	Oxidizers	Irritant Dermal Sensitizer Acute Toxicity (harmful) Narcotic Effects Respiratory Tract Irritation	Explosives Self Reactives Organic Peroxides
Corrosion	**Gas Cylinder**	**Health Hazard**	**Skull and Crossbones**
			
Corrosives	Gases Under Pressure	Carcinogen Respiratory Sensitizer Reproductive Toxicity Target Organ Toxicity Mutagenicity Aspiration Toxicity	Acute Toxicity (severe)

A. Prior Approval

The supervisor must give prior approval before any new or non-routine task is started that involves the use of hazardous materials. The following items require prior approval:

- The same procedure but with new or different materials
- Any significant change in the procedure, particularly changes in temperature or pressure
- The use of new equipment or equipment that has been in storage
- A significantly new procedure

B. Particularly Hazardous Substances

The use of select carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity **REQUIRES** a written standard operating procedure (SOP) be completed and on file in the lab. The SOP must include the establishment of a designated area with appropriate signs warning of the hazards associated with the substance, the use of a fume hood or equivalent containment device, procedures for decontaminating the designated area, and procedures for safe removal of contaminated waste. **An SOP template can be found in Appendix K.** In all cases, make sure to consult the SDS to determine if a chemical meets the definition of a particularly hazardous substance. **NOTE: Everyone working in a lab/shop/studio that contains particularly hazardous substances (whether the individual uses the chemical or not) must review the SOP and know how to respond in an emergency.**

1. Definitions

Particularly hazardous substances, by MIOSHA definition, are "select carcinogens", reproductive toxins and substances which have a high degree of acute toxicity.

Select Carcinogen means any substance which meets one of the following criteria:

i. It is regulated by OSHA as a carcinogen; or

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

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

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

   a. After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3; or

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

   c. After oral dosages of less than 50 mg/kg of body weight per day.

For practical purposes, the GHS classification for carcinogenicity may be used as an approximate equivalency of the above criteria to determine if a chemical is a "select carcinogen". Part D of Appendix C to the Hazard Communication Standard (§1910.1200) provides approximate equivalencies among IARC, NTP, and GHS carcinogenicity classifications.

APPROXIMATE EQUIVALENCES AMONG CARCINOGEN CLASSIFICATION SCHEMES		
IARC	**GHS**	**NTP RoC**
Group 1	Category 1A	Known
Group 2A	Category 1B	Reasonably Anticipated (See Note 1)
Group 2B	Category 2	Reasonably Anticipated (See Note 1)
Note 1:		
1. Limited evidence of carcinogenicity from studies in humans (corresponding to IARC 2A/GHS 1B);		
2. Sufficient evidence of carcinogenicity from studies in experimental animals (again, essentially corresponding to IARC 2A/GHS 1B);		
3. Less than sufficient evidence of carcinogenicity in humans or laboratory animals; however:		
a. The agent, substance, or mixture belongs to a well-defined, structurally-related class of substances whose members are listed in a previous RoC as either "Known" or "Reasonably Anticipated" to be a human carcinogen, or		
b. There is convincing relevant information that the agent acts through mechanisms indicating it would likely cause cancer in humans.		

By this equivalency, GHS Category 1A carcinogens will always meet "select carcinogen" criteria (i), (ii), or (iii). GHS categories 1B and 2 for carcinogenicity are approximately equivalent to the criteria (iv) under the "select carcinogen" definition. Therefore, GHS categories 1B and 2 carcinogens may be broadly classified as select carcinogens for the purposes of identifying particularly hazardous substances. In some cases, a substance may be categorized into GHS 1B or 2, but does not meet any of (a), (b), or (c) for criteria (iv). In such cases, the principal investigator of the laboratory may elect not to categorize the substance a select carcinogen. GHS hazard classifications for carcinogenicity are described in the table below.

Hazard Categories For Carcinogens	
CATEGORY 1:	**Known or presumed human carcinogens** The classification of a substance as a Category 1 carcinogen is done on the basis of epidemiological and/or animal data. This classification is further distinguished on the basis of whether the evidence for classification is largely from human data (Category 1A) or from animal data (Category 1B):
Category 1A:	**Known to have carcinogenic potential for humans. Classification in this category is largely based on human evidence**
Category 1B:	**Presumed to have carcinogenic potential for humans. Classification in this category is largely based on animal evidence.** The classification of a substance in Category 1A and 1B is based on strength of evidence together with weight of evidence considerations. Such evidence may be derived from: - human studies that establish a causal relationship between human exposure to a substance and the development of cancer (known human carcinogen); or - animal experiments for which there is sufficient evidence to demonstrate animal carcinogenicity (presumed human carcinogen). In addition, on a case-by-case basis, scientific judgment may warrant a decision of presumed human carcinogenicity derived from studies showing limited evidence of carcinogenicity in humans together with limited evidence of carcinogenicity in experimental animals.
CATEGORY 2:	**Suspected human carcinogens** The classification of a substance in Category 2 is done on the basis of evidence obtained from human and/or animal studies, but which is not sufficiently convincing to place the substance in Category 1A or B. This classification is based on strength of evidence together with weight of evidence considerations. Such evidence may be from either limited evidence of carcinogenicity in human studies or from limited evidence of carcinogenicity in animal studies.
Other considerations:	Where the weight of evidence for the carcinogenicity of a substance does not meet the above criteria, any positive study conducted in accordance with established scientific principles, and which reports statistically significant findings regarding the carcinogenic potential of the substance, must be noted on the safety data sheet.

Reference: MIOSHA Part 430; Hazard Communication; Appendix A.

Carcinogens are identified with the following pictogram:

Reproductive toxins mean chemicals that affect the reproductive capabilities including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring. Chemicals classified as reproductive toxins in accordance with the Hazard Communication Standard (§1910.1200) shall be considered reproductive toxins for purposes of this section.

The Hazard Communication Standard defines reproductive toxins as chemicals that affect the reproductive capabilities, including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring. Adverse effects on sexual function and fertility means any effect of chemicals that interferes with reproductive ability or sexual capacity. This includes, but is not limited to, alterations to the female and male reproductive system, adverse effects on onset of puberty, gamete production and transport, reproductive cycle normality, sexual behavior, fertility, parturition, pregnancy outcomes, premature reproductive senescence, or modifications in other functions that are dependent on the integrity of the reproductive systems. Adverse effects on or via lactation are also included in reproductive toxicity, but for classification purposes, such effects are treated separately. Information on reproductive effects will be listed on the SDS. The following table explains the categories of reproductive toxins. Note: An SOP is required for category 1 and 2 reproductive toxins.

Hazard Categories For Reproductive Toxicants	
CATEGORY 1:	**Known or presumed human reproductive toxicant** Substance shall be classified in Category 1 for reproductive toxicity when they are known to have produced an adverse effect on sexual function and fertility or on development in humans or when there is evidence from animal studies, possibly supplemented with other information, to provide a strong presumption that the substance has the capacity to interfere with reproduction in humans. The classification of a substance is further distinguished on the basis of whether the evidence for classification is primarily from human data (Category 1A) or from animal data (Category 1B).
Category 1A:	**Known human reproductive toxicant** The classification of a substance in this category is largely based on evidence from humans.
Category 1B:	**Presumed human reproductive toxicant** The classification of a substance in this category is largely based on evidence from experimental animals. Data from animal studies shall provide sufficient evidence of an adverse effect on sexual function and fertility or on development in the absence of other toxic effects, or if occurring together with other toxic effects the adverse effect on reproduction is considered not to be a secondary non-specific consequence of other toxic effects. However, when there is mechanistic information that raises doubt about the relevance of the effect for humans, classification in Category 2 may be more appropriate.

Hazard Categories For Reproductive Toxicants	
CATEGORY 2:	**Suspected human reproductive toxicant** Substances shall be classified in Category 2 for reproductive toxicity when there is some evidence from humans or experimental animals, possibly supplemented with other information, of an adverse effect on sexual function and fertility, or on development, in the absence of other toxic effects, or if occurring together with other toxic effects the adverse effect on reproduction is considered not to be a secondary non-specific consequence of the other toxic effects, and where the evidence is not sufficiently convincing to place the substance in Category 1. For instance, deficiencies in the study may make the quality of evidence less convincing, and in view of this, Category 2 would be the more appropriate classification.

Reference: MIOSHA Part 430; Hazard Communication; Appendix A.

As stated earlier, adverse effects on or via lactation are also included in reproductive toxicity, but for classification purposes, such effects are treated separately. The following table addresses lactation:

Hazard Category For Effects On Or Via Lactation	
Effects on or via lactation shall be classified in a separate single category. Chemicals that are absorbed by women and have been shown to interfere with lactation or that may be present (including metabolites) in breast milk in amounts sufficient to cause concern for the health of a breastfed child, shall be classified to indicate this property hazardous to breastfed babies. This classification shall be assigned on the basis of:	
(a)	absorption, metabolism, distribution, and excretion studies that indicate the likelihood the substance would be present in potentially toxic levels in breast milk; and/or
(b)	results of one or two generation studies in animals which provide clear evidence of adverse effect in the offspring due to transfer in the milk or adverse effect on the quality of the milk; and/or
(c)	human evidence indicating a hazard to babies during the lactation period.

Reference: MIOSHA Part 430; Hazard Communication; Appendix A.

Reproductive toxins are identified with the following pictogram:

Chemicals with a high degree of acute toxicity are not defined in the Laboratory Standard. Therefore, the MIOSHA Hazard Communication values defining the respective categories for acute toxicity will be used.

Acute toxicity refers to those adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours. Substances can be allocated to one of four toxicity categories based on acute toxicity by the oral, dermal or inhalation route according to the numeric cut-off criteria as shown in Table A.1.1.

At Central Michigan University, Category 1 and Category 2 chemicals represent those considered to have a high degree of acute toxicity hazard and a SOP is required. Acute toxicity values are expressed as (approximate) LD_{50} (oral, dermal) or LC_{50} (inhalation) values or as acute toxicity estimates (ATE). See the footnotes following Table A.1.1 for further explanation on the application of these values. The hazard(s) of a chemical may also be listed on its container label. Additionally, if the hazard of a chemical is not evident from the container label, the SDS will list the specific hazards.

Acute toxicity is identified with the following pictograms:

Acute Toxicity
(harmful)

Acute Toxicity
(fatal/toxic)

TABLE A.1.1
ACUTE TOXICITY HAZARD CATEGORIES AND ACUTE TOXICITY ESTIMATE (ATE) VALUES DEFINING THE RESPECTIVE CATEGORIES

Exposure Route	Category 1	Category 2	Category 3	Category 4
Oral (mg/kg bodyweight) see: Note (a) Note (b)	≤ 5	>5 and ≤ 50	>50 and ≤ 300	>300 and ≤ 2000
Dermal (mg/kg bodyweight) see: Note (a) Note (b)	≤ 50	>50 and ≤ 200	>200 and ≤ 1000	>1000 and ≤ 2000
Inhalation - Gases (ppmV) see: Note (a) Note (b) Note (c)	≤ 100	>100 and ≤ 500	>500 and ≤ 2500	>2500 and ≤ 20000
Inhalation - Vapors (mg/l) see: Note (a) Note (b) Note (c) Note (d)	≤ 0.5	>0.5 and ≤ 2.0	>2.0 and ≤ 10.0	>10.0 and ≤ 20.0
Inhalation – Dusts and Mists (mg/l) see: Note (a) Note (b) Note (c)	≤ 0.05	>0.05 and ≤ 0.5	>0.5 and ≤ 1.0	>1.0 and ≤ 5.0

Note: Gas concentrations are expressed in parts per million per volume (ppmV).

(a) The acute toxicity estimate (ATE) for the classification of a substance is derived using the LD_{50}/LC_{50} where available;

(b) The acute toxicity estimate (ATE) for the classification of a substance or ingredient in a mixture is derived using:

(i) the LD_{50}/LC_{50} where available. Otherwise,

(ii) the appropriate conversion value from Table 1.2 that relates to the results of a range test, or

(iii) the appropriate conversion value from Table 1.2 that relates to a classification category;

(c) Inhalation cut-off values in the table are based on 4-hour testing exposures. Conversion of existing inhalation toxicity data which has been generated according to 1 hour exposure is achieved by dividing by a factor of 2 for gases and vapors and 4 for dusts and mists;

(d) For some substances the test atmosphere will be a vapor which consists of a combination of liquid and gaseous phases. For other substances the test atmosphere may consist of a vapor which is nearly all the gaseous phases. In these latter cases, classification is based on ppmV as follows: Category 1 (100 ppmV), Category 2 (500 ppmV), Category 3 (2500 ppmV), Category 4 (20000 ppmV).

The terms "dust", "mist" and "vapor" are defined as follows:

(i) Dust: solid particles of a substance or mixture suspended in a gas (usually air);

(ii) Mist: liquid droplets of a substance or mixture suspended in a gas (usually air);

(iii) Vapor: the gaseous form of a substance or mixture released from its liquid or solid state.

Reference: MIOSHA Part 430; Hazard Communication; Appendix A.

For further help in determining the hazard of a chemical, contact your supervisor or OLFS.

2. Designated Areas

Work with chemicals requiring an SOP must be conducted in a designated area. Designated areas may include a hood, glove box, portion of a laboratory, or entire laboratory room. Post signs on designated areas and clearly mark/define the boundaries.

3. Guidelines/Procedures for Employees Working in Designated Areas

Employees shall:

- Be trained to work with these chemicals. Review the SOP and sign and date the SOP form.
- Use the smallest amount of chemical that is practical.
- Use high-efficiency particulate air (HEPA) filters or high-efficiency scrubber systems to protect vacuum lines and pumps.
- Decontaminate a designated area when work is completed.
- Prepare wastes in accordance with the Resource Conservation and Recovery Act (RCRA) and as designated by the University Hazardous Waste Manager.
- Wear appropriate PPE as noted in the SOP.

C. Corrosive Chemicals and Contact-Hazard Chemicals

A corrosive substance is a chemical that produces destruction of skin tissue, namely, visible necrosis through the epidermis and into the dermis, in at least 1 of 3 tested animals after exposure up to a 4-hour duration. Corrosive reactions are typified by ulcers, bleeding, bloody scabs and, by the end of observation at 14 days, by discoloration due to blanching of the skin, complete areas of alopecia and scars. Skin irritation is the production of reversible damage to the skin following the application of a test substance for up to 4 hours. Solid substances (powders) may become corrosive or irritant when moistened or in contact with moist skin or mucous membranes. Likewise, pH extremes like ≤ 2 and ≥ 11.5 may indicate skin effects. In the absence of any other information, a substance is considered corrosive (Skin Category 1) if it has a pH ≤ 2 or a pH ≥ 11.5.

A contact-hazard chemical is an allergen or sensitizer that is so identified in the SDS or label, is so identified in the medical or industrial hygiene literature or is known to be an allergen or sensitizer that leads to an allergic response following skin contact.

Another contact hazard class is respiratory sensitizer, which means a chemical that will lead to hypersensitivity of the airways following inhalation of the chemical. Sensitization includes two phases: the first phase is induction of specialized immunological memory in an individual by exposure to an allergen. The second phase is elicitation, i.e., production of a cell-mediated or antibody-mediated allergic response by exposure of a sensitized individual to an allergen. Usually, for both skin and respiratory sensitization, lower levels are necessary for elicitation than are required for induction. Evidence that a substance can lead to specific respiratory hypersensitivity will normally be based on human experience. In this context, hypersensitivity is normally seen as asthma, but other hypersensitivity reactions such as rhinitis/conjunctivitis and alveolitis are also considered. The condition will have the clinical character of an allergic reaction. However, immunological mechanisms do not have to be demonstrated.

The following pictograms indicate corrosive, irritant/dermal sensitizer, and respiratory sensitizer:

Corrosive Irritant Respiratory Sensitizer
Dermal Sensitizer
Respiratory Tract Irritation

Take the following precautions when working with corrosive chemicals and contact-hazard chemicals:

- Always wear proper PPE, especially eye protection (items may include safety goggles and face shield, gloves known to be resistant to permeation or penetration, laboratory aprons, laboratory coats).
- Add acids and alkalis to water; never add water to acids or alkalis.
- Add acid to water slowly, as a great deal of heat will be formed.
- Provide secondary containment for storage bottles unless bottles are PVC-coated.
- Treat any accident resulting in contact with the skin or eyes immediately. Wash affected area with large amounts of water for at least 15 minutes. Seek immediate medical attention for chemical burns resulting from concentrated solutions.
- Always separate and store acids, alkalis, and other corrosive materials below eye level in properly labeled storage cabinets.
- Store acids away from cyanides.
- Store acids and bases away from flammable liquids and solvents.
- Inspect containers frequently for corrosion.
- Make an effort to minimize quantities according to your application.

D. Pyrophoric/Water Reactive Chemicals

Pyrophoric and water reactive materials can ignite spontaneously on contact with air, moisture in the air, oxygen, or water. Failure to follow proper handling procedures can result in fire or explosion, leading to serious injuries, death and/or significant damage to facilities.

Any handling of a pyrophoric/water reactive material is high risk and must be controlled with adequate system design, supervision, and training. These tasks are two person tasks and workers should not work alone. Handle all reactive chemicals with extreme care and store them away from incompatible chemicals. Wear proper PPE at all times when handling these chemicals.

Pyrophoric liquids and solids are defined in the MIOSHA Hazard Communication Part 430 Standard as materials, which even in small quantities are liable to ignite within five minutes after coming into contact with air. Water reactive chemicals are defined as solid or liquid chemicals which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.

The following pictograms indicate pyrophoric and water reactive properties:

Flammables
Self-reactives
Pyrophorics
Self-heating
Emits Flammable Gas
Organic Peroxides

Explosives
Self Reactives
Organic Peroxides

See Appendix Q (Pyrophoric and Water-Reactive Chemicals) for further information.

E. Explosives

Explosives can be defined as a solid or liquid chemical that is 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. An explosive item is an item containing one or more explosive chemicals. An unstable explosive is an explosive, which is thermally unstable and/or too sensitive for normal handling, transport, or use. The following pictogram indicates explosive properties:

Some examples of explosive chemicals include the following:

- ammonium nitrate
- benzoyl peroxide (explosion-sensitive to shock, heat, and friction)
- picric acid
- sodium azide

Many chemicals form highly explosive compounds when mixed together. Others become highly explosive when allowed to decompose or when exposed to air. Handle chemicals that are known to be potentially explosive with extreme care while wearing proper PPE. When working with these chemicals, make safe handling techniques the number one priority to prevent any accidental mishaps.

F. Organic Peroxides or Peroxide-Forming Chemicals

Organic peroxides and peroxide formers are very unstable explosives. They are extremely sensitive to shock, sparks, heat, or other forms of accidental explosive initiation. Organic peroxides may have one or more of the following properties:

1. Be liable to explosive decomposition
2. Burn rapidly
3. Be sensitive to impact or friction
4. React dangerously with other substances

The following pictograms indicate Organic Peroxide:

Substances can form peroxides upon standing or when in contact with air. After peroxides form, they may dry in the threads on the container's top or may become concentrated if the chemical is distilled. Dry or concentrated peroxides formed in this manner are highly explosive. Some examples include the following:

- aldehydes
- ethers, especially cyclic ethers, and ethers derived from primary and secondary alcohols (ethyl ether, isopropyl ether)
- most alkenes (cyclohexene, cyclooctene)
- vinyl and vinylidene compounds (vinyl acetate, vinylidene chloride)

Exercise extreme caution when heating or distilling any known peroxide former. Check expiration date on the label and ensure proper storage conditions. Laboratory explosions have resulted from such procedures on expired peroxide formers.

Label all peroxide-forming chemicals with the date the container was received from the supplier and the date the container was first opened, even if the chemical contains inhibitors to retard peroxide formation. Use or dispose of any peroxide-forming chemical prior to the expiration date. A physical inventory must be performed annually to verify active inventory records.

All peroxide-forming chemicals have a limited shelf life, whether the container is opened or not. Acceptable shelf life varies by compound; the maximum permissible storage life of any peroxidizable substance is 12 months. Storage past these limits is discouraged, as highly explosive compounds are likely to form. Exceptions must be approved by the Office of Laboratory and Field Safety. Storage limits start when the chemical is first received, whether or not it is opened. If in doubt of the stability of the chemical, do not move it until you have received directions from the Hazardous Waste Manager. **Dried crystals or residues are indications of a highly explosive state!** Store shock and heat sensitive chemicals in a dedicated cabinet.

For further information on handling and storage limits of Peroxidizable Compounds, see Appendix S.

G. Flammable Liquids

Flammable liquid means a liquid having a flash point of not more than 93ºC (199.4ºF). The flash point means the minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid, as determined by standardized ASTM methods. Consult the chemical label or SDS to determine the flash point of a chemical.

A flammable liquid shall be classified in one of four categories:

Criteria for Flammable Liquids

Category	Criteria
1	Flash point < 23°C (73.4°F) and initial boiling point ≤ 35°C (95°F)
2	Flash point < 23°C (73.4°F) and initial boiling point > 35°C (95°F)
3*	Flash point ≥ 23°C (73.4°F) and ≤ 60°C (140°F)
4**	Flash point > 60°C (140°F) and ≤ 93°C (199.4°F)

Reference: MIOSHA Hazard Communication Part 430, Appendix B

Note:

*When a Category 4 flammable liquid is heated for use to within 16.7 °C (30 °F) of its flashpoint, it shall be handled in accordance with the requirements for a Category 3 liquid with a flashpoint at or above 37.8 °C (100 °F).

**When liquid with a flashpoint greater than 93 °C (199.4 °F) is heated for use to within 16.7 °C (30 °F) of its flashpoint, it shall be handled in accordance with the requirements for a Category 4 flammable liquid.

The following pictogram indicates flammable:

Note the following storage precautions when working with flammable liquids:

- Keep flammable liquids in appropriate containers and store them in flammable liquid storage cabinets away from any possible ignition source.
- Keep solvents in safety cans. Drums and five-gallon containers are not allowed in laboratories unless stored in a flammable liquid cabinet or safety can.
- Store flammable solvents requiring refrigeration in refrigerators/freezers engineered with no internal components that could trigger an explosion.
- Do not store flammable liquids, including waste stock, in exits and stairways.

Maximum allowable container capacity for flammable liquids:

Container Type	Category 1	Category 2	Category 3	Category 4
Glass or Approved plastic	1 pint	1 quart	1 gallon	1 gallon
Metal (other than DOT drums)	1 gallon	5 gallons	5 gallons	5 gallons
Safety cans	2 gallons	5 gallons	5 gallons	5 gallons

Reference: MIOSHA General Industry Safety Standards, Part 75. Flammable Liquids, Table H-12, page 15.

Exception: Glass containers up to one gallon in size are permitted for storage of flammable liquids if the required purity would be adversely affected by storage in a metal or approved plastic container, or if the liquid would cause excessive corrosion or degradation of the metal or approved plastic container.

Per MIOSHA Part 75, 1910.106(d)(3)(i), not more than 60 gallons of Category 1, 2, or 3 flammable liquids, nor more than 120 gallons of Category 4 flammable liquids may be stored in a storage cabinet.

When using flammable liquids:

- Avoid handling the liquids around open flames.
- Handle only appropriate quantities of liquids at any given time.
- Handle only in well-ventilated areas.
- Keep containers, beakers, etc. closed or covered when possible to avoid release of flammable vapors.
- Never use an open flame for heating flammable solvents.
- Evaporate large quantities of liquids in a contained system that will minimize escape of material.
- Keep hot plates, Glascol heaters, and water baths at a moderate heat setting.
- Do not fill flasks more than half-full and use boiling chips when heating.

Some examples of flammable liquids are the following:

- acetaldehyde
- acetone
- acetonitrile
- acrylonitrile
- allyl alcohol
- n-amyl acetate
- sec-amyl acetate
- n-amyl alcohol
- tert-amyl alcohol
- benzene
- 1-butanol (n-butanol)
- tert-butyl alcohol
- carbon disulfide
- chlorobenzene
- cyclohexane
- cyclohexene
- 1,1- and 1,2-dichloroethane
- diethyl ether
- 1,1- and 1,2-dimethylhydrazine
- dioxane
- ethanol
- ethyl acrylate
- ethylenediamine
- ethyl formate
- gasoline
- n-heptane
- n-hexane
- isoamyl alcohol
- isobutyl alcohol (isobutanol)
- isopropyl acetate
- isopropyl alcohol
- methanol
- isopropylamine
- methyl ethyl ketone
- morpholine
- nitromethane
- 2-nitropropane
- pentane
- propylene oxide
- pyridine
- toluene
- 31rimethylamine
- vinyl acetate
- xylene

H. Oxidizers

Oxidizer means a chemical, other than a blasting agent or explosive, that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases. Oxidizers may be in the form of a gas, liquid or solid. Consult the SDS for proper safe handling techniques.

The following pictogram indicates oxidizer:

Store oxidizers away from flammable/combustible liquids and other combustible materials. Store compressed gas cylinders of oxygen at least 20 feet from flammables or separate by a firewall.

Some examples include the following:

- chlorate compounds (potassium chlorate)
- permanganate compounds (potassium permanganate)
- nitrate compounds (potassium nitrate, uranyl nitrate, zinc nitrate)
- acid dichromate
- chromic acid
- chromium trioxide
- hydrogen peroxide (>30%)
- nitric acid
- sodium peroxide
- sulfuric acid
- chlorine gas
- manganese dioxide
- perchloric acid (see section I)
- potassium nitrite

I. Perchloric Acid

Perchloric acid is an extremely hazardous and powerful oxidizing agent. Contact with combustible materials (wood, paper, grease, oil, and most organic compounds) can cause these materials to become extremely flammable, and they may explode spontaneously or with impact, friction, or heating. Fumes from perchloric acid may form explosive metal perchlorates in fume hoods causing explosions. This chemical requires special precautions when handling. The following rules apply to the use of perchloric acid:

- Use of heated perchloric acid is restricted to specially designed perchloric acid hoods identified as follows: FOR PERCHLORIC ACID OPERATIONS.
- Use of perchloric acid requires the approval of the Department and OLFS.

- Use of perchloric acid requires a standard operating procedure along with special training on the specific safety hazards that are present with the use of perchloric acid.

J. Picric Acid

Picric acid (trinitrophenol) is explosive when it is dry. Dry picric acid is more explosive than TNT. Picric acid in a solution of at least 10% water is considered flammable but not explosive. Picric acid in a solution less than 10% water is considered explosive and should not be handled. Dry picric acid can accumulate on the outer surface of the container or in cap threads. Dry picric acid in cap threads is not always visible and can present a significant friction-sensitive hazard. Extreme caution should be given to containers with metal caps containing any solution of picric acid. Shock-sensitive picrates are formed when picric acid vapors come in contact with metals such as copper, lead, or zinc. Contact with concrete floors can also form sensitive calcium picrate salts. Extreme caution should be exercised when encountering bottles of picric acid with the following characteristics:

- Little or no moisture content within the bottle.
- A metal cap on the container.
- Any observable needle-like structures within the container.
- Any sign of accumulation on the surface of the bottle.

In any of these cases, contact OLFS and the Hazardous Waste Manager immediately, and do not attempt to move the container. Qualified safety personnel with appropriate safety equipment will move it. This container is highly explosive!

K. Formaldehyde

Formaldehyde is a colorless gas that has a bitter odor. Formalin is an aqueous solution containing 37-50 percent formaldehyde. Overexposure to formaldehyde can lead to serious health concerns. The MIOSHA Formaldehyde Standard (Part 306) establishes a 0.75 ppm permissible exposure limit (PEL), 2.0 ppm short term exposure limit (STEL) and a 0.5 ppm action limit. The standard requires exposure monitoring and enrollment in the medical surveillance program for employees exposed above the action level or STEL.

Exposure to formaldehyde can occur through inhalation, ingestion, skin contact or contact with body openings such as the eyes and nose. Follow these guidelines when working with formaldehyde:

- Wear proper PPE as determined from the standard operating procedures developed for each procedure involving formaldehyde.
- Minimize exposures through the use of engineering controls and workplace practices.
- If required, participate in the medical surveillance program.

Contact OLFS for exposure monitoring of all procedures where formaldehyde is used outside of a fume hood. For areas where exposure monitoring has been conducted and levels are found to be above the PEL or STEL, the area must be posted with the following information:

DANGER
FORMALDEHYDE
IRRITANT AND POTENTIAL CANCER HAZARD
AUTHORIZED PERSONNEL ONLY

Label receptacles containing formaldehyde as follows:

FORMALDEHYDE
POTENTIAL CANCER HAZARD

For further guidance on controlling exposure to formaldehyde and emergency procedures, see Appendix R.

L. Benzene

Benzene is a colorless to light yellow liquid with an aromatic odor. It is flammable and is a known human carcinogen and a possible reproductive toxin. It can be found as either a liquid or a vapor and has a high evaporation rate. Because of this high evaporation rate, benzene liquid can quickly vaporize, generating increased concern for respiratory and fire hazards. The MIOSHA Benzene Standard (Part 311) establishes a 1.0 ppm PEL, 5 ppm STEL and a 0.5 ppm action limit. The standard requires exposure monitoring and enrollment in the medical surveillance program for employees exposed to benzene above the action level. Follow these guidelines when working with benzene:

- Wear proper PPE as determined from the standard operating procedures developed for each procedure involving the use of benzene.
- Minimize exposure through the use of engineering controls and workplace practices.
- If required, participate in the medical surveillance program.

Contact OLFS for exposure monitoring of all procedures where benzene is used outside of a fume hood. In areas where exposure monitoring has been conducted and levels are found to be above the PEL or STEL, the area must be posted with the following information:

DANGER
BENZENE
CANCER HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATOR REQUIRED

Label receptacles containing benzene as follows:

DANGER
CONTAINS BENZENE
CANCER HAZARD

M. Liquid Nitrogen

Overview

Liquid nitrogen (abbreviated LN_2) is a colorless and odorless cryogenic liquid maintained at a very low temperature. The extremely low temperature of liquid nitrogen requires storage in special vacuum insulated flasks, often called Dewar flasks. Dewar flasks hold the liquid nitrogen as it boils at -196°/-321°F. Liquid nitrogen is used for a variety of commercial and scientific applications. Liquid nitrogen poses significant health and safety hazards, requiring special handling and training provisions before use. **Prior to using or handling liquid nitrogen, one must obtain specific department approval and complete the required safety training.**

Safety Hazards Associated with Handling Liquid Nitrogen:

- The extremely low temperatures of liquid nitrogen can cause severe frostbite or eye damage. Brief contact with skin will usually not result in tissue damage because of temporary protection provided by the Leidenfrost Effect. However, extended contact from pooled or trapped liquid or contact to the eyes can cause severe tissue damage.
- Items super-cooled by the liquid become extremely cold and pose added frostbite risk, without the insulating effects granted by the Leidenfrost Effect. In addition, many objects, such as common glass and large solid plastics, become brittle upon contact with liquid nitrogen and may shatter when cold, sending pieces of the material flying.
- On vaporization, liquid nitrogen expands by a factor of 700; one liter of liquid nitrogen becomes 24.6 cubic feet of nitrogen gas. This expansion factor can cause an explosion of a sealed container of liquid nitrogen or if pressure release devices fail.
- Gaseous nitrogen is non-toxic and makes up 78% of the atmosphere, (21% oxygen, 1% other), but it can displace oxygen resulting in dangerous oxygen levels below 19.5%. Rapid vaporization from liquid nitrogen can displace oxygen in the room and cause asphyxiation (lack of oxygen) without warning. Confined or poorly ventilated spaces are especially prone to oxygen deficient atmospheres.
- Because the boiling point of oxygen is higher than that of nitrogen, vessels containing liquid nitrogen can condense oxygen from air. Dewar flasks containing liquid nitrogen left uncovered for an extended period can build up liquid oxygen, which may cause violent reactions and fire.

Personal Protective Equipment (PPE) Required When Handling Liquid Nitrogen:

- Safety goggles, unvented (not safety glasses) – Required at all times.
- Face shield – Required when pouring or filling.
- Insulated gloves should be loose fitting or with an elastic cuff so they can be thrown off if liquid pours inside – Required when pouring or filling.
- A lab coat or long sleeves are required to minimize skin contact when performing transfers. In addition, pant legs should be worn on the outside of boots or work shoes when filling Dewar flasks to prevent injury in the event of spillage.

Safe Handling Procedures:

- Users are required to obtain department approval prior to use. Wear the assigned PPE at all times.
- Use liquid nitrogen only in well-ventilated places. Nitrogen is colorless and odorless – the cloud it forms when you pour liquid nitrogen is condensed water vapor from the air, not nitrogen gas.
- Avoid all direct skin contact with liquid nitrogen. Splashing may cause liquid nitrogen to become trapped in clothing or PPE.
- Do not touch any item that has been immersed in liquid nitrogen until it has warmed to room temperature.
- Do not ride in passenger elevators with liquid nitrogen or other cryogenic materials. If the elevator becomes stuck, the expanding gas from the container can displace the oxygen inside the elevator, leading to asphyxiation of the passenger. When using passenger

elevators to transport cryogenic materials, follow the procedure described in Appendix U of the Chemical Hygiene Plan.

- Never insert hollow rods or tubes into liquid nitrogen. The liquid may rapidly spurt from the tube.
- Consult the Hazardous Waste Manager for proper disposal of liquid nitrogen. Proper disposal does not include dumping on the floor, which can instigate asphyxiation, or dumping down the drain. Mixtures of liquid nitrogen and another chemical may require special waste procedures.

Liquid Nitrogen Storage Practices:

- Store only in well-ventilated areas. Offices and non-approved storage closets are not suitable storage environments. Room exhaust and ventilation flow rates for applicable laboratories and storage areas must be sustained during "unoccupied" room settings.
- Always use containers and vessels specifically designed for use with liquid nitrogen. Cryogenic containers are designed to withstand rapid, extreme temperature changes. Confirm the right type of flask is used for liquid nitrogen before purchase and use.
- Do not store liquid nitrogen in any container with a tight-fitting lid. A tightly sealed container will build up pressure as the liquid boils and may explode after a short time. Use only approved unsealed containers. Do not store liquid nitrogen for long periods in an uncovered container. Use only fittings that have been designed specifically for the use with cryogenic liquids, as non-specialized equipment may crack or fail. Do not transport liquid nitrogen in wide-mouthed glass Dewar flasks not protected with safety tape.
- Always make sure that containers of liquid nitrogen are suitably vented and unlikely to be blocked due to ice formation.

Filling Dewar flasks and cylinders:

- Do not fill cylinders or Dewar flasks to more than 80% of capacity since expansion of gases during warming may cause excessive pressure build-up.
- Always fill warm Dewar flasks slowly to reduce temperature shock effects and to minimize splashing.
- Note that outside of normal working hours (M-F 8:00a.m.-5:00p.m.), transfer of liquid nitrogen from the Dow loading dock area is prohibited without a second trained person present. A large spill or container failure could result in asphyxiation or serious injury. Ensure a trained individual is present to provide aide or call emergency services in case of an accident.

In case of emergency:

Large spills or releases - evacuate immediately and call 911. For small and large spills, releases, or container failures, immediately evacuate the area of the spill. Prevent others from entering the space. Liquid nitrogen will evaporate rapidly at room temperature and dissipate into the atmosphere. Until the excess nitrogen dissipates, breathable oxygen may be dangerously low. If a person becomes dizzy or loses consciousness, move the person to fresh air immediately.

Do not enter a low oxygen environment to rescue an unconscious individual. Only trained responders with appropriate air monitoring equipment or breathing apparatus should be allowed entry.

Personal Exposure:

Frostbite: Direct contact with liquid nitrogen or chilled surfaces can quickly cause frostbite or damage organs. If frostbite occurs, place the body part in a warm water bath not above 40ºC/104ºF. Do not rub affected skin following contact because it can damage tissue. Never use dry heat to warm frostbitten tissue. Seek immediate medical attention.

Eye exposure: Flush eyes with emergency eyewash for at least 15 minutes. Hold eyelids open to ensure flushing of entire eyeball. Seek immediate medical attention.

Ingestion: Accidental ingestion of cryogenic liquids will cause extreme internal injuries. Call 911 immediately if ingestion occurs.

Equipment failure or container over pressurization:

Immediately cease use of any equipment that is damaged or fails to vent properly. If you suspect a vessel has over pressurized, immediately evacuate and contact emergency services.

Report all liquid nitrogen releases, personal exposures, and safety concerns to the Office of Laboratory and Field Safety at 989-774-4474.

N. Nanomaterials

Nanomaterials are defined as materials with at least one external dimension (length, width, or depth) in the size range from approximately 1-100 nanometers. Nanomaterials can be reagents, catalysts, or the desired product of research. Engineered nanomaterials are intentionally made for specific purposes, such as shape, size, properties, or content. They have unique properties and functions because of their nano-scale size and dimensions. Often, the behavior of nanomaterials may depend more on surface area than particle composition itself. Examples of engineered nanomaterials include carbon buckeyballs or fullerenes; carbon nanotubes; metal or metal oxide nanoparticles (e.g., gold, titanium dioxide) and quantum dots. Very little is known about the safety risks that engineered nanomaterials might pose, beyond some data indicating that they possess certain properties associated with safety hazards in traditional materials. Depending on their composition and structure, some nanomaterials may initiate catalytic reactions that, based on their chemical composition, would not otherwise be anticipated.

Nanomaterials fall under OSHA General Industry Standards, which includes established exposure limits for naturally occurring nanomaterials. Although there are currently no established (legal) exposure limits (US or International) for Engineered Nanomaterials, NIOSH has developed Recommended Exposure Limits (RELs) for carbon nanotubes (8-hr TWA 1 $\mu g/m^3$) and nano-titanium dioxide (8-hr TWA 0.3 mg/m^3). When controlling potential exposures within a workplace, NIOSH has recommended a hierarchical approach to reduce worker exposures.

There must be an approved Standard Operating Procedure (SOP) in place before work begins with nanomaterials and all personnel working with nanomaterials must be trained and adhere to all components of the SOP, including required PPE. Restrict access to the laboratory where nanomaterials are used and display proper signage indicating nanomaterials are present.

See Appendix P for detailed guidance on working safely with nanomaterials.

VIII CHEMICAL DISTRIBUTION/STORAGE/INVENTORY/DISPOSAL

A. Ordering Chemicals

Prior to ordering chemicals, do the following:

- Check the chemical inventory to verify that the chemical is not already available in the department. Obtain PI approval before sharing between labs.
- Obtain information concerning proper handling, storage, and disposal of the chemical.
- Determine the minimum amount of chemical needed to complete the work. Do not order extra amounts of chemicals that will not be used in a timely manner. Disposal costs far outweigh the slight cost savings by ordering large quantities.

Chemicals must arrive with the proper hazard communications labeling and SDS. Do not accept a chemical container without the proper hazard communications labeling.

B. Chemical Stockrooms and Storerooms

Stockrooms are defined as areas where chemicals are mixed, repackaged and/or distributed for laboratory use. Storerooms are defined as areas where chemicals are stored with no manipulation of chemicals.

- Store hazardous materials, when not in immediate use, in an environmentally controlled, stockroom, storeroom, or storage cabinet.
- Do not use storerooms as preparation or repackaging areas.
- Record the removal of any chemical or apparatus for inventory purposes.
- Do not transport chemicals from the stockroom unless they are in a secondary container.
- Wear proper PPE when moving chemicals.

C. Transporting Chemicals on Campus

- Use secondary containers, such as a bucket, to hand carry hazardous chemicals, concentrated acids, flammable solvents, or other corrosives.
- Do not ride in passenger elevators with poison inhalation hazards or cryogenic materials. If the elevator becomes stuck, the expanding gas from the container can displace the oxygen inside the elevator, leading to asphyxiation of the passenger. Toxic inhalation chemicals can also be deadly if a release occurs inside an elevator. When using passenger elevators to transport these materials, follow the procedure described in Appendix U.
- Wear proper PPE when moving chemicals.

D. Chemical Storage

Follow these general procedures for storage of chemicals:

- Conduct routine inspections to check containers for deterioration and integrity.
- Store the smallest amounts of hazardous materials as practical in the laboratory.
- Do not use fume hoods as storage areas for chemicals.
- Store chemicals in cabinets or on shelves, not on the floor.
- Store chemicals according to hazard class, not alphabetically.
- Do not store incompatible materials together.

- Secure bottle caps to prevent accidental spills and minimize odors.
- Provide spill trays in liquid storage areas.
- Store large quantities and heavy chemicals on lower shelves. Store only lightweight or small quantities above eye level.
- Do not store corrosive materials of any quantity above eye level.
- Wear appropriate PPE, including eye protection, when handling chemicals stored above eye level.
- Keep a ladder or step stool available for reaching overhead storage.
- Store chemicals away from heat and direct sunlight.
- Conduct periodic, scheduled inventories. Return chemicals not required for the present work to the stockroom for storage or proper disposal.
- Avoid containers derived from disposable food products in labs where hazardous chemicals are used.

1. Flammable Liquid Storage

- Store flammable liquids, when not stored in flammable storage containers and when not in use, in flammable storage cabinets designed specifically for and labeled as "Flammable Liquids". Do not store other materials in the cabinet.
- Store plastic squeeze bottles that contain flammable materials (normally used for rinse purposes) in a flammable storage cabinet at the end of the workday.
- Store flammable liquids requiring cold storage in Lab-Safe or flammable storage refrigerators/freezers. The interior of these units has no switches that could arc, or other spark points to provide a source of ignition. Ethanol/water solutions containing more than 50% ethanol are considered flammable.
- Follow the guidelines in section VII part G for allowable quantities and container sizes.

2. Corrosive Liquid Storage

- Store mineral acids, such as sulfuric and hydrochloric acids, in acid storage cabinets.
- Store bases and solutions of bases separately from acids.
- Store oxidizing acids, such as nitric and perchloric acids, with oxidizing materials and away from organics.
- Store organic acids, such as acetic and formic acids, with flammable materials.

3. Oxidizer Storage (see definition in section VII part H)

- Store oxidizers, such as hydrogen peroxide and chlorine bleach, away from all organic materials and reducing agents.
- Do not store near any combustible materials.

4. Compressed Gas Storage

- Chain or secure all gas cylinders to a permanent fixture and store with the caps on when not in use.
- Store oxygen cylinders away from fuels and other combustible materials.
- Mark empty cylinders as "Empty" or "MT" and store away from other cylinders.

- Cylinders not in active use should be removed from laboratory work areas to a designated storage area for the building. Cylinders should not be stored for more than 3 years.
- Cylinders of hydrogen fluoride and hydrogen bromide should be returned to the supplier within 2 years of the delivery date.
- Toxic, corrosive, or unstable gases
    a. These gas cylinders must be dated when they arrive. Order only the smallest quantity needed for the work.
    b. These gases must be stored and used in a ventilated gas cabinet, exhausted enclosure, or a ventilated separate gas storage room.
    c. Gases that are not being used should be turned in to the hazardous waste manager or returned to the supplier within one year from the delivery date. Gases that are kept for more than one year can degrade, or the cylinder and connections can degrade in such a way as to become very unstable and dangerous.
    d. Emergency procedures should be made clear to all involved, including personnel from adjacent labs.
    e. Fume hoods and other ventilation need to be tested before use and checked frequently during the project involving toxic gas.
    f. For transportation guidance, see section VIII part C.

5. Toxic Chemicals and High Risk Chemicals

- Store toxic materials separately from other chemicals.
- Store in a vented cabinet.
- Store materials that are highly acute toxins and other high-risk chemicals with the parent container inside an unbreakable secondary container.
- Post specific warning signs on the storage area.
- Maintain records of use and disposal.

6. Reactive Chemicals (see definition in section VII part D)

- Store reactive chemicals away from other chemicals.
- Store water reactive chemicals in cabinets protected from the fire sprinkler system or other water sources.
- Store specified reactive materials under either inert atmosphere and/or refrigeration.
- Inventory materials that may form organic peroxides and dispose of them at the time of expiration.
- Store explosive materials as specified by the manufacturer. Only knowledgeable and trained individuals may handle these materials.

Guidance for chemical storage and compatibility are in Appendix W and X respectively.

E. Chemical Inventory

Maintain a real-time chemical inventory and update the inventory biannually in Laboratory Registration Manager for regulatory reporting and emergency response purposes. The inventory template is located in Appendix J.

F. Shipping Hazardous Chemicals

Do not ship hazardous chemicals using commercial vendors without prior approval from the Hazardous Waste Manager. The Department of Transportation has very specific regulations governing the shipping of hazardous materials. Failure to comply with these regulations could result in severe penalties. Contact the Hazardous Waste Manager with any questions regarding shipping of hazardous materials.

G. Employee Transporting of Chemicals Outside the Facility

Do not transport any chemical or hazardous material outside of the University without prior approval from OLFS. The employee is responsible for ensuring that the Department of Transportation regulations on shipping chemicals are not violated by transporting chemicals in a private car or on a commercial carrier. OLFS will assist with any questions regarding these regulations.

H. Hazardous Waste Disposal

The goal of any waste disposal program is to reduce the potential harm to people and the environment that could result from the improper disposal of a hazardous chemical. Consider first the minimization of the amount of waste generated. If possible, use non-hazardous alternatives. Recycle or reclaim materials when possible. Know the disposal requirements before ordering a new material. **Note: Contact the Hazardous Waste Manager for the proper disposal requirements and methods for all chemical wastes. Keep a detailed inventory of the contents and quantities of waste placed into the waste container!**

1. What is a Hazardous Waste?

Hazardous waste is defined in the Federal Resource Conservation and Recovery Act (RCRA). Waste is considered toxic and/or hazardous according to RCRA if it will "cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed."

In particular, RCRA regulations (40 CFR 261 and 262) specify that a waste is hazardous if it is a listed waste or has the characteristics of a hazardous waste. A hazardous waste meets any of the following conditions:

- Has been named as a hazardous waste and listed as such in the regulations (see Appendix F for listed wastes).
- Exhibits any of the characteristics of a hazardous waste (ignitable, corrosive, reactive, toxic) = characteristic hazardous waste (see Appendix G for more details on a characteristic hazardous waste).
- Is a mixture containing a listed hazardous waste and a nonhazardous waste.
- Is a waste derived from the treatment, storage, or disposal of a listed hazardous waste.

<u>Mixture Rule</u>

A listed hazardous waste plus a non-hazardous waste is always a hazardous waste. A characteristic hazardous waste plus a non-hazardous waste may or may not be a hazardous waste depending on whether the resulting waste demonstrates characteristics of a hazardous waste.

See the Hazardous Waste Manager if there are any questions on whether a waste is hazardous or not!

2. Waste Accumulation, Storage, and Disposal

The following procedures apply to hazardous waste containers in laboratories:

- Place a "Hazardous Waste" label (template available on Hazardous Waste website), on the container before any waste is put into it, marking the applicable hazard warnings. Include the full chemical name(s) with percent composition of the waste. Note the date the first drop of waste is added to the container on the label. Hazardous waste must be collected no later than one year after the first date of waste accumulation, so choose an appropriately sized container for the anticipated amount of waste to be generated.
- At no time should you accumulate more than 55 gallons of hazardous waste or 1kg (2.2 pounds) of acutely hazardous waste.
- Keep containers closed except when adding waste and store container in a secondary containment device.
- Use only containers that are in good condition, compatible with the waste, and appropriately sized for the amount you will generate.
- Keep containers under the generator's control.
- Inspect containers on a regular basis.
- Keep an inventory of the contents. Record the name and amount of each chemical added to the waste container along with the date it was added.
- When adding new waste to a container, check to see that the new waste is compatible with the original contents.
- Date waste containers when waste is first placed in the container.
- When the container is full, complete the hazardous waste label with percentages of each chemical and the date the container became full. The % column must equal 100%.
- A container is full when the liquid level reaches close to, but not all the way to the top of the container. This will prevent the build-up of excessive vapors while ensuring adequate room for expansion.
- Notify the Hazardous Waste Manager for waste pick-ups within 3 days of the container being full by submitting the Hazardous Waste Disposal Form online.
- Researchers and laboratories that have chemicals that are no longer needed (related to a lab clean-out or because of process changes) but still in the original container are encouraged to consult with colleagues in their department to see if another researcher/lab can use said chemical. Once it has been determined the chemical is truly unwanted, affix a completed Hazardous Waste Label to the container and submit the Hazardous Waste Disposal Form online. For unwanted chemicals that were mixed or made in the laboratory, affix a completed Hazardous Waste Label to the container and submit the disposal form online as these are unlikely to be reused by another lab or researcher.

<u>Disposal of experimental compounds</u>

- Dispose of experimental compounds of unknown toxicity as hazardous waste.
- Label the container with your name, department, and chemical structure.
- Do not, under any circumstances, dispose of unknown compounds down the drain or in the laboratory trash bins.

Drain disposal of chemicals

- Salts, sugars, and starches that do not contain any hazardous material may be put down the drain if they present no possibility of coagulation within the drain.
- "Neutral" buffer solutions (pH between 6 and 8) may be put down the drain.
- Drain disposal of all other chemicals is prohibited!

Laboratory glass waste

Glass should not go into the regular trashcans to protect the custodial staff from injury. Lab glass should be disposed of in a labeled "glass waste" receptacle. The custodial staff will take it to the dumpster; it just needs to be segregated. The rules for the glass waste are as follows:

1. Clean glass only.
2. No liquids.
3. No highly toxic residues.
4. No needles or razor blades.

Sharps waste

Sharps are needles (and attached syringes), lancets, scalpel, and razor blades (even if not contaminated) or any item sharp enough to penetrate the skin that is contaminated with potentially infectious material.

Sharps are collected in an FDA cleared sharps container that is color coded, leak proof, puncture-resistant, closable and bears the biohazard symbol. A sharps container must be permanently closed when the contents reach the fill line indicated on the sharps container or ¾ full. The container must be disposed of within 90 days of the date that the first sharp was placed in it. Label sharps containers with the date that the first sharp is placed in the container as well as disposal date. Keep the 90-day collection limit in mind when purchasing sharps containers so they are appropriately sized.

Sharps will be disposed of by incineration through a contracted, licensed, regulated medical waste hauler. Be sure your sharps containers are closed and placed in the pickup locations before scheduled waste pickups.

Non-disposable sharps are placed in puncture resistant, closable, leak proof containers, appropriately labeled for transport to a processing area for decontamination. If reusable sharps are to be autoclaved in-house, they should be free of chemical or drug residues that may be aerosolized during sterilization. Clearly label these containers "Do Not Autoclave" if residual chemical contaminants may be present.

Sharps not exposed to chemical, radiation or biologicals that are used in a non-laboratory setting may be placed in rigid, puncture-resistant containers that are appropriately labeled and transported to a sanitary landfill in a manner that retains the integrity of the container according to Michigan's Medical Waste Regulatory Act.

Empty Chemical/Solvent Bottles

1. Deface the chemical label on all empty containers.
2. Solvent bottles must be rinsed and/or air-dried in a chemical fume hood until they are free of liquid and odor. All rinsate should be disposed of as hazardous waste.

3. Corrosive liquid bottles should be triple rinsed with water and free of hazards and odor. Collect rinsate as hazardous waste.
4. Rinse and/or clean all bottles formerly containing hazardous powders or solid chemicals. Collect rinsate as hazardous waste.
5. Cleaned plastic containers can go in trash.
6. Cleaned glass containers can either go in the lab glass waste or directly to the dumpster.

Spill response for hazardous waste

Spill response materials must be available and readily accessible for any satellite waste accumulation site. For labs, satellite waste accumulation sites include all spaces with hazardous waste containers.

I. Laboratory Decommissioning Criteria

If you are faculty leaving the University, contact OLFS to make an appointment for checkout of your laboratory, shop, or studio space. All chemicals, hazardous waste, student projects and any other potentially hazardous materials must be properly dealt with before you leave. Additionally, cleaning and decontamination of the space must be completed prior to your departure. OLFS will update the lab door sign and lab registration database to reflect who is responsible for the area while it is unoccupied. If you are simply moving your laboratory, shop, or studio to another location or you are leaving CMU, but the lab will remain functioning with another PI, you still must properly decommission your laboratory workspace to ensure chemicals and hazardous waste are handled appropriately. If the principal investigator is unable to decommission the space, then arrangements must be made for someone else to assist. Complete the **checkout for labs/shops/studios-personnel departures and space cleanout form located in Appendix V** and follow the **lab equipment decontamination procedure** located in Appendix O when individuals depart and when PIs vacate a space. When individuals close out projects and leave a laboratory, shop, or studio, the PI or supervisor must walk through the space with the individual to ensure spaces are clean and all materials are stored, transferred, or disposed properly. **Each department must come up with a strategy to address the following*:***

1. Hazardous chemical waste and unwanted chemicals should be disposed through the Hazardous Waste Manager at least 14 days prior to the actual move date.
2. Before leaving the laboratory, all chemical storage areas should be completely clean. Wipe down all surfaces, and empty shelves, cabinets, and drawers. If non-fixed chemical storage equipment (corrosive cabinets, flammable liquid storage cabinets, laboratory refrigerators and freezers) are relocated, they must be decontaminated prior to moving.
3. Clean out all fume hoods. All research apparatus must be decontaminated prior to moving.
4. If non-laboratory personnel are involved with moving research apparatus, the apparatus must be decontaminated.
5. All compressed gas cylinders should be removed prior to leaving the laboratory. Compressed gas cylinders must be properly secured and capped when they are transported. Compressed gas cylinders must be transported in an approved cylinder cart.
6. Practice good general housekeeping. All papers, rags, empty bottles, boxes etc. should be properly disposed of prior to vacating the laboratory.

IX CHEMICAL EMERGENCY ACTION

Always be prepared! One of the best ways to avoid emergencies is to think and plan ahead. Know the main and alternate evacuation routes from the area. Prior to working with chemicals in the laboratory, locate the following items:

- Eyewash
- Emergency shower
- First aid kit
- Fire extinguisher
- Spill-control kit
- Emergency shut-off valves
- Telephone
- Emergency phone numbers (names of contact personnel should be listed on the laboratory doors, and it is recommended that phone numbers of contact personnel are posted near phones)

A. Spill Procedures

The most common incident involving a hazardous material usually involves a liquid/solid spill or the accidental release of a gas or vapor. Fires and explosions can also occur. Because of the quantities used in most procedures on campus, spills will usually be small. However, the vapor released from a small spill can be dangerous either if inhaled or if it is flammable. Any spill of a hazardous material outside of a chemical fume hood is considered dangerous, and steps to remediate must be taken immediately.

Spills are classified as either hazardous or incidental. A hazardous spill is an emergency of unknown nature, a situation which may be immediately dangerous to life and health, is a threat to personnel and/or the public, threatens the surrounding area or facility, and/or involves a toxic gas leak, or a toxic, corrosive, or reactive hazardous material. Members of a hazardous cleanup response team will clean up all hazardous spills.

An incidental spill creates no fire hazard and involves low to moderately toxic materials in small amounts, which can be absorbed, neutralized, contained, or otherwise controlled by employees in the immediate release area. In general, incidental spills can be cleaned up by the individual who was using, storing, or transporting the material spilled, as long as they are properly trained and use approved spill cleanup kits and PPE. If the individual is not properly trained, another trained individual should be called for the cleanup.

1. Hazardous Spills

In the event of a hazardous chemical spill, do the following:

- Eliminate all sources of ignition and evacuate the immediate area.
- Close all doors leading into the spill area.
- If applicable, assist contaminated persons to a safety shower or eyewash station.
- Notify CMU Police by dialing 911
- Report the spill immediately to your supervisor and to OLFS. Report whether the spill has entered the air, ground, sanitary or storm sewers, or any surface water.

2. Incidental Spills

If you are unsure of the hazardous nature of a spill or need assistance with selection of PPE, contact OLFS prior to any attempt at cleaning up the spill. Only those people who have been properly trained and have the appropriate spill cleanup kits and PPE should conduct cleanup of incidental spills. Training will be provided by your department or by OLFS. In the event of an incidental spill, do the following:

- Assess the hazard.
- Wear appropriate PPE. At a minimum, this requires gloves, lab coat, and safety glasses/goggles.
- Isolate/barricade the affected area.
- Notify a coworker that you are cleaning up the spill.
- Neutralize strong acids and bases.
- Contain and clean up the spill with approved cleanup kits located either in the laboratory or in the stockroom.
- Dispose of all chemical spill cleanup material as hazardous waste.
- Write a brief report describing how the spill occurred and the cleanup procedures used. Send a copy to your supervisor.
- If you are not trained to cleanup spills, call OLFS at 774-4474. Remain at the scene to serve as a resource.

3. Mercury Spills

Mercury vapors are highly toxic. Requiring the use of non-mercury containing items can eliminate mercury spills. All spills of mercury, no matter how small, are considered toxic and must be cleaned up by a trained employee. All collected mercury must be disposed of as hazardous waste. In the event of a mercury spill, do the following:

- Isolate/barricade the area.
- Call OLFS (774-4474).
- Remain at the scene to serve as a resource.

B. Personal Chemical Exposure

Chemical exposure can lead to irritation or burns of the skin, eyes, throat, and lungs, dizziness, headaches, disorientation or unconsciousness, or damage to internal organs.

If your eyes are splashed with a chemical:

- Immediately flush them in the nearest eyewash fountain for 15 minutes.
- Keep your eyes open while washing them.
- Seek medical attention.

If your skin comes in contact with a chemical:

- Flush the area with water for 15 minutes and remove contaminated clothes.
- If large areas are exposed, go to the emergency shower and begin flushing with water at once while removing clothes in the shower. Continue flushing with water for 15 minutes.
- Seek medical attention.

If you inhale a chemical, immediately move to fresh air. Seek medical attention.

If you ingest a chemical, you may or may not induce vomiting depending on the chemical. Refer to the SDS for recommended first aid. Never induce vomiting when corrosives are ingested. Seek medical attention.

C. Detection of Chemical Odors

The human nose cannot and should not be relied on as an adequate warning device against chemical hazards. Some materials, such as hydrogen sulfide, can cause olfactory fatigue rendering the sense of smell useless as a warning device. Alternatively, some materials are very odorous and thus have good warning properties. In either case, if a release or spill is suspected, immediately secure any operating equipment, and leave the area. Call 911. Do not return to the area until given the approval to do so.

D. Fire

In the event of a fire, do the following:

- Activate the fire alarm pull station.
- Clear the area of all personnel. Instruct all personnel to evacuate the facility.
- If it can be done safely, and if you are trained in the use of a fire extinguisher, attempt to extinguish the fire using a portable fire extinguisher. Keep the PASS system in mind when using any fire extinguisher in a fire situation.

P=Pull	pull the fire extinguisher pin
A=Aim	aim the nozzle at the base of the fire
S= Squeeze	squeeze the handle
S=Sweep	sweep the base of the fire from side to side

If the fire spreads from its origin or is not put out within 30 seconds, evacuate immediately!

- Confine the fire by closing doors as you leave the area.
- Stay near the building to advise emergency personnel on the nature of the fire and to make sure everyone is accounted for.

E. Utility Failure

The interruption of any utility service either scheduled or from natural causes, is considered an emergency event.

- If the ventilation system shuts down, cease and safely shut down any operations in ventilated areas. Close and secure all chemical containers. A building evacuation may be required.
- Loss of water can affect cooling systems. Shut down any procedure using circulating cooling water.
- Shut down ovens and kilns in the event of the loss of gas service. Notify Facilities Management before restarting the equipment. Do not use any ignition sources before the pilot lights have been lit.

F. Reporting Injuries

If anyone is in need of emergency medical attention, call CMU Police by dialing 911 for assistance. Indicate the nature of the problem, your identification, and your location. See Appendix M for guidelines for handling injuries on campus.