Chemical Hygiene Plan

Last Review Date: June 2023

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Laboratory Safety and Chemical Hygiene Plans at UM-Flint and UM-Dearborn

Laboratory safety programs at the University of Michigan Flint and University of Michigan Dearborn regional campuses are administered and enforced by their respective Environment, Health and Safety departments. The University of Michigan Chemical Hygiene Plan and general laboratory safety guidelines have been adopted in part at the these regional campuses and modified by each campus to more accurately reflect their specific operations, processes and conditions. Contact the following regional environment, health and safety departments regarding laboratory safety:

University of Michigan – Flint
Environment, Health and Safety (EHS)
432 N. Saginaw, Suite 801 Northbank Center
Flint, Michigan 48502
810-766-6763 office
810-424-5572 fax
Contact: Michael Lane, Director

University of Michigan – Dearborn
Environmental Health and Safety (EHS)
1335 Campus Support Services Bldg.
4901 Evergreen Rd.
Dearborn, MI 48128
313-583-6679 office
313-583-5441 fax
Contact: David Fogle, Director

1.0 LABORATORY SAFETY MANAGEMENT POLICY

1.1 POLICY STATEMENT

The University of Michigan (U-M) is committed to:

- Promoting a culture of safety among faculty, staff, students, and visitors.
- Providing a safe and healthy place to work, study, live, or visit.
- Protecting the natural environment.
- Complying with all applicable workplace safety, health, and environmental rules and regulations.

This Chemical Hygiene Plan (CHP) establishes a written program in accordance with the requirements of the Michigan Occupational Safety and Health Act (MIOSHA) Part 431 Hazardous Work in Laboratories Standard. The CHP is available on the EHS website. The CHP also provides information on best practices in laboratory research activities to promote a healthy and safe work environment. The Laboratory Director/Supervisor must inform laboratory personnel of the location and availability of the U-M CHP. The U-M Chemical Hygiene Officer (CHO) will review and update the plan annually or as necessary.

This CHP is also a resource for information used for planning experiments and laboratory operations to ensure that all laboratory personnel have working knowledge about the hazardous chemicals they use. Any hazards beyond those covered in this CHP must be addressed by the Laboratory Director in the form of lab specific SOPs and lab specific training, which must be documented.

This CHP is supported by the U-M Academic Laboratory and Research Safety Policy issued jointly by the Department of Environment, Health & Safety (EHS) and the Office of Research Ethics & Compliance (UMOR), in accordance with SPG 605.01 Safety, Health & Environmental Policy, with direction and endorsement by the Executive Vice President & Chief Financial Officer (EVP/CFO) and the Vice President for Research (VPR). The full policy document is located on the Research Ethics & Compliance website.

1.2 SCOPE

The U-M CHP applies to all research, teaching, student and other laboratories at the U-M covered by the MIOSHA Hazardous Work in Laboratories Standard. The standard applies to all facilities where the "laboratory use of hazardous chemicals" occurs. "Hazardous chemical" means any chemical that is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified. "Laboratory use of hazardous chemicals" is defined as handling or use of such chemicals in which all of the following conditions are met:

A. Chemical manipulations are carried out on a "laboratory scale", or work with substances in which the containers used are designed to be easily and safely manipulated by one person
B. Multiple chemical procedures or chemicals are used
C. The procedures involved are not part of a production process, nor in any way simulate a production process
D. "Protective laboratory equipment" is available and in common use to minimize the potential for exposure to hazardous chemicals

1.3 REGULATORY INTRODUCTION

In January 1991, the Occupational Safety and Health Administration (OSHA) promulgated a final rule for occupational exposure to hazardous chemicals in laboratories (29 CFR 1910.1450). Included in the standard is the requirement that all employees covered by the standard must carry out the provisions of a CHP. The equivalent standard in Michigan is MIOSHA Hazardous Work in Laboratories.

A CHP is a written program which sets forth policies and procedures for protecting employees from the health hazards presented by potentially hazardous chemicals (and other agents) used in workplaces. Components of a CHP must include:

- Standard Operating Procedures (SOPs) relevant to safety and health to be followed whenever laboratory work includes the use of hazardous chemicals and other agents.
- Criteria used to determine and implement control measures to reduce worker exposure to hazardous chemicals including engineering controls, the use of PPE and hygiene practices.
- Requirements that fume hoods and other protective equipment are functioning properly and for maintaining adequate performance of such equipment.
- Provisions for employee information and training
- Circumstances under which a particular laboratory operation, procedure, or activity would require special approval from the Laboratory Director prior to implementation.
- Provisions for medical consultation and medical examinations.
- Determination and implementation of control measures to reduce employee exposures to hazardous chemicals.
- Provisions for additional employee protection for work involving particularly hazardous substances and conditions.
- Availability of Safety Data Sheets (SDS) and other sources of information, to describe potential hazards and safety precautions.

For additional information on health and safety regulations impacting laboratory safety see **Appendix 1.**

1.4 RESPONSIBILITIES

Everyone working at the U-M has the right to expect a safe and healthy work environment. They also have a responsibility to help assure a safe and healthy environment for themselves and others. Everyone has an important role.

Standard Practice Guide 605.01 (Safety, Health and Environmental Policy) identifies the general responsibilities that various University groups have toward promoting a safe and legally compliant culture. The University academic, research, clinical, and operations units will assess the safety and environmental impact of lab and research projects and will implement strategies to reduce the risk. University units with specialized health and safety requirements for their operations, based upon federal, state, or other organization rules, must develop specific policies and procedures that are consistent with SPG requirements and external legal obligations.

The Academic Laboratory and Research Safety Policy further details laboratory health and safety responsibilities for all faculty, staff, other employees, and students that must be adhered to while in University laboratories or when conducting University research regardless of location. Role specific responsibilities for each category below can be found in the Policy:

- All faculty, staff, other employees and students
- Anyone in a management, supervisory, or mentorship role
- Graduate Student Research Assistants/Trainees

- Post-Doctoral Trainee/Fellow
- Lab Director (Faculty/Lab Manager/Supervisor)
- Department Chair
- Facility Managers/Department Managers/Key Administrators/Chief Department Administrators
- Unit (School/College/Department) Safety Coordinators
- Unit (School/College/Department) Safety Committees
- University Research and Academic Safety Committee (RASC)
- U-M Office of Research (UMOR)
- Department of Environment, Health & Safety (EHS)
- Executive Officers, Deans, Research Associate Deans, and Directors
- Vice President for Research and Executive Vice President and Chief Financial Officer

This CHP further identifies specific responsibilities related to the implementation of the CHP within the lab. Primary responsibility to provide a healthy and safe work environment and to comply with applicable regulations lies with the Lab Director (LD) and/or Principal Investigator (PI). For the purpose of this CHP, the terms Principal Investigator and Lab Director may be used interchangeably and are meant to indicate the person with the highest level of authority within the lab. The following section designates areas of responsibility specific to the implementation of this CHP.

The Lab Director (LD) is responsible for the planning and conduct of safe research and is, by default, the CHO of their lab. The LD may delegate the safety duties for which he/she is responsible, but must make sure that any delegated safety duties are carried out.

The LD is responsible for determining, implementing, and documenting appropriate safety policies and procedures in accordance with the U-M CHP. The following is a detailed list of LD responsibilities:

- Be fully aware of the risks posed by their research materials/methods and effectively communicate these risks to their staff and students through written standard operating procedures (SOPs) and training.
- Develop written SOPs for hazards beyond those identified in the CHP such as Particularly Hazardous Chemicals or highly reactive chemicals or higher risk experimental procedures. Provide an approval process for the use of LD restricted chemicals or procedures.
- SOPs must include precautions and warnings that address protective equipment, chemical storage, use of engineering controls, emergencies and waste disposal. These precautionary instructions should be written into the protocol at points where the risks appear.
- Ensure completion of all required and supplemental training. Lab-specific training can be documented in the laboratory-specific EHS Document Binder or equivalent. Training completed online is documented in the UM learning management system.
- Complete and maintain the laboratory-specific EHS Document Binder.
- Provide laboratory personnel access to the CHP and EHS Document Binder.
- Complete and update a list of hazardous chemicals in the lab annually.
- Provide/maintain appropriate and functional personal protective equipment (e.g., gloves, goggles).
- Personally verify that approved methods and precautions are being followed. This may be done by observing behavior of their staff and enforcing safe work practices and adherence to the CHP and SOP. Ensure personnel do not operate equipment or handle

hazardous chemicals without proper training and authorization.

- In the event laboratory personnel are not following standard safety precautions or are ignoring good lab practices, firm action must be taken to clarify safety expectations in the lab.
- Perform documented routine periodic inspections of their research operations and facilities as noted in this CHP. Confirm engineering controls and safety equipment are functional. Promptly correct problem areas and document all follow-up actions.
- Report laboratory accidents and injuries to Work Connections and EHS.
- Make available required medical surveillance or medical consultation/examination for laboratory personnel.
- Inform non-laboratory personnel and outside contractors of potential lab-related hazards when they are required to work in the laboratory. Minimize potential hazards to provide a safe environment for the work.
- Continuously evaluate the efficacy and applicability of the SOPs in the EHS Document Binder.

All Personnel in Laboratories are responsible for learning and following safe work practices. This includes employees, volunteers, students, and visitors in U-M laboratories. The following is a detailed list of responsibilities:

- Complete all required health, safety and environmental training.
- Read and follow all safety rules in the CHP and the EHS Document Binder.
- Follow oral and written laboratory safety rules, regulations, and standard operating procedures required for the tasks assigned.
- Keep the work areas safe and uncluttered.
- Review and understand the hazards of materials and processes in their laboratory research prior to conducting work.
- Utilize appropriate measures to control identified hazards, including consistent and proper use of engineering controls, personal protective equipment (PPE), and administrative controls.
- Understand the capabilities and limitations of PPE issued to them.
- Gain prior approval from the LD for the use of restricted chemicals.
- Consult with the LD before using higher risk chemicals or conducting certain higher risk experimental procedures. Examples of higher risk procedures include procedures that may involve high temperature, high pressure, high energy, explosives, toxic gases, high volumes of flammable liquids, or pyrophoric materials.
- Promptly report accidents and unsafe conditions to the LD.
- Participate in the medical surveillance program, when required.
- Inform the LD of any work modifications ordered by a physician as a result of medical surveillance, an occupational injury or exposure.
- Notify the supervisor or LD of any hazardous conditions or unsafe work practices.

The U-M Department of Environment, Health & Safety (EHS) is responsible for administering and overseeing institutional implementation of this Plan. EHS has designated a Chemical Hygiene Officer (CHO) to assist in this implementation. EHS also provides technical guidance to personnel at all levels of responsibility on matters pertaining to the laboratory use of hazardous chemicals. The following are EHS and CHO responsibilities:

- Establish, maintain and review the effectiveness of the CHP at least annually and update safety rules as appropriate.
- Monitor procurement, use, storage and disposal of chemicals.
- Assist the LD in the selection of appropriate safety controls, laboratory practices,

personal protective equipment, engineering controls, and training.

- Perform hazard assessments, upon request.
- Maintain area and personnel exposure-monitoring records.
- Provide technical consultation and investigation, as appropriate, for laboratory accidents and injuries.
- Assist in the determination of medical surveillance requirements for laboratory personnel.
- Manage the Engineering Control Certification program for fume hoods, biological safety cabinets, and other local exhaust points.
- Audit laboratory facilities on a periodic basis, distribute the results and maintain records.
- Provide expertise in the development and maintenance of laboratory facilities.

Other units within EHS support the CHP by providing management oversight or assistance in chemical compliance, hazardous waste management, chemical inventory, training, and hazardous materials spill/release response.

The U-M Police Department (UMPD) is responsible for emergency efforts within the University, including the dispatch of officers for response, communications between public safety agencies, and incident command of emergencies.

1.5 AUTHORITY TO SUSPEND/STOP WORK

Ability to Suspend Work

Any faculty, staff, student or visitor working in a research or academic laboratory setting has the ability to suspend their work if they believe there is a safety or environmental issue to deal with. The issue must be reported immediately to the LD or their delegate so that the issue can be quickly resolved, and work can continue.

Authority to Stop Work
If an issue presents an immediate danger to personnel, visitors, users, contractors, the public, or the environment, faculty and staff are empowered and obligated to stop that activity. This authority is referred to as "stop-work authority." Individuals who exercise "stop-work authority" are also obligated to immediately report this action to their LD, Department Chair, and EHS. After an individual has stopped work, it may not resume until the LD and EHS have verified that appropriate hazard control measures are in place.

In situations of serious or continuing non-compliance with or violations of policies, rules or regulations pertaining to laboratory and research safety, the VPR, EVP/CFO, Deans, and designated research oversight committees reserve the right to issue a "stop-work authority" order to a laboratory or research program until the issue is satisfactorily resolved. If there is a dispute regarding the severity of the matter and need to stop work, the Executive Director of EHS is the final authority.

Imminent hazard situation
The Executive Director of EHS, or designee, may issue an immediate Stop Work Order to the appropriate administrative authority in an imminent hazard situation that may cause death, serious injury, or significant harm to the environment if not immediately corrected. The Order must be respected and adhered to by the faculty, staff, students, and guests engaged in the unsafe situation; failure to do so will incur unit-driven sanctions for the noncompliant individual(s). The Order may not be lifted until the concern(s) can be properly addressed.

Final Reporting/Closeout
During the correction of safety or environmental issues, the LD is responsible for the process, working with EHS, UMOR and other unit individuals. The LD must notify EHS when the corrective action has been completed. EHS, working with UMOR, will determine if reporting to federal or state agencies is necessary and notify appropriate executive officers prior to filing the reports. EHS will then compile information regarding the issue and resolution, and reports to the Laboratory and Research Safety Committee, who will in turn determine the need to raise any issues/concerns to the executive officers.

Under federal and state laws government agencies do have the authority to levy fines against the unit or individuals within the unit for failure to follow appropriate laws and regulations. Unless there are extenuating circumstances agreed to by the executive officers on a case-by-case basis, the unit responsible for the research will be responsible for paying the fines if they have not been following established precautions or clearly stated procedures.

1.6 LABORATORY SAFETY COMPLIANCE

The safety performance of each laboratory will be reviewed by EHS through safety inspections comprised of comprehensive physical inspections, checks of relevant documentation, reviews of self-inspection reports, and interviews with laboratory personnel. Each laboratory will be inspected on a periodic basis based on the Lab Hazard Rank (LHR) assigned to the space by EHS. The LHR provides a framework to rank the potential hazards found within each lab and prioritize inspections based on: types and quantities of hazardous materials present, hazardous operations and equipment, engineering controls and procedures, and facility history.

Deficiencies identified in the inspections will be reported to the LD to rectify. Standard deficiencies identified during the inspection require correction within 30 days and critical deficiencies identified require immediate action and full resolution within two business days. A critical deficiency is defined as a situation that creates an unsafe condition where there is reasonable probability that if allowed to continue would result in serious physical harm, fire, or significant environmental impact. An imminent danger situation will result in immediate stoppage of work related to the process. Imminent danger means there is high probability that immediate serious physical harm would result if the situation were allowed to continue.

Failure of a LD to submit verification of corrective action may affect their ability to obtain approvals for permits and grant certifications requiring validation of compliance with applicable state and federal regulations.

Compliance Hotline

The U-M Compliance Hotline is a tool for U-M employees, students, vendors and others to raise concerns regarding financial, regulatory, NCAA, and patient safety issues.

U-M is committed to providing an environment where individuals feel comfortable discussing compliance problems—no matter how big or small—and where people can safely and confidentially come forward to identify instances of fraud or other serious concerns. Callers to the U-M Compliance Hotline can also remain anonymous.

Call 1-866-990-0111 or visit the U-M Compliance Hotline.

1.7 RESOURCES

The U-M provides health, safety, and environmental resources to the research community through EHS. Technical assistance regarding research material risks, method refinement, equipment specifications and training, hazard containment, protective equipment, and hazardous waste disposal is available from EHS. The EHS web page is a readily available resource for initial query into these areas.

Templates for SOPs, safety plans, and recommended methods are all easily accessible from this on-line site. EHS representatives, available by phone or email, will provide personalized service for specific challenges.

Another resource provided is the U-M Safety Culture Leading Indicators workbook. The indicators offer a means to evaluate your lab safety culture based on recommendations from published documents on the topic. Implementing these recommendations and tracking progress can lead to improvement in the laboratory and research safety culture in your sphere of operations. The goal is to develop leading indicators that proactively measure successes to improve U-M's safety culture.

1.8 EXCLUSIONS

This CHP does not cover work with radioactive materials, biological agents or bloodborne pathogens. Procedures for work with these materials are addressed via the University's Radiation Safety Service website, Biosafety Manual, and Exposure Control Plan respectively.

2.0 SAFETY TRAINING AND DOCUMENTATION

It is the responsibility of the LD / Supervisor to make sure that all employees have received the mandatory lab safety training provided by EHS and provide verification through documentation. The LD / Supervisor can request access to the EHS Training Verification Tool through the main page of the MI Safety Portal.

Records must be maintained for all training, including lab-specific SOPs. Records should be maintained for 5 years past the end of employment.

2.1 MANDATORY EHS TRAINING

EHS provides new hire training for laboratory personnel on Hazardous Work in Laboratories. All laboratory employees are required to complete this training shortly after being hired and before they begin working in the laboratory. Registration for all web-based and instructor led classes is available on the EHS training web site. Refresher training is recommended for Hazardous Work in Laboratories at least every three years thereafter.

2.2 LABORATORY-SPECIFIC TRAINING

The LD / Supervisor must establish and implement a laboratory-specific training program. This training is to be provided at the time of initial assignment to the laboratory, and prior to assignments involving new exposure situations and hazardous operations. Laboratory-specific training must be documented in the EHS Document Binder.

This training must cover necessary work practices, procedures and policies to ensure that employees are protected from all potentially hazardous chemicals, biological pathogens, and dangerous equipment used in the workplace. Someone thoroughly knowledgeable of all the specific hazards and proper safety techniques is responsible for conducting laboratory-specific training.

2.3 WORK CONDUCTED AUTONOMOUSLY OR INDEPENDENTLY

The LD / Supervisor shall provide access to the online CHP and lab specific EHS document binder to persons working autonomously or performing independent research before they undertake work in U-M laboratories. Anyone working in U-M laboratories, regardless of employment status, is required to take all general and lab-specific training applicable to their work. Persons working autonomously are responsible for ensuring they have any other training that is appropriate to the work they conduct in U-M laboratories.

3.0 IDENTIFICATION/EVALUATION OF CHEMICAL AND PHYSICAL HAZARDS

Research laboratories work with chemicals, materials, and processes that have recognized hazards. It is critical that all SOPs developed provide information on the inherent physical, chemical and toxicological properties. The following sections in this chapter describe the main categories of recognized chemical hazards to provide a basic understanding of the risks.

3.1 SAFETY DATA SHEETS

Chemical-specific hazard information can be found in Safety Data Sheets (SDS), provided by all manufacturers and vendors of hazardous chemicals for their products and are required to be kept for chemicals currently in use. At U-M, SDS are available to all laboratory personnel through the EHS Safety Data Sheet page (ChemWatch [Gold FFX] database). The Gold FFX program contains over 13 million SDS for chemicals and chemical mixtures in multiple languages. The program can also be used to print safety labels and view molecular structures.

In addition to locating a particular vendor SDS, departmental SDS folders can be created within the Gold FFX program to allow for easier SDS retrieval. SDS location posters must be conspicuously posted on departmental bulletin boards and in each laboratory. These posters are available through EHS and online at the State of Michigan. Location of laboratory SDS must be indicated on the poster.

SDS concerning the identity of a substance or agent need not be retained for any specified period as long as some record of the identity (chemical name if known) of the substance or agent, where it was used, and when it was used is retained for at least thirty (30) years.[1]

Other Sources of Chemical Hazard Information

EHS provides Hazard Guidelines on various chemical and physical hazards. Other sources on the hazards, signs & symptoms of exposure, safe handling, storage & disposal of hazardous chemicals include the following:

- National Library of Medicine, National Institutes of Health
- Pocket Guide to Chemical Hazards distributed by the National Institute of Occupational Safety and Health (NIOSH).

3.2 FLAMMABLE AND COMBUSTIBLE LIQUIDS

Flammable and combustible liquids are classified according to their flash point, with flammable liquids having a flash point of less than 100°F and combustible liquids having a flash point between 100-200°F. Flammable and combustible liquids are both considered fire hazards. Flammable/combustible liquids include alcohols, ketones, xylenes and carboxylic acids. Most organic chemicals are also flammable or combustible.

Refer to the Flammable and Combustible Liquids SOP for additional information.

3.3 CORROSIVE CHEMICALS

Corrosive chemicals can cause visible and irreversible tissue damage through chemical action at the point of contact. Corrosive chemicals can be liquids, solids, or gases and can affect the skin, eyes, and respiratory tract. The damage will be acute, i.e. within 24 hours. Chemicals with a low or high pH are considered corrosive. Therefore, acids and bases are

[1] MIOSHA Part 470 Employee Medical Records and Trade Secrets

corrosive. Examples of corrosive chemicals include ammonium hydroxide, hydrochloric acid, nitric acid, phenol, sodium hydroxide and sulfuric acid.

Refer to the Corrosive Chemicals SOP for additional information.

3.4 OXIDIZING CHEMICALS

Oxidizing chemicals can react with other substances and promote combustion. Reactions with easily oxidizable materials like metal powders, organic materials (paper, wood), and organic compounds can result in vigorous reaction, fire or an explosion. Examples of common oxidizers are chlorates, perchlorates, peroxides, nitric acid, nitrites and permanganates. Bromine, chlorine, fluorine, and iodine gases act similarly.

Refer to the Oxidizing Chemicals SOP for additional information.

3.5 HIGHLY REACTIVE / UNSTABLE CHEMICALS

Highly reactive or unstable materials are those that have the potential to vigorously polymerize, decompose, condense, or become self-reactive under conditions of shock, pressure, temperature, light, or contact with another material. They can release heat, toxic gas, or flammable gas upon contact with water or air, or moisture in air. Water reactive materials react violently in contact with water. Examples: lithium, sodium, potassium, organometallic compounds, aluminum bromide, calcium oxide and phosphorus pentachloride.

Pyrophoric materials can react with air and ignite spontaneously at or below 113°F (45°C). Pyrophoric materials should be handled and stored in inert environments. Examples: chlorine trifluoride, phosphine, tert-butyl lithium, silane, white or yellow phosphorous and many finely divided metals. Safe handling of these materials depends on the specific material and the conditions in which they are handled. Persons working with these materials must receive training and approval from the LD or lab manager.

See the following video example of procedures: Pyrophoric Liquid Safety from **UCLA** (YouTube). Refer to the SOPs for Reactive Chemicals, Water Sensitive Chemicals, and Pyrophoric Materials for additional information.

3.6 PEROXIDE FORMING CHEMICALS

Peroxidizable chemicals can undergo auto oxidation to form organic peroxides that can become explosive with impact, heat or friction. These chemicals will become more hazardous as they age; peroxides may even form in unopened containers. Peroxide forming chemical examples include isopropyl ether, divinyl acetylene, vinylidene chloride, dioxane, cyclohexene, furan, tetrahydrofuran, sodium amide, methyl isobutyl ketone, ethyl ether, vinyl ethers, styrene, butadiene, vinyl acetate and tetrafluoroethylene.

Refer to the Peroxide Forming Chemicals SOP for additional information.

3.7 EXPLOSIVES (Highly Energetic Compounds)

Explosives are chemicals (or combinations thereof) that may cause a sudden release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature. Some common functional groups for explosive compounds include organic azides, metal cyanides, diazo compounds, alkyl or acyl peroxides and metal fulminates, etc. Safe handling of these materials depends on the specific material and the conditions under which it is handled. The lab must develop specific procedures (SOP) that include hazards, personal protective equipment and engineering controls. Persons working with these materials must receive training and approval from the LD or lab manager.

Special approval is required to work with an explosive that falls within the scope of Title 18, United States Code, Chapter 40 “Importation, Manufacture, Distribution, and Storage of Explosive Materials” and materials classified as explosive by Title 49 CFR, Parts 100-199. Please contact the U-M EHS Fire Safety Services to review any use of these materials and obtain a formal hazard analysis.

Refer to the Explosives SOP for additional information.

3.8 CRYOGENIC LIQUIDS

Cryogenic liquids have boiling points below minus 130°F (minus 90°C) and are used in research to provide extremely low temperatures for frozen storage and experimentation. Common cryogenic liquids of concern include nitrogen, helium, hydrogen, and argon. Cryogenic liquids undergo substantial volume expansion when released to air, potentially depleting workplace oxygen content to hazardous levels. Other concerns with cryogenic liquids are extreme cold and potentially hazardous gases.

Refer to the Cryogenic Liquids SOP for additional information.

3.9 COMPRESSED GASES

A compressed gas is any gas or mixture of gases exerting in a container, a pressure exceeding 40.6 psia (280 kPa, abs) at 68°F (20°C). Generally, the term “compressed gas” also refers to liquefied and dissolved gases meeting these criteria as well as cryogenic gases. Currently, there are more than 200 different substances commonly shipped in compressed gas containers that can be considered compressed gases. The primary hazards with compressed gas cylinders are the incredible amount of stored energy due to the high pressure, the large volume of gas present, and properties of the gas itself. A rupture can result in a powerful release of gas that can propel the heavy steel cylinder in a deadly manner.

All compressed gases are dangerous and must be handled using the basic safety rules found in the Compressed Gas Use Program guideline. The guideline contains specific provisions mandating facility permitting, engineering controls, protective equipment, storage requirements, emergency response plans, warning systems and personnel training based on the type and quantity of toxic gas used.

Toxic gases pose additional potentially acute health hazards to laboratory personnel and the public, and as such, are considered “Restricted Gases” that require prior approval by EHS to purchase. The Restricted Gas Purchase Approval process also applies to oxidizing and flammable gases.

Refer to the Compressed Gases SOP for additional information.

3.10 SELECT CARCINOGENS AND REPRODUCTIVE TOXINS

Select carcinogens and reproductive toxins are considered high-risk materials. MIOSHA defines a select carcinogen as:

- Any substance that is regulated by OSHA as a carcinogen
- Any substance listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition)

- Any substance listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions)
- Any substance 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:
  - After inhalation exposure of 6 to 7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3 ;
  - After repeated skin application of less than 300 (mg/kg of body weight) per week;
  - After oral dosages of less than 50 mg/kg of body weight per day.

Refer to the Carcinogens SOP for additional information.

Reproductive toxins are 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.

Refer to the Reproductive Toxins SOP for additional information

3.11 SENSITIZERS

A sensitizer is a substance that causes most people to develop an allergic reaction after repeated exposure. The first exposure may cause little or no reaction but repeated exposure may cause a marked allergic response not necessarily limited to the contact site. Both skin and respiratory sensitization are possible. Once sensitization occurs, allergic reactions can result from exposure to extremely low doses of the chemical. Allergic reactions can be immediate and result in death if not treated. Examples of sensitizers used in laboratories include diazomethane, formaldehyde, various isocyanates, certain phenol derivatives, and proteins (e.g. latex, commonly found in natural rubber latex lab gloves).

Refer to the Sensitizer SOP for additional information

3.12 IRRITANT CHEMICALS

Irritants are non-corrosive chemicals that cause reversible inflammatory effects by chemical action at the site of contact (skin, eyes, nose or respiratory tract). Higher concentrations of some irritants could cause permanent health effects or even death. A wide variety of organic and inorganic compounds, including alcohols and weak acids are irritants; thus, avoiding skin contact with all laboratory chemicals is prudent.

Refer to the Irritants SOP for additional information.

3.13 ENGINEERED NANOMATERIALS

A nanoparticle is a collection of atoms with one dimension less than 100 nanometers. Nanoparticles can be naturally occurring (e.g., volcanic ash) or incidental byproducts of combustion processes (e.g., welding, diesel engines). Engineered nanoparticles are intentionally produced and designed with very specific properties related to shape, size, surface properties and chemistry. They may be bought from commercial vendors or generated via experimental procedures by researchers in the laboratory. Examples of engineered nanomaterials include fullerenes, carbon nanotubes, metal oxide nanoparticles, and quantum dots, among many others. The health effects of exposures to nanomaterials are not fully understood at this time.

The EHS Guideline for Engineered Nanomaterials addresses procedures for overseeing the safe use, storage, transportation, and disposal of these materials. It is designed to provide reasonable and consistent guidance for managing the potential risks associated with nanomaterials whose hazards have not been fully characterized.

Refer to the Nanomaterials SOP for additional information.

3.14 RADIOACTIVE MATERIALS AND RADIATION-PRODUCING DEVICES

Radioactive material compounds, radiation-producing devices, radioactive sealed or plated sources, and devices that contain a radioactive source require special authorization, training, and adherence to U-M policies and procedures. The U-M Radiation Safety Service (RSS) manages all aspects of radiological health and safety and can be contacted at (734) 764-6200.

3.15 INFECTIOUS AGENTS AND BIOLOGICAL TOXINS

An infectious agent is a viable microorganism, or its toxin, which causes or may cause disease in humans or animals, and includes those agents listed in 42 CFR 72.3 or any other agent that causes or may cause severe, disabling, or fatal disease. The U-M Biological Safety program area is responsible for all biosafety related health and safety programs.

3.16 CONTROLLED SUBSTANCES

The purchase, storage, and use of many drugs is regulated under Title 21 CFR Part 1300-1399 and the State of Michigan Act 368, Article 7 as controlled substances. The U-M Office of Research administers the Controlled Substances in Research Oversight Program.

3.17 ANESTHETIC GASES

Anesthetic gases used during research involving animals must be properly controlled to avoid overexposure in animal research personnel. Workers acutely exposed to excess amounts of anesthetic gas can experience symptoms of drowsiness, headache, nausea, poor judgment and loss of coordination. Chronic symptoms of overexposure can include liver, kidney and reproductive effects. Anesthetics of concern include ether, nitrous oxide, and halogenated agents including enflurane, halothane and isoflurane. Use of anesthetic gases requires engineering controls (typically ventilation) to prevent overexposure. EHS must conduct an evaluation if engineering controls are not available to ensure personnel safety.

Refer to the Animal Anesthetics SOP for additional information.

3.18 ANIMAL SAFETY

Employees who care for and use animals in research face several occupational health and safety risks, including the possibility of allergic reactions, animal related injuries such as bites or kicks, zoonoses (diseases that spread from animals to humans), and exposure to hazardous materials. The U-M is committed to compliance with all applicable federal and state laws and standards concerning occupational exposure to research activities.
Refer to the Animal Handler Occupational Health & Safety Program for additional information.

Use of Hazardous Substances and Drugs in Animal Facilities and Research Spaces
Indirect exposure to chemicals and hazardous drugs can occur when preparing and administering these agents to research animals. The IACUC protocol approval process requires the researcher to identify these agents. EHS provides housing requirements and guidance on how to protect researchers and animal care workers in the EHS Safety Findings section during the protocol approval process. The EHS Safety Findings must be printed and

included in the EHS Document Binder, Section 6. All animal research staff who will be handling the hazardous substances must review this information.

3.19 SUPERCONDUCTING MAGNETS

Superconducting magnets, such as those contained in Nuclear Magnetic Resonance (NMR) and Magnetic Resonance Imaging (MRI) equipment, pose unique safety concerns. These concerns include cryogen safety, the potential for creation of oxygen deficient atmospheres and strong magnetic fields.

Liquid helium and liquid nitrogen are used to maintain the magnetic field in NMR and MRI systems. Both liquids are extremely cold (liquid helium -452 degrees F, liquid nitrogen -320 degrees F), colorless, and odorless. A sudden boil-off of cryogens and accompanying loss of magnetic field (called a "quench") can displace oxygen in the air, resulting in an oxygen deficient atmosphere.

Ferromagnetic objects are strongly attracted to the magnet and can become potentially lethal projectiles. Personnel can be severely injured and/or equipment can be damaged if hit by objects that are attracted to the magnet at a high rate of speed. Life threatening situations can occur if a person is pinned against the magnet by a large ferromagnetic object. Absolutely no ferromagnetic objects are allowed inside a magnet room or within the pre-determined radius of the magnetic field.

Metallic implants and prostheses and foreign metallic bodies (even those that are not ferromagnetic) can move or dislodge, causing severe injury. Examples include aneurysm clips, implanted pins, shrapnel, insulin pumps, prosthetic limbs, cochlear implants, pacemakers, and cardiac or neural defibrillators. Persons with pacemakers should be restricted to areas where the magnetic field is less than 5 Gauss.

Refer to the Magnet Safety SOP for additional information.

4.0 CONTROLS TO REDUCE EXPOSURES TO HAZARDOUS CHEMICALS

There are three types of controls used in the lab to reduce exposures to hazardous materials below permissible limits: engineering, administrative and personal protective equipment (PPE).

Engineering controls are those that actually remove the hazardous material from the work environment. Administrative controls are procedures that reduce the amount of material, duration or extent of exposure to the material. PPE provides a barrier between the user and the material. Engineering controls are the primary method used in U-M labs to reduce exposures. Administrative controls and PPE are used as secondary controls in most cases.

4.1 ENGINEERING CONTROLS

Local exhaust ventilation (LEV) is the most common engineering control and is provided in almost every lab setting. LEV systems protect users from various airborne hazards by exhausting the material at the point of generation. Types of LEV include fume hoods, biological safety cabinets, glove boxes, snorkel exhaust, ventilated gas cabinets, canopy hoods, paint booths, canopies, and slot hoods.

All Fume Hoods, BSC, and other LEV systems on campus must be certified by EHS annually. Notify EHS at (734) 647-1143 if certification is needed. If the LEV does not perform within required performance limits, it will be tagged out of service by EHS and either repaired by EHS or reported to the Facilities Service Center for repair. ***Do not use any system tagged out of service.***

The proper use of LEV systems is critical to reducing potential exposures. Please observe the following general rules when working with LEV:

- Check for a current EHS certification date of less than one year.
- Seek training on the proper operation.
- Confirm proper operation before use. If the fume hood is not functioning, call Facilities Service Center at (734) 647-2059.
- Use the engineering control as it was designed.
- Re-evaluate the use of the engineering controls if the research protocol changes.
- Contact EHS for assistance in determining the correct engineering control your research needs.

In addition, laboratories are designed with a one-pass general exhaust system that maintains the lab under negative pressure compared to adjacent non-lab space. EHS designates air change rates based on an assessment of the potential airborne hazards.

Additional engineering controls for minimizing exposures to hazardous chemicals may include:

- Substituting a less hazardous chemical (e.g., using isoflurane for animal anesthesia instead of ether, or using toluene instead of benzene).
- Isolating or enclosing an experiment within a closed system (i.e., glove box, sealed chamber).
- Micro scaling the size of the experiment to reduce the amount of chemical usage.

Fume Hoods (Laboratory Hoods, Chemical Hoods)
A fume hood is typically the primary engineering control for working with hazardous chemicals in the lab. As a rule, use a fume hood or other local exhaust ventilation device when working with any appreciably volatile substance or material easily dispersible in air.
An average face velocity of 100 feet per minute (fpm) is considered optimal for containment of contaminants in a standard fume hood. A Reduced Face Velocity (RFV) fume hood is designed to operate safely with an average face velocity of 70 fpm. The EHS certification sticker on the hood will note the passing face velocity measurement.

Perchloric acid fume hoods are designed specifically for the use of perchloric acid. These hoods contain water spray systems to wash down the interior of the hood, duct, fan, and stack to prevent accumulation of explosive perchlorate crystalline material. You must receive lab-specific training before performing any work in a perchloric acid fume hood.

Refer to the Fume Hoods SOP for additional information.

Biological Safety Cabinet (BSC)
A BSC is the primary engineering control for working with hazardous biological materials. Class II BSCs protect the users, the product and the environment. BSC Manufacturers currently supported by EHS include Baker, Labconco, Nuaire, ESCO, and Thermo.

A Class III BSC is a totally enclosed, airtight, negatively pressured, ventilated cabinet. All operations are performed through rubber gloves, and the supply and exhaust air are filtered with HEPA filters. The exhaust air is discharged to the outdoor environment. A Class III BSC is NOT a glove box and does not provide a moisture and/or oxygen-free atmosphere. Pyrophorics or other highly reactive chemicals CANNOT be used in a Class III BSC.

Refer to the Biosafety Cabinets SOP for additional information.

Glovebox (Sometimes referred to as an isolator or isolation chamber)
A glovebox can be used for chemicals, pharmaceuticals, nuclear materials, and in some instances biological materials. The glovebox must be specifically designed for the type of materials used. The glovebox can have several types of positive pressure atmospheres like inert gases (argon, nitrogen) or negative pressure atmospheres (vacuum).

Guidance documents containing detailed information on the proper selection, maintenance, and use of gloveboxes are available for purchase from The American Glovebox Society. The manufacturer's representative or EHS may also be contacted for advice on the appropriate type or proper installation of a glovebox.

Selection Criteria for Proper Use of Fume Hoods, BSC, and Glove Boxes

Chemical fume hoods are sometimes mistakenly used as a BSC or glove box. The following chart and section provides guidance on which engineering control to use for various hazardous materials.

Fume Hood	Glove Box/Isolator	BSC
Volatile chemicals	Air reactive compounds	Biological aerosols including human blood
Flammable liquids	Highly toxic compounds	Biosafety Level 2 and 3 agents
Toxic materials	Controlled environment	Tissue culture
Hot processes		Sterile field
Open flames		Necropsy (Not Perfused)
Acids and bases		Non-volatile drugs
Gases		
Necropsy (Perfused)		

Snorkel Exhaust

A snorkel exhaust is a piece of flexible duct or hose connected to an exhaust system, designed to give the user some degree of mobility in placing it where ventilation is needed. Snorkels are commonly used to capture exhaust from gas chromatographs, vacuum pumps, and other equipment and processes. A snorkel CANNOT effectively or safely capture airborne contaminants beyond the distance at which it was certified for, which is typically one-half diameter from the end of hose. Please refer to the EHS certification sticker on the snorkel and use it in accordance with the specified capture distance.

Ventilated Compressed Gas Cabinets

Gas cabinets are enclosures designed to house compressed gas cylinders and/or dispense toxic and flammable gases. They are not intended for cryogenic liquids. The gas cabinet prevents escaping gas, due to leaks or other failures, from entering the laboratory space and provides fire protection. Gas cabinets may have features that monitor for leaks and excessive flow and automatically shut off gas flow. Toxic compressed gases in cylinders larger than a lecture bottle must be contained in a gas cabinet.

Refer to the Compressed Gas Use Program document for additional information.

Wet Benches

Wet benches or wet station hoods are often used in semiconductor fabrication processes. They are ventilated workstations that may be freestanding or enclosed and are used to house various chemical baths containing flammable, corrosive, oxidizing, or toxic liquids. Typically, a slot-type hood is placed over and around the deck surface of the bath or is designed with slotted sink exhausts. Splash shields may be incorporated to alter the direction of airflow and provide limited splash protection. These may have plumbing or heating systems in the baths. Baths of incompatible chemicals should not be used within the same wet bench.

Grossing Stations

Grossing stations, also called downdraft hoods or necropsy tables, pull contaminated air down through ventilation slots along the sides of the work area. The air is then exhausted to the outside environment. These are effective when chemicals with vapor densities heavier than air are used.

Paint Booths
Paint booths, also called spray booths, are ventilated and fire-protected enclosures that range in size from bench top to walk in sized booths. Along with ventilation, filters are used to capture paint and glaze contaminants and must be regularly replaced. Paint, dust, and pigment accumulation may prevent the hood from performing effectively. Often times the user must be standing laterally with the direction of airflow in order for the hood to work properly.

Horizontal Laminar Flow Hoods (clean bench, vertical laminar flow hood)
Laminar flow hoods are designed to protect processes and products from contamination by flowing HEPA filtered air onto the work area. Laminar flow hoods **do not** provide personal protection and cannot be used to work with hazardous biological materials or toxins.

Canopy Hood Exhaust
Canopy hoods are ventilated horizontal enclosures suspended above a bench or work area, similar to a kitchen range hood. Canopy hoods work best when there are thermal or evaporative forces that direct contaminants into the capture zone of the hood. Canopies are used when a larger working space is needed and when air contaminants are relatively low in toxicity.

The drawbacks of canopy hoods include:
- A relatively large amount of air is required to be exhausted to remove contaminants thereby increasing operational costs.
- Contaminated air may pass through the breathing zone of the user.
- Competing air currents occurring nearby may compromise the capture ability of the hood.

Slot Hoods
Slot hoods are designed to capture airborne contaminants for a specific process or operation such as open surface tanks like acids bath and work benches. Slot hoods are appropriate when a larger working space is needed and the air contaminants are relatively low in toxicity. To perform effectively, the geometry, flow rate, and velocity of the slot hood must be appropriate for the air contaminant being captured.

Bench Top Vented Enclosures
Bench top enclosures are relatively small enclosures that may or may not be exhausted by the building exhaust system. These enclosures are designed to contain and remove low-to-moderately toxic air contaminants. Most enclosures are made of acrylic, so the material compatibility of the air contaminants and the acrylic must be evaluated.

House Vacuum Systems
Though not technically an engineering control, the house or central vacuum systems are sometimes used to prevent escape of contaminants such as biological aerosols, particulates, vapors and gases from procedures performed on the benchtop. Condensation or deposition on the interior of the vacuum tubing behind the walls can create hazards such as re-entry of contaminants into the building or potential exposure to workers performing maintenance on the system.

To prevent contamination, all lines leading from experimental apparatus to the vacuum source should be equipped with filtration or other trapping as appropriate. For biological aerosols, use a liquid vacuum flask followed by a HEPA filter. For particulates, use filtration capable of efficiently trapping the particles in the size range being generated. For solvents and other volatile liquids, use a cold trap of sufficient size and cold enough to condense vapors generated followed by a filter flask capable of collecting fluid that could be aspirated out of the cold trap. For highly reactive, corrosive, toxic or waste anesthetic gases, use a sorbent canister or scrubbing device capable of trapping the gas. Contact EHS at 647-1143 or ehs-labsafety@umich.edu for evaluation/guidance if needed.

Ductless Hoods

***The use of ductless hoods is not recommended*.** Ductless hoods do not exhaust contaminated air to the outside environment but rather pull air in through the hood inlet and into a filtration system, which is then recirculated back into the room. Inappropriate filter selection, overloading of the filter and any failure of the hood can result in exposure. The use of ductless hoods at U-M will be restricted to very specific procedures, nuisance chemicals or small quantities that could be used safely on an open bench.

4.2 ADMINISTRATIVE CONTROLS

Administrative controls are normally used in conjunction with other controls that more directly prevent or control exposure to the hazard. Some administrative controls include continual review of the work environment and safe work practices, regular equipment maintenance, hazard correction procedures, and a medical surveillance program when needed to help prevent workplace hazards and exposures.

Safe work practices include general workplace rules and other operation-specific rules. For example, even when a hazard is enclosed exposure can occur when maintenance is necessary. Through established safe work practices, exposure to hazards can be further reduced.

4.3 PERSONAL PROTECTIVE EQUIPMENT

When exposure to hazards cannot be engineered completely out of normal operations or maintenance work, and when safe work practices and other forms of administrative controls cannot provide sufficient additional protection, the use of protective clothing or equipment provides a supplementary means of control. This is collectively called personal protective equipment, or PPE. PPE is not a substitute for engineering controls, work practices, and/or administrative controls.

PPE must be provided at no cost to employees, including temporary and part time staff. Prescription eyewear and protective footwear have special requirements that are described in the EHS PPE Guideline. A form is available on the EHS webpage to request prescription safety glasses.

Appropriate Lab Attire

Although not technically PPE, personal attire in the laboratory that covers the torso, legs, and feet can reduce your risk of exposure to hazardous agents and the potential of physical injury by providing an extra layer of protection against spills or splashes of hazardous materials. The following attire and practices shall be adhered to in all laboratories with hazardous materials or processes:

- Appropriate lab attire is required to enter a lab that contains hazardous materials, equipment or processes:
  - Shirts or tops must cover the upper torso. Layered clothing is a benefit to safety and provides an extra layer of protection. Natural, tightly woven materials are recommended.
  - Shorts, skirts or pants that leave any part of the leg exposed are not allowed.

Natural, tightly woven materials are recommended. Panty hose are not recommended due to an increased risk of injury from chemicals or heat melting the nylon to the skin.

    - Shoes must completely cover the feet to protect the wearer from chemical splashes, hot liquids and sharp objects. Sandals, open toe, open weave, or shoes with holes are not allowed. Shoe material should not be readily absorbent; leather that is easily cleanable is recommended. Good shoes will also be slip resistant.

- Personnel working in laboratories where hazardous materials and/or equipment are present and are conducting work with chemical, biological, and/or radiological materials must wear at minimum: appropriate eye protection, lab coats, and appropriate gloves.

The following rules are related to appropriate lab attire and are mandatory only when actively working with hazardous materials, operations, or equipment.

- Long hair and loose clothing or jewelry must be secured to avoid contact with hazardous materials, laboratory surfaces, open flames or becoming entangled in equipment. Hair must not impede vision.
- Caps or other headgear must not impede vision, interfere with protective eyewear, hang loose or come in contact with chemicals, biologicals, equipment or open flames.
- Because many synthetic fabrics are flammable and can adhere to the skin, they can increase the severity of a burn. Therefore, cotton is the preferred fabric.

Hazard Assessment and PPE Selection

The MIOSHA standard regarding PPE requires an assessment to determine the hazards in the workplace, PPE selection and training. A documented Hazard Assessment is required to be maintained in the EHS Document Binder. Lab Directors are also responsible for determining if there are areas in the lab where PPE is not required and are encouraged to work with EHS to assess risks. If the Lab Director or PI wishes to designate areas in the lab where PPE is not required - i.e. when seated at a desk - then they must also complete and document a risk assessment. The risk assessment takes into account the likelihood of an incident occurring and the severity of harm that can result from uncontrolled hazards in the laboratory work area. Options include removing hazardous work when possible or redesigning spaces to isolate hazardous from non-hazardous work. Physical modifications to the laboratory, including the addition of barriers, require approval to ensure codes, regulations and guidelines are met. EHS can assist in determining which U-M entities need to be involved to review proposed modifications.

A Hazard Assessment Worksheet and Risk Assessment template are provided in the EHS Document Binder, Section 6. These documented assessments also serve as a training tool for the staff.

The LD or their designee is responsible to review the Hazard Assessment Worksheets in the EHS Document Binder and determine if they fully cover the hazards in the lab. PPE must be selected to protect against any hazard that is likely to occur or has a serious injury impact if it does occur. PPE recommendations to assist in completing the Hazard Assessment Worksheets are provided in the EHS Document Binder, Section 6.

It is important to become familiar with the potential hazards, the type of protective equipment that is available, and the level of protection provided by that equipment, i.e., splash protection, impact protection, etc. The following hazard sources should be considered:

- High or low temperatures

- Chemical exposures (Review SDS and other hazard information to determine appropriate PPE to wear based on chemical hazards encountered)
- Flying particles, molten metal or other eye, face, or skin hazards
- Light radiation, e.g., welding, arc lamps, heat treatment, lasers
- Falling objects or potential for dropping objects
- Sharp objects
- Rolling or pinching that could crush the hands or feet
- Electrical hazards
- Infectious agents

Where these hazards could cause injury to employees, PPE must be selected that will substantially eliminate the injury potential.

Using PPE requires hazard awareness and training on the part of the user. Laboratory personnel must be aware that the equipment does not eliminate the hazard. If the equipment fails, exposure will occur. To reduce the possibility of failure, equipment must be properly fitted for the individual and maintained in a clean and serviceable condition. Whenever possible, select adjustable PPE. Personnel input in the selection process is critical. PPE that fits properly and is comfortable will more likely be worn. Damaged or defective protective equipment shall be immediately taken out of service to be repaired or replaced.

Eye Protection

MIOSHA requires employers to ensure that employees have appropriate eye or face protection if they are exposed to *front and/or side impact hazards* from:

- Flying objects and particles
- Molten metal
- Liquid chemicals
- Acids or caustic liquids
- Chemical gases or vapors
- Harmful contacts
- Exposures
- Electrical flash
- Injurious radiation
- Glare
- A combination of these hazards

Safety glasses, at a minimum, must be worn when working with or handling hazardous materials or equipment. As a best practice and due to the uncertainty of research related activities, safety glasses must also be worn by those in the vicinity of the work and be offered to visitors/observers. Appropriate eye protection shall be used where a potential hazard exists due to the use of the following examples: liquid chemicals, gases, vapors, pressurized systems, equipment that may pose mechanical hazard, cryogenic liquids, biological liquids, molten metal, or injurious light radiation.

Select eye and face protection based on Tables I and II in the hazard assessment. If the appropriate protection is not listed in the tables, such as laser eyewear, contact EHS for further assistance. All protective eye and face protection must comply with ANSI Z87.1.

The following general guidance applies to eye protection:

- Safety glasses must have side shields and meet ANSI Z87.1 standards. Standard prescription glasses are not considered a form of eye protection.
- Safety glasses should be chosen to conform to the wearers face and minimize gaps around the glasses.
- Chemical goggles may be required for certain processes where safety glasses are deemed inadequate. Safety glasses do not provide protection from chemical vapors, liquids, or caustic dust hazards. When exposure to these hazards cannot be avoided by use of engineering controls, chemical goggles shall be worn.
- If safety glasses or goggles are worn over prescription glasses, they must be of a type intended to be worn over prescription glasses.
- Prescription ANSI Z87.1 protective eyewear can be obtained through the EHS Prescription Safety Glasses Program with the approval of your Supervisor and the EHS office. The appropriate forms are completed by your Supervisor and forwarded to EHS.
- Contact lenses may be worn if appropriate protective eyewear is also worn. Contact lenses ARE NOT considered a form of eye protection and do not provide protection against chemicals or particulates.
- MIOSHA recommends against wearing contact lenses when working with acrylonitrile, 1,2 dibromo-3-chloropropane, ethylene oxide, methylene chloride, and 4,4' -methylene dianiline.
- ANSI Z87.1 chemical goggles must be worn during chemical transfer/ handling operations or during any other operations having any likelihood for chemical splash or spray (i.e., processes above or below ambient pressure).
- In addition to safety eyewear, an ANSI Z87.1 face shield must be worn when working with highly corrosive chemicals, where there is any likelihood for chemical splash/spray, or where flying fragments/particles are generated.
- Laser safety eyewear must be specific for the lasers present. EHS can be contacted to help determine appropriate laser eyewear.

Face Protection

Face protection shall be used where a hazard exists to the face due to flying objects or particles, molten metal, liquid chemicals, gases, vapors, or injurious light radiation. A face shield worn over safety glasses is required for certain processes as determined by the LD and/or the PPE hazard assessment table in Section 6 of the Document Binder. Face shields must always be worn over safety glasses or goggles, *not instead of* safety glasses or goggles. The use of face shields over safety glasses is required with processes involving high pressure (>30 PSI), pneumatic lines (>30 PSI), or machining operations.

Head Protection (Hard Hats)

Protective headwear is not typically required in laboratories. Helmets are required to shield the head from the impact and penetration of falling objects, working in low clearance areas, and in some cases high voltage electric shock and burns. Head protection should be worn whenever the potential exists for injuries to the head due to falling objects or when head clearance is restricted. Contact EHS if additional information is needed.

Foot Protection

The minimum level of protective footwear required in laboratories is a closed toe shoe. No sandals, flip-flops, etc. are allowed.

Additional protective footwear is required when employees work in areas where there is a danger of foot injuries due to falling and rolling objects, objects piercing the sole, and where employees' feet are exposed to electrical hazards. When deemed necessary by a hazard assessment, safety shoes must be provided to employees by the employer. Protective footwear can be obtained through local vendors like Red Wing Shoes.

Hand Protection

Protective gloves are required to prevent skin absorption of harmful substances, severe cuts or lacerations, severe abrasions, punctures, chemical burns, and harmful temperature extremes. Appropriately resistant gloves must be worn when handling chemical, biological, or radiological materials.

It is important to select the appropriate glove for a particular application and to determine how long the glove can be worn and whether it can be reused. Chemically protective gloves should be selected based on tested performance against specific chemicals. Section 6 of the Document Binder contains the PPE Hazard Assessment that provides guidance on glove selection for certain classes of chemicals and common physical hazards.

Glove manufacturers have developed recommendations for the proper selection and use of chemically protective gloves.

- No single material can protect against all chemical, physical (e.g., cuts, abrasions, burns, temperature extremes) or biological hazards. It is critical to select the correct glove for the hazard.
- Incorrect selection results in a false sense of security and increased exposure. A Dartmouth researcher died in 1997 from exposure to dimethylmercury, which penetrated her latex gloves.
- See the EHS Glove Selection web page for links to various glove manufacturers' information for selecting gloves for chemical use.

Proper use of gloves:

- Inspect gloves for tears or rips before and after each use.
- Discoloration or stiffness may indicate chemical degradation.
- Replace torn or damaged gloves immediately.
- Gloves should be selected that do not put the user at risk by causing a loss of dexterity, risk of being caught in rotating equipment, or risk of ergonomic injury from gloves that are too heavy or stiff for manipulating small objects.
- For disposable gloves, replace when chemical contact occurs, or when damage is suspected.
- Wash hands after removing gloves (even when double gloving).
- Remove gloves before you leave the lab or handling objects such as doorknobs, telephones, or computer keyboards.
- Disposable gloves are not to be reused.
- For reusable gloves, wash after removal and air dry in lab.
- Store gloves in clean area away from chemicals, temperature extremes, and other hazards.
- Dispose of contaminated gloves in the proper hazardous waste container.

Lab Coats

Lab coats are required when handling chemical, biological or radiological materials. The requirement also applies to working at a lab bench or with equipment where such materials are handled. The coats must be maintained in good condition and reasonably clean so as to not create a hazard.

Lab coats are made of various fabrics and blends. The fabric material shall be selected primarily based on the hazards present. See the table below for selection information.

Fabric	Hazards	Notes
20%-60% cotton - polyester blends	Appropriate for biological materials, powders, and small volume liquid chemical manipulation.	Burns more readily than 100% cotton or FR. Not appropriate for use with flammable liquids, pyrophoric materials, or near open flame.
100% cotton	Appropriate for hazards above plus light flammable liquids use and can be used around open flames (such as alcohol burners).	Burns less readily than polyester blends. Not appropriate for use with pyrophoric materials.
Flame Resistant (FR) materials	Appropriate for hazards above. Flame resistant (FR) material is required for handling pyrophoric materials and for heavy use of flammable liquids.	FR fabrics can be made of Nomex, FR treated cotton or Tecasafe Plus. Some of these materials have special washing instructions.

Proper fit of the lab coat is also important. The coats should cover the user's legs to the knees and arms to the wrist.

Persons working with pyrophoric liquids are also required to wear 100% cotton clothing underneath the FR lab coat on days that they handle these materials in the lab.

Clean rooms and other specialty areas are excluded from this requirement provided that personnel are furnished with appropriate alternative protective garments for working with hazards present.

Lab coats and gloves are not to be worn in offices, lunchrooms, break rooms, rest rooms, conference rooms, meeting rooms or other public access areas. Whenever possible, hang lab coats in the lab before exiting. Where a research group has multiple contiguous labs, lab coats may be worn between labs but must be removed prior to leaving the area to enter restrooms, offices and other public areas.

A commercial company (i.e. Cintas, Sohn Linen) must launder lab coats. Home laundering of lab coats is not allowed. Some schools or departments have contracts with different outside vendors. Check with your departmental administrator on specific procedures. It is recommended that lab coats be laundered no less than once a month or if they become visibly soiled with non-hazardous materials.

Lab coats contaminated with animal dander must be identified as such prior to sending for professional laundering. Lab coats which are grossly contaminated by over use or because of a spill (on to the lab coat) should not be turned in for laundering if the contaminants include heavy metals, nanomaterials, NFPA health hazard 4 chemicals, biologically hazardous materials, or flammable solvents. In such a case, the lab coat will be disposed of as hazardous waste or autoclaved if biologically contaminated.

Skin Protection, Other than Gloves

Skin protection should be worn when there is a possibility of chemical splashes to the body, when the atmosphere may contain contaminants that could damage the skin or be absorbed by the skin, or when contaminants could remain on the street clothes of an employee. The amount of coverage is dependent on the area of the body that is likely to be exposed. For small controlled processes, an apron may be sufficient; for work above the head, a full body coverall may be required. The process for selecting chemically resistant clothes is similar to that for gloves. Please check the manufacturer's recommendations for the proper selection of chemically protective clothing.

Respiratory Protection

Respirators are worn on the face to protect the respiratory system from hazardous air contaminants. Respiratory protection is not normally warranted in laboratory settings where exposures are controlled through the use of various engineering controls designed into the lab. When it is not feasible to conduct operations within a fume hood, or where there otherwise may be a need for respiratory protection, EHS must be contacted for initial exposure assessment and respirator approval. EHS provides employee respirators from N95s to air-purifying respirators as well as all replacement cartridges and parts. Regulations require that all employees complete a medical questionnaire, fit test & training before receiving any type of respiratory protection. Note that the medical questionnaire may prompt the need for a physical examination. EHS will work with your Supervisor to coordinate this effort per the EHS Respiratory Protection Program.

Hearing Protection

Hearing protection is rarely required during laboratory operations but may be necessary when sound levels exceed comfortable noise levels (typically at 85 decibels or greater). If a laboratory operation generates noise conditions in which researchers have to raise their voices to be heard, contact EHS for an assessment.

PPE Training Guidelines

The LD / Supervisor is responsible for providing training to each employee who is required to use PPE. Each employee shall demonstrate an understanding of the training and the ability to use personal protective equipment properly before being allowed to perform work requiring the use of PPE. Any training format can be used as long as a hands-on session is included. The length and complexity of training should reflect the complexity of the PPE. The U-M PPE Guideline Appendix B provides information to assist the LD / Supervisor in fulfilling this training requirement.

EHS staff is also available to conduct training; contact the EHS representative assigned to your area.

Reassessment and Retraining

Reassessment of the workplace should be conducted when new equipment, chemicals or processes are introduced that could create new or additional hazards. Incident records should be reviewed and the suitability of previously selected PPE reevaluated, if warranted. When the supervisor has reason to believe that any affected employee who has been trained does not have the understanding or skills required to use the personal protective equipment properly, the supervisor shall retrain such employees. Retraining is also required when there have been changes in the workplace or change in type(s) of PPE that render previous training obsolete.

4.4 GOOD LAB PRACTICES

Some practices are basic and fundamental to a strong safety culture in any laboratory where potential hazards exist. By incorporating simple practices into your daily routine, it will be more likely that more complex and perhaps less intuitive safety procedures driven by higher hazard work will also be followed.

Basic Safety Practices for U-M Laboratories

The Basic Safety Practices listed below, while not mandated in federal or state regulations, have been vetted by many national agencies such as the National Research Council of the National Academies. As such, they are considered good prudent practices to be followed by all laboratories where chemical, radiological, and/or biological materials are used or stored in order to protect the safety and health of all persons working in the laboratory. In certain instances, (identified where appropriate) the practices have been written directly into federal guidance and are considered mandatory. The LD can develop lab-specific rules that are more stringent, and include them in their EHS Document Binder.

- **Consumption, storage and preparation of food and drink are prohibited in research spaces where animals, hazardous chemicals, or human tissues/fluids are located, as well as in all laboratories that have been designated as Biosafety Level 1 - 3. Glassware used for laboratory operations is prohibited from use to prepare or consume food or beverages, regardless of where the consumption occurs. Laboratory refrigerators, ice chests, cold rooms, ovens, and so forth shall not be used for food storage or preparation.** Note: The prohibition in all areas where animals are located, or where bloodborne or other potential pathogens are stored or used, is identified specifically by the accrediting and regulatory agencies. The designation of clean areas within the lab for food storage, preparation and consumption is not allowed as interpreted by accrediting and regulatory agencies. Desk areas within the laboratory are not exempt from the restriction on food and drink.

  Food and drink is allowed in non-laboratory areas or desks that are physically separated from the laboratory operation by a door, partition, or engineered barrier which prevents cross contamination of the consumable items with the hazardous materials.

  Each School, Department, and Division is responsible for identifying spaces where eating, drinking, and similar activities are allowed, and for notifying individuals of appropriate areas for such activities.

- **Smoking, vaping, applying cosmetics, chewing gum, adjusting contact lenses, taking/storing medicine, and other related activities are not permitted in areas where chemical and/or biological materials are used or stored. The use of tobacco products and e-cigarettes is not permitted on campus property.** Note: The prohibition in all areas where animals are located, or where blood-borne or other potential pathogens are stored or used, is identified specifically by the accrediting and regulatory agencies.

- **Chairs covered with fabric or cloth material** are **not recommended** in laboratories that handle biological agents or other hazardous materials/chemicals because proper decontamination after contacting these materials is difficult to achieve. It is <u>*required*</u> that all fabric chairs in any areas of laboratories where biological agents or other hazardous materials/chemicals <u>*are handled*</u> **must** be covered with a non-porous material that can be easily decontaminated. It is <u>*recommended*</u> that all fabric chairs in labs - even those used at desk areas - be replaced with those that have a vinyl or other non-fabric material covering or are constructed of solid materials such as plastic, metal or wood.

- **Laboratory water sources and deionized laboratory water should not be used as drinking water.**

- **Laboratory chemicals should never be tasted, and mouth pipetting is prohibited. A pipette bulb or aspirator should be used to pipette chemicals or to start a siphon.**

- **Hands should be washed with soap and water immediately after working with any laboratory chemicals, even if gloves have been worn.**

- **Portable space heaters are prohibited in laboratories using and/or storing flammable, combustible, or explosive (highly energetic compounds) chemicals.**

- **Maintain Situational Awareness** - While in the laboratory, researchers must be fully aware of their surroundings and the events taking place around them. Be aware of the hazards posed by the work of others in the laboratory and any additional hazards that may result from contact between materials and chemicals from different work areas. Laboratory personnel actively working with hazardous materials, operations, or equipment must be especially cautious and make sure they are not distracted while working with the hazard or unable to hear warnings from those around them. Inadequate situational awareness has been identified as one of the primary factors in accidents attributed to human error. Thus, wearing of electronic devices that impede awareness of laboratory activities or emergency situations is discouraged for those actively working with hazardous materials, operations, or equipment. This rule applies to the use of electronic devices with earbuds or headphones like MP3 players and cell phones. If such devices are worn, only one ear may be occluded or covered. All cords must be secured inside the lab coat so they do not dangle. Visitors to laboratories including delivery personnel, vendors, and custodial or other university staff are required to follow this rule at all times within the laboratory. The LD may approve the use of a radio set to a volume that does not interfere with communication.

- **Weighing of Hazardous Chemicals -** Weighing powders can suspend them in the air, which may result in inhalation. It can also contaminate equipment and work surfaces, which can lead to skin contact and ingestion. When weighing hazardous chemicals or controlled substances, use an enclosed scale with sliding doors. Placement of the scale is important as environmental factors can influence accuracy. User error can influence scale accuracy and function. Laboratory staff must be trained on how to use and maintain the scale. The manual or operating instructions for the scale should include information on how to properly use, calibrate, and clean the scale after each use. Place the scale on a level surface in the fume hood to avoid personal exposure to the material and to prevent fluctuation in readings. Gloves, a lab coat, and safety glasses must be worn. Tools (weighing paper, tray, small spatula, vial) must be available to assist in material measuring to prevent contamination. Clean the scale before and after each use to avoid cross-contamination and exposure. Store the scale away from other chemicals, dust, and liquids.

Additional practices for maintaining a safe laboratory environment~~:~~

- Keep all laboratory doors closed and latched at all times for the following reasons:
  - NFPA 80 requires fire doors to remain closed and latched. Fire doors are typically identified by a label affixed to the door on the hinge edge. The label will indicate the rating of the door (45 minute, 90 minute, etc.). Fire doors cannot be propped open with wedges or kick-stop hold open devices.
  - To limit the spread of smoke and fire, maintain the integrity of the egress corridors for safe evacuation, and help protect the research in surrounding laboratories.

  - To improve safety by discouraging casual access, which aids in prevention of theft and unauthorized access to chemicals and other potentially hazardous materials.
  - To ensure proper operation and effectiveness of the ventilation system. Ventilation systems are installed, calibrated and tested based on doors being closed. Propping doors open impairs the effectiveness of the ventilation system. In addition, laboratories have increased ventilation rates for safety, and are designed and balanced to maintain appropriate pressure relative to surrounding spaces.
- Do not work alone when using hazardous materials, equipment or operations – use a buddy system so that emergency assistance is available.
- Laboratory personnel should not deviate from the assigned work schedule without prior authorization from the laboratory supervisor so that someone knows you are in the lab.
- Never perform unauthorized experiments.
- Plan appropriate protective procedures and the positioning of all equipment before beginning any operation. Follow the appropriate SOPs at all times in the laboratory.
- Always read and understand the SDS and the label before using a chemical in the laboratory and make others in the laboratory aware of any special hazards associated with your work.
- Wear appropriate PPE when handling hazardous materials. Inspect all gloves for holes and defects before using.
- Use appropriate ventilation such as laboratory chemical hoods when working with hazardous chemicals.
- Know the location and proper use of all safety equipment (eyewash unit, safety shower, fire extinguisher, first-aid kit, fire blanket, emergency telephone, and fire alarm stations).
- Report all work-related injuries and illnesses immediately to your Supervisor. The Supervisor must complete and submit an Illness and Injury Report Form to Work Connections and an EHS Incident and Near-Miss Report Form as soon as possible.
- Notify your LD or Supervisor of any chemical sensitivities or allergies.
- For liability, safety, and security reasons, do not allow unauthorized persons in the laboratory.
- Properly dispose of all chemical wastes.
- Always protect hands with appropriate gloves when cutting glass tubing. To avoid breakage, do not attempt to dry glassware by inserting a glass rod wrapped with paper towels. Always lubricate glassware with soap or glycerin before inserting rods, tubing, or thermometers into stoppers. Be sure that glassware has cooled before touching it. Hot glass looks just like cold glass.
- To reduce the chances of injuries from projectiles, when heating a test tube or other apparatus, never point the apparatus toward yourself or others.
- Dilute concentrated acids and bases by slowly pouring the acid or base into the water while stirring – never pour water into the acid or base as it can easily splash concentrated material during the chemical reaction.
- Contact your LD or EHS representative if you have questions about the adequacy of the safety equipment available or chemical handling procedures.

Visitors

Visitors, including minors, are permitted in laboratories when there is a legitimate business or educational purpose. Visitors to the lab are required to wear appropriate lab attire and PPE, including eye protection, as required in section 4.3 Personal Protective Equipment. All visitors must be properly trained for the tasks that will be performed and assigned the appropriate protective equipment. In addition, all minors must be incompliance with the

EHS guideline on Minors in Research Laboratories as well as SPG 601.34 Children on Campus and SPG 201.20 Employment of Minors.

Unsupervised volunteers and visitors, as well as children and pets, create a risk for injury and additional liability on the University. The LD must appoint a responsible person to supervise all visitors or volunteers when they enter a laboratory to work, or for a visit. If minors are expected in a laboratory (e.g., as part of an educational or classroom activity), ensure that they are under the direct supervision of qualified adults at all times. All laboratory personnel and volunteers in the area should be made aware that minors are present. Refer to the EHS Visitor's Guideline.

Pets

Pets are not permitted in laboratories. *Note: service animals are not pets. They are highly trained and may be present in a laboratory after a risk assessment has been conducted by EHS. A clean, safe area must be provided where the animal can wait.

Working Alone in the Laboratory

It is not prudent to work alone in a laboratory with hazardous materials or procedures. The American Chemical Society states that one should, "never work alone in the laboratory". The MIOSHA Hazardous Work in Laboratories Standard states, "Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous." Accidents are unexpected by definition and if a person is working alone when one occurs, his or her ability to respond appropriately could be severely impaired, which could result in personal injury or death. Thus, it is imperative that, whenever working in the laboratory, others are actively aware of your activities. If faced with a situation where you feel it is necessary to work alone in a laboratory:

- Reconsider the need. Is the work really that critical?
- Reconsider the timing and setup of the work. Can the task be accomplished another time when others will be present?
- If the timing of the task cannot be changed and you still feel it must be accomplished is there any other person trained in laboratory procedures who can accompany you?
- If not, is there anyone else within the building who could act as a "buddy" to check on you periodically during the time that you feel you must work alone?
- If no one can accompany you and you cannot find a "buddy," **do not proceed with the work.** Speak to your supervisor to make arrangements to complete the work in a safe manner.

Unattended Reactions

At times, it may be necessary to leave a laboratory operation unattended. Many organic reactions need hours and sometimes days to reach complete synthesis. On occasion, it may be necessary to allow a reaction to run overnight or for several hours unattended.

Give careful consideration to laboratory operations involving hazardous substances that are sometimes carried out continuously or overnight. It is the responsibility of the researcher to design these overnight reactions with provisions to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas. If you feel it is necessary to proceed with the reaction overnight:

Reconsider the need. Is the work really that critical?

- Reconsider the timing and setup of the work. Can the task be accomplished another time?
- Obtain approval from your lab director before you begin a reaction that must be left unattended.
- Choose a vented enclosure to setup your reaction. This includes but is not limited to a fume hood or a glovebox.
- Ensure there are no combustibles, clutter, or items surrounding your setup.
- Have someone else check your setup before you leave.
- Double-check all glassware, hoses, and clamps for cracks, damage, and security.
- If cooling water is needed, can you use a submersible pump in a 5-gallon bucket instead of using a faucet and running water?
- Use protection devices and sensors to turn off the experiment if there is an interruption in power, water flow, gas flow, device failure or excessive pressure or temperature that would have a potentially serious impact.
- Close the fume hood sash if applicable.
- Leave laboratory lights on and post appropriate signs on the entrance door(s) as well as near the experiment identifying the nature of the experiment and the hazardous substances in use.
- Leave information on the signs indicating how to contact you in the event of an emergency.

Good Housekeeping Practices in the Laboratory

Good housekeeping practices are those that promote general care, cleanliness, orderliness and maintenance of the laboratory. These practices in the laboratory can reduce potential risks of chemical exposure, fire, slip and fall, etc. Good housekeeping can also help reduce scientific error by reducing the chance of samples becoming mixed up or contaminated and keeping equipment clean and in good working order.

Clearance Distances

Maintaining appropriate clearance distances in front of various items in the lab is necessary to ensure access in the event of an emergency. The table below lists the clearance requirements for each item. Additional requirements may apply to each situation. Please contact your EHS Lab Safety representative for questions or additional details.

TOPIC	CLEARANCE	COMMENT
Aisle egress	44"	Applies to clearance for egress path
Electrical panel	36"	Applies to panels under 240 volts (42" for panels over 240 volts)
Emergency eyewash	6"	Applies to clearance around eyewash unit or eyewash bowl
Emergency shower	32"	Applies to clearance in front of shower
Fire extinguisher	Visible and accessible	Must be visible and accessible
Gas Shut Off Valve	Visible and accessible	Must be visible and accessible
Horn and Strobe	Visible	Must be visible throughout room
Sprinkler heads	18"	No storage is allowed above a plane 18" below the sprinkler head. However, storage is allowed above the 18" plane along a wall, provided a minimum clearance of 18" is maintained from all sprinkler heads.

Laboratory Equipment and Tools

Laboratory staff is responsible for routine inspection of the equipment and tools to check for functionality and damage. If an inspection finds any equipment or tools not functioning as expected or are damaged, the laboratory is also responsible for removing that equipment or tool from service and arranging appropriate maintenance by trained and qualified technicians. Laboratory staff shall not conduct their own equipment or tool maintenance. This will usually be conducted by a technician from the manufacturer of the equipment or other specifically trained individual. Laboratory equipment and tools shall not be used after being found to require service.

Equipment or tools that are taken out of service must be decontaminated by the laboratory staff prior to service, for both on-site and off-site service. Laboratories must use the EHS Equipment Decontamination Form.

When using laboratory equipment and tools, manufacturer's recommendations must be followed. Contact the manufacturer for more information regarding proper use and technical assistance for specific equipment and tools. Procedures involving modified use of equipment or tools require a laboratory-specific SOP to outline any special health and safety considerations. See Section 5.0 of the CHP for more information on SOPs.

Electrical Safety

Electrical equipment and connections must be checked regularly and kept clear of high traffic areas. Connections and cords must be insulated and undamaged. Equipment must be grounded when appropriate. Extension cords and daisy chained power strips are not permitted. Contact the facilities manager to arrange for installation of receptacle drops or additional wall receptacles if more receptacles are required. A licensed electrician must perform all installations and electrical work. Laboratory staff is not permitted to modify or work with facility electrical equipment or connections. High voltage panels must remain unblocked. Laboratory staff cannot access high voltage panels. Use of these panels presents a serious electrical hazard.

Any field-fabricated equipment must have SOPs outlining electrical safety and general safety procedures. Contact your EHS Representative if you are planning to fabricate a new piece of equipment for assistance in facilitating control measures for any associated hazards. See the Field Fabricated Experimental Equipment Guideline and EHS Electrical Safety page for more information.

4.5 CHEMICAL EXPOSURE ASSESSMENT

Many chemicals routinely used in laboratories present a significant health risk when handled improperly. The Swiss physician Paracelsus (1493-1541) is known as "the father of toxicology." Paracelsus is famous for his quote, "What is it that is not poison? All things are poison and nothing is without poison. It is the dose alone that makes a thing not a poison". In that same spirit, trained laboratory personnel are encouraged to reduce personal risk by minimizing exposure to hazardous chemicals and by eliminating unsafe work practices in the laboratory. Routes of exposure to hazardous materials include contact with skin and eyes, inhalation, ingestion, and injection.

Overexposure to chemicals can result in adverse acute or chronic health effects. Acute exposure is defined as short durations of exposure to high concentrations of hazardous materials in the workplace. Acute health effects appear rapidly after only one exposure and symptoms include rashes, dizziness, coughing, burns, etc. Chronic exposure is defined as continuous or repeated contact with a toxic substance over a long period of time in the workplace. Diagnosis of chronic health effects may take months or years. Symptoms of chronic health effects include joint pain, neurological disorders, tumors, etc.

To keep laboratory chemical exposures to a minimum, practice consistent adherence to general safe laboratory practices in conjunction with appropriate use of exposure controls. Exposure risk is more likely to increase when handling hazardous chemicals outside of a fume hood, especially chemicals:

- Having high acute or chronic toxicity, or which are carcinogens or reproductive toxins
- Having a permissible exposure limit of less than 50 ppm (or 0.25 mg/m^3 for particulate matter)
- That are appreciably volatile or easily dispersible in air
- That are used in large volumes (e.g., greater than 1 liter)

U-M EHS has professionals experienced in evaluating laboratory chemical exposures. Employees are encouraged to contact EHS at (734) 647-1143 with concerns or requests for an evaluation. In some instances, EHS will conduct exposure monitoring to measure levels of airborne contaminants. Depending on the chemical, some measurements can be made directly, and potential exposures may be known right away. In other situations, samples of air must be collected in containers or passed through special collection media, with subsequent laboratory analysis.

Exposure monitoring *may* be conducted by EHS under the following conditions:

- Lab personnel are experiencing strong odors associated with hazardous material usage in the laboratory
- Lab personnel are experiencing any physical symptoms associated with exposure to a particular hazardous material
- The use of engineering controls is not possible with the use of certain hazardous materials
- There is reason to believe that exposure levels for a substance exceeds the MIOSHA Action Level (AL) or Permissible Exposure Limit (PEL).
- An employee makes a request

EHS performs exposure monitoring at no cost to U-M general fund units. The initiation, frequency, and termination of monitoring are done in accordance with the relevant regulation. Monitoring results are provided to laboratory personnel per the time requirements of the relevant regulation, or within 15 days of receipt of monitoring results. In the event of monitoring results above regulatory limits, EHS will work with the lab to implement controls to reduce exposure. EHS maintains copies of exposure monitoring per the regulatory requirement. A copy of all individual lab exposure monitoring must be maintained by the lab for employee review in their EHS Blue Binder.

Reproductive Health at the U-M

Another aspect of your safety involves your reproductive health. Reproductive success relies on a delicate balance between maternal, paternal and fetal systems. Any disruption of the balance can result in a broad range of effects including infertility, poor pregnancy outcomes, childhood cancers or heritable alterations affecting future generations. Proper use of engineering controls, lab safety procedures and adhering to SOPs will greatly reduce your potential risk. Contact EHS professionals to conduct a Reproductive Hazard Evaluation.

4.6 INSTRUCTIONAL LABORATORY OPERATIONS

Where instructors are performing demonstrations or students are conducting experiments using hazardous materials, the instructor shall be required to perform a documented hazard risk assessment, provide a safety briefing to students, provide adequate personal protective equipment (PPE), and place a safety barrier (as required) between students and the demonstration or experiment to prevent personal injury.

Instructors in teaching labs shall be trained and knowledgeable in fire safety procedures, emergency plans, the hazards present in the lab, the appropriate use of PPE, and how to properly conduct a hazard risk assessment. The minimum PPE required in teaching labs includes a lab coat, safety glasses and gloves.

Chemical Storage and Handling

Bulk quantities of chemicals shall be stored outside of the classroom whenever possible. Quantities of chemicals in an instructional lab shall be limited to the lowest possible level necessary.

Dispensing of bulk quantities of chemicals for an experiment or demonstration shall be performed in a prep room outside of the classroom. If a separate preparation room is not available, the dispensing of bulk quantities of chemicals for experiments or demonstrations shall be performed prior to the arrival of the students in the classroom.

The minimum amount of chemical(s) needed to perform the experiment or demonstration shall be transferred to a small, appropriately labeled, sealable bottle(s). Bottles of chemicals shall only be open in the classroom only when the experiment or demonstration is being performed.

Performance of Experiments or Demonstrations

Experiments or demonstrations for students involving open flames, fire, or the use of flammable, reactive, toxic or corrosive chemicals shall be performed in a location that does not block access to the primary means of egress from the laboratory work area.

Experiments or demonstrations that involve or produce hazardous quantities of fumes, vapors, particulates, or gases shall be performed in a chemical fume hood or other ventilation device adequate to capture the materials being evolved.

Experiments or demonstrations involving chemicals that are performed outside a fume hood where a shield is not utilized shall be performed in a location that is at least 3.05 m (10 ft.) from students.

Experiments or demonstrations involving chemicals that are performed outside a fume hood where the separation distance is not possible shall be performed behind an impact-resistant plastic or tempered-glass safety shield. Select the appropriate size shield to protect students and secure it to the work surface with bolts or clamps to keep it in place.

A knowledgeable instructor shall perform experiments or demonstrations using flammable liquids and open flames. If students conduct experiments, the instructor shall be responsible for conducting a safety briefing prior to the start of each experiment to review the hazards of the chemicals used, the personal protective equipment required for the experiment, and emergency procedures.

5.0 STANDARD OPERATING PROCEDURES (SOP)

Ultimately, the LD is responsible to ensure all written SOPs provided for laboratory activities involving hazardous chemicals and equipment he/she directs are adequate and provide sufficient guidance to laboratory personnel to maintain a safe work place. A risk assessment considers every aspect of an experiment in advance to help identify the risks of harm and determine appropriate controls for the hazards inherent in all steps of an experimental process. Use the information obtained from the risk assessment to write a SOP that integrates safe work practices.

Laboratory personnel working autonomously or performing independent research are responsible for developing SOPs that should be reviewed by the LD or supervisor prior to performing work.

Give priority for SOP development to any operation involving restricted and higher-hazard chemicals and higher-risk research procedures.

5.1 WRITTEN SOP

The EHS website has SOPs available for many specific chemicals, classes of chemicals, physical hazards, and laboratory equipment. The information contained in the SOPs is believed to be accurate at the time of posting on the website. Always consult a current SDS for the most up-to-date information.

Modify all SOPs downloaded from the EHS website to reflect lab-specific use details. A template is also available to provide guidance in the creation of lab-specific SOPs. The scope of coverage and degree of detail provided in the SOPs should be appropriate for prudent experiment planning in most commonly encountered laboratory situations. Only individuals familiar with the chemicals and processes should conduct experiments involving the SOPs.

For assistance in identifying and evaluating lab controls, please contact EHS Research Health & Safety. 92
Prudent Practices in the Laboratory, by the National Research Council, is an additional resource.

5.2 RESTRICTED CHEMICALS REQUIRING PRIOR APPROVAL

Laboratory personnel shall seek, and the LD / Supervisor must provide, prior approval of any chemical usage involving Restricted Chemicals listed in the table below, as well as any higher hazard materials. In addition, the LD / Supervisor must provide prior approval for the use of substances with a hazard ranking of 4 in any ChemWatch Gold FFX rating for Flammability, Toxicity, Body contact, Reactivity or Chronic.

*2-Acetylaminofluorene (53-96-3)	Ethylene oxide (75-21-8)
Acrolein (107-02-8)	Fluorine (7782-41-4)
*4-Aminodiphenyl (92-67-1)	Hexamethylphosphoramide (680-31-9)
Anhydrous ammonia (7664-41-7)	Hydrazine (302-01-2)
Arsine (7784-42-1)	Hydrogen cyanide (74-90-8)
*Benzidine (92-87-5)	Lithium aluminum hydride (16853-85-3)
Boron trifluoride (7637-07-2)	*alpha-Naphthylamine (134-32-7)
Butyllithiums (and related alkyl lithium reagents)	*beta-Naphthylamine (91-59-8)

*Chloromethyl methyl ether (107-30-2)	Nickel carbonyl (13463-39-3)
*bis-Chloromethyl ether (542-88-1)	*4-Nitrobiphenyl (92-93-3)
Cyanogen bromide (506-68-3)	*N-Nitrosodimethylamine (62-75-9)
Diazomethane (334-88-3)	Osmium tetroxide (20816-12-0)
Diborane (19287-45-7)	Palladium on carbon (7440-05-3)
*3,3'-Dichlorobenzidine (and its salts) (91-94-1)	Phosgene (75-44-5)
Diethylnitrosamine (and related nitrosamines)	Phosphine (7803-51-2)
*4-Dimethylaminoazo-benzene (60-11-7)	*beta-Propiolactone (57-57-8)
Dimethylmercury (593-74-8)	Sodium azide (26628-22-8)
Dimethyl sulfate (77-78-1	Toluene diisocyanate (584-84-9)
Ethylene dibromide (106-93-4)	Trimethylaluminum (75-24-1) and related organoaluminum compounds
*Ethyleneimine (151-56-4)	Trimethyltin chloride (1066-45-1)

** Denotes chemicals regulated under the MIOSHA Part 350 - Carcinogens Standard.*

5.3 SPECIAL PROVISIONS FOR OTHER HIGHER HAZARD CHEMICALS AND OPERATIONS

Each LD/Supervisor will identify those materials and procedures in their lab requiring special provisions and will write a SOP that includes the necessary special provisions. In developing a SOP for higher hazard chemicals and operations, consideration must be given to:

- Establishment of a designated area
- The conditions of handling
- Skin exposure potential
- Inhalation hazard
- Use of personal protective equipment
- Continuous air monitors
- Alarms
- Need for contamination control devices such as glove boxes
- Decontamination procedures
- Procedures for the handling and safe removal of waste materials

To implement special safety precautions where appropriate, laboratory personnel must consult with their LD / Supervisor on the following:

- A change that significantly increases the overall hazard of an existing procedure such as introduction of a higher hazard chemical, an increase in chemical concentration or scale up of an experimental procedure or operation.
- Unattended operations that represent significant likelihood of fire, explosion, or exposure to personnel if a malfunction such as a utility outage, runaway reaction, broken container, chemical spill, etc. were to occur.
- Plans to conduct work at night, on weekends or holidays.

6.0 CHEMICAL PROCUREMENT, LABELING, STORAGE, AND INVENTORY

Anyone who purchases a chemical assumes responsibility for ownership of that chemical. Once in the lab, hazardous chemicals must be stored, labeled and inventoried properly to avoid confusion or mistaken identity of a chemical, to provide separation of incompatible materials, and to provide information for emergency response personnel.

6.1 CHEMICAL PROCUREMENT

Prior to procuring a chemical, consider all purchasing, handling and disposal costs to effectively manage chemical inventories and minimize accumulation of unused or unwanted chemicals. Also, consider the following questions:

- Has the purchase been reviewed to ensure that any special requirements can be met? Consider:
    - Storage requirements such as inert environment, freezer/refrigerator availability, etc.
    - Required engineering controls such as a fume hood or other LEV
    - Necessary PPE
    - Special containment considerations in the event of spill, fire or flood
- Is the material already available? The Chemical Reuse program provides U-M research and teaching labs with an opportunity to obtain desired chemicals and solvents free of charge. EHS stores the unexpired and unused surplus chemicals in a repository for redistribution. Through this program, labs can request a chemical, donate a chemical, or request a standing order. This Chemical Reuse program is available to the U-M research community only.
- What is the minimum quantity that will suffice for the current use? The potential savings when buying in bulk is often outweighed by the disposal cost for excess chemicals.
- What is the maximum size container or overall quantity allowed in the lab where the chemical will be used and/or stored? Contact EHS for assistance in determining maximum quantities.
- Will arrangements need to be made to notify someone as soon as the chemical arrives?
- Has a SOP been developed that addresses proper handling, storage and disposal for the chemical?

Chemicals should be delivered to a central location in the building where someone is available to accept the delivery. Chemicals must not be delivered to administrative offices or mailrooms.

Any person accepting delivery of a chemical must be trained to:

- Check for an identifying label
- Be able to identify signs of breakage (e.g. rattling) and leakage (e.g. wet spot or stain). Contact EHS HMM if assistance is needed in cleaning up or disposal of the chemical.
- Respond appropriately if a cylinder of compressed gas is leaking

Restricted chemical procurement procedures are detailed in section 6.5 of this document.

6.2 CHEMICAL LABELING

The MIOSHA Hazard Communication Standard (HCS) is intended to ensure chemical safety in the workplace by requiring employers to provide information about the identities and hazards of chemicals that employees handle and use. The HCS is now aligned with the Globally Harmonized System (GHS) of classification and labeling of chemicals. GHS provides a standardized approach to label elements and safety data sheets (SDS).

All hazardous chemical containers will have a primary label from the chemical manufacturer/supplier containing pictograms, signal words, hazard statements and precautionary statements. In addition, the label will have the common product or chemical name and the supplier or manufacturer name, address and telephone number.

The pictogram is a symbol plus other graphic elements, such as a border, background pattern, or color that is intended to convey specific information about the hazards of a chemical. There are eight (8) required (*as applicable*) standardized pictograms and one (1) optional pictogram, under the GHS. Each pictogram consists of a different symbol on a white background within a red square frame set on a point, i.e. a red diamond. All pictograms are diamond shaped with a red border and black image.

HCS Pictograms and Hazards

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

Signal words are used on the label to indicate the relative level of severity of hazard and alert the reader to a potential hazard. The two signal words to be used are “Danger” and “Warning”. "Danger" is used for the more severe hazards, i.e., for hazard categories 1 & 2 while “Warning" is used for less severe hazards. Only one signal word corresponding to the class of the most severe hazard should be used on a label.

A hazard statement is assigned to a hazard class and category that describes the nature of the hazard(s) of a chemical, including, where appropriate, the degree of hazard. Examples:

- Flammable liquid and vapor
- Causes skin irritation
- May cause cancer
- May cause liver & kidney damage

A precautionary statement is a phrase that describes recommended measures to be taken to minimize or prevent adverse effects resulting from exposure to a hazardous chemical or improper storage or handling of a hazardous chemical.
Examples:

- Wear eye & face protection
- Avoid breathing fumes or mist
- Keep away from heat, sparks, open flames & other sources of ignition
- Store in well-ventilated space

Secondary containers of chemicals and any in-house dilutions made from stock chemical bottles are required to be labeled with the full chemical name (no abbreviations), concentration, and primary health and/or physical hazard(s). Labels can be hand written or printed. The Gold FFX Safety Data Sheet program, located on the EHS website, has the capability of creating and printing various size labels for use in the lab.

Physical hazards under GHS are:

• Explosives	• Pyrophoric Liquids
• Flammable Gases	• Pyrophoric Solids
• Flammable Aerosols	• Self-Heating Substances
• Oxidizing Gases	• Substances which, in contact with water, emit flammable gases
• Gases Under Pressure	• Oxidizing Liquids
• Flammable Liquids	• Oxidizing Solids
• Flammable Solids	• Organic Peroxides
• Self-Reactive Substances	• Corrosive to Metals

Health hazards under GHS are:

• Acute Toxicity	• Reproductive Toxicology
• Skin Corrosion/Irritation	• Target Organ Systemic Toxicity – Single Exposure
• Serous Eye Damage/Eye Irritation	• Target Organ Systemic Toxicity – Repeated Exposure
• Respiratory or Skin Sensitization	• Aspiration Toxicity
• Germ Cell Mutagenicity	
• Carcinogenicity	

GHS adds severity rankings to each of the hazard classifications. Categories range from 1 to 5 with “1” indicating the most severe and “5” indicating least severe. Note: This ranking system conflicts with the NFPA and HMIS systems where the number “4” indicates a severe hazard.

6.3 CHEMICAL STORAGE

To lessen risk of exposure to hazardous chemicals, trained laboratory personnel must separate and store all chemicals according to hazard category and compatibility. In the event of an accident involving a broken container or a chemical spill, incompatible chemicals that are stored in close proximity can mix to produce fires, hazardous fumes, and explosions. Laboratory personnel should read the SDS and heed the precautions regarding the storage requirements of the chemicals in the laboratory.

Date incoming chemical shipments promptly upon receipt, and rotate chemical stock to ensure use of older chemicals. Peroxide forming chemicals must be dated upon receipt and again when the container is opened so that the user can dispose of the material according to the recommendations on the SDS. Peroxide formers should be stored away from heat and light in sealed airtight containers with tight-fitting, nonmetal lids. Test regularly for peroxides and discard the material prior to the expiration date. For more information about storage and handling of peroxides, refer to the Peroxide Forming Chemicals SOP.

Basic Guidelines for Chemical Storage:

- Storage areas should be cool, dry, ventilated, well lit and away from direct heat and sunlight.
- Keep appropriate chemical spill kits and fire extinguishers near storage areas.
- Check that containers are sealed, capped and in good condition.
- Keep the outside of the containers clean of chemical residue.
- When storing chemicals on open shelves, always use sturdy shelves that are secured to the wall.
- Do not store liquid chemicals above shoulder height.
- Use secondary containment devices (i.e., chemical-resistant trays) where appropriate.
- Place chemical, biological, or radiological materials in secondary containers to safely transport between labs or from the chemical stock room.
- Do not store chemicals in the laboratory chemical hood, on the floor, in the aisles, in hallways, in areas of egress, or on the benchtop.
- Store chemicals by compatibility – not alphabetically!
    - Reference the compatibility chart below
- Download the Chemical Reactivity Worksheet, a free software program from the Center for Chemical Process Safety, to your computer.
- Designate a well-ventilated secure area for highly hazardous chemicals.

Rooms used specifically for chemical storage and handling (i.e., preparation rooms, storerooms, waste collection rooms, and laboratories) should be controlled-access areas that are identified with appropriate signage. Chemical storage rooms should be designed to provide proper ventilation, two means of access/egress, vents and intakes at both ceiling and floor levels, a diked floor, and a fire suppression system.

Storage Guidelines for General Classes of Chemicals

- Flammable Liquids – Flammable liquids are required to be stored in flammable liquid storage cabinets approved by the National Fire Protection Association (NFPA) or flammable liquid storage rooms meeting MIOSHA requirements. MIOSHA's requirements include ventilation, dikes, explosion proof lighting, intrinsically safe wiring, grounding and bonding. Oxidizers, acids and other incompatible chemicals are prohibited from being stored in these areas. Do not permit sources of ignition in or near storage areas. Consult EHS Fire Safety Services for assistance, if needed.

  Only laboratory-grade flammable liquid storage refrigerators and freezers may be used to store properly sealed and labeled flammable chemicals that require cool storage in the laboratory. Periodically clean and defrost the refrigerator and freezer to ensure maximum efficiency. *Domestic refrigerators and freezers must not be used to store flammable chemicals; they possess ignition sources and can cause dangerous and costly laboratory fires and explosions.*

- Corrosives – Corrosives can be acidic or basic. Acids and bases should never be stored together. Corrosives should not be stored with flammable or combustible materials. Use spill trays to contain leaks.

- Oxidizers – Store in an isolated area away from flammable or combustible materials. These agents may react at room temperature producing fire or explosions. Strong oxidizers – i.e. perchloric acid, chromic acid, and hydrogen peroxide – can be explosive on contact with organic materials.

- Toxic and Poisonous Materials – Store in isolated areas. Do not store with acids or flammable materials.

- Cryogenic Liquefied Gases – Store in well-ventilated areas. Cryogenic gases boil off at room temperatures, and dewars are vented to prevent dangerous excessive pressure build up. This vented gas can displace oxygen in enclosed or unventilated areas. The liquid form of cryogenic gases will instantly cause cold-contact burns to living tissue upon contact.

- Water Reactive Compounds – Store in isolated location away from any water sources.

- Pyrophoric Compounds – Store in isolated location under nitrogen or other appropriate storage method from the chemical manufacturer.

- Peroxide Forming Compounds –Store in airtight containers in a dark, cool but not freezing, and dry area. Do not permit sources of heat, friction, grinding, or impact near storage areas. For more information about storage and handling of peroxides, see Section 3.6.

- Special Compounds – Follow specific storage instructions from chemical manufacturers. Check for moisture in the bottle of explosive chemicals that must be stored wet or in solution. Date all incoming shock sensitive explosive chemicals and dispose of them immediately upon reaching their expiration date. Both picric acid and benzoyl peroxide must be kept wet. If the solution dries, the crystals form very sensitive explosive compounds and any shock or friction could set these off. Contact EHS HMM for assistance if a dry solution is found. Some chemicals like diethyl pyrocarbonate must be refrigerated to remain stable. Once unstable, removing the cap could cause an explosion.

- Do not mix combustibles with perchlorates. Many perchlorates become explosive when mixed with combustibles. Examples include silver perchlorate, ammonium perchlorate, sodium perchlorate, and potassium perchlorate. Organic perchlorates like methyl perchlorate are self-contained explosives.

- Compressed Gas Cylinders – Compressed gas cylinders must be secured in an upright position away from excessive heat, highly combustible materials, and areas where they might be damaged or knocked over. A chain, bracket or other restraining device shall be used to secure the cylinder at all times to prevent them from falling. Placement of the restraint should be no lower than 1/3 of the distance from the top of the cylinder. The cylinder status as to “full” or “empty” must be indicated on the cylinder and the valve cap must be in place whenever the cylinder is not connected for use.

  Cylinders must be stored in ventilated areas. Closets and lockers are not acceptable storage locations. Hallways, corridors, stairwells or near elevators are also unacceptable. Additionally, cylinders of oxygen and other oxidizers must not be stored within 20-feet of fuel-gas or other combustible materials unless separated by a specific barrier, e.g., a noncombustible wall, not less than 5-feet high, having a fire-resistance rating of ½-hour. Securing devices can be purchased from any laboratory safety supply company, or the Sheet Metal Shop can develop a restraining system.

Additional Safety Procedures – Handling and storage procedures, outlined on the SDS, should be incorporated into your SOP. Prior to working with chemicals, training on proper use and storage must be provided. If you are unsure of the correct safe handling procedures for any chemical, please contact EHS for assistance.

Chemical Compatibility Charts: **Adapted from the** [Fisher Scientific Chemical Stockroom Handbook]()

Incompatibilities by Hazard Class

	Acids Inorganic	Acids Oxidizing	Acids Organic	Alkalis Bases	Oxidizers	Poisons Inorganic	Poisons Organic	Water Reactive	Organic Solvents
Acids Inorganic			X	X		X	X	X	X
Acids Oxidizing			X	X		X	X	X	X
Acids Organic	X	X		X	X	X	X	X	
Alkalis Bases	X	X	X				X	X	X
Oxidizers			X				X	X	X
Poisons Inorganic	X	X	X				X	X	X
Poisons Organic	X	X	X	X	X	X			
Water Reactive	X	X	X	X	X	X			
Organic Solvents	X	X		X	X	X			

X *indicates incompatibility between two chemical product groups. Incompatible products should not be stored in close proximity.*

Specific Chemical Incompatibilities

Chemical	Store Separately From
Acetic acid	Chromic acid, nitric acid, perchloric acid, peroxides, permanganates and other oxidizers
Acetone	Concentrated nitric and sulfuric acid mixtures, and strong bases
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia, anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium

Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic acid and Chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids, organic or inorganic
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Oxidizing acids, Oxidizers, Acetaldehyde
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids
Hydrogen sulfide	Fuming nitric acid, other acids, oxidizing gases, acetylene, ammonia (aqueous or anhydrous), hydrogen
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease and oils
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate and perchlorate	Sulfuric and other acids, alkali metals, magnesium and calcium
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural

Sulfides	Acids
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals: sodium, lithium, etc.)
Tellurides	Reducing agents

(From Manufacturing Chemists' Association, Guide for Safety in the Chemical Laboratory, pp. 215–217, Van Nostrand)

Additional Incompatible by Chemical Class

1	Inorganic Acids	1															
2	Organic Acids	X	2														
3	Caustics	X	X	3													
4	Amines & Alkanolamines	X	X		4												
5	Halogenated Compounds	X		X	X	5											
6	Alcohols, Glycols & Glycol Ethers	X					6										
7	Aldehydes	X	X	X	X		x	7									
8	Ketones	X		X	X			x	8								
9	Saturated Hydrocarbons									9							
10	Aromatic Hydrocarbons	X									10						
11	Olefins	X				X						11					
12	Esters	X		X	X								12				
13	Halogens			X			X	X	X	X	X	X	X	13			
14	Ethers	X													14		
15	Acid Anhydrides	X		X	X		X	X							X	15	
16	Oxidizers	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	16

NOTE: Identify class to which a specific compound belongs, read unsafe combinations with other classes both horizontally and vertically. X = Unsafe Combination

6.4 CHEMICAL INVENTORY

The LD is required to maintain a current inventory of all potentially hazardous chemicals (including gases) stored, used, or produced within each laboratory that is under their responsibility. It is the responsibility of the LD to determine if chemicals in use or in storage present a potential hazard, which must be identified on the chemical inventory.

Non-hazardous materials do not need to be entered into the inventory. A hazardous chemical is any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or hazard not otherwise classified.

Chemicals in quantities less than 10 mL or 10 grams do not need to be entered into the inventory unless they are designated as:

- A Department of Homeland Security Chemical of Interest

- A DEA Controlled Substance
- A HHS Select Agent Toxin

All containers holding small quantity chemicals should include a reference number related to the actual chemical. Small quantity chemicals with similar chemical properties should be placed into a larger labeled secondary container. The container/box will be entered into the inventory (i.e. Box 1), with no additional requirements. Please note that these chemicals may also be covered by hazardous waste rules and therefore the exemption from the inventory requirements does not mean an exemption from chemical disposal rules.

EHS manages a chemical inventory tracking system for laboratories to use in maintaining their chemical inventories called the MI Safety Portal (MISP). The MISP is a web-based, online, limited access database that is used to maintain chemical inventories. This system is maintained on a secure internet server and is an easy to use, long-term, convenient way for researchers to maintain their inventories, generate various built-in inventory reports and export data to Excel.

All labs, except those taking part in the Earth and Environmental Sciences or Chemistry Department's chemical tracking system or the Lurie Nanofabrication facility, are required to use MISP. Chemical lists already in Excel, Access, or other systems can be uploaded into MISP by contacting EHS. After a list has been uploaded, MISP should be used exclusively for chemical inventory maintenance and report generation.

The chemical inventory ***must be updated immediately when new chemicals arrive*** into the laboratory. At a minimum, the chemical inventory must be reviewed on an annual basis. Certification of the annual review is accomplished by clicking on the "Chemical Inventory Review Statement" link within MI Safety Portal and submitting the acknowledgement.

There are many benefits of performing annual reviews of chemicals in use/storage and regularly updating the inventory in MISP:

- ensures integrity of shelving and storage cabinets,
- ensures that chemicals are stored according to compatibility tables,
- eliminates unneeded or outdated chemicals,
- promotes more efficient use of laboratory space,
- checks expiration dates of peroxide formers,
- encourages laboratory supervisors to make "executive decisions" about discarding unnecessary chemicals,
- provides opportunity to repair/replace torn or missing labels and broken caps on containers,
- ensures compliance with all federal, state, and local record-keeping regulations, e.g., HHS/USDA's Select Agents and Toxins, DHS' Chemicals of Interest, etc.
- promotes good relations and a sense of trust with the community and the emergency responders, and
- may reduce costs by entering chemicals into the chemical reuse program.

Important safety issues to consider when performing a chemical review and update are:

1. Wear appropriate PPE and have extra gloves available.
2. Use a chemical cart with side rails and secondary containment.
3. Watch out for chemicals stored on high shelves and relocate to a safer height (i.e. not above shoulder height).
4. Know where the safety shower and emergency eyewash are located.

5. If necessary, cease all other work in the laboratory while performing the review.

Information on obtaining access to MISP and a summary of its capabilities is available on the EHS website.

6.5 RESTRICTED CHEMICALS, GASES, AND CONTROLLED SUBSTANCES

In order to provide a safe working environment in U-M research facilities, EHS has instituted a program with U-M Procurement Services that requires written EHS approval for a relatively narrow range of hazardous gas purchases. These gases are of particular concern due to high toxicity, flammability, or reactivity - particularly in quantities that could defeat normal precautions and emergency responses. Under no circumstances should a researcher purchase more than a 1-year supply. See the Hazardous Gases Purchasing Program for more details.

Departments must complete an authorization form to purchase restricted gases. EHS must approve the request before the department orders the gas from a Strategic Supplier.

Select Agent Toxins

Researchers who wish to obtain or transfer Select Agent pathogens or regulated amounts of Select Agent toxins, specifically listed by CDC and USDA, must contact EHS Biosafety at EHSBiosafety@umich.edu for additional information and guidance.

Controlled Substances in Research

The U-M Controlled Substances in Research Monitoring Program ensures compliance with federal and state regulations pertaining to controlled substances in the research setting at U-M, including controlled substances associated with animal research, administered to human subjects as part of a research protocol, and used for in vitro or analytical research. Information regarding requirements is available on the Research, Ethics and Compliance website.

EHS offers additional guidance for research practices found in the Controlled Substances SOP.

6.6 TRANSPORTING, TRANSFERRING, AND SHIPPING CHEMICALS

Transporting Chemicals

It is prudent practice to use a secondary containment device (i.e., rubber pail) when transporting chemicals from the storeroom to the laboratory or even short distances within the laboratory. When transporting several containers, use carts with attached side rails and trays of single piece construction at least 2 inches deep to contain potential spills. Separate bottles of liquids to avoid breakage.

Avoid high-traffic areas when moving chemicals within the building. When possible, use freight elevators when transporting chemicals and do not allow other passengers. If you must use a general traffic elevator, ask other passengers to wait until you have delivered the chemicals.

Transferring Chemicals between Containers

Often, laboratory operations require transferring chemicals from the original labeled container into a secondary container (e.g., beaker, flask, or bottle). Check chemical compatibility with containers to verify that chemical storage is appropriate to the container.

Labels on portable containers are not required if the worker who made the transfer uses all of the contents during the work shift. Portable containers must comply with all labeling requirements listed in section 6.2 if any of the following events occur:

- The material is not used within the work shift of the individual who makes the transfer
- The worker who made the transfer leaves the work area

Transferring substances, especially when filling small containers from a larger one, can be quite dangerous. Follow these guidelines when transferring chemicals to make sure you do it safely:

- Make sure that the large container is stable and in your control if you are lifting to pour liquid out of it
- Use a funnel and pour slowly to prevent splashing and airlocks in the funnel
- If the substance is flammable keep it away from any source of heat or ignition
- Use a properly operating chemical fume hood, local exhaust, or adequate ventilation when transferring chemicals
- If the substance is corrosive, wear gloves, safety goggles, a face shield and a rubber apron
- Whenever possible use a hand-pump or siphon to transfer liquids, rather than pouring
- If transferring flammable liquids from a drum, always ground and bond the drum and receiving vessel to prevent static charge buildup

Shipping Hazardous Materials and Dry Ice

The International Air Transport Association (IATA) Dangerous Goods and US Department of Transportation (DOT) regulate shipment of hazardous substances including infectious substances and chemicals. Anyone who ships hazardous materials, including dry ice, must be trained. Serious fines can result if a package of hazardous materials is not declared on the shipping papers and marking/labeling on the parcel. The UM offers shipping assistance through M-Ship. This service prepares packages for shipments of biological materials, including dry ice for all U-M research faculty and staff. Those utilizing M-Ship services must still receive appropriate training, but the M-Ship shipping consultants will prepare and package the materials including the appropriate documentation and paperwork.

EHS provides guidance on this area of regulatory compliance and certain training services, mainly geared toward the shipping of biological hazards. If chemically hazardous materials need to be shipped by a research organization on campus, EHS should be contacted to provide a risk assessment and consultative services on the regulatory requirements. Refer to the EHS Transporting Biological Materials page for training and additional information.

7.0 HAZARDOUS WASTE MANAGEMENT, CONTROLLED SUBSTANCE DISPOSAL AND ENVIRONMENTAL MANAGEMENT

7.1 HAZARDOUS WASTE MANAGEMENT

Proper handling and disposal of hazardous materials is the responsibility of all U-M personnel. EHS provides services and oversight to ensure compliance with the regulations pertaining to hazardous waste collection, packaging, and manifesting.

The EHS Hazardous Materials Management (HMM) program collects and disposes of regulated wastes generated from laboratories, maintenance areas, construction sites, housing units, and healthcare clinics across campus. Regulated waste includes:

- Chemical waste
- Radioactive waste
- Biological waste
  - Solids
  - Liquids
  - Sharps
  - Pathological
  - Uncontaminated
- Universal waste
  - Batteries
  - Bulbs (lamps)
  - Ballasts
  - Consumer electronics

Waste containers are available free of charge and are delivered directly to U-M labs. Request waste collection and supplies online or by calling (734) 763-4568.

In addition to hazardous waste pickup, EHS HMM provides the following services to the University community:

- Technical advice on identification, labeling and manifesting of waste.
- Emergency response to accidental spills chemical, biological, radioactive material, and environmental-impacting spills that occur in campus facilities or on campus grounds.
- Laboratory cleanouts.
- Technical advice and training on emergency response to spills.
- Waste disposal supplies.
- Pollution prevention / waste minimization.

Refer to the EHS HMM section of our website for additional information.

7.2 CONTROLLED SUBSTANCE DISPOSAL

The U-M Office of Research (UMOR) administers the Controlled Substances in Research Oversight Program. Please follow the guidance provided by UMOR for the proper handling, storage, and disposal of Controlled Substances.

Contact the EHS Hazardous Materials Management (HMM) office at (734) 763-4568 for proper disposal of all controlled substances.

7.3 ENVIRONMENTAL MANAGEMENT

Ongoing operations and research activity must employ sound environmental practices to provide environmental stewardship and limit liabilities. EHS works with labs to reduce or eliminate concerns and maintain compliance with the constantly changing regulations. Examples of the assistance EHS provides to promote environmental stewardship include:

Wastewater/Drain Disposal – Wastewater discharged from inside U-M facilities flows into the sanitary sewer system and is treated at the Ann Arbor Wastewater Treatment Plant prior to discharge into the Huron River watershed. Pouring other materials (pollutants) down the drain such as chemicals, metals, solids, and oils can interfere with the treatment process. More information on sanitary drain disposal restrictions is available on the EHS website.

Sustainability in Labs – The Office of Campus Sustainability (OCS) works with labs to promote and practice sustainable operations in a more standardized way. The Sustainable Lab Recognition Program is a collaborative effort between OCS and an individual lab that is interested in integrating some or all of the following practices into their research operations: Pollution prevention, Recycling, Waste minimization, Green chemistry,
Green purchasing. Since there is a higher risk of hazardous or dangerous materials entering the recycling stream, only approved items may be recycled by laboratories. Refer to the OCS Reuse and Recycling Guide for Laboratories.

Chemical Reuse Program – The Chemical Reuse Program, operated by OCS in partnership with EHS, provides U-M research and teaching labs with an opportunity to obtain desired chemicals and solvents ***free of charge***. EHS stores the unexpired and unused surplus chemicals in a repository for redistribution. Through this program, labs can request a chemical, donate a chemical, or request a standing order. This program serves the U-M community only.

Mercury Elimination Program – The U-M has successfully removed over 6,000 mercury thermometers and 3,000 pounds of elemental mercury from our campus since 2002. Through the Green Purchasing program of the U-M Procurement Services department we have entered into an agreement with Fisher Scientific to replace mercury thermometers with non-mercury devices. For technical assistance our Fisher Scientific representative can be reached at 734-657-8669 or by e-mail at gary.debusscher@thermofisher.com.

8.0 LABORATORY INSPECTIONS

A program of periodic laboratory inspections helps keep laboratory facilities and equipment in a safe operating condition by identifying and addressing potential health and safety deficiencies. Periodic inspections will also help to ensure all regulatory compliance requirements are being met. Inspections safeguard the quality of U-M's laboratory safety program.

The goals of the inspection program are to:

- Maintain laboratory facilities and equipment in a safe, code-compliant operating condition.
- Provide a comfortable and safe working environment for all personnel and the public.
- Ensure that all laboratory activities are conducted in a manner to prevent employee exposure to hazardous chemicals.
- Ensure that trained laboratory personnel follow the CHP.

EHS Safety Inspections

U-M EHS conducts laboratory inspections on a routine basis. These inspections may be comprehensive, targeted to certain operations or experiments, focused on a particular type of inspection such as safety equipment and systems, or audits to check the work of other inspectors. EHS also conducts short unannounced inspections for key indicators of lab safety. These unannounced visits may take place on weekends or other off hours. More information on EHS inspections follows in section 8.1, below.

Routine Self-Inspections

Each LD or their designee is required to conduct short, monthly self-inspections of their lab space within MI Safety Portal. Knowledgeable and trained laboratory personnel, with the oversight of the LD, should conduct the self-inspections. Each month a set of core questions is presented accompanied by a few more questions on a specific safety topic. These monthly inspections provide an excellent opportunity to promote a culture of safety, and interaction with individuals in the lab is important. Labs should strive to complete each self-inspection by the end of the month they are assigned. All twelve (12) monthly self-inspections must be completed annually.

Laboratory personnel can provide a great deal of information and feedback for possible improvements to the laboratory safety program. Take notes regarding workers issues of interest or concern that may fall outside the scope of the actual inspection. Make comments using the "Action Item" field available with each question in MI Safety Portal to be able to recall the details and describe any problems or ideas for improvement. Point out problems as they are found and show laboratory personnel how to fix them. If the problem is corrected during the inspection, make a note that it was resolved.

Certain types of equipment in constant use, such as gas chromatographs, may require daily inspections. Other types of equipment may need only weekly or monthly inspection, or inspection prior to use if operated infrequently. Keep a record of the inspection attached to the equipment or in a visible area.

The inspections maintained in MISP do not need to be printed and maintained in the Document Binder.

Inspections by External Entities

Many types of inspections or audits may be conducted by outside experts, regulatory agencies, emergency responders, or other organizations. They may inspect a particular facility, equipment, or procedure either during the pre-experiment design phase or during operations. As a matter of safety and security, if someone requests entry to a laboratory for the purpose of an audit without a recognized escort, ask to see his or her credentials and contact U-M EHS at (734) 647-1143.

Regulatory agencies may conduct announced or unannounced inspections on a routine or sporadic basis. Laboratories must keep their programs and records up-to-date at all times to be prepared for such inspections. Any significant incident or accident within a lab may trigger one or more inspections or investigations by outside agencies. Evidence that the underlying safety programs are sound may help limit negative findings and potential penalties. U-M EHS acts as a liaison with federal and state safety/environmental regulatory agencies when dealing with concerns impacting University activities. All such inspections by regulatory agencies must be reported to U-M EHS at (734) 647-1143 as soon as possible.

8.1 EHS INSPECTION FREQUENCY AND RECORDKEEPING

EHS has developed a Lab Hazard Ranking (LHR) system for inspections, which provides a framework to rank the potential hazards found within each lab. The LHR presents an objective approach to prioritize labs for audit based on: type of hazardous materials present and quantities, hazardous operations and equipment, engineering controls and procedures, and facility history.

There are five LHR classes ranging from the least hazardous (LHR 0) to the most potentially hazardous (LHR 4). The LHR indicates the required frequency of audits for the lab. MISP contains the records of completed inspections for each lab, along with the actions taken to correct identified unsafe conditions.

LHR 4 High Hazard (6-month inspection program)

LHR4 has the highest potential severity of hazards present. LHR 4 labs typically work with:

- Large or production volumes of solvent or corrosives and/or
- Large quantities of particularly hazardous materials (nanomaterials, chemotherapy agents, highly toxic compounds)
- Full size cylinders of toxic/pyrophoric gases or over 3 cylinders of flammable gases
- Risk Group 3 biological agents
- Select agents
- Large quantities of Risk Group 2 agents
- Non-traditional use of hazardous materials, lab equipment, or research-fabricated equipment

Labs that have had previous serious accidents, occupational disease, or poor previous audit results are also LHR 4.

LHR 3 Moderate Hazard (12-month inspection program)

LHR 3 is a standard lab that works with:

- Non-production volumes of many toxic and flammable chemicals
- Small quantities of carcinogens, pyrophorics, acutely toxic materials, sensitizers, and reproductive toxins

- Lecture bottle sizes of toxic gases
- Two full size cylinders of flammable gas
- Risk Group 2 infectious agents
- Recombinant DNA
- Bloodborne pathogens
- Class 3B or 4 lasers with controls

A lab in this category may use LHR 4 materials and quantities if the lab has been specifically designed to do so with superb engineering controls and procedures. LHR 2 or LHR 1 laboratories with previous major accidents, occupational disease, or poor previous audit results may be moved up into this category.

LHR 2 Low Hazard (18-month inspection program)
LHR 2 labs are relatively low hazard labs. Typical chemical work involves:

- Small volumes of solvents, acids and toxic chemicals.
- Hazardous materials used with good engineering controls as necessary
- Low-hazard gases
- Tissue culture, PCR, and work with BL1 infectious agents
- Well-managed clinical labs working with larger volumes of solvent, formaldehyde, and tissue preparation procedures with good engineering controls

Other low hazard or well-controlled labs involving class 3R and lower lasers, electronics labs, machine shops, fabrication labs, analytical labs, MRI and NMR facilities are LHR 2.

LHR 1 Very Low Hazard (24-month inspection program)
Laboratories in this category have minimal quantities of hazardous chemicals perhaps only used for critical surface cleaning. Hazards still exist but are well controlled with standardized equipment and procedures. LHR 1 includes:

- Teaching labs
- Autoclave and dishwashing rooms
- High-performing BSL 1 or 2 labs, and those with an excellent safety and health record

Additional LHR 1 space includes lab-related storage rooms, support spaces, freezer rooms, linear equipment corridors, and equipment rooms.

EHS Inspection Report
After an inspection, EHS will prepare a report for the LD, lab supervisor and others, as appropriate. This may include the CHO, the Chair or Manager of the department, lab supervisors, and directors. The report will include all problems noted during the inspection, along with the criteria for correcting them. All critical deficiencies (one that creates an unsafe condition where there is reasonable probability that if allowed to continue will result in serious physical harm, fire, or significant environmental impact) must be abated within 2 business days. Correction of non-critical deficiencies must be completed as soon as possible and no later than 30 days following the inspection. After this time, a copy of the inspection report will be sent to the Chair of the department. Once each year EHS will send a report to the Dean of each school that details any deficiencies that were not documented as corrected. Inspection reports and inspection status can be viewed and updated in MISP.

8.2 PERFORMANCE VERIFICATION OF ENGINEERING CONTROLS AND SAFETY EQUIPMENT

To help assure that primary engineering controls such as fume hoods, biosafety cabinets (BSC) and other types of local exhaust ventilation (LEV) systems provide proper and adequate performance, U-M EHS provides annual performance verification checks.

Additional information about the services provided can be found in the EHS Standards of Care:
[EHS Standard of Care #1: Ventilation Engineering Controls]
[EHS Standard of Care # 2: Unsafe Engineering Control Equipment]
[EHS Standard of Care # 3: BSC Service Criteria]
[EHS Standard of Care # 4: BSC Maintenance]
[EHS Standard of Care # 5: BSC Warranty Work]
[EHS Standard of Care # 6: BSC Decommissioning for Sale, Transfer or Scrap]

Safety equipment including fire extinguishers, eyewash stations and emergency showers must function properly at all times and must be tested as indicated below. Documentation of a monthly emergency eyewash flush for each emergency eyewash is required. The lab must complete an eyewash checklist for each. EHS provides the Appendix 3 eyewash checklist tags to be attached to each unit.

Equipment	Frequency	Responsible Party
Eyewash	Annual Inspection	Facilities and Operations Maintenance
	Monthly Flush in labs	*Laboratory Personnel*
	Monthly Flush in public corridors	Facilities and Operations Maintenance
Safety shower	Annual Flush and inspection	Facilities and Operations Maintenance
	Weekly Visual	*Laboratory Personnel*
LEV Systems: Fume hoods, BSC, Snorkels, etc.	Annually	EHS
Glove boxes	*Weekly*	*Laboratory Personnel*
Fire extinguishers	Monthly	Facilities and Operations Maintenance

8.3 LABORATORY DECOMMISSIONING

Lab directors (faculty/lab managers/supervisors) must ensure that their vacated laboratory space is cleared for unrestricted future use (i.e. are free of all chemical, biological, and radioactive materials) when:

- Leaving U-M space
- Moving to a different U-M space (another building or lab within the same building complex)
- Electing to permanently terminate the use of radioactive material

Research personnel are responsible for ensuring proper removal of all hazardous materials and cleaning all chemical, biological, and radioactive contamination identified by EHS until the laboratory space is officially designated as being decommissioned. Properly label, manifest and package all chemicals for EHS HMM pickup. In the event there are unusually large amounts of chemical waste or several laboratories within close proximity will be vacated at one time, EHS HMM may be able to provide additional assistance, as necessary, to expedite the process. EHS strongly recommends disposing of all unwanted chemicals at least 14-days prior to the actual move date.

After the laboratory space is free of all chemical, biological, and radioactive materials, EHS **must** verify that the decommissioned laboratory space is ready for re-occupancy or renovation.

The Checklist for Decommissioning a Laboratory identifies the decommissioning tasks **required** as part of the laboratory decommissioning process. If you are also terminating the use of radioactive materials, you **must** also complete the decommissioning tasks listed in the Checklist to Terminate Using Radioactive Materials. For more information, refer to the Laboratory Decommissioning guideline. LDs will be notified of the results of the final inspections by RHS, Biological Safety, and Radiation Safety Services (RSS).

NOTE: If you are renovating any laboratory or non-laboratory space, complete the Laboratory Space Modification Form prior to starting the renovation project.

8.4 LABORATORY EQUIPMENT DECONTAMINATION

All laboratory equipment used in conjunction with hazardous materials must be decontaminated before being sent out for service, sale, or disposal. Hazardous materials include all potential chemical, radioactive, and biological contaminants.

Current U-M policy requires that a "Laboratory Equipment Decontamination Form" be completed by the equipment owner and attached to the outgoing equipment. Facilities & Operations and some outside contractors currently require that this form be completed before servicing the equipment. The form requires a signature certifying that the laboratory personnel have decontaminated the equipment.

EHS RSS requires notification from the lab before removing equipment used for radioactive work from the radiation use area. RSS will survey the equipment and determine when there are no detectable levels of radioactive contamination. Contact RSS at (734) 764-6200.

8.5 LABORATORY COMMISSIONING

Although not technically an inspection, the U-M requires that all newly assigned laboratory space receive a commissioning visit by the U-M EHS staff. The purpose of this consulting visit is to foster a strong safety partnership with the research staff in order to protect individuals and the facility, and to help ensure regulatory compliance. Potential hazards, methods to reduce the risk, training requirements, and proper use of protective equipment are topics of discussion during the visit. The new Academic Laboratory and Research Safety Policy makes the department Chair responsible for initiating the commissioning process. To start the process complete the Laboratory Commissioning Checklist.

8.6 LABORATORY MODIFICATION

As research protocols evolve, LDs may find that modifications to their lab space are required to meet the needs of the "new" protocol. If you find yourself at a point in which you need to change your lab space (or convert an office space to a laboratory space), whether to install a sink or reconfigure the room layout or add new equipment, you **must** complete the Laboratory Space Modification Form.

After receiving your submittal, EHS, Facilities Maintenance Services, or AEC (as applicable) will schedule a consulting visit or call to further discuss these proposed modifications. By completing the Form, you help ensure that all codes, regulations, and guidelines are understood **and** in compliance well before the renovation project begins. For more information, contact EHS at (734) 647-1143.

9.0 EMERGENCY RESPONSE AND INCIDENT REPORTING: EXPOSURE, FIRE, INJURY, AND CHEMICAL SPILLS

In case of any emergency: U-M Police Department (UMPD) Emergency: 9-1-1

Report non-Emergencies to UMPD at (734) 763-1131 and EHS at (734) 647-1143.

If you become ill or are injured at work, seek medical assistance at either U-M Occupational Health Services or the UMHS emergency room. All costs involved with such service will be paid for through the U-M's Department of Risk Management. The employee will incur no costs for treatment involving an occupational exposure or injury.

9.1 INCIDENT REPORTING

It is vital that you report all incidents in the laboratory including near misses, injuries resulting from your activities, non-compliance with safety and environmental rules, and general unsafe work conditions. A "Near-Miss" is an unplanned event, condition, or behavior that did not result in injury but had the potential to do so.

All work-related illnesses and injuries in all departments at U-M must be reported to WorkConnections immediately (within 24 hours). The WorkConnections website is a great resource for all issues related to illness and injury.

The following information can help instruct you where and how to report an incident. If in doubt about whether or not to report an incident, it is better to err on the side of caution and report the event. There are no repercussions for reporting incidents or near misses.

Injuries or illnesses: Work Connections Illness or Injury Report Form

Near misses, fires/explosions, property damage, injuries, or illnesses Incidents relating to research: EHS Incident and Near Miss Report Form

Radioactive material contamination or inadvertent exposure to ionizing radiation from radiation sources on campus: **Immediately notify EHS**. For instruction and assistance contact:

- Radiation Safety Service at 764-6200 during EHS business hours
- UM-DPSS at 911 (24 hours)

Report *all* unplanned fires, regardless of magnitude, to UMPD 9-1-1 as soon as discovered.

Refer to the EHS website for more information on Incident Reporting.

Non-Emergency Situation

Report concerns for any non-emergency situation to the LD. Alternatively, contact EHS directly at 647-1143 or DPSS 763-1131. EHS staff will work with the laboratory to investigate the issue and identify corrective measures. Implementing corrective measures is the responsibility of the laboratory in conjunction with their Unit. EHS can help assist the lab to help resolve the safety or environmental issue.

9.2 LABORATORY POSTING REQUIREMENTS

The following postings enhance emergency response and should be available within the laboratory:

- Emergency response poster - available from U-M Emergency Management by request
  - Once at the website, click Emergency Signs
  - Enter Kerberos username and password
  - Request Posters
  - Click Request Service and complete the form
- A list of laboratory specific emergency contact names and numbers
- The U-M laboratory door sign
  - The sign must include current emergency contact names, office location, and work phone number. A cell or home phone number may be included if desired.
  - Review this information at least annually and update as necessary.

9.3 CHEMICAL SPILL RESPONSE

Only knowledgeable and experienced personnel should clean up chemical spills. When available, consult a chemical or process specific SOP for detailed information on spill and emergency response.

A minor chemical spill is one that the laboratory staff is capable of handling safely without the assistance of EHS and emergency personnel. All other chemical spills are considered major. For a major chemical spill, contact UMPD 9-1-1.

9. 4 GAS ALARMS, EXHAUST FLOW MONITORS, ETC.

All types of monitors and alarms are used to warn occupants of an unsafe condition. In the event an alarm is activated, appropriate response is mandatory. Report alarms to the LD or Supervisor. If the alarm or monitoring system is facility-specific, follow the established specific emergency response procedures. Contact the Facilities Services Center (FSC) at (734) 647-2059 for repair of fume hood systems in alarm.

9.5 FIRST AID KITS

First aid kits are recommended in each laboratory, but not required due to the near proximity of the U-M hospital. If a first aid kit is made available in the lab, the following items are suggested:

Basic Kit Contents	Quantity
Absorbent compress, 32 sq. in.	1
Adhesive bandages 1 in. X 3 in.	16
Adhesive tape, 5 yd.	1
Antiseptic, 0.5 g	10
Burn treatment, 0.5 g	6
Medical exam gloves	2 pair
Sterile pads 3 in. x 3 in.	4
Triangular bandage, 40 in. x 40 in. x 56 in.	1

In addition, if hydrofluoric acid (HF), or another fluoride-containing chemical that may react with acid or water to produce HF (e.g. ammonium fluoride, sodium fluoride, sulfur tetrafluoride, and ammonium bi-fluoride), is used in the lab, an unexpired, unopened tube of calcium gluconate gel must be available to apply after rinsing with water. Refer to the applicable SOP for additional instruction on how to respond to an exposure of either chemical.

9.6 EMERGENCY EVACUATION AND UTILITY OUTAGES

In the event there is an emergency evacuation or a utility outage (electrical, gas, ventilation or water) that affects your laboratory space, it is important to ensure the safety of the laboratory's occupants as well as others who may respond to assist. Prior to leaving the lab and ***only if safe to do so***, secure the laboratory:

- Stop all reactions, chemical processes, etc.
- Unplug or turn off non-essential electrical equipment (including ovens & hot plates),
- Shut off research gases & water
- Fully close all fume hoods & biological safety cabinets
- Cover and seal all chemical, biological, radioactive materials and hazardous waste containers
- Securely close all refrigerators and freezers

Vacate and inform emergency responders of any processes, experiments or equipment still in operation that may pose a threat to health, property or the environment. Report utility outages to the building's Facilities contact or to the FSC at (734) 647-2059.

9.7 CONTINUITY OF OPERATIONS PLANNING

In the event of an extended shutdown, laboratories are encouraged but not required to prepare a Continuity of Operations Plan. Consider including the following information in your plan:

- Identify procedures and processes that require regular personnel attention (e.g. cell culture maintenance, animal studies, human subjects contacts).
- Assess and prioritize critical laboratory research activities.
- Identify personnel able to safely perform essential activities.
- Include contact information for your critical staff.
- Cross-train research staff to fill in for others who may be out sick or unable to come to work. Document all training provided.
- Consider documenting critical step-by-step instructions.
- Coordinate with colleagues who have similar research activities to identify ways to ensure coverage of critical activities.
- Maintain a sufficient inventory of critical supplies that may be impacted by global shipping delays.
- Consider installing remote-control monitoring devices for critical equipment (e.g., -80C freezers, liquid nitrogen storage dewars, incubators).
- Ensure that high-risk materials (radioactive, biohazards, chemicals) are secured and freezers are labeled with emergency contact information.

10.0 MEDICAL CONSULTATION, EXAMINATION, AND SURVEILLANCE

Medical consultation, examination, and surveillance are provided for employee laboratory personnel when:

- Symptoms or signs of exposure to a hazardous chemical develop
- Exposure monitoring reveals an overexposure
- A spill, leak, explosion or other occurrence results in a hazardous exposure (potential overexposure)
- Any work-related injury
- A regulatory standard triggers medical surveillance
- An EHS Representative refers an employee for medical surveillance

Refer to the medical surveillance information on the EHS website***.***

10.1 HEALTH CARE PROVIDERS

In the event of a chemical exposure, burn or other injury, medical consultations and examinations for employees are provided via:

U-M Occupational Health Services
C380 Med Inn Building
U-M Hospitals
1500 E. Medical Center Drive
Ann Arbor, MI 48109-5835
Phone: (734) 764-8021
Fax: (734) 763-7405
MON – FRI: 7:00am – 4:30pm

U-M students can receive medical consultations and examinations via:

University Health Service
207 Fletcher
Ann Arbor, MI 48109-1050
Phone: (734) 764-8320
MON – FRI: 8:00am – 4:30pm, SAT: 9:00am – 12:00pm

Critical Care and After Hours: UMHS Emergency Department

Employees are responsible for informing the LD/Supervisor of any work modifications ordered by the clinician as a result of exposure.

10.2 RETENTION OF MEDICAL RECORDS/ACCESS TO MEDICAL RECORDS

The U-M maintains medical records for the duration of the employee's employment plus 30 years. The confidentiality of medical records and test results is protected under the law; the U-M receives no test results or diagnoses concerning the employee’s general health or particular conditions. The U-M receives only a physician’s determination as to whether or not an employee is physically fit to work under the stressors presented by their work environment and any required personal protective equipment. An employee medical determination of not physically fit for a particular type of work or task must be discussed in detail with the employee and noted as a restriction on the physician’s determination.

10.3 ANIMAL HANDLER OCCUPATIONAL HEALTH & SAFETY PROGRAM

The Animal Handler Occupational Health & Safety Program covers the following information:

- Hazard identification
- Risk assessment
- Control of operations
- The occupational medicine program for monitoring personnel

The program applies to all faculty, staff, students and affiliates who:

- Have direct contact with animals
- Have direct contact with non-sanitized animal caging or enclosures
- Have direct contact with non-fixed or non-sterilized animal tissues, fluids, or wastes
- Provide service support to animal equipment, devices, or facilities
- Provide compliance review services

The species of animals and associated hazards that will be encountered in the workplace determine what type of health assessment and safety training each employee will receive.

11.0 CHEMICAL SECURITY

To minimize the risk of theft or improper use of hazardous chemicals and substances, all laboratories and shops should observe the following practices:

- Ensure that hazardous chemicals and substances are secured at all times.
- Always lock doors when leaving the area unattended.
- Contact UM-DPSS at 911 or 734-763-1131 to report suspicious activity in or around laboratories or shops, or if items are discovered missing.

APPENDIX 1: Regulatory Overview for Laboratory Safety

(Derived from OSHA Laboratory Safety Guidance document OSHA 3404-11R 2011)

MI 408.1011 Section 11(a) of the *Michigan Occupational Safety and Health Act 154 of 1974* requires that employers shall "furnish to each employee, employment and a place of employment that is free from recognized hazards that are causing or likely to cause death or serious physical harm to the employee." Therefore, even if a standard has not been promulgated that deals with a specific hazard or hazardous operation, protection of workers from all hazards or hazardous operations may be enforceable under section 11(a) of the MiOSH Act. For example, best practices that are issued by non-regulatory organizations such as the National Institute for Occupational Safety and Health (NIOSH), the Centers for Disease Control and Prevention (CDC), the National Research Council (NRC), and the National Institutes of Health (NIH) can be enforceable under section 11(a). The principal MIOSHA standards that apply to all nonproduction laboratories are listed below. Although this is not a comprehensive list, it includes standards that cover the major hazards that workers are most likely to encounter in their daily tasks. Employers must be fully aware of these standards and must implement all aspects of the standards that apply to specific laboratory work conditions in their facilities.

The Hazardous Work in Laboratories standard (Part 431), commonly referred to as the Laboratory safety standard, requires that the employer designate a Chemical Hygiene Officer and have a written CHP, and actively verify that it remains effective. The CHP must include provisions for worker training, chemical exposure monitoring where appropriate, medical consultation when exposure occurs, criteria for the use of personal protective equipment (PPE) and engineering controls, special precautions for particularly hazardous substances, and a requirement for a Chemical Hygiene Officer responsible for implementation of the CHP. The CHP must be tailored to reflect the specific chemical hazards present in the laboratory where it is to be used. Laboratory personnel must receive training regarding the Laboratory standard, the CHP, and other laboratory safety practices, including exposure detection, physical and health hazards associated with chemicals, and protective measures.

The Hazard Communication standard (Part 430), sometimes called the HazCom standard, is a set of requirements first issued in 1983 by OSHA. The standard requires evaluating the potential hazards of chemicals, and communicating information concerning those hazards and appropriate protective measures to employees. The standard includes provisions for: developing and maintaining a written hazard communication program for the workplace, including lists of hazardous chemicals present; labeling of containers of chemicals in the workplace, as well as of containers of chemicals being shipped to other workplaces; preparation and distribution of safety data sheets (SDSs) to workers and downstream employers; and development and implementation of worker training programs regarding hazards of chemicals and protective measures. This standard requires manufacturers and importers of hazardous chemicals to provide safety data sheets to users of the chemicals describing potential hazards and other information. They must also attach hazard warning labels to containers of the chemicals. Employers must make SDSs available to workers. They must also train their workers in the hazards caused by the chemicals workers are exposed to and the appropriate protective measures that must be used when handling the chemicals.

The Bloodborne Infectious Diseases standard (Part 554) requires employers to protect workers from infection with human bloodborne pathogens in the workplace. The standard covers all employers that have employees with occupational exposure to blood and other potentially infectious material. It requires that information and training be provided before the worker begins work that may involve occupational exposure to bloodborne pathogens, annually thereafter, and before a worker is offered hepatitis B vaccination. The Bloodborne Pathogens standard also requires advance information and training for all workers in research laboratories who handle human immunodeficiency virus (HIV) or hepatitis B virus (HBV). The standard was issued as a performance standard, which means that the employer must develop a written exposure control plan (ECP) to provide a safe and healthy work environment but is allowed some flexibility in accomplishing this goal. Among other things, the ECP requires employers to make an exposure determination, establish procedures for evaluating incidents, and determine a schedule for implementing the standard's requirements, including engineering and work practice controls. The standard also requires employers to provide and pay for appropriate PPE for workers with occupational exposures. Although this standard only applies to bloodborne pathogens, the protective measures in this standard (e.g., ECP, engineering and work practice controls, administrative controls, PPE, housekeeping, training, post-exposure medical follow-up) are the same measures for effectively controlling exposure to other biological agents.

The Personal Protective Equipment (PPE) standard (Part 433) requires that employers provide and pay for PPE and ensure that it is used wherever hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants are encountered in a manner capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical contact. In order to determine whether and what PPE is needed, the employer must assess the workplace to determine if hazards are present, or are likely to be present, which necessitate the use of [PPE]. Based on that assessment, the employer must select appropriate PPE (e.g., protection for eyes, face, head, extremities; protective clothing; respiratory protection; shields and barriers) that will protect the affected worker from the hazard, communicate selection decisions to each affected worker, and select PPE that properly fits each affected employee. Employers must provide training for workers who are required to use PPE that addresses when and what PPE is necessary, how to wear and care for PPE properly, and the limitations of PPE.

The Eye and Face Protection standard (325.60008) requires employers to ensure that each affected worker uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

The Respiratory Protection standard (Part 451) requires that a respirator be provided to each worker when such equipment is necessary to protect the health of such individual. The employer must provide respirators that are appropriate and suitable for the purpose intended. The employer is responsible for establishing and maintaining a respiratory protection program, as required by reference in OSHA29 CFR 1910.134(c) that includes, but is not limited to, the following: selection of respirators for use in the workplace; medical evaluations of workers required to use respirators; fit testing for tight-fitting respirators; proper use of respirators during routine and emergency situations; procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing and discarding of respirators; procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators; training of workers in respiratory hazards that they may be exposed to during routine and emergency situations; training of workers in the proper donning and doffing of respirators, and any limitations on their use and maintenance; and regular evaluation of the effectiveness of the program.

The Hand Protection standard (325.60010) requires employers to select and ensure that workers use appropriate hand protection when their hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes. Further, employers must base the selection of the appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified.

The Control of Hazardous Energy standard (Part 85) often called the "Lockout/Tagout" standard, establishes basic requirements for locking and/or tagging out equipment while installation, maintenance, testing, repair, or construction operations are in progress. The primary purpose of the standard is to protect workers from the unexpected energization or startup of machines or equipment, or release of stored energy. The procedures apply to the shutdown of all potential energy sources associated with machines or equipment, including pressures, flows of fluids and gases, electrical power, and radiation.

In addition to the standards listed above, other MIOSHA standards pertain to general industry as well as laboratories: electrical safety; fire safety (Portable Fire Extinguishers standard); slips, trips and falls; and Means of Egress. When laboratory workers are using large analyzers and other equipment, their potential exposure to electrical hazards associated with this equipment must be assessed by employers and appropriate precautions taken. Similarly, worker exposure to wet floors or spills and clutter can lead to slips/trips/falls and other possible injuries and employers must assure that these hazards are minimized. While large laboratory fires are rare, there is the potential for small bench-top fires, especially in laboratories using flammable solvents. It is the responsibility of employers to implement appropriate protective measures to assure the safety of workers.

APPENDIX 2: Definitions

Action level: The airborne chemical concentration that triggers air monitoring and the implementation of additional control measures. The action level is always lower than the corresponding OSHA permissible exposure limit (PEL) and is designed to protect personnel from overexposure. At U-M, the more conservative of either the OSHA-defined action level (generally one-half the PEL) or one-half the ACGIH Threshold Limit Value is used as the action level.

Carcinogen: See “Select Carcinogen”

Chemical Hygiene Officer: An employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the CHP. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer’s organizational structure.

Compressed gas:
1. A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70° F (21.1°C); or
2. A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130° F (54.4°C) regardless of the pressure at 70° F (21.1° C); or
3. A liquid having a vapor pressure exceeding 40 psi at 100° F (37.8° C) as determined by ASTM D-323-72.

Controlled Substances: Drugs and certain other chemicals, both narcotic and non- narcotic, which come under the jurisdiction of federal DEA and state laws regulating their manufacture, sale, distribution, use and disposal.

Corrosive: Substance causing irreversible destruction of living tissue by chemical action at the site of contact (dermal or respiratory). Major classes of corrosive substances include strong acids, strong bases, and dehydrating agents.

Cryogenic liquids: Materials with extremely low boiling points (i.e. less than –150 °F). Common examples of cryogenic liquids are liquid nitrogen, helium, and argon. Dry ice is the common term for frozen carbon dioxide. One special property of both cryogenic liquids and dry ice is that they undergo substantial volume expansion when converted to a gas phase, which can potentially lead to an oxygen deficient atmosphere where ventilation is limited.

Explosive: A chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

Flammable: A chemical that falls into one of the following categories:

(1) "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(2) "Gas, flammable" means:

(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or

(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air greater than 12 percent by volume, regardless of the lower explosive limit.

(3) "Liquid, flammable" means any liquid having a flashpoint below 100° F (37.8° C), except any mixture having components with flashpoints of 100° F (37.8° C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(4) "Solid, flammable" means a solid, other than a blasting agent or explosive as defined in 29 CFR 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Hazardous Chemical: A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed laboratory personnel (includes carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes).

Hematopoietic toxicants: Substances that decrease hemoglobin function and deprive the body tissues of oxygen (e.g. carbon monoxide, cyanides).

Hepatotoxin: Substances that produce liver damage (e.g. nitrosamines, carbon tetrachloride).

Highly Toxic: also referred as highly acute toxin) A chemical falling within any of the following categories:
1. A chemical with a median lethal dose (LD50) of 50 mg or less per Kg of body weight when administered orally to albino rats weighing between 200 and 300 gm each.
2. A chemical with a median lethal dose (LD50) of 200 mg or less per Kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 Kg each.
3. A chemical that has a median lethal concentration (LC50) in air of 200 ppm by volume or less of gas or vapor, or 2 mg per liter or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 gm each.

Incompatible: Materials that could cause dangerous reactions by direct contact with one another.

Irritant: A substance, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact (dermal or respiratory).

NOTE: Wide varieties of organic and inorganic compounds are irritants and consequently exposure to all laboratory chemicals should always be avoided.

Laboratory Director: The person with the highest level of authority within the lab. In research labs, this is typically the Principal Investigator (PI).

Laboratory Personnel: Includes both employee and non-employee laboratory personnel who perform research activities, and covers individuals employed in the laboratory workplace that may be exposed to hazardous chemicals in the course of their assignments. Employees include faculty and staff and may include research associates, undergraduate and graduate students and postdoctoral researchers, depending on their employment status. Non-employees include visiting scholars and may include research associates, undergraduate and graduate students, and postdoctoral researchers depending on their employment status.

Laboratory Supervisor: The individual in charge of the daily laboratory operations. It may be a Principal Investigator (PI), laboratory instructor, or laboratory manager.

Micro scaling (of process): Reducing the quantities of hazardous chemical used in a research operation to "microscale" quantities in order to reduce the risks to personnel and property and to minimize chemical waste streams. Microscale quantities range from 50-1,000 milligrams.

Nanoparticle: A collection of tens to thousands of atoms approximately 1 to 100 nanometers in diameter that may be naturally occurring or engineered. Examples include carbon buckeyballs or fullerenes; carbon nanotubes; metal oxide nanoparticles (e.g., titanium dioxide); quantum dots, among many others.

Nephrotoxin: Substances causing damage to the kidneys (e.g. certain halogenated hydrocarbons).

Neurotoxin: Substances that produce their primary toxic effects on the nervous system (e.g. mercury, acrylamide, carbon disulfide).

Non-Laboratory personnel: Laboratory personnel such as administrative staff, plumbers, and Heating, Ventilation & Air Conditioning (HVAC) technicians entering research laboratories to perform maintenance, administrative, or other non-research laboratory tasks.

Organic peroxide: An organic compound that contains the bivalent –o-o- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

Oxidizer: A chemical other than a blasting agent or explosive, that initiates or promotes combustion in other materials.

Particularly Hazardous Substance (PHS): OSHA broadly defines a PHS to be a carcinogen, a reproductive toxin, or a substance with high acute toxicity. Ultimately, it is up to the PI, in collaboration with EHS, to determine the degree of hazard a specific chemical poses and the necessary safeguards to ensure safe work.

Permissible exposure limit (PEL): the maximum permitted 8-hour time-weighted average concentration of an airborne contaminant.

Pyrophoric: A chemical that ignites spontaneously in air at a temperature of 130°F or below**.**

Reproductive Toxin: A chemical that affects the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis). *IMPORTANT: Lab personnel should recognize that many chemicals have not been thoroughly assessed for their reproductive toxicity. Prior to selecting/using chemicals in the laboratory, researchers should determine their potential reproductive toxicity risks.*

Sensitizer: A substance that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the substance. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock**.**

Select Agents: Bacteria, viruses, toxins, rickettsia, and fungi identified by the United States Department of Health and Human Services (HHS), Centers for Disease Control and Prevention (CDC), the United States Department of Agriculture (USDA), and the Animal and Plant Health Inspection Service (APHIS) that pose a potential threat to public health or welfare. NOTE: The safety practices and precautions provided by the CHP are most applicable with the use of Select Agent toxins as opposed to infectious agents.

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/m^3;
(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.

IMPORTANT: Lab personnel should recognize that many chemicals have not been thoroughly assessed for their carcinogenicity. Prior to selecting chemicals for use in laboratory procedures, researchers should be familiar with the specific classes of compounds and functional group types that have been correlated to carcinogenic activity.

Substitution: When designing and planning a laboratory operation, using the least hazardous chemical possible to minimize risk to personnel and property.

Toxic Gas: A *highly toxic* gas has a median Lethal Concentration (LC 50) in air of 200 parts per million or less by volume of gas or vapor, or 2 milligrams per liter or less of mist, fume or dust, when administered by continuous inhalation for an hour, or less if death occurs within one hour, to albino rats weighing between 200 and 300 grams each.

A *toxic gas h*as a LC 50 in air more than of 200 parts per million but not more than 3,000 parts per million by volume of gas or vapor, or more than 2 milligrams per liter but not more than 30 milligrams per liter of mist, fume or dust, when administered by continuous inhalation for an hour, or less if death occurs within one hour, to albino rats weighing between 200 and 300 grams each.

Toxic Substance: Substances that cause adverse effects to specific target organs (i.e., lungs, liver, skin), or the nervous or blood systems. These substances can result in acute and/or chronic effects at moderate levels. A toxic substance must fall within one of the following categories:
(a) A substance that has a median lethal dose (LD50) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
(b) A substance that has a median lethal dose (LD50) of more than 200 milligrams per kilogram but not more than 1,000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
(c) A substance that has a median lethal concentration (LC50) in air of more than 200 parts per million but not more than 2,000 parts per million by volume of gas or vapor, or more than two milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by

continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

Unstable (reactive): A chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

Water-reactive: A chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

APPENDIX 3: Monthly Eyewash Inspection Checklist

Eyewash Monthly Check
Initial to Confirm that all items are OK:

- Eyewash access unobstructed
- Eyewash covers in-place
- Bowl & eyepieces clean
- Flow is effective & continuous
- Covers come off when activated
- Adequate flow from both eyepieces
- Water drains from bowl

Flush for 3-minutes *or until water is clear*

Year: ____________

Month	**Initials**	**Month**	**Initials**
JAN		JUL	
FEB		AUG	
MAR		SEP	
APR		OCT	
MAY		NOV	
JUN		DEC	

Contact FSC at 7-2059 if there are mechanical problems or missing/broken components.

ENVIRONMENT, HEALTH & SAFETY

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ENVIRONMENT, HEALTH & SAFETY

APPENDIX 4: Major CHP Revisions

Revision	Date
1. Changed “Principal Investigator” to “Lab Director” throughout document	March 11, 2016
2. Added Section 3.6 Instructional Laboratory Operations	March 11, 2016
3. Added Appendix 6 Major CHP Revisions	October 24, 2016
4. Added details to the eyewash inspection table in section 8.3 Performance Verification of Engineering Controls and Safety Equipment	October 24, 2016
5. Corrected web links to new OSEH web page.	October 24, 2016
6. OSEH name change to EHS throughout.	October 2017
7. EHS web page links corrected throughout.	October 2017
8. Plant Operations name change throughout	October 2017
9. Updated SOP list	October 2017
10. Added phrase on Biosafety manual in Section 1.2 Scope	October 2017
11. Added Unattended Reactions paragraph in section 3.4	October 2017
12. Added updated Appendix 6	October 2017
13. Modified the “Eye Protection” section in chapter 3.3 Personal Protective Equipment. Modifications based on LRSC recommended language to provide information on risk assessment and protective barriers.	February 2018
14. Remove reference to Emergency Response Flip Chart (9.3)	April 2018
15. Update all hyperlinks	April 2018
16. Changed name of EHSA inventory program to MI Safety Portal	April 2018
17. Updated all hyperlinks throughout document	January 2019
18. Removed reference to discontinued EHS safety shoe program under “Foot Protection” in Section 3.3.	January 2019
19. Removed Appendix 6 (Academic Lab Research Safety policy) and renumbered. Added web hyperlinks to Academic Lab Research Safety policy throughout document.	January 2019
20. Added Section 9.8 Emergency Evacuation	January 2019
21. Added a paragraph to Section 8.2 to allow lab self-inspections and recordkeeping of those inspections in the online MI Safety Portal database.	January 2019
22. Updated the EHS Blue Binder and Self-Inspection checklist with MISP lab self-inspection information.	January 2019
23. In Section 2.8 required all compressed gases to be recorded in chemical inventory for the lab.	January 2019
24. Added Section 2.18 Superconducting Magnets	January 2019
25. Added paragraph in Section 1.8 on leading indicators.	January 2019
26. In Section 9.2 Incident Reporting - other departmental lab incident forms (COE, Chemistry) will no longer be accepted by EHS. Added “Near Miss” definition.	February 2019
27. In Section 3.4 prohibited space heaters in labs with combustible, flammable, and explosive chemicals.	May 2019
28. In Section 2.17 added Use of Hazardous Substances and Drugs in Animal Facilities and Research Spaces	June 2019
29. In Section 3.4 added vaping in areas of chemical and biological use and storage and the use of e-cigarettes on campus to prohibited activities.	June 2019

30. In Section 2.3 Oxidizers, modified definition of oxidizers for clarity.	November 2019
31. Revised order of chapters. Safety training information, formerly in Chapter 7, is now Chapter 2. Chemical hazard information formerly in Chapter 7 with training has been incorporated into Chapter 3, Identification and Evaluation of Chemical and Physical Hazards.	January 2021
32. Section 1.6, Expectations to Plan Safe Research, has been incorporated into Section 1.4, Responsibilities.	January 2021
33. Updated information on Infectious Agents and Biological Toxins to be consistent with the Biosafety Manual.	January 2021
34. Chapter 4 and Appendix 1 reflect changes to safety glasses policy.	January 2021
35. Instructions on performing lab risk assessments removed from Chapter 5 and added as a new Appendix 5.	January 2021
36. Updated information on Select Agents and Biological Toxins in Chapter 6 to be consistent with the Biosafety Manual.	January 2021
37. Link to the Research, Ethics and Compliance website has been added to Chapter 6 for information on controlled substances.	January 2021
38. Information on emergency responses and incident reporting in Chapter 9 has been reformatted, updated and consolidated.	January 2021
39. Updated information on Animal Handler Occupational Health and Safety Program in Chapter 10.	January 2021
40. Added new Appendix 7, Suggested Safety Topics for Discussion for Use at Research Group Meetings	January 2021
41. Deleted Appendix 1 and moved the information into the EHS Document Binder, Section 6	March 2021
42. Added new Hazard Assessment Worksheet and Risk Assessment to EHS Document Binder, Section 6	March 2021
43. Revised information in Section 4.3 to clarify requirements for safety glasses to be worn in labs where hazardous materials/equipment are present. Added information on MIOSHA requirements for eye and face protection from front and side impact hazards.	May 2021
44. Information added to Section 4.4 on Good Lab Practices regarding need to keep lab doors closed. • Additional information on responding to chemical exposures in general, and hydrofluoric acid and ammonium fluoride specifically provided in Chapter 10.	August 2021
45. Updated EHS Director for Dearborn campus	September 2021
46. Added information regarding house vacuum systems to Section 4.1	November 2021
47. • Moved all "Laboratory Risk Assessment" information to the Document Binder and deleted Appendix 4. Re-numbered Appendices 5 and 6 to 4 and 5, respectively. • Section 4.4, Additional Practices – Updated information regarding need to keep laboratory doors closed. • Section 6.4, Chemical Inventory – Added information regarding requirements for entering small quantity chemicals into MISP • Section 7.3, Environmental Management – Sustainability in Labs – Added clarification regarding recycling of materials in labs • Section 8.0, Laboratory Inspections – Updated information on Routine	February 2022

Self Inspections to reflect change from annual hard copy inspection reports to monthly inspections done within MISP	
48. • Added table of Clearance Distances to section 4.4, Good Lab Practices • Updated link to DPSS Emergency Response Poster to section 9.2, Laboratory Posting Requirements	May 2022
49. • 1.2 Updated "hazardous chemical" definition, removed redundant text. • 1.4 Updated LRSC to RASC, clarified training documentation requirements. • 4.4 Added clearance requirement for gas shut off valves. • 9.5 Clarified first aid for chemicals that could potentially produce HF. • Added new section 11.0 Chemical Security. • Appendix 2, added PHS definition to Appendix 2.	November 2022
50. • 4.4 Added section "Weighing of Hazardous Chemicals." • 5.2 Update chemicals with an asterisk to align with MIOSHA Part 350.	June 2023

APPENDIX 5: Suggested Safety Topics for Discussion

Most research groups have regular meetings to discuss research plans and progress. Brief but effective discussions on basic safety topics such as those listed below can be included as part of these or other regular meetings. EHS can attend meetings to discuss specific safety topics.

- **Introduction:** Read through the entire online CHP and review SOPs. Determine lab location for the EHS Document binder so that any employee can use it as a reference at any time.
- **Emergencies:** Review emergency information in the CHP and any specific emergency information in relevant SOPs. Discuss any related questions. Do you have the type of fire extinguishers that you need? Do you have spill cleanup capabilities? Do you have first aid supplies? Set a policy for locking doors to maintain security. Plan what to do in the event of a power failure. Draw up an evacuation plan, including what is turned off and what stays on in an emergency.
- **Responsible Persons:** Are health & safety duties properly assigned within your lab(s)? Are people properly performing their assigned duties in your lab(s)?
- **Basic Safety Rules:** Note rules with special importance for your laboratory. Set up a buddy system for working after hours. Discuss procedures for unattended operations.
- **Chemical Inventories:** Review the Chemical Inventory for your laboratory. Plan your next inventory-taking session. Discuss disposing of unused or expired chemicals.
- **Waste Disposal Program:** Review the U-M (EHS) Waste Handling Procedures in chapter 7.0 of the CHP. Discuss and answer any related questions. Are wastes being properly managed in your lab(s)? Do you have unusual waste disposal problems? Are wastes being adequately labeled? For compliance with the training and information requirements for hazardous waste regulations, all laboratory personnel are required to know the following:
    - The hazards of the waste chemicals in the lab
    - How to properly contain and store the waste in the lab, and
    - What to do in an emergency involving the lab waste
- **Chemical Procurement, Distribution, and Storage:** Discuss current chemical storage practices. Develop lab-specific procedures for chemical procurement, distribution, and storage.
- **Particularly Hazardous Procedures:** Discuss the use of toxic materials in the lab or how to get rid of old, time-sensitive chemicals. Designate a specific area for use of highly toxic materials. Develop any related, lab-specific procedures. Review procedures for storage and use of any explosive or pyrophoric materials.
- **Procedures Requiring Special Prior Approval:** What additional safety concerns need to be addressed? Develop any lab-specific procedures requiring special prior approval or any lab-specific procedures not covered in earlier sections.
- **Working with Special Equipment:** Discuss electrical safety. Are electrical cords damaged? Are gas cylinders chained up, valve protection caps on, empty or unused cylinders set for pickup? Schedule a refrigerator/freezer clean out. Develop procedures for any lab-specific equipment. Review previous incidents attributed to using the equipment and develop ways to prevent another incident.
- **Protective Apparel and Equipment:** Discuss when safety glasses, goggles, or face shields are required. Discuss any need for respirators. Discuss fume hood and glove box use. Develop any related, lab-specific procedures.
- **Housekeeping, Maintenance, and Inspections:** Discuss materials stored or frequently present on the floor. Identify emergency exits. Discuss maintenance items. Develop any related, lab-specific procedures.
- **Environmental Monitoring:** Discuss MIOSHA PELs for chemicals in use and how to reduce employee exposure. Discuss building ventilation and proper use of hoods, biosafety cabinets and other types of local exhaust ventilation. In conjunction with EHS, develop any lab-specific

procedures for environmental monitoring as needed.

- **Working with Biologically Hazardous Materials:** Review applicable materials in the exposure control plan or biosafety manual and discuss any related questions. Is a labeled area set aside for work with biohazardous materials? Are cold/warm rooms, refrigerators/freezers properly labeled? Develop any related, lab-specific procedures.
- **Working with Animals:** Review symptoms of allergic reactions, animal related injuries such as bites, scratches or kicks, zoonoses (diseases that spread from animals to humans), and exposure to hazardous materials.
- **Working with Radioisotopes:** Review materials in the CHP and discuss any related questions. Ensure that all workers are properly badged and trained. Ensure that all inventories of radioisotopes are up-to-date. Is a specific location set aside for radioisotope use? Are all signs and postings up? Develop any related, lab-specific procedures.
- **Medical Program:** Discuss lab-specific injuries. Is the health of each employee working with hazardous materials being adequately monitored?
- **Training Program:** Have employees attended appropriate Departmental and EHS training sessions? Develop and document internal training. Are workers reading, understanding, and following SDS precautions? Are signs and labels properly posted? Are adequate safety supplies, including spill cleanup materials, available? Are official records up-to-date?
- **Additional Safety Session Topics:**
    - Recent incidents/accidents/injuries and how to prevent reoccurrence
    - New equipment and corresponding SOP and training
    - New procedure and corresponding SOP and training
    - Results of recent inspections and how to correct problem areas
    - New chemicals in the laboratory