Chemical Hygiene Plan

Michigan State University

Environmental Health and Safety
4000 Collins Road, room B20
Lansing MI 48910
517-355-0153

November 2018

Table of Contents

MSU Chemical Hygiene Plan Latest Revisions

GENERAL: Title page date reflects most current revision of November 2018

GENERAL: Addition of “Latest Revisions” page to Chemical Hygiene Plan for easier reference to most current changes in the CHP.

GENERAL: The use of the acronym MSDS and Material Safety Data Sheet was amended to SDS and Safety Data Sheet throughout the document to reflect MIOSHA adoption of the Globally Harmonization System’s terminology.

GENERAL: The use of the acronym P.D. and the phrase “Project Director” was amended to P.I. and Principal Investigator to bring the Chemical Hygiene Plan language into alignment with university vernacular to distinguish the primary individual responsible for the health and safety of laboratory workers under their employment, and for compliance with applicable regulations and institutional policy governing the conduct of research at Michigan State University

1.2 SCOPE: MIOSHA Laboratory Standard: Update Chemical Hygiene Plan to reflect most current version of the MIOSHA Hazardous Work in Laboratories Standard to January 12, 2014

1.4 HAZARDOUS CHEMICAL DEFINITIONS: Update hazard classes of chemicals to reflect GHS hazard definitions as adopted by MIOSHA Hazard Communications Standard.

1.4 HAZARDOUS CHEMICAL DEFINITIONS: Additional statement to further clarify reproductive toxicants defined by MIOSHA

3.6.12 PHYSICAL HAZARDS: Per MIOSHA Hazard Communications Standard, the definition of Self-heating chemical was included

3.6.13 PHYSICAL HAZARDS: Per the MIOSHA Hazard Communications Standard, the definition of combustible dusts was added.

APPENDIX A: Update language to change MSDS to SDS, and to update the address and contact information for MSU Environmental Health and Safety

APPENDIX J: Update the MIOSHA Air Contaminants table to reflect most current edition of February 2017

APPENDIX K Update list of hazardous materials subject to prior approval from EHS to include: controlled substances, toxic gases, chemicals in APPENDIX H, ATF Regulated Explosives, and flammable chemicals in use or storage in excess of 5 gallons per container or process

APPENDIX O Change Equipment Release form to reflect updated format

APPENDIX R Update MIOSHA Hazardous Work in Laboratories Standard to latest revision

1.0 SCOPE

1.1 MICHIGAN STATE UNIVERSITY STATEMENT OF RESPONSIBILITY

It is the responsibility of Michigan State University, as an employer, to take every reasonable precaution to provide a work environment that is free from recognizable hazards for its employees in accordance with the "general duty" clause of the Michigan Occupational, Safety and Health Act, Section 11(a).

Furthermore, MSU is required by the Michigan Occupational Safety and Health Administration (MIOSHA) Hazardous Work in Laboratories standard (the Laboratory Standard - §408.1024 of the Michigan Compiled Laws) to ensure that the necessary work practices, procedures and policies are implemented to protect all employees working in University owned and operated laboratories from hazardous chemicals in the work area.

Michigan State University and its employees have the responsibility to be well informed regarding hazardous chemicals and risks associated with using hazardous chemicals in the laboratory environment. This document is intended for University-wide compliance with the MIOSHA Laboratory Standard and will serve as a broad-based Chemical Hygiene Plan for all University owned and operated laboratories.

1.2 THE MIOSHA LABORATORY STANDARD (adopted by MIOSHA January 1, 1992, revised January 12, 2014)

The Michigan Occupational Safety and Health Administration (MIOSHA) has determined that laboratories typically differ from industrial operations in the use and handling of hazardous chemicals. A different approach than that found in MIOSHA's substance specific health standards is warranted to protect workers. The Laboratory Standard applies to all laboratories that use hazardous chemicals in accordance with the definitions of laboratory use and laboratory scale provided in this document. Generally, where this standard applies it supersedes the provisions of all other standards in the MIOSHA Right-to-Know Law and the federal Occupational Safety and Health Administration (OSHA) Hazard Communication Standard 29 CFR, part 1910.1200, except the obligation to maintain employee exposures at or below the permissible exposure limits (subpart Z of 1910.1200), prohibition of skin and eye contact where specified by any OSHA/MIOSHA standard and in other instances where the scope of hazards are not adequately addressed by this standard.

First Publication Date: May 1, 1995	Revision 8: June, 2009
Revision 1: October 25, 1996	Revision 9: November, 2010
Revision 2: April 20, 1998	Revision 10: February, 2012
Revision 3: July 22, 2002	Revision 11: March, 2013
Revision 4: September 29, 2003	Revision 13: January 12, 2014
Revision 5: November 22, 2005	
Revision 6: April 23, 2007	
Revision 7: May, 2008	

1.3 SCOPE AND APPLICATION

This document serves as the written guide for MSU compliance to the Laboratory Standard and the Chemical Hygiene Plan (CHP) requirements contained therein. All units at Michigan State University engaged in the laboratory use (as defined by this document) of hazardous chemicals are required to comply with this document.

The primary objective of this document is to provide a general guide for handling hazardous chemicals in laboratories. The Chemical Hygiene Plan establishes the basic safety principles for laboratory procedures, equipment and work practices that are capable of protecting employees from physical and health hazards of hazardous chemicals in laboratories.

This document is intended only to highlight those safety measures necessary for achieving a safe and healthy work environment. Where the scope of hazards are not adequately addressed by this general document, specific Standard Operating Procedures must be developed by the project director. This CHP does not, however, apply to:

1. Work involving chemicals that do not meet the conditions of the definition of laboratory use of hazardous chemicals. In such cases, the employer shall comply with all relevant specific substance standards even if such use occurs in a laboratory type setting.

2. Work involving the laboratory use of hazardous chemicals that does not have the potential for employee exposure.

This document will hereafter be known as the Michigan State University Chemical Hygiene Plan (MSU CHP).

1.4 HAZARDOUS CHEMICAL DEFINITIONS

A hazardous chemical is defined by MIOSHA as any chemical, chemical compound, or mixture of compounds which is a physical and/or health hazard.

A chemical is a **physical hazard** by MIOSHA definition means a chemical that is classified as posing one or more of the following hazardous effects:

- Explosive
- Flammable (gases, aerosols, liquids or solids)
- Oxidizer as a (liquid, solid or gas)
- Self-reactive
- Pyrophoric as a (gas, liquid or solid)
- Self-heating
- Organic peroxide
- Corrosive to metal
- Gas under pressure
- In contact with water emits flammable gas
- Combustible dust

A chemical is a **health hazard** by MIOSHA definition means a chemical that is classified as posing one of the following hazardous effects:

- Acute toxicity (any route of exposure)
- Skin corrosion or irritation

- Serious eye damage or eye irritation
- Respiratory of skin sensitization
- Germ cell mutagenicity
- Carcinogenicity
- Reproductive toxicity
- Specific target organ toxicity (single or repeated exposure)
- Aspiration hazard

Particularly hazardous substances, by MIOSHA definition, are select carcinogens, reproductive toxicants and chemicals with a high degree of acute and chronic toxicity.

Select carcinogens are chemicals listed by MIOSHA as carcinogens, by the National Toxicology Program (NTP) as "known to be carcinogens" and by the International Agency for Research on Cancer (IARC) as Group 1 carcinogens. Also included are chemicals or processes listed in either Group 2A or 2B by IARC or under the category “reasonably anticipated to be carcinogens” by NTP and that cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

1. 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
2. After repeated skin application of less than 300 mg/kg of body weight per week
3. After oral dosages of less than 50 mg/kg of body weight per day

MIOSHA; IARC Group 1, 2A, and 2B, as well as the NTP carcinogens, are listed in *APPENDIX I*.

Reproductive toxicants are defined by MIOSHA as any chemical which affects the reproductive capabilities, including adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on the development of the offspring.

Chemicals with a high degree of acute and chronic toxicity are not defined in the Laboratory Standard. Therefore, the MIOSHA Hazard Communication definition of a highly toxic chemical will be used. Chemicals with a high degree of acute toxicity are chemicals that have a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each. The LD_{50} is that dose at which a lethal response is observed in 50% of the test animals.

The following sources have established lists of hazardous chemicals based on substantiated tests:

1. OSHA, 29 CFR 1910.1200 Subpart Z, Toxic and Hazardous Substances and Appendices A and B of OSHA 29 CFR 1910.1200 which are referenced in MIOSHA R325.70101(2)

2. American Conference of Governmental Industrial Hygienists (ACGIH), “Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment,” (latest edition)

The hazard(s) of a chemical may also be listed on its container label. Additionally, if the hazard of a chemical is not evident from the container label, the **Safety Data Sheet (SDS)** will list the specific hazards. Use the SDS to address chronic toxicity. For further help in determining the hazard of a chemical, contact your supervisor, instructor or EHS.

1.5 RESPONSIBILITY

The Office of Environmental Health and Safety (EHS) shall be responsible for assuring University compliance with State and Federal standards and for preparing any reports, as established in the "Policies, Procedures and Guidelines for Radiation, Chemical and Biological Safety" document. In this vein, EHS is responsible for oversight of University compliance with the MIOSHA Laboratory Standard and the Chemical Hygiene Plan required therein and will develop the provisions of the Michigan State University Chemical Hygiene Plan.

The Chemical Safety Officer of EHS will serve as the Chemical Hygiene Officer (CHO). The CHO, along with EHS, can assign areas of responsibility to units, Principal Investigators, laboratory supervisors and other individuals as necessary, to implement and carry out the provisions of the CHP. The CHO will serve on the Chemical Hygiene Subcommittee (CHS). The CHS will share in responsibility for oversight of the MSU CHP.

EHS, the CHO and the CHS will serve as the on-campus authorities and sources of information for the MIOSHA Laboratory Standard and the MSU CHP.

Unit (departments, institutes, schools, outlying field stations, service groups, facilities, etc.): Unit chief administrative officers are responsible for maintaining a unit safety system, including identification of a safety officer. They have the responsibility to support and ensure the enforcement of the MSU CHP and to support the CHO and the CHS in implementing the provisions of this plan within their respective units.

Principal Investigator: The legal responsibility for safety and well-being of all personnel in contact with any university-related activity utilizing radiation, chemical or biological hazards lies with the Principal Investigator (P.I.) and the administrative officers responsible at the various university levels. Specifically, the P.I. is responsible for:

1. Ensuring all employees under his/her supervision have received general chemical training from EHS.

2. Providing all employees under his/her supervision with site-specific training and documenting such training.

3. Following appropriate guidelines proscribed in this document.

Employee: Individual laboratory employees are responsible for their own safety. All individuals performing work with hazardous substances must accept a shared responsibility for operating in a safe manner once they have been informed about the extent of risk and safe procedures for their activities. They also have the responsibility to inform their supervisors of accidents and work practices or working conditions they believe hazardous to their health or to the health of others.

Student: While students are not covered under the provisions of the MIOSHA Laboratory Standard, students should be made aware of chemical health and safety hazards in classroom situations and should be provided with information and equipment to protect themselves from those hazards. Units should provide student training at the beginning of each course in which hazardous chemicals are used. Specific safety instructions should be provided at the beginning of each class period.

1.6 EMPLOYEE RIGHTS

It is the employee's right to receive information about the known physical and health hazards of the hazardous chemicals in their work areas and to receive adequate training to work safely with these substances.

Employees have the right to work in a safe environment and inform the P.I. or laboratory supervisor about potential risks in the laboratory.

1.7 AVAILABILITY

The MSU Chemical Hygiene Plan must be readily available to employees and employee representatives through their P.I., supervisor or departmental office.

Additional copies of this document are available from the EHS office and the EHS web site: http://www.ehs.msu.edu/

1.8 ANNUAL REVIEW

The MSU Chemical Hygiene Plan will be reviewed annually from its effective date by the Chemical Hygiene Officer and the Chemical Hygiene Subcommittee.

1.9 EMPLOYEE INFORMATION AND TRAINING

Employees must have access to information and training to ensure that they are apprised of the hazards of chemicals present in the work area. Such information must be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignment involving new exposure situations. Employees should receive periodic refresher information and training to ensure that they are aware of the risks of exposure to hazardous chemicals.

Information: Information provided by EHS/Units/P.I.s/Supervisors to employees must include:

1. The contents of the MIOSHA Hazardous Work in Laboratories standard.

2. The location and availability of the MSU CHP.

3. The permissible exposure limits for OSHA/MIOSHA regulated substances or published exposure limits for other hazardous chemicals where there is no applicable OSHA/MIOSHA standard.

4. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory (available on Safety Data Sheets).

5. The location and availability of known reference materials on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory, including, but not limited to, Safety Data Sheets received from the supplier.

All of the above information is available from the EHS web site: http://www.ehs.msu.edu.

Method of Training: General chemical hygiene training will be provided by EHS via online training courses Site-specific training will be provided by P.I.s or an appropriate designee.

Information regarding required online chemical hygiene training can be found at the EHS website: http://www.ehs.msu.edu.

General chemical hygiene training provided by EHS to employees will include:

1. Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.).

2. General physical and health hazards of chemicals in the work area. This must include an awareness that many factors influence whether a given chemical might constitute a hazard (e.g. dose, exposure time, genetic background, developmental state, mixtures of interactions of chemicals, etc.).

3. The measures employees can take to protect themselves from these hazards, including specific procedures the University or department has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

4. The applicable details of the MSU CHP.

Site-specific training provided by Units/P.I.s/Supervisors to employees will include:

1. Site-specific standard operating procedures.

2. Specific physical and health hazards of chemicals in the work area (available on Safety Data Sheets).

3. Site-specific information and training on relevant laboratory equipment

Documentation: General chemical hygiene training required by the CHP will be documented by EHS. EHS will maintain these training records in electronic format. Site-specific training must be documented and maintained by the unit/P.I./supervisor and be available to representatives of EHS, the CHO, members of the CHS or other regulatory officials upon request.

1.10 RECORD KEEPING

EHS will retain records of all employees who complete the general chemical hygiene training given by EHS.

It is required that records of specific laboratory training for individual laboratories be retained by the P.I. in the laboratory or the department.

Accident records for employees should be written and retained within the laboratory or unit.

The amount of time a unit chooses to retain training records is not specified in the Laboratory Standard. It is recommended by this document that such records be retained for at least one year after an employee leaves a position. Ideally, training records should be retained indefinitely.

2.0 STANDARD OPERATING PROCEDURES

EHS has developed generic standard operating procedures relevant to safety and health considerations when laboratory work involves the use of hazardous chemicals. Where the scope of hazards is not adequately addressed by this general document, units and/or P.I.s must develop written standard operating procedures for work area specific operations. Standard operating procedures must be provided to all affected laboratory employees. **The Standard Operating Procedures in this document specify minimum regulations and recommendations.**

Note: "Prudent Practices for Handling Hazardous Chemicals in Laboratories" (National Research Council, 1981) was used as the basis for the standard operating procedure guidelines.

2.1 GENERAL SAFETY PRINCIPLES

The following guidelines have been established to minimize hazards and to maintain basic safety in the laboratory.

A. Examine the known hazards associated with the materials being used. Never assume all hazards have been identified. Carefully read the label before using an unfamiliar chemical. When appropriate, review the Safety Data Sheet (SDS) for special handling information. Determine the potential hazards and use appropriate safety precautions before beginning any new operation.
B. Be familiar with the location of emergency equipment - fire alarms, fire extinguishers, emergency eyewash and shower stations and know the appropriate emergency response procedures.
C. Avoid distracting or startling other workers when they are handling hazardous chemicals.
D. Use equipment and hazardous chemicals only for their intended purposes.
E. Always be alert to unsafe conditions and actions and call attention to them so that corrective action can be taken as quickly as possible.
F. Wear eye and face protection when appropriate.
G. Always inspect equipment for leaks, tears and other damage before handling a hazardous chemical. This includes fume hoods, gloves, goggles, etc.
H. Avoid tasting or smelling hazardous chemicals.

2.2 HEALTH AND HYGIENE

The following practices have been established to protect laboratory employees from health risks associated with the use of hazardous chemicals:

A. Avoid direct contact with any hazardous chemical. Know the types of protective equipment available and use the proper type for each job.
B. Employees shall confine long hair and secure loose clothing and jewelry before beginning work.
C. Do not mouth pipette.
D. Use appropriate safety equipment whenever exposure to gases, vapors or aerosols is suspected and ensure exhaust facilities are working properly.
E. Wash thoroughly with soap and water after handling chemicals, before leaving the laboratory and before eating or drinking.
F. Contact lenses may be worn in the laboratory, depending on the compounds being used. Consult the chemical SDS for further limitations and precautions of contact lens use and wear.

G. Replace personal protective equipment as appropriate.
H. Laboratory employees shall be familiar with the symptoms of exposure for the chemicals with which they work and the precautions necessary to prevent exposure.

2.3 FOOD AND DRINK IN THE LABORATORY

The following statement is the accepted practice on food and drinks in laboratories and should be followed at all times:

> "There shall be no food, drink, smoking or applying cosmetics in laboratories which have radioactive materials, biohazardous materials or hazardous chemicals present. There shall be no storage, use or disposal of these 'consumable' items in laboratories (including refrigerators within laboratories). Rooms which are adjacent, but separated by floor to ceiling walls, and do not have any chemical, radioactive or biohazardous agents, present, may be used for food consumption, preparation, or applying cosmetics at the discretion of the project director responsible for the areas."

2.4 HOUSEKEEPING

Safety follows from good housekeeping practices. Use the following guidelines to maintain an orderly laboratory:

A. Keep work areas clean and uncluttered with chemicals and equipment. Clean up work areas upon completion of an operation or at the end of each work day, including floors.
B. Dispose of waste as per the **Michigan State University Hazardous Waste Disposal Guide**.
C. A separate waste receptacle must be designated for non-contaminated glass. Follow guidelines established in the MSU Hazardous Waste Disposal Guide for disposal of contaminated glass.
D. Clean spills immediately and thoroughly, as per the guidelines established in section *4.1* of this document. Ensure a chemical spill kit is available and that employees know how to use it.
E. Do not block exits, emergency equipment or controls or use hallways and stairways as storage areas.
F. Assure hazardous chemicals are properly segregated into compatible categories (see section *5.1.4* and *APPENDIX B* of this document).
G. Keep laboratory windows free of obstructions or coverings that could impair visual assessment of a chemical spill or accident within the laboratory; except where necessary for research integrity, security or by prior approval from EHS.

2.5 CHEMICAL HANDLING AND STORAGE

The decision to use a hazardous chemical should be a commitment to handle and use the chemical properly from initial receipt to disposal.

A. Information on proper handling, storage and disposal of hazardous chemicals and access to related Safety Data Sheets should be made available to all laboratory employees prior to the use of the chemical.
B. Always purchase the minimum amount necessary to maintain operations.
C. Chemical containers with missing or defaced labels or that violate appropriate packaging regulations should not be accepted.

D. Chemicals utilized in the laboratory must be appropriate for the laboratory's ventilation system.
E. Chemicals should not be stored on high shelves, and large bottles should be stored no more than two feet from floor level.
F. Chemicals shall be segregated by compatibility.
G. Chemical storage areas must be labeled as to their contents (see section *5.1.4*)
H. Storage of chemicals at the lab bench or other work areas shall be kept to a minimum.
I. Any chemical mixture shall be assumed to be as toxic as its most toxic component.
J. Substances of unknown toxicity shall be assumed to be toxic.

2.6 TRANSPORTING OF CHEMICALS WITHIN THE BUILDING

When transporting chemicals between laboratory areas, precautions should be taken to avoid dropping or spilling chemicals.

A. Carry glass containers in specially designed bottle carriers or a leak resistant, unbreakable secondary container.
B. When transporting chemicals on a cart, use a cart that is suitable for the load and one that has high edges to contain leaks or spills.
C. When possible, transport chemicals in freight elevators to avoid the possibility of exposing people on passenger elevators.

2.7 COMPRESSED GASSES

Special systems are needed for handling materials under pressure. Cylinders pose mechanical, physical and/or health hazards, depending on the compressed gas in the cylinder.

A. **Cylinders with regulators must be individually secured**. Only cylinders with valve protection caps securely in place may be safely gang-chained (chained in groups).
B. When storing or moving a cylinder, have the valve protection cap securely in place to protect the stem.
C. Cylinders must be secured in an upright position at all times. Use suitable racks, straps, chains, or stands to support cylinders against an immovable object, such as a bench or a wall, during use and storage. Do not allow cylinders to fall or lean against one another.
D. Use an appropriate cart to move cylinders.
E. Never bleed a cylinder completely empty. Leave a slight pressure to keep contaminants out.
F. Oil or grease on the high pressure side of an oxygen cylinder can cause an explosion. Do not lubricate an oxygen regulator or use a fuel gas regulator on an oxygen cylinder. Use an oxygen approved regulator.
G. Always wear goggles or safety glasses with side shields when handling compressed gases.
H. Always use appropriate gauges, fittings, and materials compatible with the particular gas being handled.
I. When working with a toxic, corrosive, or reactive gas is planned, EHS should be contacted for information concerning specific handling requirements. Generally, these gases will need to be used and stored with local exhaust ventilation such as a lab hood or a gas cabinet designed for that purpose.

2.8 UNATTENDED OPERATIONS

At times, it may be necessary to leave a laboratory operation unattended. Follow these basic guidelines in the design of an experiment to be left unattended:

A. Always check with your laboratory supervisor to determine if it is necessary to leave a laboratory operation unattended. If necessary, develop a protocol with your laboratory supervisor for the unattended operation of potentially dangerous equipment or methods. Develop a protocol for potential interruptions in electric, water, inert gas and other services and provide containment for toxic substances as part of the protocol.
B. A warning notice must be posted in the vicinity of the experiment if hazardous conditions are present.

2.9 WORKING ALONE

No one shall work alone in laboratories when using equipment, processes and/or chemicals with the potential for explosions, fire, electrocution or serious physical harm. This includes toxic and highly reactive chemicals, poison gases, high energy lasers, power tools and equipment. Employees must consult with their Principal Investigators before performing any operations after normal working hours or when others will not be present. All high hazard activities must have site-specific written standard operating procedures, and be performed only when other trained employees are present.

2.10 STORAGE AND DISPOSAL OF HAZARDOUS WASTE

For guidelines on the storage and disposal of hazardous wastes from laboratory operations at Michigan State University, refer to the **Michigan State University Hazardous Waste Disposal Guide.** Copies of this document are available from EHS.

3.0 STANDARD LABORATORY SAFE HANDLING / STORAGE REQUIREMENTS

3.1 HAZARD IDENTIFICATION

Identifying the specific hazard associated with a chemical greatly reduces chances of misuse by regular laboratory employees, new users, or visitors to the laboratory. At the very minimum, hazardous chemical containers must have the chemical name(s) and hazard identification(s). With respect to identifying containers, storage areas and laboratory entranceways, the following conditions entail hazard identification:

1. P.I.s/supervisors must ensure that labels on incoming containers of hazardous chemicals for laboratory use are not removed or defaced. Labels contain information on the identity of the chemical(s) in the container and the hazard identification of the chemical(s). It is recommended that incoming containers be labeled with the P.I.'s name and date of receipt.

2. P.I.s/supervisors must ensure that laboratory containers (those containers filled from the original shipping container) of chemicals are labeled (see section *3.4.1*).

3. P.I.s/supervisors must ensure that hazardous chemical storage areas are labeled per the guidelines established in section *5.1.4*.

4. P.I.s/supervisors must ensure that entranceways to laboratory facilities are labeled with the appropriate warning signs per the guidelines established in section *5.1.2*.

5. P.I.s/supervisors must ensure that employees have access to SDSs (see section *5.1.1*).

3.2 HAZARDS SUBJECT TO REVIEW OR PRIOR APPROVAL

The Laboratory Standard requires that project directors identify those activities that the project director believes to be of a sufficiently hazardous nature to warrant prior approval before implementation by an employee. Prior approval for using Class A Carcinogens and performing perchloric acid digestions are required by EHS (*APPENDIX K*). The purchase, storage and/or use of: 55 gallon drums in laboratory units, DEA controlled substances, toxic gases, ATF regulated explosives and chemicals listed in *APPENDIX H* require prior approval from MSU EHS. Use of *APPENDIX K* also contains the list of chemicals for which MIOSHA has specific regulations for use.

3.3 CHEMICALS DEVELOPED IN THE LABORATORY

The following requirements apply to chemical substances developed in the laboratory:

1. If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the P.I. must determine if it is a hazardous chemical. This can be done by a literature search for similar substances. If the chemical is determined to be hazardous, the P.I. must provide appropriate training to protect employees.

2. If the chemical produced is a product or a by-product whose composition is not known, the P.I. must assume that the substance is hazardous and must comply with the requirements of the CHP.

3. If the chemical is produced for sale or use outside of the laboratory, the P.I. must prepare an appropriate SDS in accordance to the Michigan Right-to-Know Law.

3.4 LABELING

3.4.1 Container Labels. All containers of hazardous chemicals must be labeled with the name of the chemical and the hazard(s), if not provided by the manufacturer. If a chemical has more than one hazard, it must be labeled with both hazards. For example, acetaldehyde is both a flammable and a carcinogen, and must be labeled appropriately. Additionally, the subsequent guidelines shall be followed:

1. Labeling Basics

a. For containers labeled by the manufacturer:
   - Inspect the labeling on incoming containers.
   - Replace damaged or semi-attached labels.

b. For transferred products or prepared solutions labeled by the user:
   - Label each chemical container with the chemical name and hazard warning.
   - Refer to the Safety Data Sheet (SDS) for hazard warning

2. Alternate Method for Labeling Multiple Small Containers

a. Legend Method:
   - Label containers with abbreviated chemical name and a hazard warning.

- Provide a key in a visible location in the lab with complete chemical name.
- Document that employees are trained on the labeling system.

c. Box or Tray Method:
- Put containers in box or tray.
- Label tray with chemical name and hazard warning
- If containers are removed from the box/tray they must be properly labeled or returned to the box or tray within the work-shift.
- Document that employees are trained on the labeling system

3. Labeling Peroxide Forming Chemicals

d. Peroxidizable chemicals are listed in *APPENDIX G* and must be labeled with:
- Date Received
- Date Opened
- Date Tested
- Test Results

4. Consumer Products. Anything available over the counter to the general public is exempt from labeling requirements if it has already been labeled by the manufacturer. This includes consumer products such as cans of spray paint or turpentine.

5. Stationary Containers. Stationary process containers such as tanks may be identified with signs, placards, process sheets, batch tickets or other written materials instead of actually affixing labels to process containers. The sign or placard must convey the same information that a label would and be visible to employees throughout the work shift.

6. Portable Containers. Portable containers into which hazardous chemicals are transferred from labeled containers and which are intended to be under the use and control of the person who transferred it, within the work shift in which it was transferred, are exempt from labeling. However, it is recommended that a temporary label identifying the chemical and its primary hazard be affixed to the container.

7. Refrigerators and Freezers: All refrigerator and freezer units used in laboratories must be marked as “SAFE FOR FLAMMABLE STORAGE” or “UNSAFE FOR FLAMMABLE STORAGE” on the exterior surface of the unit as appropriate. All cold rooms must be marked “UNSAFE FOR FLAMMABLE STORAGE”.

3.4.2 Waste Containers. All hazardous chemical waste should be segregated and labeled according to the MSU Hazardous Waste Disposal Guide. Special attention should be given to the following areas:

1. Waste containers for non-contaminated glass **must be labeled** (label as "Broken Glass") and kept separate from other non-contaminated waste.

2. Upon initial waste collection, attach a dated MSU Materials Pick Up tag and label containers with the words "Hazardous Waste."

3. Once a chemical has been dated and labeled as a hazardous waste, it may not be accumulated for more than 90 days. Please request a hazardous waste pick-up from EHS once the 90 day storage limit is approached.

For more specific information regarding hazardous wastes, reference the MSU Hazardous Waste Disposal Guide.

3.5 PROVISIONS FOR PARTICULARLY HAZARDOUS SUBSTANCES

3.5.1 Permissible Exposure Limits. The Laboratory Standard requires that employers, for laboratory uses of substances regulated by OSHA/MIOSHA occupational health standards, assure that employees' exposures do not exceed the Permissible Exposure Limits (PELs). The PELs represent Time Weighted Averages (TWA's) in parts per million (ppm) or milligrams of substance per cubic meter of air (mg/m^3). The TWA represents the ratio between exposure and work shift. *APPENDIX J* lists the PELs established by OSHA and referenced by MIOSHA.

The American Conference of Governmental Industrial Hygienists (ACGIH) has established Threshold Limit Values (TLV's), which are TWA values similar to PEL's. The TLV's are in some cases lower than the PELs. To keep employee exposures as low as reasonably achievable, employers will be expected to uphold the lowest exposure limit, be it a PEL or a TLV.

3.5.2 Employee Exposure Determination. Employers must contact EHS to perform employee exposure monitoring under the following circumstances:

1. Initial monitoring must be performed if there is reason to believe employee exposure levels routinely exceed the action level, or Permissible Exposure Limit (PEL).

2. Periodic monitoring must be performed when initial monitoring reveals an exposure. The employer must comply with exposure monitoring provisions of the relevant standard.

Monitoring can be terminated in accordance with the relevant standard. Employers must notify the employee of the monitoring results within 15 working days after receipt of monitoring results. The results must be either individually distributed in writing or posted in a location accessible to all affected employees.

3.5.3 Special Considerations. The MIOSHA Laboratory Standard requires that special precautions for additional employee protection be followed for the laboratory use of **select carcinogens, reproductive toxicants and chemicals with a high degree of acute and chronic toxicity (defined in section *1.4*)**.

Protection from these hazards is provided by assuring exposure to such hazards is minimized, i.e. kept under the PEL, TLV, or STEL, or eliminated. To minimize exposure, it is necessary to determine the route by which exposure may occur, whether by inhalation, absorption, injection, ingestion or a combination of exposure routes. To ensure employees do not receive exposures in excess of the PEL or TLV, hygienic standards have been established for many toxic materials. The following general hygiene standards should be observed when using select carcinogens, reproductive toxicants and chemicals with a high degree of acute and chronic toxicity.

Establish a designated area.

A. Use materials only in designated areas appropriate for the particularly hazardous substance such as a fume hood, glove box, or portion of a lab designated for use of highly toxic substances. This may also include designated equipment such as balances or

centrifuges used to process these substances. Assure that all personnel with access are aware of necessary safety precautions.

B. Label all containers, storage and use areas appropriately. Follow the guidelines established in sections *3.4.1*, *5.1.3* and *5.1.4* of this document.

Use proper containment devices for the protocol and chemical(s) being used.

A. Use a hood or other containment device for procedures which may result in the generation of aerosols or vapors; trap released vapors to prevent their discharge with fume hood exhaust.
B. It is recommended that breakable containers be stored in chemical-resistant trays. Work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper.

Removal of Contaminated Waste

A. Follow the guidelines established in the MSU Hazardous Waste Disposal Guide.

Follow decontamination procedures prior to leaving the designated area.

Decontamination procedures for particularly hazardous substances should be in writing and familiar to all personnel working with these substances. Decontamination procedures should developed with consideration for the type of chemical, amount used, location of use, PPE requirements and other factors. If necessary, contact EHS for assistance in developing an appropriate decontamination procedure.

Always take extra precautions when working with particularly hazardous chemicals.

A. Consult the SDS for toxic properties and follow the specific precautions and procedures.
B. Guard against spills and splashes. Appropriate safety apparel, especially gloves, should be worn. All hoods, glove boxes, or other essential engineering controls should be operating properly before work is started.
C. Notify the P.I. of all incidents of exposure or spills.

3.6 PHYSICAL HAZARDS

Materials which present a physical hazard (see section *1.4*) can be safely used if the specific hazard(s) are understood. If appropriate precautions are not taken, personal injury or property damage may occur. Additionally, certain chemicals cannot be safely mixed or stored with other chemicals because of the danger of a violent reaction or a reaction that generates toxic gas. See *APPENDIX B* for a table of incompatible chemicals.

Hazardous chemicals require that employees follow special procedures for handling and storage. The P.I. or laboratory supervisor must create specific SOP's for unit safety.

3.6.1 Flammable Materials: Flammable materials can include flammable liquids, solids, gases and aerosols. When handling flammable materials, observe the following guidelines:

A. Eliminate ignition sources such as open flames, hot surfaces, sparks from welding or cutting, operation of electrical equipment, and static electricity.

B. Store flammable liquids in NFPA approved flammable liquid containers or storage cabinets, in an area isolated from ignition sources or in a special storage room designed for flammable materials.
C. Ensure there is proper bonding and grounding when it is required, such as when transferring or dispensing a flammable liquid from a large container or drum. Assure bonding and grounding is checked periodically.
D. Assure appropriate fire extinguishers and/or sprinkler systems are in the area.
E. Flammable gases must be kept at least 20 feet from oxidizing gases, or separated by a 2 hour fire rated wall.
F. Flammable chemicals may not be stored in household-type refrigerators, freezers and cold rooms. Use laboratory-safe refrigerators and freezers specifically designed for such purpose to store flammable chemicals.

3.6.1.1 Flammable Liquids: Flammable liquid means a liquid having a flash point of not more than 93°C (199.4°F) Flash point means the minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air near the surface of the liquid. Flammable liquids are classified in one of four categories:

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

3.6.1.2 Flammable Solids: Flammable solid means a solid which is a readily combustible solid, which may cause or contribute to fire through friction. Readily combustible solids are powdered, granular or pasty chemicals which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly

3.6.1.3 Flammable Gases: Flammable gas means a gas having a flammable range with air at 20°C and a standard pressure of 101.3kPa.

CRITERIA FOR FLAMMABLE GASES		
Category	**Criteria**	
1	Gases at 20°C (68°F and pressure of 101.3 kPa (14.7 psi)	
	(a)	are ignitable when in a mixture of 13% or less by volume in air; or
	(b)	Have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit.
2	Gases, other than those of Category 1, which, at 20°C (68°F) and a pressure of 101.3 kPa have a flammable range when mixed in air	
NOTE: Aerosols should not be classified as flammable gases. See *3.6.12*		

3.6.1.4 Flammable Aerosols: Aerosols means any non-refillable receptacle containing a gas compressed, liquefied or dissolved under pressure, and fitted with a release device allowing the contents to be ejected as particles in suspension in a gas, or as a foam, paste, powder, liquid or gas. Flammable aerosols shall be considered flammable if they contain any component which is classified as a flammable liquid, gas or solid.

3.6.2 Corrosive to metal: A chemical which is corrosive to metals means a chemical which by chemical action will materially damage, or even destroy, metals. See *APPENDIX E*.

A. Containers and equipment used for storage and processing of corrosive materials should be corrosion resistant.
B. Corrosives can damage personal protective equipment such as gloves, lab coats and eye protection. Ensure personal protective equipment is rated to withstand use of corrosives.

3.6.3 Oxidizers: materials which react with other substances by giving off electrons and undergoing reduction. This reaction may result in fire or explosion. When working with oxidizing substances, observe the following:

A. Know the reactivity of the materials involved in the experiment or process. Ensure there are no extraneous materials in the area which could become involved in a reaction.
B. If the reaction is anticipated to be violent or explosive, use shields or other methods for isolating the materials or the process.
C. Oxidizing gases must be kept at least 20 feet away from flammable gases, or separated by a 2 hour fire wall per NFPA 55.

3.6.3.1 Oxidizing Gases: Oxidizing gases means any gas which may, generally by providing oxygen, cause or contribute to the combustion of other material more than air does (pure gases or mixtures with an oxidizing power greater than 23.5%).

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

3.6.3.1 Oxidizing solids: Oxidizing solid means a solid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other materials.

3.6.4 Water Reactive Chemicals: Chemicals which, in contact with water, emit flammable gases are solid or liquid chemicals which, by interaction with water, are liable to become spontaneously flammable or give off flammable gases in dangerous quantities. Examples of water reactive chemicals include alkali metals such as lithium, sodium, and potassium; acid anhydrides, and acid chlorides.

3.6.5 Pyrophoric Materials: Pyrophoric materials are those chemicals which can ignite in contact with air. Often the flame is invisible. Examples of pyrophoric materials are silane, silicon tetrachloride, and white or yellow phosphorous. Pyrophoric chemicals should be used and stored in inert environments.

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

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

3.6.6 Organic Peroxides: Organic peroxide means a liquid or a solid organic chemical which contains the bivalent –O-O- structure and is such is considered a derivative of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by oxygen radicals. Organic peroxides are thermally unstable chemicals, which may undergo exothermic self-accelerating decomposition. In addition, they may have one or more of the following properties:

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

Some chemicals can form explosive peroxides when stored; exposure to light and heat increase the rate of peroxide formation. Other chemicals form peroxides that become hazardous when concentrated, such as by distillation. See *APPENDIX G* for a list of materials which may form peroxides.

A. Date all peroxidizables upon receipt and upon opening. Dispose of or check for peroxide formation after the recommended time; 3-months or one year depending on the chemical. See *APPENDIX G*.
B. Do not open any container which has obvious solid formation around the lid.
C. Addition of an inhibitor to quench the formation of peroxides is recommended.
D. It is recommended to chemically test for peroxides periodically.
E. Follow the same basic handling procedures as for flammable materials.

3.6.8 Unstable Materials: compounds which can spontaneously release large amounts of energy under normal conditions, or when struck, vibrated, or otherwise agitated. Some chemicals become increasingly shock-sensitive with age. Of great concern in the laboratory is the inadvertent formation of explosive or shock-sensitive materials such as peroxides, perchlorates (from perchloric acid), picric acid and azides. A list of shock sensitive and explosive materials is provided in *APPENDIX H*.

A. Contact EHS when it is suspected that the inadvertent formation of shock-sensitive materials in ductwork, piping, or chemicals being stored has occurred.
B. Date all containers of explosive or shock-sensitive materials upon receipt and when opened.
C. If there is a chance of explosion, use barriers or other methods for isolating the materials or the process.

3.6.9 Cryogens: liquefied gases that condense oxygen from the air, create an oxygen rich atmosphere and increase potential for fire if flammable or combustible materials and a source of ignition are present. Pressure is also a hazard due to the large expansion ratio from liquid to gas, causing pressure build up in containers. Many materials become brittle at extremely low temperatures. Brief contact with materials at extremely low temperatures can cause burns similar to thermal burns. Some of the hazards associated with cryogens are fire, pressure, weakening of materials, and skin or eye burns upon contact with the liquid.

A. Always wear safety glasses with side shields or goggles when handling. If there is a chance of a splash or spray, a full face protection shield, an impervious apron or coat, cuffless trousers, and high topped shoes should be worn. Watches, rings, and other jewelry should not be worn. Gloves should be impervious and sufficiently large to be readily thrown off should a cryogen spill. Pot holders could also be used.
B. Containers and systems containing cryogens should have pressure relief mechanisms.
C. Containers and systems should be capable of withstanding extreme cold without becoming brittle.
D. Since glass ampoules can explode when removed from cryogenic storage if not sealed properly, storage of radioactive, toxic or infectious agents should be placed in plastic cryogenic storage ampoules. Reheat cold sample containers slowly.

3.6.10 Explosives: An explosive chemical is a solid or liquid chemical which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such speed as to cause damage to the surroundings. Pyrotechnical chemicals are included even when they do not evolve gases.

Explosive chemicals classified as Division 1.1-1.6 are not approved for use on campus in any amount.

3.6.11 Gases Under Pressure: Gases under pressure are gases which are contained in a receptacle at a pressure of 200 kPa or more, or which are liquefied or liquefied and refrigerated. The compromise compressed gases, liquefied gases, dissolved gases and refrigerated liquefied gases.
When using gases under pressure, observe the following guidelines:

A. Compressed gas cylinders must be secured to an unmovable surface by means of a strap or stand
B. Use the correct regulator for the gas in use
C. Toxic and pyrophoric gases may require special ventilation and storage requirements. Consult with MSU EHS before purchasing toxic or pyrophoric gases

3.6.12 Self-heating chemicals: A self-heating chemical is a solid or liquid chemical, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is liable to self-heat; this chemical differs from a pyrophoric liquid or solid in that it will ignite only when large amounts (kilograms) and after long periods of time (hours or days).

3.6.13 Combustible dusts: A finely divided combustible particulate solid that presents a flash-fire hazard or explosion hazard when suspended in air or the process-specific oxidizing medium over a range of concentrations. Combustible metals are any metals composed of distinct particles or pieces, regardless of size, shape or chemical composition that will burn. Dispersion of dust particles in sufficient quantity and concentration can cause rapid combustion known as deflagration. If the event is confined by an enclosure such as a building, room, vessel or process equipment, the resulting pressure rise may cause an explosion. To identify factors that may contribute to an explosion, consult with EHS to perform a thorough hazard assessment of:

- All materials handled
- Operations conducted, including by-products
- All spaces (including hidden ones); and
- All potential ignition sources

3.7 HEALTH HAZARDS

Materials which present a health hazard (see section *1.4*) can be safely used if the specific hazard(s) are understood. If appropriate precautions are not taken, acute or long term adverse health effects can occur.

3.7.1 Acute Toxicity: Acute toxicity refers to those adverse effects occurring following oral or dermal administration of a single dose of a substance, or multiple doses given within 24 hours, or an inhalation exposure of 4 hours. Acutely toxic substances are classified into four categories:

ACUTE TOXICITY HAZARD CATEGORIES				
Exposure Route	**Category 1**	**Category 2**	**Category 3**	**Category 4**
Oral (mg/kg bodyweight)	≤ 5	>5 and ≤ 50	>50 and ≤ 300	>300 and ≤2000
Dermal (mg/kg bodyweight)	≤ 50	>50 and ≤ 200	>200 and ≤1000	>1000 and ≤2000
Inhalation – Gases (ppmV)	≤100	>100 and ≤500	>500 and ≤2500	>2500 and ≤20000

3.7.2 Skin Corrosion / Irritation: Skin corrosion is the production of irreversible damage to the skin; namely, visible necrosis through the epidermis and into the dermis, following the application of a substance for up to 4 hours. Corrosive reactions are typified by ulcers, bleeding, bloody scabs, and, by the end of observation at 14 days, by discoloration due to blanching of the skin, complete areas of alopecia, and scars. Skin irritation is the production of reversible damage to the skin following the application of a substance for up to 4 hours. When working with corrosive substances, observe the following:

A. Eye protection and rubber gloves should always be used when handling corrosive materials. A face shield, rubber apron, and rubber boots may also be appropriate, depending on the work performed.
B. Never add water to acid. When mixing concentrated acids with water, add the acid slowly to water.
C. An eyewash and safety shower must be readily accessible to areas where corrosives are used and stored. In the event of skin or eye contact with corrosives, immediately flush the area of contact with cool water for 15 minutes. Remove all affected clothing. Obtain medical help. See section *5.3* "Personal Protective and Safety Equipment" for eyewash and safety shower specifications.

3.7.3 Serious Eye Damage / Eye Irritation: Serious eye damage is the production of tissue damage in the eye, or serious physical decay of vision, following exposure of a substance to the anterior surface of the eye, which is not fully reversible within 21 days of initial exposure. Eye irritation is the production of changes in the eye following exposure to a substance to the anterior of the eye, which is fully reversible within 21 days of initial exposure.

3**.7.4 Respiratory and Skin Sensitization:** Respirator sensitizer means a chemical that will lead to hypersensitivity for airways following inhalation of the chemical. Skin sensitizer means a chemical that will lead to an allergic response following skin contact.

3.7.5 Germ Cell Mutagenicity: Substances known to induce heritable mutations or to be regarded as if they induce heritable mutations in the germ cells of humans. Hazard categories for substances classified as germ cell mutagens are as follows:

HAZARD CATEGORIES for GERM CELL MUTAGENS	
Category 1A	Substances known to induce heritable mutations in germ cells of humans, based on evidence from human epidemiological studies
Category 1B	Substances which should be regarded as if they induce heritable mutations in the germ cells of humans, based on evidence from positive results from mammalian in vivo testing
Category 2	Substances which cause concern for humans owing to the possibility that they induce heritable mutations in the germ cells of humans, based on positive evidence obtained from experiments in mammals and/or in some cases from in-vitro experiments

3.7.6 Carcinogenicity: Substances or a mixture of substances which induce cancer or increase its incidence. Hazard categories for substances classified as carcinogens are as follows:

HAZARD CATEGORIES FOR CARCINOGENS	
Category 1A	Known to have carcinogenic potential for humans based on human evidence
Category 1B	Presumed to have carcinogenic potential for humans, based largely on animal evidence.
Category 2	Suspected human carcinogens, based on evidence from human and/or animal studies.

3.7.7 Reproductive Toxicity: Substances that induce adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on development of the offspring. This can include alterations to the male and female reproductive system, adverse effects on the onset of puberty, gamete production and transport, reproductive cycle normality, sexual behavior, fertility, parturition, pregnancy outcomes, premature reproductive senescence, interference in the normal development of offspring before or after birth and adverse effects on or via lactation. Hazard categories for substances classified as reproductive toxicants include:

HAZARD CATEGORIES FOR REPRODUCTIVE TOXICANTS	
Category 1A	Known human reproductive toxicant, via evidence from humans
Category 1B	Presumed human reproductive toxicant, largely based on evidence from experimental animals
Category 2	Suspected human reproductive toxicant, via some evidence from humans or experimental animals supplemented with other information

3.7.8 Specific Target Organ Toxicity – Single Exposure: Substances than can cause specific, non-lethal target organ toxicity arising from a single exposure to a chemical. This can include consistent and identifiable toxic effects in humans or experimental animals which have

produced serious changes to the biochemistry or hematology of the organism, and that these changes would be relevant to human health.

3.7.10 Specific Target Organ – Repeated Exposure: Substances that can cause specific organ toxicity arising from repeated exposure. This can include consistent and identifiable toxic effects in humans or experimental animals which have produced serious changes to the biochemistry or hematology of the organism, and that these changes would be relevant to human health.

3.7.11 Aspiration Hazard: Liquid or solid substances that can gain entry to the body directly via the oral or nasal cavity, or indirectly from vomiting into the trachea and lower respiratory system. This can produce severe acute effects such as chemical pneumonia, pulmonary injury or death following aspiration.

3.8 RADIOACTIVE MATERIAL HAZARDS

Use of radioactive materials at MSU is strictly controlled. Contact EHS if you plan to use radioactive materials.

3.9 BIOLOGICAL MATERIAL HAZARDS

Use of biological materials at or above Biosafety Level 2 at MSU is strictly controlled. Contact EHS if you plan to use biological materials at or above Biosafety Level 2.

4.0 EMERGENCY / MEDICAL PROCEDURES

4.1 BASIC STEPS FOR EMERGENCY AND SPILL RESPONSE

Uncontrolled releases of hazardous substances that pose a significant threat to health and safety or that, by their very nature, require an emergency response regardless of the circumstances surrounding the release or the mitigating factors. The following definitions designate an **emergency situation**:

1. The situation is unclear to the person causing or discovering the spill.
2. The release requires evacuation of persons.
3. The release involves or poses a threat of
    A. Fire, suspected fire, explosion or other imminent danger
    B. Conditions that are Immediately Dangerous to Life and Health (IDLH)
    C. High levels of exposure to toxic substances.
4. The person(s) in the work area is uncertain they can handle the severity of the hazard with the personal protective equipment (PPE) and response equipment that has been provided and/or the exposure limit could easily be exceeded.

Conversely, releases that do not pose significant safety or health hazards to person(s) in the immediate vicinity or to the person(s) cleaning releases, do not have the potential to become emergencies within a short time frame are not emergency situations. The following situations **ARE NOT emergency situations**:

1. The person causing or discovering the release understands the properties and can make an informed decision as to the exposure level.

2. The release can be appropriately cleaned up by the lab personnel using authorized (certified) spill kits.

3. The materials are limited in quantity, exposure potential, or toxicity and present minor safety or health hazards to persons in the immediate work area or those assigned to clean up the activity.

4. Incidental releases of hazardous substances that are routinely cleaned up by EHS or trained custodians from outside the immediate release area need not be considered an emergency.

4.1.1 Emergency Situation - Fire. The following steps are basic protocol for handling a fire or fire-related emergency situation in the laboratory:

1. Pull the fire alarm.

2. Call 9-1-1 from a safe location.

3. Notify the unit emergency coordinator.

4. Evacuate.

4.1.2 Emergency Situation - Spill. If the spill is of high toxicity or flammability or you are unsure of how to proceed or is more than one liter, execute the following:

1. Call 9-1-1.

2. Evacuate personnel from the spill area and alert neighbors to the spill.

3. Remove ignition sources and shut down equipment if you can do so safely.

4. Activate the emergency purge systems on fume hoods if you can do so safely.

5. Isolate the spill area by closing doors while evacuating from the area.

Evacuation of the building is mandatory if chemicals or contaminants could enter the air circulation system of a building.

Attend to victims for a body splash:

1. Call 911
2. Remove person(s) from spill area to fresh air only if attempts to rescue victim(s) do not present a danger to the rescuers.
3. Remove contaminated clothing while under an emergency shower.

4. Flood affected area with tepid water for at least 15 minutes or until medical assistance arrives.
5. Inform emergency response personnel of the chemical(s) involved.

Attend to victims for an eye splash:

1. Call 911
2. Remove victim(s) from spill area to fresh air only if attempts to rescue victim(s) do not present a danger to the rescuers.
3. Lead the victim(s) immediately to an emergency eye wash facility.
4. Hold the victim's eye lids open.
5. Flush eyes for at least 15 minutes or longer if pain persists.
6. Inform emergency response personnel of the chemical(s) involved.

4.1.3 Mercury Spills. For very small spills, less than 1 cc, such as a broken thermometer, use a trapped vacuum line attached to a tapered glass tube, similar to a medicine dropper, to pick up mercury droplets.

1. Do not use a domestic or commercial vacuum cleaner.

2. Cover small droplets in accessible areas with one of the following:

- sodium polysulfide solution
- powdered sulfur
- silver metal compounds
- dry ice to freeze the mercury droplets

3. Place residue in container for hazardous waste collection.

For large spills, i.e. greater than 1 cc, contact EHS for spill cleanup, instructions or assistance.

4.1.4 Spill Kits. Ready access to a chemical spill kit is required in laboratories that work with hazardous chemicals. Minimally, such a kit should contain:

- splash resistant goggles
- chemical resistant gloves
- plastic bags
- multi-chemical sorbent (enough for 2 gallon spill)
- scooper

Most spills greater than 1 liter in volume requires assistance from trained personnel from EHS.

Some sorbents are chemically specific. The best sorbents are those which can be used to clean up all types of chemical spills. Check absorbents in spill kits for their absorbency range.

Each laboratory's spill kit should be kept in a readily accessible location and each employee should be trained on how to use the spill kit.

4.1.5 Non-Emergency Situation - Spill. If the spill is less than one liter and the chemical involved is of low toxicity and a low flammable hazard, handle it in the following manner:

If there are questions about proper spill response techniques, call EHS at 355-0153.

1. Locate the spill kit.

2. Choose the proper protective equipment:

- Always wear gloves and protective eye wear
- Use additional protective equipment such as an apron, coveralls, or boots

3. Confine or contain the spill.

For non-reactive spills:

A. Cover liquid spills with spill kit absorbent and scoop into a plastic disposal bag.
B. Sweep solid materials into a dust pan and place in a sealed container.
C. Dispose of waste via EHS.

For reactive or potentially reactive spills, if you can do so safely:

A. Cover liquid spill with spill kit absorbent and scoop into an appropriate disposal container.
B. Wet mop dry substances to avoid spreading hazardous dust, provided it is non-water reactive.
C. If spilled chemical is a volatile solvent, transfer disposal bag to a hood for evaporation of solvent.
D. Follow the MSU Hazardous Waste Disposal Guide for disposal.

4.1.6 Power Outages. If emergency lighting and fire alarms **ARE NOT** operable, perform the following steps if you can do so safely before exiting the building:

- Place lids on all open containers of volatile chemicals
- Lower the sash on chemical fume hoods
- Shut down all equipment (leave cooling water and purge gases on as necessary)
- Turn off ignition sources
- Secure or isolate reactions that are underway (boiling liquid on a hot plate, distillations)
- Close fire doors
- Take your books, coats, purse/wallet, keys, etc.
- Lock outside door to lab

In anticipation of possible power outages, do the following:

- Have a flashlight conveniently located or other emergency lighting
- Make sure that all emergency contact numbers on the door are accurate and updated

4.2 INJURY AND ILLNESS

For emergency medical assistance, call 911.

For other non-emergencies, consult individual departmental procedures, and use the following links to report the illness or injury to the university:

- http://www.hr.msu.edu/benefits/benefits_docs/InvoiceMSU.pdf
- http://www.hr.msu.edu/benefits/benefits_docs/AccidentReport.pdf

Employees who suffer a work-related illness/injury should immediately report the injury to the P.I./supervisor.

P.I./Supervisor:

1. Immediately call an ambulance (9-1-1) if the illness/injury is a critical emergency. The ambulance driver will transport the individual to the nearest medical facility available for treatment.

2. When the illness/injury is not critical, the supervisor is to complete the Authorization to Invoice MSU and direct the employee to the medical facility indicated on the Authorization.

    - The primary medical provider designated by MSU Human Resources Workers' Compensation is LANSING URGENT CARE. Locations include:

      Frandor 505 North Clippert St Lansing, MI 48912 (open 24 hours)
      Dewitt 12970 US Hwy 27 DeWitt, MI 48820
      Okemos 2289 Grand River Okemos, MI 48864
      Southside 320 E. Jolly Road Lansing, MI 48910
      Westside 4440 West Saginaw Lansing, MI 48917
      Bath 16945 Marsh Rd Haslett, MI 48840
      Mason 132 S Cedar St Mason, MI 48854

    - Potentially life threatening emergencies should seek treatment at SPARROW HOSPITAL Emergency Department 1215 E Michigan Avenue Lansing MI 48909 517-364-4141

    - If an injury or illness involves the following and/or the employee is treated at Sparrow Hospital, the employee must follow up at Lansing Urgent Care:
        - hepatitis, AIDS, human blood, or bodily fluids exposure,
        - work with a respirator,
        - work around or with asbestos,
        - work with formaldehyde, ethylene oxide, hazardous waste,
        - work with pesticides or other chemicals, and/or
        - work with or around animals.

3. For an on-campus work-related injury cases when the illness/injury is not critical and the employee cannot drive him/herself to Lansing Urgent Care, Capitol Transport Cab Service may be called anytime at 517-485-4400.

4. Within 24 hours after a reported illness/injury, the injured worker is to complete the Report of Claimed Occupational Injury or Illness. Copies must be distributed to the parties listed at the bottom of the form. Do not wait for medical reports before filling out this form.

5. An Occupational Injury Restriction Report, with or without restrictions, must be provided by the employee to his/her immediate supervisor. An employee capable of performing the essential functions of his/her job will be returned to work. An employee requesting reasonable accommodation of his/her position will also be returned to work upon accommodation.

- Accommodation requests should be communicated to the employee's immediate supervisor. Supervisors needing assistance with these requests may contact the Resource Center for Persons with Disabilities (517-353-9642) (see Policy and Procedure for disability/reasonable accommodations).

6. Out-of-town supervisors should send employees with injuries to the nearest medical facility that has the capability of treating the injury. An Authorization to Invoice MSU for employees not in the Lansing area should be completed and sent with the injured individual.

4.3 MEDICAL CONSULTATIONS AND EXAMINATIONS

1. Health assessments prior to work assignment for new employees will be performed under the following conditions:

   A. When conditions specified by the **Exposure to Health Risks** form (available at: http://www.hr.msu.edu/hiring/hiring_docs/HealthRiskPhysDemands.pdf are met, the employee must send the completed form to the MSU Occupational Health Service and schedule an appointment for a medical examination prior to work assignment. Note that there are separate forms for full-time employees and student employees.

2. Units must provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

   A. When an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee must be provided an opportunity to receive an appropriate examination.

   B. Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the Permissible Exposure Limit) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

   C. Whenever an event takes place in the work area, such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultations shall be for the purpose of determining the need for a medical examination.

   D. All medical consultations and examinations must be performed by or under the direct supervision of a licensed physician and must be provided without cost to the employee, without loss of pay and at a reasonable time and place.

3. The unit shall provide the following information to the physician:

   A. The identity of the hazardous chemical(s) to which the employee may have been exposed.

   B. A description of the conditions surrounding the exposure, including available quantitative exposure data.

C. A description of the signs and symptoms of exposure that the employee is experiencing, if any.

4. The unit shall obtain a written opinion from the examining physician which shall include the following:

   A. Any recommendation for further medical follow-up.

   B. The results of the medical examination and any associated tests.

   C. Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace.

   D. A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

      i. The written opinion of the physician shall not reveal specific finding of diagnoses unrelated to occupational exposure.

5.0 STANDARD LABORATORY FACILITY REQUIREMENTS

5.1 SIGNS AND INFORMATION

Labels and warning signs should alert employees to potentially hazardous materials and allow those unfamiliar with the laboratory surroundings to identify hazardous chemical use and storage areas, safety facilities, emergency equipment, exits, and aid emergency response personnel. Signs and labels are generally available from EHS.

5.1.1 Safety Data Sheets (SDSs). A Safety Data Sheet (SDS) is a document containing chemical hazard identification and safe handling information and is prepared in accordance with the OSHA Hazard Communication Standard and the Michigan Right-to-Know law.

Chemical manufacturers and distributors must provide the purchasers of hazardous chemicals an appropriate SDS for each hazardous chemical/product purchased.

The Michigan Right-to-Know law requires that units and/or P.I.s keep SDSs in a systematic and consistent manner. The system a unit uses to store SDSs can vary from keeping them in a notebook or file cabinet to using the EHS request system. The system adopted must provide easy access to SDSs for hazardous chemicals used in the lab. Each unit must post a Michigan Right-to-Know Law poster, which indicates the location of all SDSs for hazardous chemicals used in the lab.

EHS is a central repository for SDSs. If you wish to review a SDS, contact your P.I., supervisor, instructor or EHS. If you need SDSs for your work area file search the EHS SDS website at: https://db.ehs.msu.edu/MSDS/search.htm

If you are unable to locate an SDS on the EHS website, telephone the EHS office at 355-0153 and request assistance. Between the hours of 5:00 pm and 8:00 am, please contact MSU Police and at 355-2222. The MSU Police will contact a representative from EHS, who will provide you with a SDS as soon as you need it.

5.1.2 Generic Signs. Every laboratory shall have the following signs visibly posted:

1. The Michigan Right-to-Know law poster, listing the location of SDSs for all hazardous chemicals used in the laboratory.

2. Emergency contact numbers (two names, preferably the P.I., head technician or a graduate student) shall be posted on the external doorway to the lab. These names and numbers shall be updated when personnel change. In case of an emergency, responders need this information to contact knowledgeable personnel about specific laboratory hazards.

3. If a laboratory has 10 gallons or more of a flammable or corrosive liquid or toxic gas(es), the main doorway to the lab shall have a hazard warning sticker visibly posted on it to indicate the potential hazard. This is an aid to fire response personnel.

5.1.3 Restricted Access And Designated Areas. Facilities containing certain hazards must have warning signs posted at the designated area of the laboratory where the hazard exists, and at the entranceway to the laboratory. Any areas placarded as such are restricted access, designated areas and have certain standards regarding training and use by employees. Such hazards include:

- MIOSHA Class A carcinogens
- HIV and HBV research laboratories and production facilities*
- Biological agents that require Biosafety Level 2 or higher*
- Radioisotopes*

Other chemical hazards will be dealt with on a case-by-case basis, with consultation from EHS.

*Please contact the Biological Safety Officer or the Radiation Safety Officer at EHS for requirements on these items.

5.1.4 Storage Areas. Assure that the following areas are labeled and chemicals are stored appropriately:

1. Carcinogens
2. Corrosives
3. Flammable Liquids
4. Flammable Solids
5. Oxidizers
6. Perchloric Acid
7. Biosafety Level 2 or higher
8. Compressed Gas Storage

Additionally, storage areas for biohazardous agents and radioisotopes should be appropriately labeled. Please contact the Biological Safety Officer or the Radiation Safety Officer at EHS for information.

5.2 CONTROL MEASURES

1. The P.I. or lab supervisor must implement control measures to reduce employee exposure to hazardous chemicals. The three types of control measures are:

    A. Administrative Controls: methods of controlling employee exposures to contaminants by job rotation, work assignment or time periods away from contaminant. Examples include Standard Operating Procedures, Chemical Hygiene Plans and Safety Manuals.

    B. Engineering Controls: methods of controlling employee exposures by modifying the source or reducing the quantity of contaminants released into the work environment. Examples include fume hoods and biosafety cabinets.

    C. Personal Protective Equipment: personal safety equipment designed for secondary employee protection from hazardous chemicals. Examples include gloves and lab coats.

Note: MIOSHA R 325.51105 regarding air contaminants, states that engineering controls and administrative controls shall first be determined and implemented when feasible. When such controls are not feasible to achieve full compliance, protective equipment or any other protective measures shall be used to keep the exposure of employees to air contaminants within the limits prescribed in the rule.

2. MIOSHA requires control measures when the following circumstances are met:

    A. Whenever employees use hazardous chemicals.

    B. Whenever employee exposures exceed the action level (or, in the absence of an action level, the Permissible Exposure Limit, the published exposure limit or the Threshold Limit Value).

    C. Upon addition of new chemicals or changes in procedures.

Other situations should be dealt with on a case-by-case basis. Please consult EHS for assistance in establishing control measures.

3. The following general control measures are recommended for use in most situations requiring the use of hazardous chemicals:

    A. Use the following primary methods for detecting exposures:
        i. Determine the source of exposure.
        ii. Determine the path the contaminant follows to reach the employee.
        iii. Determine the employee's work pattern and use of personal protective equipment.
        iv. Change one or more of the above pathways to reduce or eliminate exposure.
    B. Substitute less harmful chemicals for more harmful chemicals whenever possible.
    C. Change or alter processes to minimize exposure.
    D. Isolate or enclose a process or work operation to reduce the number of employees exposed (for example, use a fume hood).
    E. Use wet methods to reduce the generation of dust.

F. Use local exhaust ventilation (hoods) at point of generation or dispersion of contaminants and use dilution (general) ventilation to reduce air contaminants.
G. Practice good housekeeping procedures to reduce unnecessary exposures.
H. Use training and education as primary administrative controls for reducing exposures.
I. Use special control methods such as shielding and continuous monitoring devices to control exposures in special situations.

5.3 PERSONAL PROTECTIVE AND SAFETY EQUIPMENT

Maintaining a safe laboratory environment is the responsibility of the P.I., but all employees play a role in observing safety guidelines. Personal protective devices and safety equipment must be provided to all employees under the appropriate circumstances and employees have the responsibility of properly using such equipment.

The SDS will provide some information on the personal protective equipment and safety procedures recommended for a given chemical, though the SDS may not provide sufficient information concerning the specific type of safety equipment required (for example, it may say "use gloves" but not list the best glove to use).

MIOSHA has adopted the American National Standards Institute (ANSI) consensus standards for eye protection and emergency shower and eyewash facilities.

5.3.1 Personal Protective Equipment

Eye and Face Protection. Eye protection must be made available to all employees or visitors to laboratories where chemicals are used and stored. Protective eye and face equipment must be used where there is a reasonable probability of injury from hazardous chemicals that can be prevented from such equipment. The minimum acceptable requirements are for hardened glass or plastic safety spectacles. **The P.I. or laboratory supervisor should establish the level of eye protection needed per laboratory activity based on the guidelines below.**

Eye and Face Protection: General Description

All eye protective devices must be stamped with "Z87" by the manufacturer if they meet ANSI standards. If the eye protection is not marked, it may not be the most effective protection available.

1. Safety glasses with side shields offer minimal protection against flying fragments, chips, particles, sand and dirt. When a splash hazard exists, other protective eye equipment should be worn.

2. Safety goggles (impact goggles) offer adequate protection against flying particles. These should be worn when working with glassware under reduced or elevated pressure or with drill presses or other similar conditions.

3. Chemical splash goggles (acid goggles) have indirect venting for splash proof sides, which provide adequate protection against splashes. **Chemical splash goggles offer the best eye protection from chemical splashes. Impact goggles should not be worn when danger of a splash exists.**

4. Face shields protect the face and neck from flying particles and splashes. Always wear additional eye protection under face shields. Ultra-violet light face shields should be worn when working over UV light sources.

5.3.2 Selecting Appropriate Eye and Face Protection in Laboratories

Safety Glasses

Required when: An impact hazard exists or when working with low hazard chemicals, or when a low probability of splash exists.

Examples:

- Pipetting
- Handling closed bottle of injurious chemical
- Mixing solutions
- Opening centrifuge tubes

Chemical Splash Goggles

Required when: Working with smaller amounts of corrosive or injurious chemicals and a reasonable probability of splash exists

Examples:

- Pouring acid out of a 1 pint bottle
- Pouring methylene chloride from a 1 liter bottle
- Working with liquids under pressure

Face Shield and Chemical Splash Goggles

Required when: Working with larger quantities of corrosive chemicals and / or a high probability of eye and face injury exists.

Examples:

- Working with an acid bath
- Pouring 4 liters of acid into a container
- Handling highly reactive chemicals that may spatter

Note: Ordinary prescription glasses do not provide adequate protection against eye injury. Eye protection equipment must be ANSI Z87 approved.

For more information on the MSU Eye and Face Protection policy, visit our web page at: www.ehs.msu.edu/chemical/eye_face.htm

Protection of Skin and Body: Skin and body protection involves the use of protective clothing to protect individuals from chemical exposure. Determine clothing needed for the chemical being used, as protective garments are not equally effective for every hazardous chemical. Some chemicals will permeate a garment in a very short time, whereas others will not.

The basic and most effective forms of protection are gloves and lab coats.

Employees working with hazardous chemicals in laboratories must wear closed-toe shoes, long pants or skirt which fully covers the legs, and a lab coat.

Even when there is minimal danger of skin contact with an extremely hazardous substance, lab coats, coveralls, aprons, or protective suits should be utilized. **These garments should not leave the work site.**

Exposures to strong acids and acid gases, organic chemicals and strong oxidizing agents, carcinogens, and mutagens require the use of specialized protective equipment that prevents skin contamination. Impervious protective equipment must be utilized. Examples include: rubber gloves, aprons, boots and protective suits.

Respirators: Michigan State University currently follows a respiratory protection program developed by EHS in accordance with MIOSHA R3501 and 3502. Use of respirators in laboratories is strongly discouraged. Respiratory use is only allowed where engineering controls are not feasible or where they are being installed.

Prior to using a respirator for the first time or for a new activity, employees must receive a medical exam from Olin Health Center, attend an EHS respiratory training session, undergo a fit test and complete an EHS respirator wearer questionnaire. Please contact EHS for a copy of the MSU Respiratory Protection Program.

5.3.3 Safety Equipment

Safety Showers: Safety showers provide an immediate water drench of an affected person. MIOSHA has adopted the following ANSI standards for location, design and maintenance of safety showers:

1. Showers shall be located within 25 feet of areas where chemicals with a pH of ≤ 2.0 or ≥ 12.5 are used.

2. Showers shall be located within 100 feet of areas where chemicals with a pH of > 2 and < 4 or ≥ 9 and < 12.5 are used.

3. The location of the shower should be clearly marked, well lighted and free from obstacles, closed doorways or turns.

Safety showers should be checked and flushed periodically.

Eye Wash Facilities: Eye wash facilities are required in all laboratories where injurious or corrosive chemicals are used or stored, and are subject to the same proximity requirements as safety showers. MIOSHA has adopted the following ANSI standards for location, design and maintenance of emergency eyewash facilities:

1. Optimally, those affected must have both hands free to hold open the eye to ensure an effective wash behind the lids. This means providing eye wash facilities that are operated by a quick release system and simultaneously drench both eyes.

2. Eye wash facilities must provide the minimum of a 15 minute water supply at no less than 0.4 gallons per minute.

3. Eye wash facilities should be flushed out for five minutes at a time, once per week. A log documenting flushes is recommended.

Please call EHS regarding specific designs for eye wash facilities.

5.4 VENTILATION CONTROLS

Ventilation controls are those controls intended to minimize employee exposure to hazardous chemicals by removing air contaminants from the work site. There are two main types of ventilation controls:

1. General (Dilution) Exhaust: a room or building-wide system which brings in air from outside and ventilates within. Laboratory air must be continually replaced, preventing the increase of air concentration of toxic substances during the work day. General exhaust systems are not recommended for the use of most hazardous chemicals.

2. Local Exhaust: a ventilated, enclosed work space intended to capture, contain and exhaust harmful or dangerous fumes, vapors and particulate matter generated by procedures conducted with hazardous chemicals.

To determine ventilation requirements, assess the SDS. Some SDS terminology, as listed below, may indicate a need for special ventilation considerations beyond general exhaust ventilation:

- use with adequate ventilation
- avoid vapor inhalation
- use in a fume hood
- provide local exhaust ventilation

Proper Use of Local Ventilation Systems: Once a local ventilation system is installed in a work area, it must be used properly to be effective. For use of hazardous chemicals warranting local ventilation controls, the following guidelines should be observed:

1. Conduct all operations which may generate air contaminants at or above the appropriate PEL or TLV inside a fume hood.

2. Keep all apparatus at least 6 inches back from the face of the hood and keep the slots in the hood baffle free of obstruction by apparatus or containers. Large equipment should be elevated at least two inches off the base of the fume hood, to allow for the passage of air underneath the apparatus.

3. Do not use the hood as a waste disposal mechanism except for very small quantities of volatile materials.

4. Minimize storage of chemicals or apparatus in the hood.

5. Keep the hood sash closed at all times except when the hood is in use.

6. Minimize foot traffic and other forms of potential air disturbances past the face of the hood.

7. Do not have sources of ignition inside the hood when flammable liquids or gases are present.

8. Use sash as a safety shield when boiling liquids or conducting an experiment with reactive chemicals.

9. Periodically check the air flow in the hood using a continuous monitoring device or another source of visible air flow indicator. If air flow has changed, contact EHS for an inspection or Physical Plant for repair.

The system must be checked prior to each use to assure it is operating. **Never work with hazardous chemicals if the required ventilation system is not working.**

EHS performs hood inspections **annually**. After an inspection, hoods are passed or failed for use based on the following criteria:

1. The face velocity of air being drawn into the hood at maximum sash height is measured quantitatively in feet per minute (fpm). One measurement is taken per square foot of face space. Hoods must have an average face velocity of 60-150 fpm, depending on their design, with 100 fpm being the ideal average face velocity.

2. The turbulence of the air is measured qualitatively by releasing smoke from a smoke tube. The smoke must be captured by the hood, with a minimum of turbulence.

If the exhaust system does not pass the face velocity test and/or has excessive turbulence, it will be posted as "failed" by the inspector. The P.I. must submit a work order to Infrastructure, Planning and Facilities (IPF) to have the system repaired before hazardous chemicals can be used in the hood.

If the exhaust system does pass, the inspector will post the date of inspection and will mark the hood to indicate proper sash position for optimum hood performance. The hood sash should be set at this point for procedures which could generate toxic aerosols, gases or vapors. In general, the sash height should be set at a level where the operator is shielded to some degree from any explosions or violent reactions which could occur and where optimum air flow dynamics are achieved. If a fume hood has no markings regarding sash height or inspection dates, please contact EHS to arrange for an inspection.

Certain types of local exhaust systems are not designed for the use of hazardous chemicals. If a local exhaust system's capabilities are not fully understood, check the manufacturer’s specifications or call EHS before using hazardous chemicals in the system.

Proper use of Ductless Ventilation Systems: Ductless, or portable fume hoods, which employ filtration media, may be an option to conventional local exhaust hoods. Contact EHS for consultation before acquiring any ductless fume hood.

5.5 SPILL KITS

Refer to Section *4.1.2*.

6.0 STANDARD REPAIR / CLOSE-OUT / DECOMMISSIONING PROCEDURES

6.1 DECONTAMINATION OF EQUIPMENT

When a request for equipment repair or transfer to another location is initiated, the following steps must be undertaken to ensure the safety of the employees responsible for repair or transfer if the equipment has been contaminated by hazardous chemicals:

A. Remove chemical contaminants with an appropriate solvent or cleaning solution.
B. Once contaminants have been eliminated, fill out an "Equipment Release Form" (located in *APPENDIX P*) and place in a prominent position on the equipment to be repaired or transferred. **The equipment must have the Equipment Release Form affixed for initiation of repair or transfer.**

The policy for laboratory close-out procedures is located in *APPENDIX N***.**

APPENDIX A: SDS Request Form

SAFETY DATA SHEET REQUEST FORM

Name:	_____	**Date:**	_____
Location:	_____	**Phone:**	_____
Dept.:	_____	**Date Needed:**	_____
Fax:	_____	**E-Mail:**	_____

Chemical Names:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Use this form to request a SDS. Mail the request form to:
MSU Environmental Health and Safety
4000 Collins Road, Room B20
Lansing, MI *48910*
Call EHS at 355-0153 if you have any questions.

APPENDIX B: Incompatibility of Common Laboratory Chemicals

When certain hazardous chemicals are stored or mixed together, violent reactions may occur because the chemicals are unsuitable for mixing, or are *incompatible*. Classes of incompatible chemicals should be segregated from each other during storage, according to hazard class. Use the following general guidelines for hazard class storage:

- Flammable/Combustible Liquids and Organic Acids
- Flammable Solids
- Mineral Acids
- Caustics
- Oxidizers
- Perchloric Acid
- Compressed Gases

Before mixing any chemicals, refer to this partial list, the chemicals' SDSs or call EHS to verify compatibility:

CHEMICAL	INCOMPATIBLE CHEMICAL(S)
Acetic acid	aldehyde, bases, carbonates, hydroxides, metals, oxidizers, peroxides, phosphates, xylene
Acetylene	halogens (chlorine, fluorine, etc.), mercury, potassium, oxidizers, silver
Acetone	acids, amines, oxidizers, plastics
Alkali and alkaline earth metals	acids, chromium, ethylene, halogens, hydrogen, mercury, nitrogen, oxidizers, plastics, sodium chloride, sulfur
Ammonia	acids, aldehydes, amides, halogens, heavy metals, oxidizers, plastics, sulfur
Ammonium nitrate	acids, alkalis, chloride salts, combustible materials, metals, organic materials, phosphorous, reducing agents, urea
Aniline	acids, aluminum, dibenzoyl peroxide, oxidizers, plastics
Azides	acids, heavy metals, oxidizers
Bromine	acetaldehyde, alcohols, alkalis, amines, combustible materials, ethylene, fluorine, hydrogen, ketones (acetone, carbonyls, etc.), metals, sulfur
Calcium oxide	acids, ethanol, fluorine, organic materials
Carbon (activated)	alkali metals, calcium hypochlorite, halogens, oxidizers
Carbon tetrachloride	benzoyl peroxide, ethylene, fluorine, metals, oxygen, plastics, silanes
Chlorates	powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid	acetone, alcohols, alkalis, ammonia, bases,
Chromium trioxide	benzene, combustible materials, hydrocarbons, metals, organic materials, phosphorous, plastics
Chlorine	alcohols, ammonia, benzene, combustible materials, flammable compounds (hydrazine), hydrocarbons (acetylene, ethylene, etc.), hydrogen peroxide, iodine, metals, nitrogen, oxygen, sodium hydroxide
Chlorine dioxide	hydrogen, mercury, organic materials, phosphorous, potassium hydroxide, sulfur
Copper	calcium, hydrocarbons, oxidizers
Hydroperoxide	reducing agents
Cyanides	acids, alkaloids, aluminum, iodine, oxidizers, strong bases
Flammable liquids	ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens

CHEMICAL	INCOMPATIBLE CHEMICAL(S)
Fluorine	alcohols, aldehydes, ammonia, combustible materials, halocarbons, halogens, hydrocarbons, ketones, metals, organic acids
Hydrocarbons (Such as butane, propane benzene, turpentine, etc.)	acids, bases, oxidizers, plastics
Hydrofluoric acid	metals, organic materials, plastics, silica (glass)
Hydrogen peroxide	acetylaldehyde, acetic acid, acetone, alcohols, carboxylic acid, combustible materials, metals, nitric acid, organic compounds, phosphorous, sulfuric acid, sodium, aniline
Hydrogen sulfide	acetylaldehyde, metals, oxidizers, sodium
Hypochlorites	acids, activated carbon
Iodine	acetylaldehyde, acetylene, ammonia, metals, sodium
Mercury	acetylene, aluminum, amines, ammonia, calcium, fulminic acid, lithium, oxidizers, sodium
Nitrates	acids, nitrites, metals, sulfur, sulfuric acid
Nitric acid	acetic acid, acetonitrile, alcohols, amines, (concentrated) ammonia, aniline, bases, benzene, cumene, formic acid, ketones, metals, organic materials, plastics, sodium, toluene
Oxalic acid	oxidizers, silver, sodium chlorite
Oxygen	acetaldehyde, secondary alcohols, alkalis and alkalines, ammonia, carbon monoxide, combustible materials, ethers, flammable materials, hydrocarbons, metals, phosphorous, polymers
Perchloric acid	acetic acid, alcohols, aniline, combustible materials, dehydrating agents, ethyl benzene, hydriotic acid, hydrochloric acid, iodides, ketones, organic material, oxidizers, pyridine
Peroxides, organic	acids (organic or mineral)
Phosphorus (white)	oxygen (pure and in air), alkalis
Potassium	acetylene, acids, alcohols, halogens, hydrazine, mercury, oxidizers, selenium, sulfur
Potassium chlorate	acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organic materials, sugars
Potassium perchlorate	Alcohols, combustible materials, fluorine, hydrazine, metals (also see chlorates), organic matter, reducing agents, sulfuric acid
Potassium permanganate	benzaldehyde, ethylene glycol, glycerol, sulfuric acid
Silver	acetylene, ammonia, oxidizers, ozonides, peroxyformic acid
Sodium	acids, hydrazine, metals, oxidizers, water
Sodium nitrate	acetic anhydride, acids, metals, organic matter, peroxyformic acid, reducing agents
Sodium peroxide	acetic acid, benzene, hydrogen sulfide metals, oxidizers, peroxyformic acid, phosphorous, reducers, sugars, water
Sulfides	acids
Sulfuric acid	potassium chlorates, potassium perchlorate, potassium permanganate

References:
Safety Data Sheets, various chemical companies

APPENDIX C: Common Laboratory Flammable & Combustible Chemicals

Flammable and combustible chemicals are commonly used hazardous chemicals. The hazard is based on its flash point, and, in the case of a flammable chemical, its boiling point as well. The National Fire Protection Association (NFPA) has identified flammability classes from the flash point and boiling point data of chemicals. The table lists some common flammable and combustible chemicals: flash points, boiling points, and NFPA flammability classes:

Chemical	Flash Point		Boiling Point		NFPA Class
	˚F	˚C	˚F	˚C	
Acetaldehyde	-38	-39	69	21	IA
Dimethyl sulfide	-36	-38	99	37	IA
Ethyl ether	-49	-45	95	35	IA
Ethylene oxide	-20	-29	55	13	IA
Pentane	-57	-49	97	36	IA
Propane	-157	-105	-44	-42	IA
Benzene	12	-11	176	80	IB
Carbon disulfide	-22	-30	115	46	IB
Cyclohexane	-4	-20	179	81	IB
Ethyl alcohol	55	13	173	78	IB
n-Hexane	-7	-22	156	69	IB
Isopropyl alcohol	53	12	180	82	IB
Methyl alcohol	52	11	149	65	IB
Methyl ethyl ketone	16	-9	176	80	IB
Pyridine	68	20	239-241	116	IB
Tetrahydrofuran	6	-14	153	67	IB
Toluene	40	4	231	111	IB
Triethylamine	20	-7	193	89	IB
tert Butyl isocyanate	80	27	185-187	85-86	IC
Chlorobenzene	82	28	270	132	IC
Epichlorohydrin	88	31	239-243	115-117	IC
2-Nitropropane	75	24	248	120	IC
Xylene	81-90	27-32	280-291	138-144	IC
Acetic Acid, glacial	103	39	244	48	II
Bromobenzene	118	48	307-316	153-158	II
Formic Acid	156	69	213	101	II
Morpholine	100	38	263	128	II
Stoddard Solvent	100-140	38-60	300-400	150-200	II
Benzaldehyde	145	63	352	178	IIIA
Cyclohexanol	154	68	322	161	IIIA
Methacrylic Acid	170	77	316	158	IIIA
Nitrobenzene	190	88	412	211	IIIA
Tetrahydronaphthalene	160	71	406	208	IIIA
Benzyl Alcohol	213	101	401	205	IIIB
Caproic Acid	215	102	400	204	IIIB
Ethylene Glycol	232	111	388	198	IIIB
Phenyl Ether	239	115	498	258	IIIB
Stearic Acid	385	196	726	386	IIIB

References: Material Safety Data Sheets and the National Fire Protection Agency document "NFPA 321: Classification of Flammable and Combustible Liquids, 1991 Edition."

APPENDIX D: Flammable Liquid Storage Limits for Laboratories

Maximum Quantities of Flammable and Combustible Liquids in Sprinklered Laboratory Units Outside of Flammable Liquid Inside Liquid Storage Areas

		Excluding Quantities in Storage Cabinets or Safety Cans		Including Quantities in Storage Cabinets or Safety Cans	
Laboratory Unit Fire Hazard Class	**Flammable or Combustible Liquid Class**	**Maximum Quantity per 100 ft² of Laboratory Unit (gals)**	**Maximum Quantity per Laboratory Unit (gals)**	**Maximum Quantity per 100 ft² of Laboratory Unit (gals)**	**Maximum Quantity per Laboratory Unit (gals)**
A	I I, II, IIIA	10 20	600 800	20 40	1200 1600
B	I I, II, IIIA I	5 10	300 400	10 20	600 800
C	I I, II, IIIA I	2 4	150 200	4 8	300 400
D	I I, II, IIIA I	1.1 1.1	75 75	2 2	150 150

Maximum Quantities of Flammable and Combustible Liquids in Nonsprinklered Laboratory Units Outside of Flammable Liquid Inside Liquid Storage Areas

		Excluding Quantities in Storage Cabinets or Safety Cans		Including Quantities in Storage Cabinets or Safety Cans	
Laboratory Unit Fire Hazard Class	**Flammable or Combustible Liquid Class**	**Maximum Quantity per 100 ft² of Laboratory Unit (gals)**	**Maximum Quantity per Laboratory Unit (gals)**	**Maximum Quantity per 100 ft² of Laboratory Unit (gals)**	**Maximum Quantity per Laboratory Unit (gals)**
A	I I, II, IIIA	10 20	300 400	20 40	600 800
B	I I, II, IIIA I	5 10	150 200	10 20	300 400
C	I I, II, IIIA I	2 4	75 100	4 8	150 200
D	I I, II, IIIA I	1.1 1.1	37 37	2 2	75 75

Laboratories listed as Class A shall be considered high hazard laboratories and shall not be used as instructional laboratories.

Laboratories listed as Class B shall be considered intermediate hazard laboratories.

Laboratories listed as Class C shall be considered low hazard laboratories.

Laboratories listed as Class D shall be considered minimal fire hazard laboratories.

Flammable Liquid Container Size Limits

Only approved containers authorized by NFPA (National Fire Protection Association) 30 shall be used to store flammable liquids.

	Flammable Class			**Combustible Class**	
Container	IA	IB	IC	II	III
Glass	1 pt*	1 qt*	1.1 gal	1.1 gal	5 gal
Metal or Approved Plastic	1.1 gal	5 gal	5 gal	5 gal	5 gal
Safety Cans	2.6 gal	5 gal	5 gal	5 gal	5 gal
Metal Drums	not allowed	5 gal	5 gal	60 gal	60 gal
Polyethylene	1.1 gal	5 gal	5 gal	60 gal	60 gal

*Class IA and IB liquids may be stored up to one gallon in glass containers if liquid purity would be affected by storage in metal containers or if metal containers could undergo excessive corrosion by the contained liquid.

APPENDIX E: Common Laboratory Corrosives

ORGANIC ACIDS
Formic Acid
Acetic Acid (Glacial)
Propionic Acid
Butyric Acid
Chloroacetic Acid
Trichloroacetic Acid
Acetyl Chloride
Acetyl Bromide
Chloroacetyl Chloride
Oxalic Acid
Propionyl Chloride
Propionyl Bromide
Acetic Anhydride
Methyl Chloroformate
Dimethyl Sulfate
Chlorotrimethylsilane
Dichlorodimethylsilane
Phenol
Benzoyl Chloride
Benzoyl Bromide
Benzyl Chloride
Benzyl Bromide
Salicylic Acid

ORGANIC BASES
Ethylenediamine
Ethylimine
Tetramethylethylenediamine
Hexamethylenediamine
Trimethylamine aq. soln.
Triethylamine
Phenylhydrazine
Piperazine
Hydroxylamine
Tetramethylammonium Hydroxide

ELEMENTS
Fluorine (gas)
Chlorine (gas)
Bromine (liquid)
Iodine (crystal)
Phosphorus

INORGANIC BASES
Ammonium Hydroxide
Calcium Hydroxide
Sodium Hydroxide
Potassium Hydroxide
Calcium Hydride
Sodium Hydride
Hydrazine
Ammonium Sulfide
Calcium Oxide

INORGANIC ACIDS
Hydrofluoric Acid
Hydrochloric Acid
Hydrobromic Acid
Hydriodic Acid
Sulfuric Acid
Chromerge™
No-Chromix™
Chlorosulfonic Acid
Sulfuryl Chloride
Bromine Pentafluoride
Thionyl Chloride
Tin Chloride
Tin Bromide
Titanium Tetrachloride
Perchloric Acid
Nitric Acid
Phosphoric Acid
Phosphorus Trichloride
Phosphorus Tribromide
Phosphorus Pentachloride
Phosphorus Pentoxide

ACID SALTS
Aluminum Trichloride
Antimony Trichloride
Ammonium Bifluoride
Calcium Fluoride
Ferric Chloride
Sodium Bisulfate
Sodium Fluoride

References :
The Foundations of Laboratory Safety, S.. R. Rayburn, 1990.
Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council, 1981.
Improving Safety in the Chemical Laboratory, 2nd Ed., J. A. Young, 1991.
Safety Data Sheets, various chemical companies.

APPENDIX F: Common Laboratory Oxidizers

Oxidizers react with other chemicals by giving off electrons and undergoing reduction. Uncontrolled reactions of oxidizers may result in a fire or an explosion, causing severe property damage or personal injury. Use oxidizers with extreme care and caution and follow all safe handling guidelines specified in the SDS.

Bleach
Bromates
Bromine
Butadiene
Chlorates
Chloric Acid
Chlorine
Chlorite
Chromates
Chromic Acid
Dichromates
Fluorine
Haloate
Halogens
Hydrogen Peroxide
Hypochlorites
Iodates
Mineral Acid
Nitrates
Nitric Acid
Nitrites
Nitrous oxide
Ozanates
Oxides
Oxygen
Oxygen difluoride
Ozone
Peracetic Acid
Perhaloate
Perborates
Percarbonates
Perchlorates
Perchloric Acid
Permanganates
Peroxides
Persulfate
Sodium Borate Perhydrate
Sulfuric Acid

APPENDIX G: Common Peroxide-Forming Chemicals

Classes of Peroxidizable Chemicals

A. Chemicals that form explosive levels of peroxides without concentration

Butadiene[a]
Chloroprene[a]
Divinylacetylene
Isopropyl ether
Tetrafluoroethylene[a]
Vinylidene chloride

B. Chemicals that form explosive levels of peroxides on concentration

Acetal
Acetaldehyde
Benzyl alcohol
2-Butanol
Cumene
Cyclohexanol
2-Cyclohexen-1-ol
Cyclohexene
Decahydronaphthalene
Diacetylene
Dicyclopentadiene
Diethyl ether
Diethylene glycol dimethyl ether (diglyme)
Dioxanes
Ethylene glycol dimethyl ether (glyme)
Other secondary alcohols
4-Heptanol
2-Hexanol
Methylacetylene
3-Methyl-1-butanol
Methylcyclopentane
Methyl isobutyl ketone
4-Methyl-2-pentanol
2-Penten-1-ol
4-Penten-1-ol
1-Phenylethanol
2-Phenylethanol
2-Propanol
Tetrahydroforan
Tetrahydronaphthalene
Vinyl ethers

C. Chemicals that may autopolymerize as a result of peroxide accumulation

Acrylic acid[b]
Acrylonitrile[b]
Butadiene[c]
Chloroprene[c]
Chlorotrifluoroethylene
Methyl methacrylate[b]
Styrene
Tetrafluoroethylene[c]
Vinyl acetate
Vinylacetylene
Vinyl chloride
Vinylpyridine
Vinyladiene chloride

D. Chemicals that may form peroxides but cannot clearly be placed in sections A-C

Acrolein
Allyl ether[d]
Allyl ethyl ether
Allyl phenyl ether
p-(n-Amyloxy)benzoyl chloride
n-Amyl ether
Benzyl n-butyl ether[d]
Benzyl ether[d]
Benzyl ethyl ether[d]
Benzyl methyl ether
Benzyl 1-naphthyl ether[d]
1,2-Bis(2-chloroethoxy)ethane
Bis(2-ethoxyethyl) ether
Bis(2-(methoxyethoxy)ethyl) ether
Bis(2-chloroethyl) ether
Bis(2-ethoxyethyl) adipate
tert-Butyl methyl ether
n-Butyl phenyl ether
n-Butyl vinyl ether
Chloroacetaldehyde diethylacetal[d]

2-Chlorobutadiene
1-(2-Chloroethoxy)-2-phen- oxyethane
Chloroethylene
Chloromethyl methyl ether[e]
ß-Chlorophenetole
o-Chlorophenetole
p-Chlorophenetole
Cyclooctene[d]
Cyclopropyl methyl ether
Diallyl ether[d]
p-Di-n-butoxybenzene
1,2-Dibenzyloxyethane[d]
Di(1-propynyl) ether[f]
Di(2-propynyl) ether
Di-n-propoxymethane[d]
1,2-Epoxy-3-isopropoxypropane[d]
1,2-Epoxy-3-phenoxypropane
Ethoxyacetophenone
1-(2-Ethoxyethoxy)ethyl acetate
2-Ethoxyethyl acetate
(2-Ethoxyethyl)-o-benzoyl benzoate
1-Ethoxynaphthalene
o,p-Ethoxyphenyl isocyanate
1-Ethoxy-2-propyne
3-Ethoxyopropionitrile
2-Ethylacrylaldehyde oxime
2-Ethylbutanol
Ethyl ß-ethoxypropionate
4-Methyl-2-pentanone
n-Methylphenetole
2-Methyltetrahydrofuran
3-Methoxy-1-butyl acetate
2-Methoxyethanol
3-Methoxyethyl acetate
2-Methoxyethyl vinyl ether
Methoxy-1,3,5,7-cycloocta tetraene
ß-Methoxypropionitrile
m-Nitrophenetole
1-Octene
Oxybis(2-ethyl acetate)
Oxybis(2-ethyl benzoate)
ß,ß-Oxydipropionitrile
1-Pentene
Phenoxyacetyl chloride
Bis(2-ethoxyethyl) phthalate
Bis(2-methoxyethyl) carbonate
Bis(2-methoxyethyl) ether
Bis(2-methoxyethyl)phthalate
Bis(2-methoxymethyl) adipate
Bis(2-n-butoxyethyl) phthalate
Bis(2-phenoxyethyl) ether
Bis(4-chlorobutyl) ether
Bis(chloromethyl) ether[e]
2-Bromomethyl ethyl ether
ß-Bromophenetole
o-Bromophenetole
p-Bromophenetole
3-Bromopropyl phenyl ether
1,3-Butadiyne
Buten-3-yne
tert-Butyl ethyl ether
p-Dibenzyloxybenzene[d]
1,2-Dichloroethyl ethyl ether
2,4-Dichlorophenetole
Diethoxymethane[d]
2,2-Diethoxypropane
Diethyl ethoxymethylenemalonate
Diethyl fumarate[d]
Diethyl acetal[d]
Diethylketene[f]
m,o,p-Diethoxybenzene
1,2-Diethoxyethane
Dimethoxymethane[d]
1,1-Dimethoxyethane[d]
Dimethylketene[f]
3,3-Dimethoxypropene
2,4-Dinitrophenetole
1,3-Dioxepane[d]
2-Ethylhexanal
Ethyl vinyl ether
Furan
2,5-Hexadiyn-1-ol
4,5-Hexadien-2-yn-1-ol
n-Hexyl ether
o,p-Iodophenetole
Isoamyl benzyl ether[d]
Isoamyl ether[d]
Isobutyl vinyl ether
Isophorone[d]
p-Isopropoxypropionitrile[d]
Isopropyl 2,4,5-trichlorophenoxy- acetate
Limonene
1,5-p-Methadiene
Methyl p-(n-amyloxy)benzoate
å-Phenoxypropionyl chloride
Phenyl o-propyl ether

p-Phenylphenetone
n-Propylether
n-Propyl isopropyl ether
Sodium 8,11,14-eicosa tetraenoate
Sodium ethoxyacetylide[f]
Tetrahydropyran
Triethylene glycol diacetate
Triethylene glycol dipropionate
1,3,3-Trimethoxypropene[d]
1,1,2,3-Tetrachloro-1,3-butadiene
4-Vinyl cyclohexene
Vinylenecarbonate
Vinylidene chioride[d]

[a] When stored as a liquid monomer
[b] Although these chemicals form peroxides, no explosions involving these monomers
[c] When stored in liquid form, these chemicals form explosive levels of peroxides without concentration. They may also be stored as a gas in gas cylinders. When stored as a gas, these chemicals may autopolymerize as a result of peroxide accumulation.
[d] These chemicals easily form peroxides and should probably be considered under part B.
[e] OSHA-regulated carcinogen
[f] Extremely reactive and unstable compound.

Safe Storage Period for Peroxide Forming Chemicals

Description	**Period**
Unopened chemicals from manufacturer	18 months
Opened containers	
Chemicals in Part A	3 months
Chemicals in Parts B and D	12 months
Unihibited chemicals in Part C	24 hours
Inhibited chemicals in Part C	12 months[a]

[a] Do not store under inert atmosphere, oxygen required for inhibitor to function.

Sources: Kelly, Richard J., Chemical Health & Safety, American Chemical Society, **1996,** Sept, 28-36
Revised 12/97

Detection And Inhibition Of Peroxides: Basic Protocols

Ferrous Thiocyanate Detection Method

Ferrous thiocyanate will detect hydroperoxides with the following test:

1. Mix a solution of 5 ml of 1% ferrous ammonium sulfate, 0.5 ml of 1N sulfuric acid and 0.5 ml of 0.1N ammonium thiocyanate (if necessary decolorize with a trace of zinc dust)

2. Shake with an equal quantity of the solvent to be tested

3. If peroxides are present, a red color will develop

Potassium Iodide Detection Method

1. Add 1 ml of a freshly prepared 10% solution of potassium iodide to 10 ml of ethyl ether in a 25 ml glass-stoppered cylinder of colorless glass protected from light (both components are clear)

2. A resulting yellow color indicates the presence of 0.005% peroxides

Inhibition of Peroxides

1. Storage and handling under an inert atmosphere is a useful precaution
2. Addition of 0.001% hydroquinone, diphenylamine, polyhydroxyphenols, aminophenols or arylamines may stabilize ethers and inhibit formation of peroxides.
3. Dowex-1® has been reported effective for inhibiting peroxide formation in ethyl ether.
4. 100 ppm of 1-naphthol is effective for peroxide inhibition in isopropyl ether.
5. Hydroquinone is effective for peroxide inhibition in tetrahydrofuran.
6. Stannous chloride or ferrous sulfate is effective for peroxide inhibition in dioxane.

Peroxides Test Strips

These test strips are available from EM Scientific, cat. No. 10011-1 or from Lab Safety Supply, cat. No. 1162. These strips quantify peroxides up to a concentration of 25 ppm. Aldrich Chemical has a peroxide test strip, cat. No. Z10,168-0, that measures up to 100 ppm peroxide. The actual concentration at which peroxides become hazardous is not specifically stated in the literature. A number of publications use 100 ppm as a control value for managing the material safely.

Please note that these methods are BASIC protocols. Should a researcher perform one of these methods, all safety precautions should be thoroughly researched.

Sources:

1. Furr, Keith Handbook of Lab Safety, 4th ed., CRC Press, 1995
2. Kelly, Richard J., Review of Safety Guidelines for Peroxidizable Organic Chemicals, Chemical Health & Safety, American Chemical Society, Sept./Oct 1996

APPENDIX H: Shock Sensitive and Explosive Chemicals

Shock sensitive refers to the susceptibility of a chemical to rapidly decompose or explode when struck, vibrated or otherwise agitated. Explosive chemicals are those chemicals which have a higher propensity to explode under a given set of circumstances than other chemicals (extreme heat, pressure, mixture with an incompatible chemical, etc.). The label and SDS will indicate if a chemical is shock sensitive or explosive. The chemicals listed below may be shock sensitive or explode under a given number of circumstances and are listed only as a guide to **some** shock sensitive or explosive chemicals. Follow these guidelines:

- Write the date received and date opened on all containers of shock sensitive chemicals. Some chemicals become increasingly shock sensitive with age.
- Unless an inhibitor was added by the manufacturer, closed containers of shock sensitive materials should be discarded after 1 year.
- Wear appropriate personal protective equipment when handling shock sensitive chemicals.

acetylene
acetylides of heavy metal
amatex
amatol
ammonal
ammonium nitrate
ammonium perchlorate
ammonium picrate
azides of heavy metals
baratol
calcium nitrate
chlorate
copper acetylide
cyanuric triazide
cyclotrimethylenetrinitramine
dinitrophenol
dinitrophenyl hydrazine
dinitrotoluene
ednatol
erythritol tetranitrate
fulminate of mercury
fulminate of silver
ethylene oxide
ethyl-tetryl
fulminating gold
fulminating mercury
fulminating platinum
fulminating silver
gelatinized nitrocellulose
guanyl
guanyl nitrsamino
guanyltetrazene
hydrazine
nitrated carbohydrate
nitrated glucoside
nitrogen triiodide
nitrogen trichloride
nitroglycerin
nitroglycide
nitroglycol
nitroguanidine
nitroparaffins
nitrourea
organic nitramines
ozonides
pentolite
perchlorates of heavy metals
peroxides
picramic acid
picramide
picratol
picric acid
picryl sulphonic acid
silver acetylide
silver azide
tetranitromethane

Mixtures:

germanium
tetranitrocarbazole
hexanitrodiphenyamine
hexanitrostilbene
hexogen
hydrazoic acid
lead azide
lead mononitroresorcinate
lead styphnate
tetracene
urea nitrate
tetrytol
trimethylolethane
trimonite
trinitroanisole
trinitrobenzene
trinitrobenzoic acid
trinitrocresol
sodium picramate
tritonal

APPENDIX I: Carcinogens

The list below is a compilation of substances classified as carcinogens by the Michigan Occupational Safety and Health Administration (MIOSHA)[a], the International Agency for Research on Cancer (IARC)[b] and/or the National Toxicology Program (NTP)[c]. Some of these substances are classified as "select carcinogens" and require special work practices. See Section *1.4* for definition of "select carcinogen".

Chemical	MIOSHA	IARC	NTP
A-alpha-C(2-Amino-9H-pyrido[2,3-b]indole)		2B	
Acetaldehyde		2B	2
Acetamide		2B	
2-Acetylaminofluorene	Class A		2
Acid mists, strong inorganic		1	
Acrylamide		2A	2
Acrylonitrile	CH	2B	2
Adriamycin		2A	2
AF-2 (2-(2-Furyl)-3-(5-nitro-2-furyl)acrylamide)		2B	
Aflatoxin M1		2B	1
Alcoholic beverage consumption		1	1
Aflatoxins, naturally occurring		1	1
2-Aminoanthraquinone			2
p-Aminoazobenzene		2B	
o-Aminoazotoluene		2B	2
4-Aminobiphenyl	Class A	1	1
1-Amino-2,4-dibromoanthraquinone		2B	2
2-Amino-3,4-dimethylimidazo[4,5-f]quinoline (MeIQ)			2
2-Amino-3,8-dimethylimidazo[4,5-f]quinoxaline (MeIQx)			2
1-Amino-2-methylanthraquinone			2
2-Amino-3-methylimidazo[4,5-f]quinilone (IQ)			2
2-Amino-1-methyl-6-phenylimidazo[4,5-b]pyridine (PhIP)			2
2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole		2B	
Amitrole		2B	2
Amsacrine		2B	
Analgesic mixtures containing phenacetin			1
Androgenic (anabolic) steroid		2A	
o-Anisidine		2B	
o-Anisidine hydrochloride			2
Anthraquinone		2B	
Antimony trioxide		2B	
Aramite		2B	
Areca nut		1	
Aristolochic acid		1	1
Arsenic and compounds	CH	1	1
Asbestos	CH	1	1
Asbestos, actinolite	CH	1	
Asbestos, anthophylite	CH	1	
Asbestos, tremolite	CH	1	
Auramine (technical-grade)		2B	

Chemical	MIOSHA	IARC	NTP
Azacitidine		2A	2
Azaserine		2B	
Azathioprine		1	1
Aziridine		2B	
Basic Red 9 monohydrochloride			2
Benzal chloride			
Benz[a]anthracene		2B	2
Benz[j]aceanthrylene		2B	
Benzene	CH	1	1
Benzidine	Class A	1	1
Benzidine-based dyes		2A	
Benzo[a]pyrene		1	2
Benzo[b]fluoranthene		2B	2
Benzo[c]pheanthrene		2B	
Benzo[j]fluoranthene		2B	2
Benzo[k]fluoranthene		2B	2
Benzofuran		2B	
Benzophenone		2B	
Benzotrichloride		2A	2
Benzoyl chloride			
Benzyl chloride			
Benzyl violet 4B		2B	
2,2-Bis(bromomethyl)propane-1,3-diol		2B	2
Beryllium and certain compounds		1	1
Betel quid with tobacco		1	
Betel quid without tobacco		1	
4,4’-bis(diemthylamino)benzophenone (Michler’s ketone)			
N,N-Bis(2-chloroethyl)-2-naphthylamine (chlornaphazine)		1	
2,2-bis-(Bromoethyl)-1,3-propanediol		2B	2
Bis(chloromethyl)ether (technical grade)	Class A	1	1
Bischloroethyl nitrosourea (BCNU)		2A	2
Bitumens, occupational exposure to hard and straight-run		2B	
Bitumens, occupational exposure to oxidized		2A	
BK polyomavirus (BKV)		2B	
Bleomycins		2B	
Bracken fern		2B	
Bromochloroacetic acid		2B	
Bromodichloromethane		2B	2
Busulfan		1	
1,3-Butadiene		2A	1
1,4-Butanediol dimethanesulfonate (Busulphan Myleran)		1	2
Butylated hydroxyanisole (BHA)		2B	2
b-Butyrolactone		2B	
C.I. Acid Red 114		2B	
C.I. Basic Red 9		2B	2
C.I. Direct Blue 15		2B	
C.I. Citrus Red no. 2		2B	

Chemical	MIOSHA	IARC	NTP
Cadmium and cadmium compounds	CH	1	1
Caffeic acid		2B	
Captafol		2A	2
Carbazole		2B	
Carbon tetrachloride		2B	2
Catechol		2B	
Ceramic Fibres (respirable size)		2B	2
Carbon-black		2B	
Carrageenan, degraded		2B	
Chloral		2A	
Chloral Hydrate		2A	
Chlorambucil		1	1
Chloramphenicol		2A	2
Chlordane		2B	
Chlordecone (Kepone)		2B	2
Chlorendic acid		2B	2
p-Chloroaniline		2B	
Chlorinated paraffins (C12 60% Chlorine)		2B	2
a-Chlorinated toluenes		2A	
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)		2A	2
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea		1	1
Chloroform		2B	2
Chloromethyl methyl ether (technical-grade)	Class A	1	1
1-Chloro-2-methylpropene		2B	
3-Chloro-2-methylpropene			2
3-Chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone		2B	
Chlorophenoxy herbicides		2B	
4-Chloro-o-phenylenediamine		2B	2
Chloroprene		2B	2
Chlorothalonil		2B	
p-Choro-o-toluidine and its strong acid salts		2A	2
Chlorozotocin		2A	2
Chromium (VI) compounds		1	1
CI Acid Red 114		2B	
CI Basic Red 9		2B	
CI Direct Blue 15		2B	
Chrysene		2B	
Ciclosporin		1	
Cisplatin		2A	2
Citrus Red No. 2		2B	
Coal-tar pitches		1	1
Coal-tars		1	1
Cobalt and cobalt compounds		2B	
Colbalt metal with tungsten carbide		2A	2
Cobalt sulfate		2B	2
Coffee (urinary bladder)		2B	
Conjugated estrogens			1

Chemical	MIOSHA	IARC	NTP
Creosotes		2A	1
p-Cresidine		2B	2
Cumene		2B	
Cupferron			2
Cycasin		2B	
Cyclopenta[cd]pyrene		2A	
Cyclophosphamide		1	1
Cyclosporin A		1	1
DDT		2B	2
Dacarbazine		2B	2
Dantron (Chrysazin; 1, 8-Dihydroxyanthraquinone)		2B	2
Daunomycin		2B	
N,N'-Diacetylbenzidine		2B	
2,4-Diaminoanisole		2B	
1,4-Diaminoanisole sulfate			2
4,4'-Diaminodiphenyl ether		2B	2
2,4-Diaminotoluene		2B	2
Diazoaminobenzene			2
Dibenz[a, h]acridine		2B	2
Dibenz[a, h]anthracene		2A	2
Dibenz[a, j]acridine		2B	2
7H-Dibenzo[c,g]carbazole		2B	2
Dibenzo[a, e]pyrene			2
Dibenzo[a, h]pyrene		2B	2
Dibenzo[a, i]pyrene		2B	2
Dibenzo[a, l]pyrene		2A	2
Dibromoacetic acid		2B	
Dibromoacetonitrile		2B	
1,2-Dibromo-3-chloropropane (DBCP)	CH	2B	2
2,3-Dibromopropan-1-ol		2B	
Tris(2,3-Dibromopropyl) phosphate			2
p-Dichlorobenzene		2B	2
3,3'-Dichlorobenzidene dihydrochloride			2
3,3'-Dichlorobenzidine (and its salts)	Class A	2B	2
3,3'-Dichloro-4-4'-diaminodiphenyl ether		2B	
Dichlorodiphenyltrichloroethane			2
1,2-Dichloroethane		2B	2
Dichloromethane		2B	2
2-(2,4-Dichlorophenoxy)propionic acid		2B	
1,3-Dichloropropene (technical-grade)		2B	2
Dichlorvos		2B	
Diepoxybutane			2
Diesel engine exhaust particulates		1	2
Diesel fuel, marine		2B	
Diethanolamine		2B	
Di(2-ethylhexyl) phthalate		2B	2
1,2-Diethylhydrazine		2B	

Chemical	MIOSHA	IARC	NTP
Diethyl Sulfate		2A	2
Diethylstilbestrol (DES)		1	1
Diglycidyl resorcinol ether		2B	2
Digoxin		2B	
Dihydrosafrole		2B	
Diisopropyl sulfate		2B	
3,3'-Dimethoxybenzidine (o-Dianisidine)		2B	2
3,3'-Dimethoxybenzidine dihydrochloride			2
2,6-Dimethylaniline		2B	
Dimethylarsenic acid		2B	
3,3'-Dimethylbenzidine (o-Tolidine)		2B	2
1,2-Dimethylhydrazine		2A	
Dimethyl sulfate		2A	2
4-Dimethylaminoazobenzene	Class A	2B	2
Trans-2-[(Dimethylamino)methylimino]-5-[2-(5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole		2B	
Dimethylcarbamoyl Chloride		2A	2
1,1-Dimethylhydrazine		2B	2
Dimethyl vinyl chloride			2
3,7-Dinitrofluoranthene		2B	
3,9-Dinitrofluoranthene		2B	
1,3-Dinitropyrene		2B	
1,6-Dinitropyrene		2B	2
1,8-Dinitropyrene		2B	2
2,4-Dinitrotoluene		2B	
2,6-Dinitrotoluene		2B	
1,4-Dioxane		2B	2
Direct Black 38			1
Direct Blue 6			1
Disperse blue 1		2B	2
Doxorubicin hydrochloride			2
Dyes metabolized to benzidine		1	1
Engine exhaust, diesel		1	
Engine exhaust, gasoline		2B	
Environmental Tobacco Smoke			1
1,2-Epoxybutane		2B	
Epichlorohydrin		2A	2
Erionite		1	1
Estrogens (not conjugated) estradiol-17ß			2
Estrogens (not conjugated) estrone			2
Estrogens (not conjugated) ethinylestradiol			2
Estrogens (not conjugated) mestranol			2
Ethanl in Alcoholic Beverages		1	
Ethyl acrylate		2B	
Ethylbenzene		2B	
Ethyl carbamate		2A	
Ethylene thiourea			2
Ethylene dibromide		2A	2

Chemical	MIOSHA	IARC	NTP
Ethylene oxide	CH	1	1
Ethyleneimine	Class A		
Ethyl methanesulfonate		2B	2
N-Ethyl-N-nitrosourea		2A	2
Etoposide		1	
Etoposide in combination with cisplatin and bleomycin		1	
Formaldehyde	CH	1	1
2-(2-Formylhydrazino)-4-(5-(5-nitro-2-furyl)thiazole		2B	
Fowler's solution			
Fuel oil, residual		2B	
Fumonisin B1		2B	
Furan		2B	2
Gallium arsenide		1	
Gasoline		2B	
Gasoline engine exhaust fumes		2B	
Gasoline, unleaded		2B	
Ginkgo biloba extract		2B	
Glass fibers: E-glass and ‘475’ glass fibers			2
Glass wool (respirable size)			2
Glu-P-1 (2-amino-6-methyldipyrido[1, 2-a:3', 2'-d]imidazole)		2B	
Glu-P-2 (2-aminodipyrido[1, 2-a:3',2'-d]imidazole)		2B	
Glycidaldehyde		2B	
Glycidol		2A	2
Goldenseal root powder		2B	
Griseofulvin		2B	
HC blue 1		2B	
Heptachlor		2B	
Hexachlorobenzene		2B	2
Hexachlorocyclohexane (all isomers)		2B	
Hexachloroethane		2B	2
2,4-Hexadienal		2B	
Hexamethylphosphoramide		2B	2
Hydrazine (anhydrous)		2B	2
Hydrazine sulfate			2
Hydrochlorothiazide		2B	
Hydrazobenzene			2
1-Hydroxyanthraquinone		2B	
Indeno[1, 2, 3-cd]pyrene		2B	2
Indium phosphide		2A	
Inorganic-acid mists, containing sulfuric acid		1	
IQ (2-Amino-3-methylimidazo[4,5-f]quinoline)		2A	
Iron-dextran complex		2B	2
Isoprene		2B	2
Kava extract		2B	
Kepone		2B	2
Lasiocarpine		2B	
Lead		2B	2

Chemical	MIOSHA	IARC	NTP
Lead and lead compounds, inorganic		2A	2
Lead acetate			2
Lead phosphate			2
Leather dust		1	
Lindane			2
Magnetic fields, extremely low frequency		2B	
Magenta		2B	
Mate, hot		2A	
MeA-a-C (2-Amino-3-methyl-9H-pyrido[2, 3]indole)		2B	
Medroxyprogestrone acetate		2B	
MelQ (2-Amino-3,4-dimethylimidazol[4, 5f]quinoline		2B	
MelQx (2-Amino-3,8-dimethylimidazo[4, 5-f]quinoxaline		2B	
Melphalan		1	1
Merphalan		2B	
Methoxsalen witn Ultraviolet A therapy		1	1
5-Methoxypsoralen		2A	
8-Methoxysoralen (methoxsalen) plus ultraviolet A radiation		1	1
Methylarsonic acid		2B	
2-Methylaziridine (propyleneimine)		2B	2
Methylazoxymethanol acetate		2B	
5-Methylchrysene		2B	2
4,4'-Methylene bis(2-chloroaniline) (MOCA)		1	2
4,4'-Methylene bis(2-methylaniline)		2B	
4,4'-Methylene bis(N,N-dimethyl)benzenamine			2
4,4'-Methylenedianiline	CH	2B	2
4,4'-Methylenedianiline dihydrochloride			2
Methyleugenol		2B	2
2-Methylimidazole		2B	
4-Methylimidazole		2B	
Methyl isobutyl ketone		2B	
Methylmercury Compounds		2B	
Methyl methanesulfonate		2A	2
2-Methyl-1-nitroanthraquinone (uncertain purity)		2B	
N-Methyl-N'-nitro-N-nitrosoguanidine (MNNG)		2A	2
N-Methyl-N-nitrosourea		2A	
N-Methyl-N-nitrosourethane		2B	
Methylstyrene		2B	
Methylthiouracil		2B	
Metronidazole		2B	2
Michler’s base [4,4'-Methylene bis(N,N-dimethyl)benzenamine]		2B	
Michler's ketone [4,4’-(Dimethylamino)benzophenone]		2B	2
Microcystin-LR		2B	
Mineral oils, untreated and mildly-treated		1	1
Mirex		2B	2
Mitomycin C		2B	
Mitoxantrone		2B	
3-Monochloro-1,2-propanediol		2B	

Chemical	MIOSHA	IARC	NTP
Monocrotaline		2B	
MOPP and other combined chemotherapy including alkylating agents		1	
5-(Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino]-2-oxazolidinone		2B	
Mustard gas		1	1
Nafenopin		2B	
Naphthalene		2B	2
a-Naphthylamine	Class A		
b-Napthylamine	Class A	1	1
Neutrons		1	1
Nickel compounds		1	
Nickel and certain nickel compounds			1
Nickel metallic, and alloys		2B	1
Niridazole		2B	
Nitrate or nitrite under conditions that result in endogenous nitrosation		2A	
Nitrilotriacetic acid		2B	2
Nitrilotriacetic acid and its salts		2B	
5-Nitroacenaphthene		2B	
2-Nitroanisole		2B	2
3-Nitrobenzanthrone		2B	
Nitrobenzene		2B	2
4-Nitrobiphenyl	Class A		
6-Nitrochrysene		2A	2
Nitrofen, technical-grade		2B	2
2-Nitrofluorene		2B	
1-[(5-Nitrofurfurylidene)amino]-2-imidazolidinone		2B	
N-[4-(5-Nitro-2-furyl)-2-thiaxolyl]acetamide		2B	
Nitrogen mustard		2A	
Nitrogen mustard N-oxide		2B	
Nitrogen mustard hydrochloride			2
Nitromethane		2B	2
2-Nitropropane		2B	2
1-Nitropyrene		2B	2
4-Nitropyrene		2A	2
N-Nitrosodi-n-butylamine		2B	2
N-Nitrosodi-n-propylamine		2B	2
N-Nitrosodiethanolamine		2B	2
N-Nitrosodiethylamine		2A	2
N-Nitrosodimethylamine	Class A	2A	2
N-Nitroso-N-ethylurea			2
3-(N-Nitrosomethylamino)propionitirile		2B	
4-(N-Nitrosomethylamino)-1-(3-pyridyl)-butanone (NNK)		2B	2
N-Nitrosomethylethylamine		2B	
N-Nitroso-N-methylurea		2A	2
N-Nitrosomethylvinylamine		2B	2
N-Nitrosomorpholine		2B	2
N-Nitrosonornicotine		2B	2

Chemical	MIOSHA	IARC	NTP
N-Nitrosopiperidine		2B	2
N-Nitrosopyrrolidine		2B	2
N-Nitrososarcosine		2B	2
n-Nitrotoluene		2A	
o-Nitrotoluene			2
Norethisterone			2
Ochratoxin A		2B	2
Oestrogen-progestogen therapy, post-menopausal		2B	
Oestrogen replacement therapy		1	
Oestrogen, nonsteroidal		1	
Oestrogen, steroidal		1	1
Oil orange ss		2B	
Oral contraceptives, combined		1	
Oral contraceptives, sequential		1	
Oxazepam		2B	
4,4’-Oxydianiline			2
Oxymetholone			2
Palygorskite (long fibers, > 5 micrometers)		2B	
Panfuran S (containing dihydorxymethylfuratrizine)		2B	
3,4,5,3',4'-Pentachlorobiphenyl (PCB-126)		1	
2,3,4,7,8-Pentachlorodibenzofuran		1	
Pentosan polysulfate sodium			
Pickled vegetables		2B	
Phenacetin		1	2
Phenazopyridine hydrochloride		2B	2
Phenobarbital		2B	
Phenolphthalein		2B	2
Phenoxybenzamine hydrochloride		2B	2
Phenyl glycidyl ether		2B	
Phenytoin		2B	2
Phlp (2-Amino-1-methyl-6-phenyl-imidazo[4,5-b]pyridine)		2B	
Piperazine estrone sulfate			1
Polycyclic aromatic hydrocarbons (PAHs)			2
Polybrominated biphenyls (PBBs)		2A	2
Polychlorinated biphenyls (PCBs)		1	2
Polychlorinated biphenyls, dioxin-like, with a Toxicity Equivalency Factor (TEF) according to WHO		1	
Polychlorophenols and their sodium salts		2B	
Ponceau 3R		2B	
Ponceau MX		2B	
Potassium bromate		2B	
Primidone		2B	
Procarbazine hydrochloride		2A	2
Progesterone			2
Progestins		2B	
Progestogen-only contraceptives		2B	
1,3-Propane sultone		2B	2
b-Propiolactone	Class A	2B	2

Chemical	MIOSHA	IARC	NTP
Propyleneimine		2B	2
Propylene oxide		2B	2
Propylthiouracil		2B	2
Pulegone		2B	
Radon 222 and its decay products		1	1
Refractory ceramic fibers		2B	
Riddelliine		2B	2
Reserpine			2
Safrole		2B	2
Salted fish, Chinese-style		1	
Selenium sulfide			2
Semustine		1	
Shale-oils		1	
Silica, crystalline cristobalite (respirable size)		1	1
Silica, crystalline tridymite (respirable size)			1
Silica, crystalline quartz (respirable size)		1	1
Sodium equilin sulfate			1
Sodium estrone sulfate			1
Sodium ortho-phenylphenate		2B	
Solar radiation		1	1
Soots		1	1
Special-purpose fibers such as E-glass and '475' glass fibers		2B	
Sterigmatocystin		2B	
Streptozotocin		2B	2
Strong inorganic acid mists containing sulfuric acid		1	1
Styrene		2B	2
Styrene-7,8-oxide		2A	2
Sulfallate		2B	2
Sulfasalazine		2B	
Sulfur mustard		1	
Talc (containing asbestos fibers)		1	
Tamoxifen		1	1
Tars			1
Teniposide		2A	
2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)		1	1
1,1,1,2-Tetrachloroethane		2B	
1,1,2,2-Tetrachloroethane		2B	
Tetrachloroethylene		2A	2
Tetrafluoroethylene		2B	2
Tetranitromethane		2B	2
Thioacetamide		2B	2
4,4'-Thiodianiline		2B	2
Thiotepa		1	1
Thiouracil		2B	
Thiourea			2
Thorium dioxide			1
Titanium dioxide		2B	

Chemical	MIOSHA	IARC	NTP
Tobacco products, smokeless		1	1
Tobacco smoke		1	1
o-Toluidine		2B	2
Toluene diisocyanates		2B	2
o-Toluidine		2A	2
o-Toluidine hydrochloride			2
Toxaphene (Polychlorinated camphenes)		2B	2
Treosulfan		1	
Triamterene		2B	
Trichlormethine (trimustine hydrochloride)		2B	
Trichloroacetic acid		2B	
Trichloroethylene		1	2
2,4,6-Trichlorophenol			2
1,2,3-Trichloropropane		2A	2
Tris (2,3-dibromopropyl)phosphate		2A	2
Trp-P-1 (3-Amino-1,4-dimethyl-5H-pyrido[4,3-b] indole)		2B	
Trp-P-2 (3-Amino-1-methyl-5H-pyrido[4,3-b]indole)		2B	
Trypan blue		2B	
Ultraviolet radiation A		1	2
Ultraviolet radiation B		1	2
Ultraviolet radiation C		1	2
Ultraviolet radiation, broad spectrum			1
Uracil mustard		2B	
Urethane		2A	2
Vanadium pentoxide		2B	
Vinyl acetate		2B	
Vinyl bromide		2A	2
Vinyl chloride	CSA	1	1
4-Vinyl cyclohexene		2B	
4-Vinyl-1-cyclohexene diepoxide			2
4-Vinylcyclohexene diepoxide		2B	
Vinyl fluoride		2A	2
Welding Fumes		2B	
Wood dust		1	1
Zalcitabine		2B	
Zidovidine		2B	

(a) Michigan Occupational Safety and Health Administration (MIOSHA):
Class A: Regulated as a known human carcinogen
CSA: listed as a Cancer Suspect Agent
CH: listed as a Cancer Hazard

(b) International Agency for Research on Cancer (IARC):
1. Carcinogenic to humans with sufficient epidemiological evidence
2A. Probably carcinogenic to humans with (usually) at least limited human evidence
2B. Probably carcinogenic to humans, but having (usually) no human evidence
For a complete listing of IARC carcinogens, mixtures and exposure circumstances, see www.iarc.fr

(c) National Toxicology Program (NTP):

1. Known to be carcinogenic with evidence from human studies
2. Reasonably anticipated to be a carcinogen, with sufficient evidence in experimental animals and/or limited evidence in humans. More information on NTP carcinogens can be found at: http://ntp-server.niehs.nih.gov

APPENDIX J: Permissible Exposure Limits for Particularly Hazardous Substances

The Michigan Occupational Safety and Health Administration and the American Conference of Governmental Industrial Hygienists (ACGIH) have determined safe exposure limits for work with hazardous chemicals. The Permissible Exposure Limits (PELs) are MIOSHA standards, which must be upheld by the employer at all times. In some cases, the Threshold Limit Value (TLV) established by ACGIH may be lower than the OSHA PEL. In these cases, employers must strive to keep exposures as low as reasonably achievable and follow the TLV's. Substances followed by the word skin refer to the potential for significant adsorption through the skin. *Note*: PELs and TLV's are explicitly defined in the glossary section of the appendices.

Please see the State of Michigan website for the latest information:

https://www.michigan.gov/documents/lara/lara_miosha_part301_426873_7.pdf

APPENDIX K: Hazardous Materials Subject to Prior Approval from EHS

Biological Materials - please contact the Biological Safety Officer from EHS

Radioactive Materials - please contact the Radiation Safety Officer from EHS

55 gallon drums – please contact MSU EHS at 517-355-0153 before purchasing, storing and/or using large quantities of chemicals in a Michigan State University laboratory unit.

Contact EHS at 355-0153 before purchasing or using any of these substances in a Michigan State University laboratory unit:

MIOSHA Class 'A' Carcinogens:

2-Acetylaminofluorene
4-Aminodiphenyl (4-aminobiphenyl)
Benzidine
bis-Chloromethyl ether
3-3'-Dichlorobenzidine (and its salts)
4-Dimethylaminoazobezene
Ethyleneimine
Methylchloromethyl ether
alpha-Naphthylamine
beta-Naphthylamine
4-Nitrobiphenyl
N-Nitrosodimethylamine
beta-Propiolactone

The following chemicals have MIOSHA specific regulations. Contact EHS if employee exposure to these chemicals could exceed the occupational health limits:

Ethylene oxide
Formaldehyde
Acrylonitrile
Inorganic arsenic
Lead
Benzene
Vinyl Chloride
1,2-Dibromo-3-chloropropane (DBCP)

APPENDIX L: MSU Human Resources Links for Occupational Injury or Illness Forms

1. Authorization to Invoice MSU
https://hr.msu.edu/benefits/workers-comp/documents/InvoiceMSU.pdf

2. **Authorization to invoice MSU outside of Lansing Area**
https://hr.msu.edu/benefits/workers-comp/documents/InvoiceMSUnonLansing.pdf

3. Report of a Claimed Occupational Injury or Illness
https://www.hr.msu.edu/ua/forms/documents/AccidentReport.pdf

4. Michigan State University Exposure to Health Risk Information
https://www.hr.msu.edu/ua/hiring/documents/healthriskphysdemands.pdf

5. Support Staff Disability /Reasonable Accommodations Policy & Procedure
https://hr.msu.edu/policies-procedures/support-staff/support-staff-policies-procedures/disability.html

APPENDIX M: Laboratory Inspection Checklist

Location: _____ Safety Rep _____

PI: _____ Inspection Date: _____

Department: _____ Inspected By _____

General

○ Yes ○ No ○ NA	1.	Emergency phone numbers are posted on the laboratory door.
○ Yes ○ No ○ NA	2.	Warning signs are posted on doors.
○ Yes ○ No ○ NA	3.	Right-to-Know law bulletin is posted within department.
○ Yes ○ No ○ NA	4.	All personnel know how to obtain MSDSs.
○ Yes ○ No ○ NA	5.	All personnel have received Lab Specific Training.
○ Yes ○ No ○ NA	6.	All personnel have received ORCBS Lab Safety Training.
○ Yes ○ No ○ NA	7.	Lab coats are available.
○ Yes ○ No ○ NA	7a.	Lab coats are worn.
○ Yes ○ No ○ NA	8.	Chemical protective gloves are available.
○ Yes ○ No ○ NA	8a.	Reusable gloves are in good condition.
○ Yes ○ No ○ NA	9.	Safety glasses/goggles are available.
○ Yes ○ No ○ NA	9a.	Safety glasses/goggles are worn.
○ Yes ○ No ○ NA	10.	An eyewash fountain is present (deck, drench, combo, faucet, plumbed, portable).
○ Yes ○ No ○ NA	10a.	Eyewash/shower is unobstructed.
○ Yes ○ No ○ NA	10b.	Eyewash test log is available.
○ Yes ○ No ○ NA	10c.	Eyewash design, location and quantity is adequate.
○ Yes ○ No ○ NA	11.	An emergency shower is present (in room, in hallway, in neighboring lab).
○ Yes ○ No ○ NA	12.	Food and beverage are not stored or used in lab.
○ Yes ○ No ○ NA	13.	Aisles are uncluttered and without a tripping hazard.
○ Yes ○ No ○ NA	14.	Chemical spill kits are available.
○ Yes ○ No ○ NA	15.	Non-contaminated broken glass bucket available.
○ Yes ○ No ○ NA	16.	Fume hoods have current ORCBS inspection sticker.
○ Yes ○ No ○ NA	17.	All exit ways are free and unobstructed.
○ Yes ○ No ○ NA	18.	Fire extinguishers are available and unobstructed.
○ Yes ○ No ○ NA	19.	Fire extinguishers have MSU IPF tag and are sealed.
○ Yes ○ No ○ NA	20.	Current inventory of chemicals is available.
○ Yes ○ No ○ NA	21.	Chemical Hygiene Plan is available.
○ Yes ○ No ○ NA	22.	Laboratory SOP's are available.

Chemical Storage and Handling

○ Yes ○ No ○ NA	1.	Gas cylinders are properly secured.
○ Yes ○ No ○ NA	2.	No leaking containers are present.
○ Yes ○ No ○ NA	3.	All chemical containers are properly labeled.
○ Yes ○ No ○ NA	4.	Chemicals are stored according to compatibility.
○ Yes ○ No ○ NA	5.	Peroxide forming reagents are dated when opened.
○ Yes ○ No ○ NA	6.	Peroxide forming reagents are disposed of or tested after expiration date.
○ Yes ○ No ○ NA	7.	Chemical storage areas are labeled.
○ Yes ○ No ○ NA	8.	Flammables are kept away from sources of heat, ignition, flames, etc.
○ Yes ○ No ○ NA	9.	Corrosive materials are stored low to the ground.
○ Yes ○ No ○ NA	10.	Carcinogen storage area(s) is labeled.
○ Yes ○ No ○ NA	11.	Chemicals in the open are kept to a minimum.
○ Yes ○ No ○ NA	12.	Flammable/Combustible liquids do not exceed NFPA storage limits.
○ Yes ○ No ○ NA	13.	Flammable/Combustible liquid total volume is not greater than 10 gallons.
○ Yes ○ No ○ NA	14.	Flammable gases are not present.
○ Yes ○ No ○ NA	15.	Poisonous gases are not present.

Chemical Waste

○ Yes ○ No ○ NA	1.	Hazardous waste containers are labeled and have closed lids.
○ Yes ○ No ○ NA	2.	Hazardous waste tags are complete.
○ Yes ○ No ○ NA	3.	Hazardous wastes are not stored beyond 90 days.

APPENDIX N: Policy for Termination of Laboratory and Containment Area Use of Hazardous Materials

Please see the MSU EHS website for the latest information:
https://ehs.msu.edu/lab-clinic/closeouts/index.html

APPENDIX O: Equipment Release Form

Please see the MSU EHS website for the latest version:
https://ehs.msu.edu/_assets/docs/lab/equipment-release-form.pdf

APPENDIX P: Industrial Toxicology - Overview

Chemical Toxicology

Toxicology is the study of the nature and action of chemical poisons.

Toxicity is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body.

Toxicity hazard is the probability that injury will occur considering the manner in which the substance is used.

Dose-Response Relationship

The potential toxicity (harmful action) inherent in a substance is exhibited only when that substance comes in contact with a biological system. A chemical normally thought of as "harmless" may evoke a toxic response if added to a biological system in sufficient amount. The toxic potency of a chemical is thus defined by the response that is produced in a biological system.

Routes of Entry into the Body

There are four main routes by which hazardous chemicals enter the body:

- Inhalation: Absorption through the respiratory tract. Most important in terms of severity.
- Skin absorption or absorption through the mucous membranes.
- Ingestion: Absorption through the digestive tract. Can occur through eating or smoking with contaminated hands or in contaminated work areas.
- Injection: Introduction of toxin into bloodstream; can occur by accidental needle stick or puncture of skin with a sharp object.

Exposure Limits as Related to Routes of Entry

Most exposure standards are based on the inhalation route of exposure. They are normally expressed in terms of parts per million (ppm) or milligrams per cubic meter (mg/m^3) concentration in air.

The Occupational Safety and Health Administration (OSHA) has established Permissible Exposure Limits (PELs) and the American Conference of Governmental Industrial Hygienists (ACGIH) has established Threshold Limit Values (TLV's) for employee exposure limits. In many instances, the PEL and TLV are represented as the same number. In the instances where one is lower than the other, it is a prudent safety practice to maintain exposures at the lowest level achievable.

If a significant route of exposure for a substance is through skin contact, the TLV or PEL will have a “skin” notation. Examples are pesticides, carbon tetrachloride, cyanides, ethylenediamine and thallium.

Appendix K of this document lists PELs and TLV's for many hazardous chemicals. For a more complete list, see the ACGIH publication "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices." The latest edition lists both TLV's and PELs.

Types of Effects

Acute poisoning is characterized by rapid absorption of the substance when the exposure is sudden and severe. Normally, a single large exposure is involved. Examples are carbon monoxide or cyanide poisoning.

Chronic poisoning is characterized by prolonged or repeated exposures of a duration measured in days, months or years. Symptoms may not be immediately apparent. Examples are lead or mercury poisoning, or pesticide exposure.

Local refers to the site of action of an agent where the action takes place at the point or area of contact. The site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc. Absorption does not necessarily occur. Examples are strong acids or alkalis.

Systemic refers to a site of action other than the point of contact and presupposes absorption has taken place. For example, an inhaled material may act on the liver. For example, inhaled benzene affects the bone marrow.

Cumulative poisons are characterized by materials that tend to build up in the body as a result of numerous chronic exposures. The effects are not seen until a critical body burden is reached. Examples are heavy metals.

Synergistic or potentiating effects occur when two or more hazardous materials present at the same time have a resulting action greater than the effect predicted based on the individual substances. For example, workers exposed to benzene may show a direct toxicity in hematopoietic tissue and therefore be more susceptible to oxygen-displacing agents such as carbon monoxide.

Other Factors Affecting Toxicity

Rate of entry and route of exposure - how fast the toxic dose is delivered and by what means.

Age - can affect the capacity to repair damaged tissue.

Previous exposure - can lead to tolerance, increased sensitivity, or make no difference.

State of health, medications, physical condition, and life style - can affect the toxic response. Pre-existing disease can result in increased sensitivity.

Environmental factors - temperature and pressure, for example, can affect exposure.

Host factors - genetic predisposition and the sex of the exposed individual.

Physical Class Effects on Toxicity

When considering the toxicity of gases and vapors, the **solubility of the substance** is a key factor. Highly soluble materials like ammonia irritate the upper respiratory tract. On the other hand, relatively insoluble materials like nitrogen dioxide penetrate deep into the lung. Fat soluble materials, like pesticides, tend to have longer residence times in the body.

An **aerosol** is composed of solid or liquid particles of microscopic size dispersed in a gaseous medium. The toxic potential of an aerosol is only partially described by its concentration in milligrams per cubic meter (mg/m3). For a proper assessment of the toxic hazard, the size of the aerosol's particles is important. Particles above 1 micrometer tend to deposit in the upper respiratory tract. Particles less than 1 micrometer in diameter enter the lung. Very small particles (< 0.2 μm) are generally not deposited.

Physiological Classifications of Toxic Materials

Irritants are materials that cause inflammation of mucous membranes with which they come in contact. Inflammation of tissue results from concentration far below those needed to cause corrosion. Examples include:

- ammonia
- hydrogen chloride
- halogens
- phosgene
- nitrogen dioxide
- arsenic trichloride
- alkaline dusts and mists
- hydrogen fluoride
- ozone
- diethyl/dimethyl sulfate
- phosphorus chlorides

Irritants can also cause changes in the mechanics of respiration and lung function. Examples include:

- sulfur dioxide
- formaldehyde
- sulfuric acid
- iodine
- acetic acid
- formic acid
- acrolein

Long term exposure to irritants can result in increased mucous secretions and chronic bronchitis.

A **primary irritant** exerts no systemic toxic action because the products formed on the tissue of the respiratory tract are non-toxic or because the irritant action is far in excess of any systemic toxic action. Example: hydrogen chloride.

A **secondary irritant's** effect on mucous membranes is over-shadowed by a systemic effect resulting from absorption. Examples include:

- hydrogen sulfide
- aromatic hydrocarbons

Exposure to a secondary irritant can result in pulmonary edema, hemorrhage, and tissue necrosis.

Corrosives are chemicals which may cause visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact. Examples include:

- sulfuric acid
- chromic acid
- potassium hydroxide
- sodium hydroxide

Asphyxiants have the ability to deprive tissue of oxygen.

Simple asphyxiants are inert gases that displace oxygen. Examples include:

- nitrogen
- carbon dioxide
- helium
- argon

Chemical asphyxiants render the body incapable of utilizing an adequate oxygen supply. They are toxic at very low concentrations (few ppm). Examples include:

- carbon monoxide
- cyanides
- hydrogen sulfide

Primary anesthetics have a depressant effect upon the central nervous system, particularly the brain. Examples include:

- halogenated hydrocarbons
- alcohols

Hepatotoxic agents cause damage to the liver. Examples include:

- carbon tetrachloride
- nitrosamines
- tetrachloroethane

Nephrotoxic agents cause damage to the kidneys. Examples include:

- halogenated hydrocarbons
- uranium compounds

Neurotoxic agents damage the nervous system. The nervous system is especially sensitive to organometallic compounds and certain sulfide compounds. Examples include:

- trialkyl tin compounds
- organic phosphorus insecticides
- tetraethyl lead
- thallium
- methyl mercury
- manganese
- carbon disulfide

Hematopoietic (blood) system agents either directly affect blood cells or bone marrow. Examples include:

- nitrites
- toluidine
- benzene
- aniline
- nitrobenzene

Pulmonary tissue (lungs) agents can be toxic, through other mean than by immediate irritant action. Fibrotic changes can be caused by free crystalline silica and asbestos. Other dusts can cause a restrictive disease called pneumoconiosis. Examples include:

- coal dust
- cotton dust
- wood dust

A **teratogen** (embryo toxic or fetotoxic agent) is an agent which interferes with normal embryonic development without damage to the mother or lethal effect on the fetus. Effects are not hereditary. Examples include:

- lead
- dibromo dichloropropane

A **mutagen** is a chemical agent which may able to react with nucleophilic structures such as DNA. Mutations can occur on the gene level (gene mutations) when, for example, one nucleotide base-pair is change to another. Mutations can also occur on the chromosomal level when the number of chromosomal units or their morphological structure is altered. Examples of mutagens include most radioisotopes, barium permanganate and methyl isocyanate.

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

- epoxides
- poison ivy
- chlorinated hydrocarbons
- amines
- nickel compounds
- chromium compounds
- formaldehyde
- toluene diisocyanate

Target Organ Effects

The following is a target organ categorization of effects which may occur from exposure to hazardous chemicals, including examples of signs and symptoms and chemicals which have been found to cause such effects.

- **Hepatotoxins (liver)**
  Signs and symptoms: jaundice, liver enlargement
  Example chemicals: carbon tetrachloride, nitrosamines, chloroform, toluene, perchloroethylene, cresol, dimethylsulfate

- **Nephrotoxins (kidney)**
  Signs and symptoms: edema, proteinuria
  Example chemicals: halogenated hydrocarbons, uranium, chloroform, mercury, dimethyl sulfate

- **Neurotoxins (nervous system)**
  Signs and symptoms: narcosis, behavioral changes, decreased muscle coordination
  Example chemicals: mercury, carbon disulfide, benzene, carbon tetrachloride, lead, mercury, nitrobenzene

- **Hematopoietic (blood) system**
  Signs and symptoms: cyanosis, loss of consciousness
  Example chemicals: carbon monoxide, cyanides, nitrobenzene, aniline, arsenic, benzene, toluene

- **Pulmonary (lung) system**
  Signs and symptoms: cough, tightness in chest, shortness of breath
  Example chemicals: silica asbestos, nitrogen dioxide, ozone, hydrogen sulfide, chromium, nickel, alcohol

- **Reproductive system (mutations and teratogenesis)**
  Signs and symptoms: birth defects, sterility
  Example chemicals: lead, dibromo dichloropropane

- **Skin (dermal layer)**
  Signs and symptoms: defatting of skin, rashes, irritation
  Example chemicals: ketones, chlorinated compounds, alcohols, nickel, phenol, trichloroethylene

- **Eye or vision**
  Signs and symptoms: conjunctivitis, corneal damage
  Example chemicals: organic solvents, acids, cresol, quinone, hydroquinone, benzyl chloride, butyl alcohol, bases

APPENDIX Q: Glossary

ACGIH -- The American Conference of Governmental Industrial Hygienists is a voluntary membership organization of professional industrial hygiene personnel in governmental or educational institutions. The ACGIH develops and publishes recommended occupational exposure limits each year called Threshold Limit Values (TLV's) for hundreds of chemicals, physical agents, and includes Biological Exposure Indices (BEI).

Action Level -- A concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

Acute -- Severe, often dangerous exposure conditions in which relatively rapid changes occur.

Acute Exposure -- An intense chemical exposure over a relatively short period of time

ANSI -- The American National Standards Institute is a voluntary membership organization (run with private funding) that develops national consensus standards for a wide variety of devices and procedures.

Asphyxiants -- A chemical (gas or vapor) that can cause death or unconsciousness by suffocation. Simple asphyxiants such as nitrogen, either use up or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to the tissues.

Autoclave -- A device to expose items to steam at a high pressure in order to decontaminate the materials or render them sterile.

Biohazard -- Infectious agents that present a risk or potential risk to the health of humans or other animals, either directly through infection or indirectly through damage to the environment.

Boiling Point -- The temperature at which the vapor pressure of a liquid equals atmospheric pressure or at which the liquid changes to a vapor. The boiling point is usually expressed in degrees Fahrenheit. If a flammable material has a low boiling point, it indicates a special fire hazard.

"**C**" or **Ceiling --** A description usually seen in connection with a published exposure limit. It refers to the concentration that should not be exceeded, even for an instant. It may be written as TLV-C or Threshold Limit Value—Ceiling (See also THRESHOLD LIMIT VALUE).

Carcinogen -- A substance that may cause cancer in animals or humans.

C.A.S. Number -- Identifies a particular chemical by the Chemical Abstracts Service, a service of the American Chemical Society that indexes and compiles abstracts of worldwide chemical literature called "Chemical Abstracts."

Chemical Hygiene Officer -- An employee who is designated by the employee and who is qualified by training and experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. 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.

Chemical Hygiene Plan -- A written program developed and implemented by the department which sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting students, instructors and other personnel from the health hazards presented by the hazardous chemicals used in that particular workplace.

Chronic exposure -- A prolonged exposure occurring over a period of days, weeks, or years.

Combustible -- According to the DOT and NFPA, COMBUSTIBLE liquids are those having a flash point at or above 100°F (37.8°C), or liquids that will burn. They do not ignite as easily as flammable liquids. However, combustible liquids can be ignited under certain circumstances, and must be handled with caution. Substances such as wood, paper, etc., are termed "Ordinary Combustibles."

Compressed Gas -- A gas or mixture of gases that, in a container, will have an absolute pressure exceeding 40 psi at 70˚F or 21.1˚C. A gas or mixture of gases having an absolute pressure exceeding 104 psi at 130˚F or 54.4˚C, regardless of the pressure at 70˚F. A liquid having a vapor pressure exceeding 40 psi at 100˚F or 37.8˚C.

Concentration -- The relative amount of a material in combination with another material. For example, 5 parts (of acetone) per million (parts of air).

Corrosive -- A substance that, according to the DOT, causes visible destruction or permanent changes in human skin tissue at the site of contact or is highly corrosive to steel.

Cutaneous/Dermal -- Pertaining to or affecting the skin.

Cytotoxin -- A substance toxic to cells in culture, or to cells in an organism.

Decomposition -- The breakdown of a chemical or substance into different parts or simpler compounds. Decomposition can occur due to heat, chemical reaction, decay, etc.

Designated Area -- An area which may be used for work with select carcinogens, reproductive toxins or substances which have a high degree of acute toxicity. This area may be the entire laboratory or an area under a device such as a laboratory hood.

Dermatitis -- An inflammation of the skin.

Dilution Ventilation -- See GENERAL VENTILATION.

DOT -- The United States Department of Transportation is the Federal agency that regulates the labeling and transportation of hazardous materials.

Dyspnea -- Shortness of breath, difficult or labored breathing.

EPA -- The Environmental Protection Agency is the governmental agency responsible for administration of laws to control and/or reduce pollution of air, water, and land systems.

EPA Number -- The number assigned to chemicals regulated by the Environmental Protection Agency (EPA).

Epidemiology -- The study of disease in human populations.

Erythemia -- A reddening of the skin.

Evaporation Rate -- The rate at which a material is converted to vapor (evaporates) at a given temperature and pressure when compared to the evaporation rate of a given substance. Health and fire hazard evaluations of materials involve consideration of evaporation rates as one aspect of the evaluation.

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 Gas -- A gas that, at an ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or, a gas that, at an ambient temperature and pressure forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

Flammable Liquid -- According to the DOT and NFPA a flammable liquid is one that has a flash point below 100°F. (See FLASH POINT).

Flammable Solid -- A solid, other than a blasting agent or explosive, 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 it creates a serious hazard.

Flash Point -- The lowest temperature at which a liquid gives off enough vapor to form an ignitable mixture and burn when a source of ignition (sparks, open flames, etc.) is present. Two tests are used to determine the flash point: open cup and closed cup. The test method is indicated on the SDS after the flash point.

Fume -- A solid particle that has condensed from the vapor state.

Gas -- Chemical substances that exist in the gaseous state at room temperature.

General Ventilation -- Also known as general exhaust ventilation, this is a system of ventilation consisting of either natural or mechanically induced fresh air movements to mix with and dilute contaminants in the workroom air. This is not the recommended type of ventilation to control contaminants that are highly toxic, when there may be corrosion problems from the contaminant, when the worker is close to where the contaminant is being generated, and where fire or explosion hazards are generated close to sources of ignition (See LOCAL EXHAUST VENTILATION).

Grams per Kilogram (g/Kg) -- This indicates the dose of a substance given to test animals in toxicity studies. For example, a dose may be 2 grams (of substance) per kilogram of body weight (of the experimental animal).

Hazardous Chemicals -- Any chemical for which there is significant evidence, that acute or chronic health effects may occur in exposed personnel. The term “health hazard” includes chemicals that are carcinogens, toxins, irritants, corrosives, sensitizers or other agents that can damage the lungs, skin, eyes or mucous membranes.

Ignitable -- A solid, liquid or compressed gas waste that has a flash point of less than 140°F. Ignitable material may be regulated by the EPA as a hazardous waste, as well.

Incompatible -- The term applied to two substances to indicate that one material cannot be mixed with the other without the possibility of a dangerous reaction.

Ingestion -- Taking a substance into the body through the mouth as food, drink, medicine, or unknowingly as on contaminated hands or cigarettes, etc.

Inhalation -- The breathing in of an airborne substance that may be in the form of gas, fumes mists, vapors, dusts, or aerosols.

Inhibitor -- A substance that is added to another to prevent or slow down an unwanted reaction or change.

Irritant -- A substance that produces an irritation effect when it contacts skin, eyes, nose, or respiratory system.

Laboratory -- A facility where relatively small quantities of hazardous materials are used on a non-production basis.

Laboratory Scale -- Work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person.

Laboratory-type Hood -- A device constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory.

Laboratory Use of Hazardous Materials -- The handling or use of chemicals in which the following conditions are met: (1) Chemical manipulations are carried out on a laboratory scale. (2) Multiple chemical procedures or chemicals are used. (3) The procedures involved are not part of a production process. (4) Protective laboratory practices and equipment are available and in common use to minimize the potential for personnel exposure to hazardous chemicals.

Laminar Air Flow -- Air flow in which the entire mass of air within a designated space move with uniform velocity in a single direction along parallel flow lines with a minimum of mixing.

Lethal Concentration$_{50}$ -- The concentration of an air contaminant **(LC_{50})** that will kill 50 percent of the test animals in a group during a single exposure.

Lethal Dose$_{50}$ -- The dose of a substance or chemical that will **(LD_{50})** kill 50 percent of the test animals in a group within the first 30 days following exposure.

Local Exhaust Ventilation (Also known as exhaust ventilation) **--** A ventilation system that captures and removes air contaminants at the point they are being produced before they escape into the workroom air. The system consists of hoods, ductwork, a fan and possibly an air cleaning device. Advantages of local exhaust ventilation over general ventilation include: removing the contaminant rather than diluting it; less airflow making it a more economical system over the long run; and conservation or reclamation of valuable materials. However, the system must be properly designed with the correctly shaped and placed hoods, correctly sized fans and correctly connected ductwork.

Lower Explosive Limit (LEL) (Also known as Lower Flammable Limit-LFL) **--** The lowest concentration of a substance that will produce a fire or flash when an ignition source (flame, spark, etc.) is present. It is expressed in percent of vapor or gas in the air by volume. Below the LEL or LFL, the air/contaminant mixture is theoretically too "lean" to burn (See also UEL).

Melting Point -- The temperature at which a solid changes to a liquid. A melting range any be given for mixtures.

MSHA -- The Mine Safety and Health Administration; a Federal agency that regulates the mining industry in the safety and health area.

Mutagen -- Anything that can cause a change (or mutation) in the genetic material of a living cell.

Narcosis -- Stupor or unconsciousness caused by exposure to a chemical.

NFPA -- The National Fire Protection Association is a voluntary membership organization whose aims are to promote and improve fire protection and prevention. NFPA has published 16 volumes of codes known as the National Fire Codes. Within these codes is Standard No. 704, "Identification of the Fire Hazards of Materials." This is a system that rates the hazard of a material during a fire. These hazards are divided into health, flammability, and reactivity hazards and appear in a well-known diamond system using from zero through four to indicate severity of the hazard. Zero indicates no special hazard and four indicates severe hazard.

NIOSH -- The National Institute for Occupational Safety and Health is a Federal agency that among its various responsibilities trains occupational health and safety professionals, conducts research on health and safety concerns, and tests and certifies respirators for workplace use.

Occupational Safety and Health Administration (OSHA) -- Federal agency under the Department of Labor that publishes and enforces safety and health regulations for most businesses and industries in the United States.

Odor Threshold -- The minimum concentration of a substance at which a majority of test subjects can detect and identify the substance's characteristic odor.

Oxidation -- The process of combining oxygen with some other substance or a chemical change in which and atom loses electrons.

Oxidizer -- Is a substance that gives up oxygen easily to stimulate combustion of organic material.

Oxygen Deficiency -- An atmosphere having less than the normal percentage of oxygen found in normal air. Normal air contains 21% oxygen at sea level.

Permissible Exposure Limit (PEL) -- An exposure limit that is published and enforced by OSHA as a legal standard. PEL may be either a time-weighted-average (TWA) exposure limit (8 hour), a 15-minute short term exposure limit (STEL), or a ceiling (C). The PELs are found in Tables Z-1, Z-2, or Z-3 of OSHA regulations 1910.1000. (See also TLV).

Personal Protective Equipment (PPE) -- Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, and chemical splash goggles.

Physical Hazard -- A chemical that has scientifically valid evidence proving it to be a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

Polymerization -- A chemical reaction in which two or more small molecules combine to form larger molecules that contain repeating structural units of the original molecules. A hazardous polymerization is the above reaction with an uncontrolled release of energy.

RAD -- The unit of absorbed dose equal to 100 ergs per gram or 0.01 joules per kilogram of absorbing material.

Reactivity -- A substance's susceptibility to undergoing a chemical reaction or change that may result in dangerous side effects, such as explosion, burning, and corrosive or toxic emissions. The conditions that cause the reaction, such as heat, other chemicals, and dropping, will usually be specified as "Conditions to Avoid" when a chemical's reactivity is discussed on a SDS.

Reproductive Toxins -- Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses.

Respirator -- A device which is designed to protect the wearer from inhaling harmful contaminants.

Respiratory Hazard -- A particular concentration of an airborne contaminant that, when it enters the body by way of the respiratory system or by being breathed into the lungs, results in some bodily function impairment.

Select carcinogen -- A chemical listed by MIOSHA as a carcinogen, by the National Toxicology Program (NTP) as "known to be carcinogenic" or by the International Agency for Research on Cancer (IARC) as a Group 1 carcinogen. Also included are chemicals or processes listed in either Group 2A or 2B by IARC, or under the category "reasonably anticipated to be carcinogens" by NTP and that cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

- 1. 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
- 2. After repeated skin application of less than 300 mg/kg of body weight per week
- 3. After oral dosages of less than 50 mg/kg of body weight per day

Sensitizer -- A substance that may cause no reaction in a person during initial exposures, but afterwards, further exposures will cause an allergic response to the substance.

Short Term Exposure Limit -- Represented as STEL or TLV-STEL, this is the maximum concentration to which workers can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between exposures. Also, the daily TLV-TWA must not be exceeded.

"Skin" -- This designation sometimes appears alongside a TLV or PEL. It refers to the possibility of absorption of the particular chemical through the skin and eyes. Thus, protection of large surface areas of skin should be considered to prevent skin absorption so that the TLV is not invalidated.

Systemic -- Spread throughout the body; affecting many or all body systems or organs; not localized in one spot or area.

Teratogen -- An agent or substance that may cause physical defects in the developing embryo or fetus when a pregnant female is exposed to that substance.

Threshold Limit Value (TLV) -- Airborne concentrations of substances devised by the ACGIH that represents conditions under which it is believed that nearly all workers may be exposed for a conventional 8-hour workday and a 40-hourworkweek, without adverse effect. TLV's are advisory exposure guidelines, not legal standards, that are based on evidence from industrial experience, animal studies, or human studies when they exist. There are three different types of TLV's: Time Weighted Average (TLV-TWA), Short Term Exposure Limit (TLV-STEL) and Ceiling (TLV-C). (See also PEL).

Time Weighted Average (TWA) -- The average time, over a given work period (e.g. 8-hour workday) of a person's exposure to a chemical or an agent. The average is determined by sampling for the contaminant throughout the time period. Represented as TLV-TWA.

Toxicity -- The potential of a substance to exert a harmful effect on humans or animals and a description of the effect and the conditions or concentration under which the effect takes place.

Trade Name -- The commercial name or trademark by which a chemical is known. One chemical may have a variety of trade names depending on the manufacturers or distributors involved.

Unstable (Reactive) -- A chemical that, in its pure state or as commercially produced, will react vigorously in some hazardous way under shock conditions (i.e., dropping), certain temperatures, or pressures.

Upper Explosive Limit -- Also known as Upper Flammable Limit, is the highest concentration (expressed in percent of vapor or gas in the air by volume) of a substance that will burn or explode when an ignition source is present. Theoretically, above this limit the mixture is said to be too "rich" to support combustion. The difference between the LEL and the UEL constitutes the flammable range or explosive range of a substance. That is, if the LEL is 1ppm and the UEL is 5ppm, then the explosive range of the chemical is 1ppm to 5ppm. (See also LEL).

Vapor -- The gaseous state of substances which are normally in the liquid or solid state (at normal room temperature and pressure). Vapors evaporate into the air from liquids such as solvents. Solvents with low boiling points will evaporate.

Vapor Pressure -- The pressure that a solid or liquid exerts when it is in equilibrium with its vapor at a given temperature.

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

APPENDIX R: MIOSHA Hazardous Work in Laboratories Standard

Please see the State of Michigan website for the latest information:
https://www.michigan.gov/documents/CIS_WSH_part431_35623_7.pdf