Chemical Hygiene Plan

Michigan State University

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Michigan State University
Chemical Hygiene Plan

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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)

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.

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Revision 1: October 25, 1996
Revision 2: April 20, 1998
Revision 3: July 22, 2002
Revision 4: September 29, 2003
Revision 5: November 22, 2005
Revision 6: April 23, 2007
Revision 7: May, 2008
Revision 8: June, 2009
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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 if there is scientifically valid evidence that it is:

- a flammable or combustible liquid
- a compressed gas
- an organic peroxide
- an explosive
- an oxidizer
- a pyrophoric
- an unstable material (reactive)
- a water reactive material

A chemical is a **health hazard** by MIOSHA definition if there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Included are:

- allergens
- carcinogens
- reproductive toxicants
- corrosives
- hepatoxins (liver)
- neurotoxins (nervous system)
- agents which damage the lungs, skin, eyes or mucous membranes
- embryotoxicants
- toxic or highly toxic agents
- irritants
- sensitizers
- nephrotoxins (kidneys)
- hematopoietic systems agents (blood)

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 J.

Reproductive toxicants are defined by MIOSHA as any chemical which affects the reproductive capabilities of males or females, including chromosomal damage (mutagenesis) and effects on fetuses (teratogenesis). Information on reproductive effects will be listed on the MSDS.

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 **Material Safety Data Sheet (MSDS)** will list the specific hazards. Use the MSDS to address chronic toxicity. For further help in determining the hazard of a chemical, contact your supervisor, instructor or the ORCBS.

1.5 RESPONSIBILITY

The Office of Radiation, Chemical and Biological Safety. The Office of Radiation, Chemical and Biological Safety (ORCBS) 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, the ORCBS 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 the ORCBS will serve as the Chemical Hygiene Officer (CHO). The CHO, along with the ORCBS, can assign areas of responsibility to units, project directors, 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.

The ORCBS, 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.

Project Directors. 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 project director (P.D.) and the administrative officers responsible at the various university levels. Specifically, the P.D. is responsible for:

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

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.D. 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.D., supervisor or departmental office.

Additional copies of this document are available from the ORCBS office and the ORCBS web site: http://www.orcbs.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 the ORCBS/Units/P.D.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 Material 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, Material Safety Data Sheets received from the supplier.

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

Method of Training. General training will be provided by the ORCBS and may take the form of individual instruction, group seminars, audiovisual presentations, handout material, or any combination of the above. Site-specific training will be provided by P.D.s or an appropriate designee. Please call the ORCBS at 432-SAFE (432-7233) for information about the general chemical safety course or sign up for a safety course on our web site: http://www.orcbs.msu.edu/.

General awareness training provided by the ORCBS 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.D.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 Material Safety Data Sheets).

Documentation. General awareness training required by the CHP will be documented by the ORCBS. The training certification form in Appendix A will be filled out by employees at the time of training. The ORCBS will maintain these training forms. Site-specific training must be documented and maintained by the unit/P.D./supervisor and be available to representatives of the ORCBS, the CHO, members of the CHS or other regulatory officials upon request.

1.10 RECORD KEEPING

The ORCBS will retain records of all employees who attend the general chemical safety seminar and the Laboratory Standard/Chemical Hygiene Plan seminar given by the ORCBS.

It is required that records of specific laboratory training for individual laboratories be retained by the P.D. 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

The ORCBS 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 are not adequately addressed by this general document, units and/or P.D.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 Material Safety Data Sheet (MSDS) 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. Confine long hair and loose clothing and always wear footwear which fully covers the feet.
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 are prohibited when using hazardous chemicals.
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 drink 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 4.0 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 C of this document).

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 Material 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

When transporting chemicals outside the laboratory, 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, the ORCBS 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

Avoid working alone whenever possible.

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 the ORCBS.

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.D.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.D.'s name and date of receipt.

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

4. P.D.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.D.s/supervisors must ensure that employees have access to MSDS's (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 is required by the ORCBS (Appendix L). Appendix L 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.D. 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.D. 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.D. 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.D. must prepare an appropriate MSDS 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 Material safety Data Sheet (MSDS) 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.

b. 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**
   a. Peroxidizable chemicals are listed in Appendix H 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.

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 the ORCBS 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 K 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 the ORCBS 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 and store materials only in **designated areas**: a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic 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.

A. On leaving the designated area, remove protective apparel (place it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck.
B. Thoroughly decontaminate or dispose of contaminated clothing or shoes. If possible, chemically decontaminate by chemical conversion to a less toxic product.
C. Decontaminate vacuum pumps or other contaminated equipment, including glassware, before removing them from the designated area. Decontaminate the designated area before normal work is resumed.
D. Use a wet mop or a vacuum cleaner equipped with a HEPA filter to decontaminate surfaces. DO NOT DRY SWEEP SPILLED POWDERS.
E. Protect vacuum pumps against contamination with scrubbers or HEPA filters and vent effluent into the hood.

Always take extra precautions when working with particularly hazardous chemicals.

A. Consult the MSDS 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.D. 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 C for a table of incompatible chemicals.

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

3.6.1 Flammable/Combustible Material: The National Fire Protection Agency (NFPA) places flammable and combustible liquids in the following classes:

	Flash Point	Boiling Point
Flammable		
Class IA	< 73 °F (22.8 °C)	< 100 °F (37.8 °C)
Class IB	< 73 °F (22.8 °C)	≥ 100 °F (37.8 °C)
Class IC	≥ 73 °F (22.8 °C) & < 100 °F (37.8˚C)	
Combustible		
Class II	≥ 100 °F (37.8 °C) & < 140 °F (60 °C)	
Class IIA	≥ 140 °F (60 °C) & < 200 °F (93 °C)	
Class IIIB	≥ 200 °F (93 °C)	

These classes give a measure of the fire risk. Appendix D lists some common flammable and combustible chemicals.

Note: the flash point is defined as 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. For handling Flammable/Combustible 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 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.

3.6.2 Corrosives: materials which can react with the skin causing burns similar to thermal burns, and/or which can react with metal causing deterioration of the metal surface. See Appendix F.

A. Containers and equipment used for storage and processing of corrosive materials should be corrosion resistant.
B. Eye protection and rubber gloves should always be used when handling corrosive materials. A faceshield, rubber apron, and rubber boots may also be appropriate, depending on the work performed.
C. **Never add water to acid.** When mixing concentrated acids with water, add the acid slowly to water.
D. 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.

3.6.3 Oxidizers: materials which react with other substances by giving off electrons and undergoing reduction. This reaction may result in fire or explosion. The intensity of the reaction depends on the oxidizing-reducing potential of the materials involved. See Appendix G.

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.

3.6.4 Water Reactive Materials: materials which react with water to produce a flammable or toxic gas or other hazardous condition. Often a fire or explosion results. Safe handling of water reactive materials will depend on the specific material and the conditions of use and storage. Examples of water reactive chemicals include alkali metals such as lithium, sodium, and potassium; acid anhydrides, and acid chlorides.

3.6.5 Pyrophoric Materials: materials which ignite spontaneously upon 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.**

3.6.6 Peroxidizable Chemicals (Organic Peroxides): materials which undergo auto-oxidation (a reaction with oxygen in the air) to form peroxides which can explode with impact, heat, or friction. Since these chemicals may be packaged in an air atmosphere, peroxides can

form even though the container has not been opened, necessitating careful handling. See Appendix H 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 H.
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.

3.6.7 Light-Sensitive Materials: materials which degrade in the presence of light, forming new compounds that can be hazardous, or resulting in conditions such as pressure build-up inside a container which may be hazardous. Examples of light sensitive materials include chloroform, tetrahydrofuran, ketones and anhydrides.

A. Store light-sensitive materials in a cool, dark place in amber colored bottles or other containers which reduce or eliminate penetration of light.

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 I.

A. Contact the ORCBS 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 Cryogen's: 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 cryogen's are fire, pressure, weakening of materials, and skin or eye burns upon contact with the liquid.

A. Equipment should be kept clean, especially when working with liquid or gaseous oxygen.
B. Mixtures of gases or fluids should be strictly controlled to prevent formation of flammable or explosive mixtures.
C. 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.
D. Containers and systems containing cryogen's should have pressure relief mechanisms.
E. Containers and systems should be capable of withstanding extreme cold without becoming brittle.
F. 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.

3.7 RADIOACTIVE MATERIAL HAZARDS

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

3.8 BIOLOGICAL MATERIAL HAZARDS

Use of biological materials at or above Biosafety Level 2 at MSU is strictly controlled. Contact the ORCBS 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

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 are emergency situations. 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 ORCBS 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. Isolate the spill area and close doors to the room where the spill occurred.

4. Remove ignition sources and shut down equipment

5. Establish exhaust ventilation to the outside of the building only. Turn on exhaust equipment. Open windows.

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. Remove person(s) from spill area to fresh air only if attempts to rescue victim(s) does not present a danger to the rescuers.
2. Remove contaminated clothing while under an emergency shower.
3. Flood affected area with cold water for at least 15 minutes or longer if pain persists.
4. Wash skin with mild soap and water - do not use neutralizing chemicals, unguents, creams, lotions or salves.
5. Contact emergency response personnel and assure they know the chemical(s) involved.

Attend to victims for an eye splash:

1. Remove victim(s) from spill area to fresh air only if attempts to rescue victim(s) does not present a danger to the rescuers.
2. Lead the victim(s) immediately to an emergency eye wash facility.
3. Hold eye lids open.
4. Flush eyes for at least 15 minutes or longer if pain persists.
5. Contact emergency response personnel and assure they know 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 the ORCBS 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 require assistance from trained personnel from the ORCBS.

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 the ORCBS 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
- Use a fitted respirator if there is an inhalation hazard above the permissible exposure limit.

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 as normal trash as long as substance is non-volatile, non-hazardous.

For reactive or potentially reactive spills:

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, evacuate the building after the following steps have been taken:

- 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 medical treatment, under current MSU policies and procedures, affected employees must seek care from one of the approved medical care facilities:

The supervisor or instructor must ensure the appropriate injury report forms are completed. See MSU Human Resources for copies of the appropriate forms. The web link to Human Resources form titled **AUTHORIZATION TO INVOICE MSU** is below. This form contains instructions for employees seeking medical attention.

http://www.hr.msu.edu/forms/Invoice.MSU.pdf

If you have any questions regarding injury and illness procedures, contact your supervisor, instructor or Human Resources.

Minor First Aid

First Aid Kits. First aid kits are not recommended except for remote operations where emergency care is not readily available. If a unit desires a first aid kit, it must be maintained with essential supplies at all times. See the General Stores Catalog for a list of essential supplies.

Do not dispense or administer any medications, including aspirin.

Do not put any ointments or creams on wounds or burns. Use cool water.

The MSDS contains specific first aid information for a given chemical.

For specific first aid information, contact your supervisor, Olin Health Center or MSU Police and Public Safety.

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 from department & Appendix M) are met, the employee must send the completed form to the MSU Occupational Health Service and then contact the MSU Olin Health Services to 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 the ORCBS.

5.1.1 Material Safety Data Sheets (MSDS's). A Material Safety Data Sheet (MSDS) 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 MSDS for each hazardous chemical/product purchased.

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

The ORCBS is a central repository for MSDS's. If you wish to review a MSDS, contact your P.D., supervisor, instructor or the ORCBS. If you need MSDS's for your work area file, send a MSDS request form (located in Appendix B) to the ORCBS, between the hours of 8:00 am and 5:00pm by

FAX: 353-4871

OR

MAIL: ORCBS, C-124 Research Complex--Engineering, Campus

OR

INTERNET: http://www.orcbs.msu.edu

A representative from the ORCBS will fax, mail or hand deliver the MSDS's. If information from an MSDS is needed in case of an emergency, call the ORCBS at 355-0153 or dial 911.

Between the hours of 5:00 pm and 8:00 am, please contact MSU Police and Public Safety at 355-2221. The MSU Police will contact a representative from the ORCBS, who will provide you with a MSDS 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 MSDS's for all hazardous chemicals used in the laboratory.

2. Emergency contact numbers (two names, preferably the P.D., 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 liquid, the main doorway to the lab shall have a flammable liquid sticker visibly posted on it. 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 the ORCBS.

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

5.1.4 Storage Areas. Chemicals should be stored according to compatibility (see Appendix C), as designated by hazard classes. Particularly hazardous chemicals should be stored and handled with extreme care. When ordering chemicals that are unfamiliar, review the MSDS before purchase so that use and storage guidelines are understood. 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

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

5.2 CONTROL MEASURES

1. The P.D. 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 the ORCBS 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.D., 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 MSDS will provide some information on the personal protective equipment and safety procedures recommended for a given chemical, though the MSDS 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.D. 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. Faceshields protect the face and neck from flying particles and splashes. Always wear additional eye protection under faceshields. 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:
- Pipeting
- 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.orcbs.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.

Protect exposed skin surfaces when there is a reasonable anticipation of a splash. Avoid wearing open-toed shoes, sandals, shorts, etc. when working with injurious or corrosive chemicals.

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 the ORCBS 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 ORCBS respiratory training session, undergo a fit test and complete an ORCBS respirator wearer questionnaire. Please contact the ORCBS 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 the ORCBS 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 MSDS. Some MSDS terminology, as listed below, may indicate a need for special ventilation considerations beyond general exhaust ventilation:

- *use with adequate ventilation*
- *use in a fume hood*
- *avoid vapor inhalation*
- *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 the ORCBS 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.**

The ORCBS 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.D. must contact Physical Plant 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 the ORCBS 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 manufacturers specifications or call the ORCBS 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 the ORCBS for consultation before acquiring any ductless fume hood.

5.5 SPILL KITS.

Refer to Section 4.1.4.

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 O.

APPENDIX A

MSU CHEMICAL HYGIENE PLAN
AWARENESS CERTIFICATION

The Michigan Occupational Safety and Health Administration (MIOSHA) requires that all laboratory employees be made aware of the Chemical Hygiene Plan (CHP) at their place of employment.

By signing the certification form at a training session, you acknowledge that you are aware of the MSU CHP and the policies and procedures applicable to the MIOSHA Laboratory Standard and have attended a training session on the applicable details of the MSU CHP provided by the Office of Radiation, Chemical and Biological Safety. Your supervisor will provide additional laboratory-specific training*.

ORCBS Chemical Safety and Chemical Hygiene Plan Awareness Training Sign-up Sheet

PLEASE PRINT

NAME: _____ DEPT: _____

EMPLOYMENT START DATE: _____ TODAY'S DATE: _____

SOCIAL SECURITY #: _____ BIRTH DATE: _____

PROJECT DIRECTOR: _____

SIGNATURE: _____

Please have all information available at the training session so that the certification form may be completely filled out.

* All laboratory-specific training must be documented and maintained by the laboratory supervisor.

APPENDIX B

MATERIAL SAFETY DATA SHEET REQUEST FORM

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

Chemical Names:

_____

_____

_____

_____

_____

_____

_____

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_____

_____

_____

Directions: Use this form to request a MSDS. Mail or Fax (353-4871) the request form to the Office of Radiation, Chemical and Biological Safety, C-124 Research Complex--Engineering. Call the ORCBS at 355-0153 if you have any questions

APPENDIX C

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' MSDS's or call the ORCBS 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, alcohol's, 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, alcohol's, alkalis, ammonia, bases,
Chromium trioxide	benzene, combustible materials, hydrocarbons, metals, organic materials, phosphorous, plastics
Chlorine	alcohol's, 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
Fluorine	alcohol's, 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)

CHEMICAL	**INCOMPATIBLE CHEMICAL(S)**
Hydrogen peroxide	acetylaldehyde, acetic acid, acetone, alcohol's 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, alcohol's, 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 alcohol's, alkalis and alkalines, ammonia, carbon monoxide, combustible materials, ethers, flammable materials, hydrocarbons, metals, phosphorous, polymers
Perchloric acid	acetic acid, alcohol's, 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, alcohol's, halogens, hydrazine, mercury, oxidizers, selenium, sulfur
Potassium chlorate	acids, ammonia, combustible materials, fluorine, hydrocarbons, metals, organic materials, sugars
Potassium perchlorate	alcohol's, 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:

Material Safety Data Sheets, various chemical companies

APPENDIX D

COMMON LABORATORY FLAMMABLE AND COMBUSTIBLE CHEMICALS

Flammable and combustible chemicals are the most commonly used hazardous chemicals. The hazard of a flammable or combustible chemical 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 following table lists some common flammable and combustible chemicals, their flash points and boiling points, and associated 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 E

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 ft^2 of Laboratory Unit (gals)**	**Maximum Quantity per Laboratory Unit (gals)**	**Maximum Quantity per 100 ft^2 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 ft^2 of Laboratory Unit (gals)**	**Maximum Quantity per Laboratory Unit (gals)**	**Maximum Quantity per 100 ft^2 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 F

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.
Material Safety Data Sheets, various chemical companies.

APPENDIX G

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 MSDS.

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 H

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)
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
Other secondary alcohols

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-phenoxyethane
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-cyclooctatetraene
ß-Methoxypropionitrile
m-Nitrophenetole
1-Octene
Oxybis(2-ethyl acetate)
Oxybis(2-ethyl benzoate)
ß,ß-Oxydipropionitrile
1-Pentene
Phenoxyacetyl chloride

Table D Continued

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

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

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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 effective for peroxide inhibition in isopropyl ether.

5. Hydroquinone effective for peroxide inhibition in tetrahydrofuran.

6. Stannous chloride or ferrous sulfate 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 I

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

References: Material Safety Data Sheets, various chemical companies

APPENDIX J

CARCINOGENS

The list below is a compilation of substances classified as carcinogens by either the Michigan Occupational Safety and Health Administration (MIOSHA), the International Agency for Research on Cancer (IARC) and the National Toxicology Program (NTP). Some of these substances are classified as "Select Carcinogens" and require special work practices. See section 1.4 for the definition of "Select Carcinogen"

Chemical Name	MIOSHA[a]	IARC[b]	NTP[c]
Acetaldehyde		2B	2
Acetamide		2B	
2-Acetylaminofluorene	Class A		2
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	
Aflatoxins, naturally occurring		1	1
A-α-C (2-amino-9H-pyrido[2,3-b]indole)		2B	
2-Aminoanthraquinone			2
p-Aminoazobenzene		2B	
o-Aminoazotoluene		2B	2
4-Aminobiphenyl	Class A	1	1
1-Amino-2-methylanthraquinone			2
2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole		2B	
Amitrole		2B	2
Amsacrine		2B	
Analgesic mixtures containing phenacetin		1	1
Androgenic (anabolic) steroid		2A	
o-Anisidine		2B	
o-Anisidine hydrochloride			2
Antimony trioxide		2B	
Aramite		2B	
Arsenic and compounds	CH	1	1
Asbestos	CH	1	1
Asbestos, actinolite	CH		
Asbestos, anthophylite	CH		
Asbestos, tremolite	CH		
Auramine (technical-grade)		2B	
Azacitidine		2A	2
Azaserine		2B	
Azathioprine		1	1
Benzal chloride		2A	
Benz[a]anthracene		2A	2
Benzene	CH	1	1
Benzidine	Class A	1	1
Benzidine-based dyes		2A	
Benzo[a]pyrene		2A	2
Benzo[b]fluoranthene		2B	2
Benzo[j]fluoranthene		2B	2
Benzo[k]fluoranthene		2B	2
Benzofuran		2B	
Benzotrichloride		2A	2
Benzoyl chloride		2A	
Benzyl chloride		2A	
Benzyl violet 4B		2B	
2,2-Bis(bromomethyl)propane-1,3-diol		2B	
Beryllium and certain compounds		1	2
Betel quid with tobacco		1	

Chemical Name	MIOSHA[a]	IARC[b]	NTP[c]
N,N-Bis(2-chloroethyl)-2-naphthylamine (chlornaphazine)		1	
Bis(chloromethyl)ether (technical grade)	Class A	1	1
Bischloroethyl nitrosourea (BCNU)		2A	2
Bleomycins		2B	
Bracken fern		2B	
Bromodichloromethane		2B	2
1,3-Butadiene		2A	1
1,4-Butanediol dimethanesulfonate (Busulphan Myleran)		1	1
Butylated hydroxyanisole (BHA)		2B	2
β-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	
Cadmium and compounds	CH	1	1
Caffeic acid		2B	
Captafol		2A	
Carbon tetrachloride		2B	2
Catechol		2B	
Ceramic Fibres (respirable size)		2B	2
Carbon-black		2B	
Carrageenan, degraded		2B	
Chlorambucil		1	1
Chloramphenicol		2A	
Chlordane		2B	
Chlordecone (Kepone)		2B	2
Chlorendic acid		2B	2
Para-Chloroaniline		2B	
Chlorinated paraffins (C12 60% Chlorine)		2B	2
α-Chlorinated toluenes		2A	
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU)		2A	2
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (Methyl-CCNU; Semustine)		1	1
Chloroform		2B	2
Chloromethyl methyl ether (technical-grade)	Class A	1	1
1-Chloro-2-methylpropene		2B	
3-Chloro-2-methylpropene			2
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
Ciclosporin		1	
Cisplatin		2A	2
Coal-tar pitches		1	
Coal-tars		1	1
Cobalt and cobalt compounds		2B	
Coffee (urinary bladder)		2B	
Conjugated estrogens			1
Creosotes		2A	1
p-Cresidine		2B	2
Cupferron			2
Cycasin		2B	
Cyclophosphamide		1	1
Cyclosporin A			1
DDT			2
Dacarbazine		2B	2
Dantron (Chrysazin; 1, 8-Dihydroxyanthraquinone)		2B	2

Chemical Name	MIOSHA[a]	IARC[b]	NTP[c]
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
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		2B	2
Dibenzo[a, h]pyrene		2B	2
Dibenzo[a, i]pyrene		2B	2
Dibenzo[a, l]pyrene		2B	2
1,2-Dibromo-3-chloropropane (DBCP)	CH	2B	2
2,3-Dibromopropan-1-ol		2B	
p-Dichlorobenzene		2B	2
3,3'-Dichlorobenzidene dihydrochloride			2
3,3'-Dichlorobenzidine	Class A	2B	2
3,3'-Dichloro-4-4'-diaminodiphenyl ether		2B	
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		2A	2
Diesel fuel, marine		2B	
Di(2-ethylhexyl) phthalate			2
1,2-Diethylhydrazine		2B	
Diethyl Sulfate		2A	2
Diethylstilbestrol (DES)		1	1
Diglycidyl resorcinol ether		2B	2
Dihydrosafrole		2B	
Diisopropyl sulfate		2B	
3,3'-Dimethoxybenzidine (o-Dianisidine)		2B	2
3,3'-Dimethoxybenzidine dihydrochloride			2
2,6-Dimethylaniline		2B	
3,3'-Dimethylbenzidine (o-Tolidine)		2B	2
1,2-Dimethylhydrazine		2A	
Dimethyl sulfate		2A	2
p-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	
1,6-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
Engine exhaust, gasoline		2B	
Environmental Tobacco Smoke			1
1,2-Epoxybutane		2B	
Epichlorohydrin		2A	2

Chemical Name	MIOSHA[a]	IARC[b]	NTP[c]
Erionite		1	1
Estrogens (not conjugated) estradiol-17ß			2
Estrogens (not conjugated) estrone			2
Estrogens (not conjugated) ethinylestradiol			2
Estrogens (not conjugated) mestranol			2
Ethyl acrylate		2B	
Ethylbenzene		2B	
Ethylene thiourea		2B	2
Ethylene dibromide		2A	2
Ethylene oxide	CH	1	1
Ethyleneimine, inhibited	Class A		
Ethyl methanesulfonate		2B	2
N-Ethyl-N-nitrosourea		2A	2
Etoposide		2A	
Etoposide in combination with cisplatin and bleomycin		1	
Formaldehyde (gas)	CH	2A	2
2-(2-Formylhydrazino)-4-(5-(5-nitro-2-furyl)thiazole		2B	
Fowler's solution		1	
Fuel oil, residual		2B	
Furan		2B	2
Gasoline		2B	
Gasoline engine exhaust fumes		2B	
Gasoline, unleaded		2B	
Glass wool (respirable size)		2B	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
Griseofulvin		2B	
HC blue 1		2B	
Heptachlor		2B	
Hexachlorobenzene		2B	2
Hexachlorocyclohexane (all isomers)		2B	2
Hexachloroethane		2B	2
Hexamethylphosphoramide		2B	2
Hydrazine (anhydrous)		2B	2
Hydrazine sulfate			2
Hydrazobenzene			2
Indeno[1, 2, 3-cd]pyrene		2B	2
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
Lasiocarpine		2B	
Lead and lead compounds, inorganic		2B	
Lead acetate			2
Lead phosphate			2
Lindane			2
Magenta (containing CI basic red 9)		2B	
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	
5-Methoxypsoralen		2A	
8-Methoxysoralen (methoxsalen) plus ultraviolet A radiation		1	1
2-Methylaziridine (propyleneimine)		2B	2
Methylazoxymethanol acetate		2B	
5-Methylchrysene		2B	2
4,4'-Methylene bis(2-chloroaniline) (MBOCA)		2A	2

Chemical Name	MIOSHA[a]	IARC[b]	NTP[c]
4,4'-Methylene bis(2-methylaniline)		2B	
4,4'-Methylene bis(N,N-dimethylbenzenamine)			2
4,4'-Methylenedianiline	CH	2B	2
4,4'-Methylenedianiline dihydrochloride		2B	2
Methyl Mercury 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	2
N-Methyl-N-nitrosourethane		2B	
Methylthiouracil		2B	
Metronidazole		2B	2
Michler's ketone [4,4'-(Dimethylamino)benzophenone]			2
Mineral oils, untreated and mildly-treated		1	1
Mirex		2B	2
Mitomycin C		2B	
Mitoxantrone		2B	
Monocrotaline		2B	
MOPP and other combined chemotherapy including alkylating agents		1	
5-(Morpholinomethyl)-3-[(5-nitrofurfurylidene)amino]-2-oxazolidinone		2B	
Mustard gas		1	1
Nafenopi		2B	
α-Naphthylamine	Class A		
2-Napthylamine	Class A	1	1
Nickel compounds		1	
Nickel and certain nickel compounds			2
Nickel metallic, and alloys		2B	
Niridazole		2B	
Nitrilotriacetic acid		2B	2
Nitrilotriacetic acid and its salts		2B	
5-Nitroacenaphthene		2B	
2-Nitroanisole		2B	2
Nitrobenzene		2B	
4-Nitrobiphenyl	Class A		
6-Nitrochrysene		2B	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-Nitropropane		2B	2
1-Nitropyrene		2B	2
4-Nitropyrene		2B	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		2A	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
N-Nitrosopiperidine		2B	2
N-Nitrosopyrrolidine		2B	2

Chemical Name	MIOSHA[a]	IARC[b]	NTP[c]
N-Nitrososarcosine		2B	2
Norethisterone		2B	2
Ochratoxin A		2B	2
Oestrogen-progestogen therapy, post menopausal		2B	
Oestrogen replacement therapy		1	
Oestrogen, nonsteroidal		1	
Oestrogen, steroidal		1	
Oil orange ss		2B	
Oral contraceptives, combined		1	
Oral contraceptives, sequential		1	
Oxazepan		2B	
4,4'-Oxydianiline		2B	2
Oxymetholone			2
Palygorskite (long fibers, > 5 micrometers)		2B	
Panfuran S (containing dihydorxymethylfuratrizine)		2B	
Phenacetin		2A	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
Polybrominated biphenyls		2B	2
Polychlorinated biphenyls (PCB's)		2A	2
Ponceau 3R		2B	
Ponceau MX		2B	
Potassium bromate		2B	
Procarbazine hydroxhloride		2A	2
Progesterone			2
Progestins		2B	
Progestogen-only contraceptives		2B	
1,3-Propane sultone		2B	2
β-Propiolactone	Class A	2B	2
Propyleneimine		2B	2
Propylene oxide		2B	2
Propylthiouracil		2B	2
Radon 222 and its decay products		1	1
Reserpine			2
Rockwool		2B	
Safrole		2B	2
Selenium sulfide			2
Shale-oils		1	
Silica, crystalline cristobalite (respirable size)		1	1
Silica, crystalline tridymite (respirable size)			1
Silica, crystalline quartz (respirable size)		1	1
Slagwool		2B	
Sodium equilin sulfate			1
Sodium estrone sulfate			1
Sodium ortho-phenylphenate		2B	
Soots		1	1
Sterigmatocystin		2B	
Streptozotocin		2B	2
Strong inorganic acid mists containing sulfuric acid			1
Styrene		2B	
Styrene-7,8-oxide		2A	
Sulfallate		2B	2
Talc (containing asbestos fibers)		1	
Tamoxifen		1	1
Tars			1

Chemical Name	MIOSHA[a]	IARC[b]	NTP[c]
Teniposide		2A	
2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)		1	1
Tetrachloroethylene		2A	2
Tetrafluoroethylene		2B	2
Tetranitromethane		2B	2
Thioacetamide		2B	2
4,4'-Thiodianiline		2B	
Thiotepa		1	1
Thiourea		2B	2
Thorium dioxide			1
Tobacco products, smokeless		1	1
Tobacco smoke		1	1
o-Tolidine		2B	2
Toluene diisocyanates		2B	2
o-Toluidine		2A	2
o-Toluidine hydrochloride			2
Toxaphene (Polychlorinated camphenes)		2B	2
Treosulfan		1	
Trichlormethine (trimustine hydrochloride)		2B	
Trichloroethylene		2A	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	
Uracil mustard		2B	
Urethane		2B	2
Vinyl acetate		2B	
Vinyl bromide		2A	
Vinyl chloride	CSA	1	1
4-Vinyl cyclohexene		2B	
4-Vinyl-1-cyclohexene diepoxide			2
4-Vinylcyclohexene diepoxide		2B	
Vinyl fluoride		2A	
Welding Fumes		2B	
2,6-Xylidine (2,6-Dimethylaniline)		2B	
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):
a. Known to be carcinogenic with evidence from human studies
b. Reasonably anticipated to be a carcinogen, with limited evidence in humans or sufficient evidence in experimental animals
More information on NTP carcinogens can be found at: http://ntp-server.niehs.nih.gov

APPENDIX K

PELs AND TLV's 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.

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Abate		–	15	–	–	–	–	–
Acetaldehyde	75-07-0	100	180	150	270	–	–	–
Acetic acid	64-19-7	10	25	–	–	–	–	–
Acetic anhydride	108-24-7	–	–	–	–	5	20	–
Acetone	67-64-1	750	1800	1000	2400	–	–	–
Acetonitrile	75-05-8	40	70	60	105	–	–	–
2-Acetylaminofluorine; see O.H. rule 2301(1)[F]	53-96-3							
Acetylene dichloride; see 1,2-Dichloroethylene								
Acetylene tetrabromide	79-27-6	1	14	–	–	–	–	–
Acetylsalicylic acid (Aspirin)	50-78-2	–	5	–	–	–	–	–
Acrolein	107-02-8	0.1	0.25	0.3	0.8	–	–	–
Acrylamide	79-06-1	–	0.03	–	–	–	–	x
Acrylic acid	79-10-7	10	30	–	–	–	–	x
Acrylonitrile; see R 325.51501 et seq.[F]	107-13-1	2	4.34	10	21.7			
Aldrin	309-00-2	–	0.25	–	–	–	–	x
Allyl alcohol	107-18-6	2	5	4	10	–	–	x
Allyl chloride	107-05-1	1	3	2	6	–	–	–
Allyl glycidyl ether (AGE)	106-92-3	5	22	10	44	–	–	–
Allyl propyl disulfide	2179-59-1	2	12	3	18	–	–	–
α Alumina (aluminum oxide)	1344-28-1							
Respirable fraction		–	5	–	–	–	–	–
Total dust		–	10	–	–	–	–	–
Aluminum (as Al)	7429-90-5							
Alkyls		–	2	–	–	–	–	–
Metal		–		–	–	–	–	–
Respirable dust		–	5	–	–	–	–	–
Total dust		–	15	–	–	–	–	–
Pyro powders		–	5	–	–	–	–	–
Soluble salts		–	2	–	–	–	–	–
Welding fumes*		–	5	–	–	–	–	–
4-Aminodiphenyl; see O.H. rule 2301(2)[F]	92-67-1							
2-Aminoethanol; see Ethanolamine								
2-Aminopyridine	504-29-0	0.5	2	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
Amitrole	61-82-5	–	0.2	–	–	–	–	–
Ammonia	7664-41-7	–	–	35	27	–	–	–
Ammonium chloride fume	12125-02-9	–	10	–	20	–	–	–
Ammonium sulfamate Respirable dust Total dust	7773-06-0	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
n-Amyl acetate	628-63-7	100	525	–	–	–	–	–
sec-Amyl acetate	626-38-0	125	650	–	–	–	–	–
Aniline and homologues	62-53-3	2	8	–	–	–	–	x
Anisidine (o- and p-isomers)	29191-52-4	–	0.5	–	–	–	–	x
Antimony and compounds (as Sb)	7440-36-0	–	0.5	–	–	–	–	–
ANTU (alpha-naphthylthiourea)	86-88-4	–	0.3	–	–	–	–	–
Arsenic, organic compounds (as As)	7440-38-2	–	0.5	–	–	–	–	–
Arsenic, inorganic compounds (as As); see R 325.51601 et seq.[F]	7440-38-2		0.01					
Arsine	7784-42-1	0.05	0.2	–	–	–	–	–
Asbestos; see R 325.51601 et seq.[F]	Varies	0.2f/cc		1f/cc				
Atrazine	1912-24-9	–	5	–	–	–	–	–
Azinphos-methyl	86-50-0	–	0.2	–	–	–	–	x
Barium, soluble compounds (as Ba)	7440-39-3	–	0.5	–	–	–	–	–
Barium sulfate Respirable dust Total dust	7727-43-7	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Benomyl Respirable dust Total dust	17804-35-2	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Benzene[E]; see R 325.77101 et seq.[F] and table G-2 for limits applicable in the operations or sectors excluded in R 325.77101[E]	71-43-2	1	3.19	5	15.97			
Benzidine; see O.H. rule 2301(3)	92-87-5							
p-Benzoquinone; see Quinone								
Benzo(a)pyrene; see Coal tar pitch volatiles								
Benzoyl peroxide	94-36-0	–	5	–	–	–	–	–
Benzyl chloride	100-44-7	1	5	–	–	–	–	–
Beryllium and beryllium compounds (as Be)	7440-41-7	See table G-2						
Biphenyl; see Diphenyl								

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^{3}[C]**	**ppm[B]**	**mg/m^{3}[C]**	**ppm[B]**	**mg/m^{3}[C]**	**Skin Designation**
Bismuth telluride, Undoped	1304-82-1							
Respirable dust		–	5	–	–	–	–	–
Total dust		–	15	–	–	–	–	–
Bismuth telluride, Se-doped		–	5	–	–	–	–	–
Borates, Tetra, Sodium Salts								
Anhydrous	1330-43-4	–	10	–	–	–	–	–
Decahydrate	1303-96-4	–	10	–	–	–	–	–
Pentahydrate	12179-04-3	–	10	–	–	–	–	–
Boron oxide, Total dust	1303-86-2	–	10	–	–	–	–	–
Boron tribromide	10294-33-4	–	–	–	–	1	10	–
Boron trifluoride	7637-07-2	–	–	–	–	1	3	–
Bromacil	314-40-9	1	10	–	–	–	–	–
Bromine	7726-95-6	0.1	0.7	0.3	2	–	–	–
Bromine pentafluoride	7789-30-2	0.1	0.7	–	–	–	–	–
Bromoform	75-25-2	0.5	5	–	–	–	–	–
1,3-Butadiene; see R 325.50091 et seq.[F]	106-99-0	1	2.2	5	11.1	–	–	–
Butane	106-97-8	800	1900	–	–	–	–	–
Butanethiol; see Butyl mercaptan								
2-Butanone (Methyl ethyl ketone)	78-93-3	200	590	300	885	–	–	–
2-Butoxyethanol	111-76-2	25	120	–	–	–	–	x
n-Butyl acetate	123-86-4	150	710	200	950	–	–	–
sec-Butyl acetate	105-46-4	200	950	–	–	–	–	–
tert-Butyl acetate	540-88-5	200	950	–	–	–	–	–
Butyl acrylate	141-32-2	10	55	–	–	–	–	–
n–Butyl alcohol (n-butanol)	71-36-3	–	–	–	–	50	150	x
sec-Butyl alcohol (sec-butanol)	78-92-2	100	305	–	–	–	–	–
tert-Butyl alcohol (tert-butanol)	75-65-0	100	300	150	450	–	–	–
Butylamine	109-73-9	–	–	–	–	5	15	x
Tert-Butyl chromate (as CrO_3)	1189-85-1	–	–	–	–	–	0.1	x
n-Butyl glycidyl ether (BGE)	2426-08-6	25	135	–	–	–	–	–
n-Butyl lactate	138-22-7	5	25	–	–	–	–	–
Butyl mercaptan	109-79-5	0.5	1.5	–	–	–	–	–
o-sec-Butylphenol	89-72-5	5	30	–	–	–	–	x
p-tert-Butyltoluene	98-51-1	10	60	20	120	–	–	–
Cadmium; see R 325.51851 et seq.[F]	7440-43-9	–	0.005	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
Calcium carbonate, Respirable dust Total dust	1317-65-3	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Calcium cyanamide	156-62-7	–	0.5	–	–	–	–	–
Calcium hydroxide	1305-62-0	–	5	–	–	–	–	–
Calcium oxide	1305-78-8	–	5	–	–	–	–	–
Calcium silicate, Respirable dust Total dust	1344-95-2	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Calcium sulfate, Respirable dust Total dust	7778-18-9	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Camphor, synthetic	76-22-2	–	2	–	–	–	–	–
Caprolactam, Dust Vapor	105-60-2	 – 5	 1 20	 – 10	 3 40	 – –	 – –	 – –
Captafol (Difolatan®)	2425-06-1	–	0.1	–	–	–	–	–
Captan	133-06-2	–	5	–	–	–	–	–
Carbaryl (Sevin®)	63-25-2	–	5	–	–	–	–	–
Carbofuran (Furadan®)	1563-66-2	–	0.1	–	–	–	–	–
Carbon black	1333-86-4	–	3.5	–	–	–	–	–
Carbon dioxide	124-38-9	10,000	18,000	30,000	54,000	–	–	–
Carbon disulfide	75-15-0	4	12	12	36	–	–	x
Carbon monoxide	630-08-0	35	40	–	–	200	229	–
Carbon tetrabromide	558-13-4	0.1	1.4	0.3	4	–	–	–
Carbon tetrachloride (Tetrachloromethane)	56-23-5	2	12.6	–	–	–	–	x
Carbonyl fluoride	353-50-4	2	5	5	15	–	–	–
Catechol (Pyrocatechol)	120-80-9	5	20	–	–	–	–	x
Cellulose, Respirable dust Total dust	9004-34-6	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Cesium hydroxide	21351-79-1	–	2	–	–	–	–	–
Chlordane	57-74-9	–	0.5	–	–	–	–	x
Chlorinated camphene (Toxaphone)	8001-35-2	–	0.5	–	1	–	–	x
Chlorinated diphenyl oxide	55720-99-5 ***or*** 31242-93-0	–	0.5	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Chlorine	7782-50-5	0.5	1.5	1	3	–	–	–
Chlorine dioxide	10049-04-4	0.1	0.3	0.3	0.9	–	–	–
Chlorine trifluoride	7790-91-2	–	–	–	–	0.1	0.4	–
Chloroacetaldehyde	107-20-0	–	–	–	–	1	3	–
2-Chloroacetophenone (Phenacyl chloride)	532-27-4	0.5	0.3	–	–	–	–	–
Chloroacetyl chloride	79-04-9	0.5	0.2	–	–	–	–	–
Chlorobenzene	108-90-7	75	350	–	–	–	–	–
o-Chlorobenzylidene malononitrile	2698-41-1	–	–	–	–	0.05	0.4	x
Chlorobromomethane	74-97-5	200	1050	–	–	–	–	–
2-Chloro-1,3-butadiene; see ß-Chloroprene								
Chlorodifluoromethane	75-45-6	1000	3500	–	–	–	–	–
Chlorodiphenyl (42% Chlorine) (PCB)	53469-21-9	–	1	–	–	–	–	x
Chlorodiphenyl (54% Chlorine) (PCB)	11097-69-1	–	0.5	–	–	–	–	x
1-Chloro-2,3-epoxy propane; see Epichlorohydrin								
2-Chloroethanol; see Ethylene chlorohydrin								
Chloroethylene; see Vinyl chloride								
Chloroform (Trichloromethane)	67-66-3	2	9.78	–	–	–	–	–
bis (Chloromethyl) ether; see O.H. Rule 2301(4)[F]	542-88-1							
Chloromethyl methyl ether; see O.H. rule 2301(8)	107-30-2							
1-Chloro-1-nitropropane	600-25-9	4	10	–	–	–	–	–
Chloropentafluoroethane	76-15-3	1000	6320	–	–	–	–	–
Chloropicrin	76-06-2	0.1	0.7	–	–	–	–	–
beta-Chloroprene	126-99-8	10	35	–	–	–	–	x
o-Chlorostyrene	2039-87-4	50	285	75	428	–	–	–
o-Chlorotoluene	95-49-8	50	250	–	–	–	–	–
2-Chloro-6-(trichloromethyl) pyridine, Respirable dust Total dust	1929-82-4	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Chlorpyrifos	2921-88-2	–	0.2	–	–	–	–	x
Chromic acid and chromates (as CrO^3)	Varies with compound	–	–	–	–	–	0.1	–
Chromium (II) compounds (as Cr)	7440-47-3	–	0.5	–	–	–	–	–
Chromium (III) compounds (as Cr)	7440-47-3	–	0.5	–	–	–	–	–
Chromium metal (as Cr)	7440-47-3	–	1	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Chrysene; see Coal tar pitch volatile								
Clopidol Respirable dust Total dust	2971-90-6	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Coal dust (less than 5% SiO_2) Respirable quartz dust	–	–	2	–	–	–	–	–
Coal dust (greater than or equal to 5% SiO_2), Respirable dust	–	–	0.1	–	–	–	–	–
Coal tar pitch volatile (as benzene solubles) anthracene, BaP, phenanthrene, acridine, crysene, pyrene	65996-93-2	–	0.2	–	–	–	–	–
Cobalt metal, dust, and fume (as Co)	7440-48-4	–	0.05	–	–	–	–	–
Cobalt carbonyl (as Co)	10210-68-1	–	0.1	–	–	–	–	–
Cobalt hydrocarbonyl (as Co)	16842-03-8	–	0.1	–	–	–	–	–
Coke oven emissions; see R 325.50101 et seq.[F]	–		0.15 (150 ug/m^3)					
Copper, Dusts and mists (as Cu) Fume (as Cu)	7440-50-8	 – –	 1 0.1	 – –	 – –	 – –	 – –	 – –
Cotton dust (raw)	–		1	–	–	–	–	–
Crag herbicide (Sesone) Total dust Respirable fraction	136-78-7	 – –	 10 5	 – –	 – –	 – –	 – –	 – –
Cresol, all isomers	1319-77-3	5	22	–	–	–	–	x
Crotonaldehyde	123-73-9 4170-30-3	2	6	–	–	–	–	–
Crufomate	299-86-5	–	5	–	–	–	–	–
Cumene	98-82-8	50	245	–	–	–	–	x
Cyanamide	420-04-2	–	2	–	–	–	–	–
Cyanides (as CN)	Varies with compound	–	5	–	–	–	–	x
Cyanogen	460-19-5	10	20	–	–	–	–	–
Cyanogen chloride	506-77-4	–	–	–	–	0.3	0.6	–
Cyclohexane	110-82-7	300	1050	–	–	–	–	–
Cyclohexanol	108-93-0	50	200	–	–	–	–	x
Cyclohexanone	108-94-1	25	100	–	–	–	–	x
Cyclohexene	110-83-8	300	1015	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Cyclohexylamine	108-91-8	10	40	–	–	–	–	–
Cyclonite	121-82-4	–	1.5	–	–	–	–	x
Cyclopentadiene	542-92-7	75	200	–	–	–	–	–
Cyclopentane	287-92-3	600	1720	–	–	–	–	–
Cyhexatin	13121-70-5	–	5	–	–	–	–	–
2,4-D (Dichlorophenoxyacetic acid)	94-75-7	–	10	–	–	–	–	–
Decaborane	17702-41-9	0.05	0.3	0.15	0.9	–	–	x
Demeton (Systox[R])	8065-48-3	–	0.1	–	–	–	–	x
Diacetone alcohol (4-Hydroxy-4-methyl-2-pentanone)	123-42-2	50	240	–	–	–	–	–
1,2-Diaminoethane; see Ethylenediamine								
Diazinon	333-41-5	–	0.1	–	–	–	–	x
Diazomethane	334-88-3	0.2	0.4	–	–	–	–	–
Diborane	19287-45-7	0.1	0.1	–	–	–	–	–
2-N-Dibutylaminoethanol	102-81-8	2	14	–	–	–	–	–
Dibutyl phosphate	107-66-4	1	5	2	10	–	–	–
Dibutyl phthalate	84-74-2	–	5	–	–	–	–	–
Dichloroacetylene	7572-29-4	–	–	–	–	0.1	0.4	–
o-Dichlorobenzene	95-50-1	–	–	–	–	50	300	–
p-Dichlorobenzene	106-46-7	75	450	110	675	–	–	–
3,3'-Dichlorobenzidine; see O.H. rule 2301(5)[F]	91-94-1							
Dichlorodifluoromethane	75-71-8	1000	4950	–	–	–	–	–
1,3-Dichloro-5,5-dimethyl hydantoin	118-52-5	–	0.2	–	0.4	–	–	–
Dichlorodiphenyltri-chloroethane (DDT)	50-29-3	–	1	–	–	–	–	x
1,1-Dichloroethane	75-34-3	100	400	–	–	–	–	–
1,2-Dichloroethylene	540-59-0	200	790	–	–	–	–	–
Dichloroethyl ether	111-44-4	5	30	10	60	–	–	x
Dichlorofluoromethane	75-43-4	10	40	–	–	–	–	–
Dichloromethane; see Methylene chloride								
1,1-Dichloro-1-nitroethane	594-72-9	2	10	–	–	–	–	–
1,2-Dichloropropane; see Propylene dichloride								
1,3-Dichloropropene	542-75-6	1	5	–	–	–	–	x
2,2-Dichloropropionic acid	75-99-0	1	6	–	–	–	–	–
Dichlorotetrafluoroethane	76-14-2	1000	7000	–	–	–	–	–
Dichlorvos (DDVP)	62-73-7	–	1	–	–	–	–	x

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Dicrotophos	141-66-2	–	0.25	–	–	–	–	x
Dicyclopentadiene	77-73-6	5	30	–	–	–	–	–
Dicyclopentadienyl iron, Respirable dust Total dust	102-54-5	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Dieldrin	60-57-1	–	0.25	–	–	–	–	x
Diethanolamine	111-42-2	3	15	–	–	–	–	–
Diethylamine	109-89-7	10	30	25	75	–	–	–
2-Diethylaminoethanol	100-37-8	10	50	–	–	–	–	x
Diethylene triamine	111-40-0	1	4	–	–	–	–	x
Diethyl ether; see Ethyl ether								
Diethyl ketone	96-22-0	200	705	–	–	–	–	–
Diethyl phthalate	84-66-2	–	5	–	–	–	–	–
Difluorodibromomethane	75-61-6	100	860	–	–	–	–	–
Diglycidyl ether (DGE)	2238-07-5	0.1	0.5	–	–	–	–	–
Dihydroxybenzene; see Hydroquinone								
Diisobutyl ketone	108-83-8	25	150	–	–	–	–	–
Diisopropylamine	108-18-9	5	20	–	–	–	–	x
4-Dimethylaminoazobenzene; see O.H. rule 2301(6)[F]	60-11-7							
Dimethoxymethane; see Methylal								
Dimethyl acetamide	127-19-5	10	35	–	–	–	–	x
Dimethylamine	124-40-3	10	18	–	–	–	–	–
Dimethylaminobenzene; see Xylidine								
Dimethylaniline (N,N-Dimethylaniline)	121-69-7	5	25	10	50	–	–	x
Dimethylbenzene; see Xylene								
Dimethyl-1,2-dibromo-2,2- dichloroethyl phosphate	300-76-5	–	3	–	–	–	–	x
Dimethylformamide	68-12-2	10	30	–	–	–	–	x
2,6-Dimethyl-4-heptanone; see Diisobutyl ketone								
1,1-Dimethylhydrazine	57-14-7	0.5	1	–	–	–	–	x
Dimethylphthalate	131-11-3	–	5	–	–	–	–	–
Dimethyl sulfate	77-78-1	0.1	0.5	–	–	–	–	x
Dinitolmide (3,5-Dinitro-o-toluamide)	148-01-6	–	5	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Dinitrobenzene (all isomers) (meta-) (ortho) (para-)	 99-65-0 528-29-0 100-25-4	–	1	–	–	–	–	x
Dinitro-o-cresol	534-52-1	–	0.2	–	–	–	–	x
Dinitrotoluene	25321-14-6	–	1.5	–	–	–	–	x
Dioxane (Diethylene dioxide)	123-91-1	25	90	–	–	–	–	x
Dioxathion (Delnav)	78-34-2	–	0.2	–	–	–	–	x
Diphenyl (Biphenyl)	92-52-4	0.2	1	–	–	–	–	–
Diphenylamine	122-39-4	–	10	–	–	–	–	–
Diphenylmethane diisocyanate; see Methylene bisphenyl isocyanate								
Dipropylene glycol methyl ether	34590-94-8	100	600	150	900	–	–	x
Dipropyl ketone	123-19-3	50	235	–	–	–	–	–
Diquat	2768-72-9	–	0.5	–	–	–	–	–
Di-sec-octyl phthalate [Di(2-ethylhexyl)phthalate]	 117-81-7	–	 5	–	 10	–	–	–
Disulfiram	97-77-8	–	2	–	–	–	–	–
Disulfoton	298-04-4	–	0.1	–	–	–	–	x
2,6-Di-tert-butyl-p-cresol (Butylated hydroxytoluene)	128-37-0	–	10	–	–	–	–	–
Diuron	330-54-1	–	10	–	–	–	–	–
Divinyl benzene	1321-74-0	10	50	–	–	–	–	–
Emery, Respirable dust Total dust	1302-74-5 –	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Endosulfan	115-29-7	–	0.1	–	–	–	–	x
Endrin	72-20-8	–	0.1	–	–	–	–	x
Epichlorohydrin	106-89-8	2	8	–	–	–	–	x
EPN	2104-64-5	–	0.5	–	–	–	–	x
1,2-Epoxypropane; see Propylene oxide								
2,3-Epoxy-1-propanol; see Glycidol								
Ethanethiol; see Ethyl mercaptan								
Ethanolamine	141-43-5	3	8	6	15	–	–	–
Ethion	563-12-2	–	0.4	–	–	–	–	x
2-Ethoxyethanol (EGEE)	110-80-5	200	740	–	–	–	–	x
2-Ethoxyethyl acetate (Cellosolve acetate)	111-15-9	100	540	–	–	–	–	x

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m3[C]**	**ppm[B]**	**mg/m3[C]**	**ppm[B]**	**mg/m3[C]**	**Skin Designation**
Ethyl acetate	141-78-6	400	1400	–	–	–	–	–
Ethyl acrylate	140-88-5	5	20	25	100	–	–	x
Ethyl alcohol (Ethanol)	64-17-5	1000	1900	–	–	–	–	–
Ethylamine	75-04-7	10	18	–	–	–	–	–
Ethyl amyl ketone (5-Methyl-3-heptanone)	541-85-5	25	130	–	–	–	–	–
Ethyl benzene	100-41-4	100	435	125	545	–	–	–
Ethyl bromide	74-96-4	200	890	250	1100	–	–	–
Ethyl butyl ketone (3-Heptanone)	106-35-4	50	230	–	–	–	–	–
Ethyl chloride	75-00-3	1000	2600	–	–	–	–	–
Ethyl ether	60-29-7	400	1200	–	500	1500	–	–
Ethyl formate	109-94-4	100	300	–	–	–	–	–
Ethyl mercaptan	75-08-1	0.5	1	–	–	–	–	–
Ethyl silicate	78-10-4	10	85	–	–	–	–	–
Ethylene chlorohydrin	107-07-3	–	–	–	–	1	3	x
Ethylenediamine	107-15-3	10	25	–	–	–	–	–
Ethylene dibromide	106-93-4	See table G-2						
Ethylene dichloride	107-06-2	1	4	2	8	–	–	–
Ethylene glycol	107-21-1	–	–	–	–	50	125	–
Ethylene glycol dinitrate (EGDN)	628-96-6	–	–	–	0.1	–	–	x
Ethylene glycol methyl acetate (EGME); see Methyl cellosolve acetate								
Ethyleneimine; see O.H. rule 2301(7)	151-56-4							
Ethylene oxide; see R 325.51151 et seq.[F]	75-21-8	1	1.8	5	9.0	-	-	-
Ethylidene chloride; see 1,1-Dichloroethane								
Ethylidene norbornene	16219-75-3	–	–	–	–	5	25	–
N-Ethylmorpholine	100-74-3	5	23	–	–	–	–	x
Fenamiphos	22224-92-6	–	0.1	–	–	–	–	x
Fensulfothion (Dasanit)	115-90-2	–	0.1	–	–	–	–	–
Fenthion	55-38-9	–	0.2	–	–	–	–	x
Ferbam, Dust	14484-64-1	–	10	–	–	–	–	–
Ferrovanadium dust	12604-58-9	–	1	–	3	–	–	–
Fluorides (as F)	Varies with compound	–	2.5	–	–	–	–	–
Fluorine	7782-41-4	0.1	0.2	–	–	–	–	–
Fluorotrichloromethane (Trichlorofluoromethane)	75-69-4	–	–	–	–	1000	5600	–
Fonofos	944-22-9	–	0.1	–	–	–	–	x

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
Formaldehyde; see R 325.51451 et seq.[F]	50-00-0	0.75	0.9	2	2.5			
Formamide	75-12-7	20	30	30	45	–	–	–
Formic acid	64-18-6	5	9	–	–	–	–	–
Furfural	98-01-1	2	8	–	–	–	–	x
Furfuryl alcohol	98-00-0	10	40	15	60	–	–	x
Gasoline	8006-61-9	300	900	500	1500	–	–	–
Germanium tetrahydride	7782-65-2	0.2	0.6	–	–	–	–	–
Glutaraldehyde	111-30-8	–	–	–	–	0.2	0.8	–
Glycerin, Respirable mist Total mist	56-81-5	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Glycidol	556-52-5	25	75	–	–	–	–	–
Glycol monoethyl ether; see 2-Ethoxyethanol								
Grain dust (Oat, wheat, barley)	–	–	10	–	–	–	–	–
Graphite, natural Respirable dust	7782-42-5	–	2.5	–	–	–	–	–
Graphite, synthetic, Respirable dust Total dust	–	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Guthion[R]; see Azinphos methyl								
Gypsum, Respirable dust Total dust	13397-24-5	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Hafnium	7440-58-6	–	0.5	–	–	–	–	–
Heptachlor	76-44-8	–	0.5	–	–	–	–	x
Heptane (n-Heptane)	142-82-5	400	1600	500	2000	–	–	–
Hexachlorobutadiene	87-68-3	–	0.02	0.24	–	–	–	–
Hexachlorocyclopentadiene	77-47-4	0.01	0.1	–	–	–	–	–
Hexachloroethane	67-72-1	1	10	–	–	–	–	x
Hexachloronaphthalene	1335-87-1	–	0.2	–	–	–	–	x
Hexafluoroacetone	684-16-2	0.1	0.7	–	–	–	–	x
n-Hexane	110-54-3	50	180	–	–	–	–	–
Hexane isomers	Varies with compound	500	1800	1000	3600	–	–	–
2-Hexanone (Methyl n-butyl ketone)	591-78-6	5	20	–	–	–	–	–
Hexone (Methyl isobutyl ketone)	108-10-1	50	205	75	300	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
sec-Hexyl acetate	108-84-9	50	300	–	–	–	–	–
Hexylene glycol	107-41-5	–	–	–	–	25	125	–
Hydrazine	302-01-2	0.1	0.1	–	–	–	–	x
Hydrogenated terphenyls	61788-32-7	0.5	5	–	–	–	–	–
Hydrogen bromide	10035-10-6	–	–	–	–	3	10	–
Hydrogen chloride	7647-01-0	–	–	–	–	5	7	–
Hydrogen cyanide	74-90-8	–	–	4.7	5	–	–	x
Hydrogen fluoride (as F)	7664-39-3	3	–	6	–	–	–	–
Hydrogen peroxide	7722-84-1	1	1.4	–	–	–	–	–
Hydrogen selenide (as Se)	7783-07-5	0.05	0.2	–	–	–	–	–
Hydrogen sulfide	7783-06-4	10	14	15	21	–	–	–
Hydroquinone	123-31-9	–	2	–	–	–	–	–
2-Hydroxypropyl acrylate	999-61-1	0.5	3	–	–	–	–	x
Indene	95-13-6	10	45	–	–	–	–	–
Indium and compounds (as In)	7440-74-6	–	0.1	–	–	–	–	–
Iodine	7553-56-2	–	–	–	–	0.1	1	–
Iodoform	75-47-8	0.6	10	–	–	–	–	–
Iron oxide fume	1309-37-1	–	10	–	–	–	–	–
Iron pentacarbonyl (as Fe)	13463-40-6	0.1	0.8	0.2	1.6	–	–	–
Iron salts (soluble) (as Fe)	Varies with compound	–	1	–	–	–	–	–
Isoamyl acetate	123-92-2	100	525	–	–	–	–	–
Isoamyl alcohol (primary and secondary)	123-51-3	100	360	125	450	–	–	–
Isobutyl acetate	110-19-0	150	700	–	–	–	–	–
Isobutyl alcohol	78-83-1	50	150	–	–	–	–	–
Isooctyl alcohol	26952-21-6	50	270	–	–	–	–	x
Isophorone	78-59-1	4	23	–	–	–	–	–
Isophorone diisocyanate	4098-71-9	0.005	–	0.02	–	–	–	x
2-Isopropoxyethanol	109-59-1	25	105	–	–	–	–	–
Isopropyl acetate	108-21-4	250	950	310	1185	–	–	–
Isopropyl alcohol	67-63-0	400	980	500	1225	–	–	–
Isopropylamine	75-31-0	5	12	10	24	–	–	–
N-Isopropylaniline	768-52-5	2	10	–	–	–	–	x
Isopropyl ether	108-20-3	500	2100	–	–	–	–	–
Isopropyl glycidyl ether (IGE)	4016-14-2	50	240	75	360	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Kaolin, Respirable dust Total dust	–	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Ketene	463-51-4	0.5	0.9	1.5	3	–	–	–
Lead inorganic (as Pb); see R 325.51901 et seq.[F]	7439-92-1	–	0.05 (50 ug/m^3)	–	–	–	–	–
Limestone, (calcium carbonate) Respirable dust Total dust	1317-65-3	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Lindane	58-89-9	–	0.5	–	–	–	–	x
Lithium hydride	7580-67-8	–	0.025	–	–	–	–	–
L.P.G. (Liquified petroleum gas)	68476-85-7	1000	1800	–	–	–	–	–
Magnesite, Respirable dust Total dust	546-93-0	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Magnesium oxide fume, Total particulate	1309-48-4	–	10	–	–	–	–	–
Malathion dust	121-75-5	–	10	–	–	–	–	x
Maleic anhydride	108-31-6	1	–	–	–	–	–	–
Manganese, Compounds (as Mn) Fume (as Mn)	7439-96-5	 – –	 – 1	 – –	 – 3	 – –	 5 –	 – –
Manganese cyclopentadienyl tricarbonyl (as Mn)	12079-65-1	–	0.1	–	–	–	–	x
Manganese tetroxide (as Mn)	1317-35-7	–	1	–	–	–	–	–
Marble (calcium carbonate), Respirable dust Total dust	1317-65-3	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Mercury Inorganic and aryl compounds (As Hg) Organic compounds (as Hg) Vapor (as Hg)	7439-97-6	 – – –	 – 0.01 0.05	 – – –	 – 0.03 –	 – – –	 0.1 – –	 x x x
Mesityl oxide	141-79-7	15	60	25	100	–	–	–
Methacrylic acid	79-41-4	20	70	–	–	–	–	x
Methanethiol; see Methyl mercaptan								
Methomyl (Lannate)	16752-77-5	–	2.5	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Methoxychlor dust	72-43-5	–	10	–	–	–	–	–
2-Methoxyethanol; see Methyl cellosolve								
4-Methoxyphenol	150-76-5	–	5	–	–	–	–	–
Methyl acetate	79-20-9	200	610	250	760	–	–	–
Methyl acetylene (Propyne)	74-99-7	1000	1650	–	–	–	–	–
Methyl acetylene-propadiene mixture (MAPP)	–	1000	1800	1250	2250	–	–	–
Methyl acrylate	96-33-3	10	35	–	–	–	–	x
Methylacrylonitrile	126-98-7	1	3	–	–	–	–	x
Methylal (Dimethoxymethane)	109-87-5	1000	3100	–	–	–	–	–
Methyl alcohol	67-56-1	200	260	250	325	–	–	x
Methylamine	74-89-5	10	12	–	–	–	–	–
Methyl amyl alcohol; see Methyl isobutyl carbinol								
Methyl n-amyl ketone	110-43-0	100	465	–	–	–	–	–
Methyl bromide	74-83-9	5	20	–	–	–	–	x
Methyl n-butyl ketone; see 2-Hexanone								
Methyl cellosolve (2-Methoxyethanol)	109-86-4	25	80	–	–	–	–	x
Methyl cellosolve acetate (2-Methoxyethyl acetate)	110-49-6	25	120	–	–	–	–	x
Methyl chloride	74-87-3	50	105	100	210	–	–	–
Methyl chloroform (1,1,1-Trichloroethane)	71-55-6	350	1900	450	2450	–	–	–
Methyl 2-cyanoacrylate	137-05-3	2	8	4	16	–	–	–
Methylcyclohexane	108-87-2	400	1600	–	–	–	–	–
Methylcyclohexanol	25639-42-3	50	235	–	–	–	–	–
o-Methylcyclohexanone	583-60-8	50	230	75	345	–	–	x
Methylcyclopentadienyl manganese tricarbonyl (as Mn)	12108-13-3	–	0.2	–	–	–	–	x
Methyl demeton	8022-00-2	–	0.5	–	–	–	–	x
4,4'-Methylene bis (2-chloroaniline) (MBOCA)	101-14-4	0.02	0.22	–	–	–	–	x
Methylene bis (4-cyclohexylisocyanate)	5124-30-1	–	–	–	–	0.01	0.11	–
Methylene bisphenyl isocyanate (MDI)	101-68-8	–	–	–	–	0.02	0.2	–
Methylene chloride, see R 325.51651 et seq.[F]	75-09-2	25	87	125	434			
Methylenedianiline (MDA); see R 325.50051 et seq.[F]	101-77-9	10 ppb**	0.08 mg/m^3	100 ppb**	0.8 mg/m^3	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
Methyl ethyl ketone (MEK); see 2-Butanone								
Methyl ethyl ketone peroxide (MEKP)	1338-23-4	–	–	–	–	0.7	5	–
Methyl formate	107-31-3	100	250	150	375	–	–	–
Methyl hydrazine	60-34-4	–	–	–	–	0.2	0.35	x
Methyl iodide	74-88-4	2	10	–	–	–	–	x
Methyl isoamyl ketone	110-12-3	50	240	–	–	–	–	–
Methyl isobutyl carbinol	108-11-2	25	100	40	165	–	–	x
Methyl isobutyl ketone; see Hexone								
Methyl isocyanate (MIC)	624-83-9	0.02	0.05	–	–	–	–	x
Methyl isopropyl ketone	563-80-4	200	705	–	–	–	–	–
Methyl mercaptan	74-93-1	0.5	1	–	–	–	–	–
Methyl methacrylate	80-62-6	100	410	–	–	–	–	
Methyl parathion	298-00-0	–	0.2	–	–	–	–	x
Methyl propyl ketone; see 2-Pentanone								
Methyl silicate	681-84-5	1	6	–	–	5	30	–
alpha-Methyl styrene	98-83-9	50	240	100	485	–	–	–
Metribuzin	21087-64-9	–	5	–	–	–	–	–
Mica; see Silicates								
Molybdemun, (as Mo) Insoluble compounds Soluble compounds	7439-98-7	 – –	 10 5	 – –	 – –	 – –	 – –	 – –
Monocrotophos (Azodrin®)	6923-22-4	–	0.25	–	–	–	–	–
Monomethyl aniline	100-61-8	0.5	2	–	–	–	–	x
Morpholine	110-91-8	20	70	30	105	–	–	x
Naphtha (Coal tar)	8030-30-6	100	400	–	–	–	–	–
Naphthalene	91-20-3	10	50	15	75	–	–	–
alpha-Naphthylamine; see O.H. rule 2301(10)[F]	134-32-7							
beta-Naphthylamine; see O.H. rule 2301(11)[F]	91-59-8							
Nickel carbonyl (as Ni)	13463-39-3	0.001	0.007	–	–	–	–	–
Nickel, Metal and insoluble compounds (as Mi) Soluble compounds (as ni)	7440-02-0	 – –	 1 0.1	 – –	 – –	 – –	 – –	 – –
Nicotine	54-11-5	–	0.5	–	–	–	–	x
Nitric acid	7697-37-2	2	5	4	10	–	–	–
Nitric oxide	10102-43-9	25	30	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
p-Nitroaniline	100-01-6	–	3	–	–	–	–	x
Nitrobenzene	98-95-3	1	5	–	–	–	–	x
p-Nitrochlorobenzene	100-00-5	–	1	–	–	–	–	x
4-Nitrodiphenyl; see O.H. rule 2301(12)[F]	92-93-3							
Nitroethane	79-24-3	100	310	–	–	–	–	–
Nitrogen dioxide	10102-44-0	–	–	1	1.8	–	–	–
Nitrogen trifluoride	7783-54-2	10	29	–	–	–	–	–
Nitroglycerin	55-63-0	–	–	–	0.1	–	–	x
Nitromethane	75-52-5	100	250	–	–	–	–	–
1-Nitropropane	108-03-2	25	90	–	–	–	–	–
2-Nitropropane	79-46-9	10	35	–	–	–	–	–
N-Nitrosodimethylamine; see O.H. rule 2301(13)[F]	62-75-9							
Nitrotoluene o-isomer m-isomer p-isomer	 88-72-2 99-08-1 99-99-0	2	11	–	–	–	–	x
Nitrotrichloromethane; see Chloropicrin								
Nonane	111-84-2	200	1050	–	–	–	–	–
Octachloronaphthalene	2234-13-1	–	0.1	–	0.3	–	–	x
Octane	111-65-9	300	1450	375	1800	–	–	–
Oil mist, mineral	8012-95-1	–	5	–	–	–	–	–
Osmium tetroxide (as Os)	20816-12-0	–	0.002	–	0.006	–	–	–
Oxalic acid	144-62-7	–	1	–	2	–	–	–
Oxygen difluoride	7783-41-7	–	–	–	–	0.05	0.1	–
Ozone	10028-15-6	0.1	0.2	0.3	0.6	–	–	–
Paraffin wax fume	8002-74-2	–	2	–	–	–	–	–
Paraquat, respirable dust	1910-42-5 2074-50-2 4685-14-7	–	0.1	–	–	–	–	x
Parathion	56-38-2	–	0.1	–	–	–	–	x
Particulates not otherwise regulated, Respirable dust Total dust	– – –	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Pentaborane	19624-22-7	0.005	0.01	0.015	0.03	–	–	–
Pentachloronaphthalene	1321-64-8	–	0.5	–	–	–	–	x
Pentachlorophenol	87-86-5	–	0.5	–	–	–	–	x

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Pentaerythritol, Respirable dust Total dust	115-77-5	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Pentane	109-66-0	600	1800	750	2250	–	–	–
2-Pentanone (Methyl propyl ketone)	107-87-9	200	700	250	875	–	–	–
Perchloroethylene (Tetrachloroethylene)	127-18-4	25	170	–	–	–	–	–
Perchloromethyl mercaptan	594-42-3	0.1	0.8	–	–	–	–	–
Perchloryl fluoride	7616-94-6	3	14	6	28	–	–	–
Perlite Respirable dust Total dust	93763-70-3	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Petroleum distillates (Naphtha) (Rubber solvent)		400	1600	–	–	–	–	–
Phenol	108-95-2	5	19	–	–	–	–	x
Phenothiazine	92-84-2	–	5	–	–	–	–	x
p-Phenylenediamine	106-50-3	–	0.1	–	–	–	–	x
Phenyl ether, vapor	101-84-8	1	7	–	–	–	–	–
Phenyl ether-biphenyl mixture, vapor	–	1	7	–	–	–	–	–
Phenylethylene; see Styrene								
Phenyl glycidyl ether (PGE)	122-60-1	1	6	–	–	–	–	–
Phenylhydrazine	100-63-0	5	20	10	45	–	–	x
Phenyl mercaptan	108-98-5	0.5	2	–	–	–	–	–
Phenylphosphine	638-21-1	–	–	–	–	0.05	0.25	–
Phorate	298-02-2	–	0.05	–	0.2	–	–	x
Phosdrin (Mevinphos[R])	7786-34-7	–	0.1	–	0.3	–	–	x
Phosgene (Carbonyl chloride)	75-44-5	0.1	0.4	–	–	–	–	–
Phosphine	7803-51-2	0.3	0.4	1	1	–	–	–
Phosphoric acid	7664-38-2	–	1	–	3	–	–	–
Phosphorus (yellow)	7723-14-0	–	0.1	–	–	–	–	–
Phosphorus oxychloride	10025-87-3	0.1	0.6	–	–	–	–	–
Phosphorus pentachloride	10026-13-8	–	1	–	–	–	–	–
Phosphorus pentasulfide	1314-80-3	–	1	–	3	–	–	–
Phosphorus trichloride	7719-12-2	0.2	1.5	0.5	3	–	–	–
Phthalic anhydride	85-44-9	1	6	–	–	–	–	–
m-Phthalodinitrile	626-17-5	–	5	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
Picloram, Respirable dust Total dust	1918-02-1	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Picric acid	88-89-1	–	0.1	–	–	–	–	x
Piperazine dihydrochloride	142-64-3	–	5	–	–	–	–	–
Pindone (2-Pivalyl-1,3-indandione)	83-26-1	–	0.1	–	–	–	–	–
Plaster of Paris (Calcium sulfate), Respirable dust Total dust	26499-65-0	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Platinum (as Pt) Metal Soluble salts	7440-06-4	 – –	 1 0.002	 – –	 – –	 – –	 – –	 – –
Portland cement, Respirable dust Total dust	65997-15-1	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Potassium hydroxide	1310-58-3	–	–	–	–	–	2	–
Propane	74-98-6	1000	1800	–	–	–	–	–
Propargyl alcohol	107-19-7	1	2	–	–	–	–	x
beta-Propriolactone; see O.H. rule 2301(14)[F]	57-57-8							
Propionic acid	79-09-4	10	30	–	–	–	–	–
Propoxur (Baygon)	114-26-1	–	0.5	–	–	–	–	–
n-Propyl acetate	109-60-4	200	840	250	1050	–	–	–
n-Propyl alcohol	71-23-8	200	500	250	625	–	–	–
n-Propyl nitrate	627-13-4	25	105	40	170	–	–	–
Propylene dichloride	78-87-5	75	350	110	510	–	–	–
Propylene glycol dinitrate	6423-43-4	0.05	0.3	–	–	–	–	–
Propylene glycol monomethyl ether	107-98-2	100	360	150	540	–	–	–
Propylene imine	75-55-8	2	5	–	–	–	–	x
Propylene oxide	75-56-9	20	50	–	–	–	–	–
Propyne; see Methyl acetylene								
Pyrethrum	8003-34-7	–	5	–	–	–	–	–
Pyridine	110-86-1	5	15	–	–	–	–	–
Quinone	106-51-4	0.1	0.4	–	–	–	–	–
Resorcinol	108-46-3	10	45	20	90	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	CAS No.[A]	TWA		STEL[D]		Ceiling		
		ppm[B]	mg/m^3[C]	ppm[B]	mg/m^3[C]	ppm[B]	mg/m^3[C]	Skin Designation
Rhodium, Insoluble compounds (as Rh) Metal fume (as Rh) Soluble compounds (as Rh)	7440-16-6	– – –	0.1 0.1 0.001	– – –	– – –	– – –	– – –	– – –
Ronnel	299-84-3	–	10	–	–	–	–	–
Rosin core solder pyrolysis products, as formaldehyde	–	–	0.1	–	–	–	–	–
Rotenone	83-79-4	–	5	–	–	–	–	–
Rouge, Respirable dust Total dust	–	– –	5 10	– –	– –	– –	– –	– –
Selenium compounds (as Se)	7782-49-2	–	0.2	–	–	–	–	–
Selenium hexafluoride (as Se)	7783-79-1	0.05	0.4	–	–	–	–	–
Silica, amorphous, precipitated and gel	112926-00-8	–	6	–	–	–	–	–
Silica, amorphous, diatomaceous earth, containing less than 1% crystalline silica	61790-53-2	–	6	–	–	–	–	–
Silica, crystalline cristobalite, Respirable dust	14464-46-1	–	0.05	–	–	–	–	–
Silica, crystalline quartz, Respirable dust	14808-60-7	–	0.1	–	–	–	–	–
Silica, crystalline tridymite, Respirable dust	15468-32-3	–	0.05	–	–	–	–	–
Silica, crystalline tripoli, Respirable dust	1317-95-9	–	0.1	–	–	–	–	–
Silica, fused, Respirable dust	60676-86-0	–	0.1	–	–	–	–	–
Silicates (less than 1% crystalline silica)								
Mica, respirable dust	12001-26-2	–	3	–	–	–	–	–
Soapstone, total dust	–	–	6	–	–	–	–	–
Soapstone, respirable dust	–	–	3	–	–	–	–	–
Talc (containing asbestos); use asbestos limit	–	R 325.51311 et seq., Asbestos for General Industry						
Talc (containing no asbestos), respirable dust	14807-96-6	–	2	–	–	–	–	–
Tremolite	R 325.51311 et seq., Asbestos for General Industry							

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Silicon, Respirable dust Total dust	7440-21-3	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Silicon carbide, Respirable dust Total dust	409-21-2	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Silicon tetrahydride	7803-62-5	5	7	–	–	–	–	–
Silver, metal and soluble compounds (as Ag)	7440-22-4	–	0.01	–	–	–	–	–
Soapstone; see Silicates								
Sodium azide (as HN_3) (as NaN_3)	26628-22-8	 – –	 – –	 – –	 – –	 0.1 –	 – 0.3	 x x
Sodium bisulfite	7631-90-5	–	5	–	–	–	–	–
Sodium fluoroacetate	62-74-8	–	0.05	–	0.15	–	–	x
Sodium hydroxide	1310-73-2	–	–	–	–	–	2	–
Sodium metabisulfite	7681-57-4	–	5	–	–	–	–	–
Starch, Respirable dust Total dust	9005-25-8	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Stibine	7803-52-3	0.1	0.5	–	–	–	–	–
Stoddard solvent	8052-41-3	100	525	–	–	–	–	–
Strychnine	57-24-9	–	0.15	–	–	–	–	–
Styrene	100-42-5	50	215	100	425	–	–	–
Subtilisins (Proteolytic enzymes)	9014-01-1	–	–	–	0.00006 (60 min.)	–	–	–
Sucrose, Respirable dust Total dust	57-50-1	 – –	 5 15	 – –	 – –	 – –	 – –	 – –
Sulfur dioxide	7446-09-5	2	5	5	10	–	–	–
Sulfur hexafluoride	2551-62-4	1000	6000	–	–	–	–	–
Sulfuric acid	7664-93-9	–	1	–	–	–	–	–
Sulfur monochloride	10025-67-9	–	–	–	–	1	6	–
Sulfur pentafluoride	5714-22-7	–	–	–	–	0.01	0.1	–
Sulfur tetrafluoride	7783-60-0	–	–	–	–	0.1	0.4	–
Sulfuryl fluoride	2699-79-8	5	20	10	40	–	–	–
Sulprofos	35400-43-2	–	1	–	–	–	–	–
Systox[R]; see Demeton								

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**ppm[B]**	**mg/m³[C]**	**Skin Designation**
2,4,5-T (2,4,5-trichlorophenoxyacetic acid)	93-76-5	–	10	–	–	–	–	–
Talc; see Silicates								
Tantalum, metal and oxide dust	7440-25-7	–	5	–	–	–	–	–
TEDP (Sulfotep)	3689-24-5	–	0.2	–	–	–	–	x
Tellurium and compounds (as Te)	13494-80-9	–	0.1	–	–	–	–	–
Tellurium hexafluoride (as Te)	7783-80-4	0.02	0.2	–	–	–	–	–
Temephos, Respirable dust Total dust	3383-96-8	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
TEPP	107-49-3	–	0.05	–	–	–	–	x
Terphenyls	26140-60-3	–	–	–	–	0.5	5	–
1,1,1,2-Tetrachloro-2, 2-difluoro-ethane	76-11-9	500	4170	–	–	–	–	–
1,1,2,2-Tetrachloro-1, 2-difluoro-ethane	76-12-0	500	4170	–	–	–	–	–
1,1,2,2-Tetrachloroethane	79-34-5	1	7	–	–	–	–	x
Tetrachloroethylene; see Perchloroethylene								
Tetrachloromethane; see Carbon tetrachloride								
Tetrachloronaphthalene	1335-88-2	–	2	–	–	–	–	x
Tetraethyl lead (as Pb)	78-00-2	–	0.075	–	–	–	–	x
Tetrahydrofuran	109-99-9	200	590	250	735	–	–	–
Tetramethyl lead (as Pb)	75-74-1	–	0.075	–	–	–	–	x
Tetramethyl succinonitrile	3333-52-6	0.5	3	–	–	–	–	x
Tetranitromethane	509-14-8	1	8	–	–	–	–	–
Tetrasodium pyrophosphate	7722-88-5	–	5	–	–	–	–	–
Tetryl (2,4,6-Trinitrophenylmethylnitramine)	479-45-8	–	1.5	–	–	–	–	x
Thallium, soluble compounds (as Tl)	7440-28-0	–	0.1	–	–	–	–	x
4,4'-Thiobis (6-tert-butyl-m-cresol) Respirable dust Total dust	96-69-5	 – –	 5 10	 – –	 – –	 – –	 – –	 – –
Thioglycolic acid	68-11-1	1	4	–	–	–	–	x
Thionyl chloride	7719-09-7	–	–	–	–	1	5	–
Thiram	137-26-8	–	5	–	–	–	–	–
Tin, Inorganic compounds (except oxides) (as Sn) Organic compounds (as Sn) Oxides (as Sn)	 7440-31-5 7440-31-5 21651-19-4	 – – –	 2 0.1 2	 – – –	 – – –	 – – –	 – – –	 – x –

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Titanium dioxide Total dust	13463-67-7	– –	10	–	–	–	–	–
Toluene	108-88-3	100	375	150	560	–	–	–
Toluene-2,4-diisocyanate (TDI)	584-84-9	0.005	0.04	0.02	0.15	–	–	–
m-Toluidine	108-44-1	2	9	–	–	–	–	x
o-Toluidine	95-53-4	5	22	–	–	–	–	x
p-Toluidine	106-49-0	2	9	–	–	–	–	x
Toxaphene; see Chlorinated camphene								
Tremolite; see Silicates								
Tributyl phosphate	126-73-8	0.2	2.5	–	–	–	–	–
Trichloroacetic acid	76-03-9	1	7	–	–	–	–	–
1,2,4-Trichlorobenzene	120-82-1	–	–	–	–	5	40	–
1,1,1-Trichloroethane; see Methyl chloroform								
1,1,2-Trichloroethane	79-00-5	10	45	–	–	–	–	x
Trichloroethylene	79-01-6	50	270	200	1080	–	–	–
Trichloromethane; see Chloroform								
Trichloronaphthalene	1321-65-9	–	5	–	–	–	–	x
1,2,3-Trichloropropane	96-18-4	10	60	–	–	–	–	–
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	1000	7600	1250	9500	–	–	–
Triethylamine	121-44-8	10	40	15	60	–	–	–
Trifluorobromomethane	75-63-8	1000	6100	–	–	–	–	–
Trimellitic anhydride	552-30-7	0.005	0.04	–	–	–	–	–
Trimethylamine	75-50-3	10	24	15	36	–	–	–
Trimethyl benzene	25551-13-7	25	125	–	–	–	–	–
Trimethyl phosphite	121-45-9	2	10	–	–	–	–	–
2,4,6-Trinitrophenol; see Picric acid								
2,4,6-Trinitrophenylmethylnitramine; see Tetryl								
2,4,6-Trinitrotoluene (TNT)	118-96-7	–	0.5	–	–	–	–	x
Triorthocresyl phosphate	78-30-8	–	0.1	–	–	–	–	x
Triphenyl amine	603-34-9	–	5	–	–	–	–	–
Triphenyl phosphate	115-86-6	–	3	–	–	–	–	–
Tungsten Insoluble compounds (as W) Soluble compounds (as W)	7440-33-7	– –	5 1	– –	10 3	– –	–	–
Turpentine	8006-64-2	100	560	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m[3C]**	**ppm[B]**	**mg/m[3C]**	**ppm[B]**	**mg/m[3C]**	**Skin Designation**
Uranium (as U)	7440-61-1							
Insoluble compounds		–	0.2	–	0.6	–	–	–
Soluble compounds		–	0.05	–	–	–	–	–
n-Valeraldehyde	110-62-3	50	175	–	–	–	–	–
Vanadium pentoxide	1314-62-1							
Fume (as V_2O_5)		–	0.05	–	–	–	–	–
Respirable dust (as V_2O_5)		–	0.05	–	–	–	–	–
Vegetable oil mists	–							
Respirable mist		–	5	–	–	–	–	–
Total mist		–	15	–	–	–	–	–
Vinyl acetate	108-05-4	10	30	20	60	–	–	–
Vinyl benzene; see Styrene								
Vinyl bromide	593-60-2	5	20	–	–	–	–	–
Vinyl chloride; see 325.51401 et seq.[F]	75-01-4	1	2.5	5	12.8			
Vinyl cyanide; see Acrylonitrile								
Vinyl cyclohexene dioxide	106-87-6	10	60	–	–	–	–	x
Vinylidene chloride (1,1-Dichloroethylene)	75-35-4	1	4	–	–	–	–	–
Vinyl toluene	25013-15-4	100	480	–	–	–	–	–
VM & P Naphtha	8032-32-4	300	1350	400	1800	–	–	–
Warfarin	81-81-2	–	0.1	–	–	–	–	–
Welding fumes (Total particulate)*	–	–	5	–	–	–	–	–
Wood dust, all soft and hard woods (except Western red cedar)	–	–	5	–	10	–	–	–
Wood dust, Western red cedar	–	–	2.5	–	–	–	–	–
Xylenes (o-,m-,p-isomers) (Dimethyl benzene)	1330-20-7	100	435	150	655	–	–	–
m-Xylene alpha, alpha'-diamine	1477-55-0	–	–	–	–	–	0.1	x
Xylidine	1300-73-8	2	10	–	–	–	–	x
Yttrium	7440-65-5	–	1	–	–	–	–	–
Zinc chloride fume	7646-85-7	–	1	–	2	–	–	–
Zinc Chromate (as Cro3)	Varies with compound	–	–	–	–	–	0.1	–
Zinc oxide fume	1314-13-2	–	5	–	10	–	–	–
Zinc oxide,	1314-13-2							
Respirable dust		–	5	–	–	–	–	–
Total dust		–	10	–	–	–	–	–

TABLE G-1-A. EXPOSURE LIMITS FOR AIR CONTAMINANTS								
Substance	**CAS No.[A]**	**TWA**		**STEL[D]**		**Ceiling**		
		ppm[B]	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**ppm[B]**	**mg/m^3[C]**	**Skin Designation**
Zinc stearate	557-05-1							
Respirable dust		–	5	–	–	–	–	–
Total dust		–	10	–	–	–	–	–
Zirconium compounds (as Zr)	7440-67-7	–	5	–	10	–	–	–

*	As determined from breathing-zone air samples.
**	Parts per billion.
A	The CAS number is for information only. Enforcement is based on the substance name. For an entry covering more than 1 metal compound measured as the metal, the CAS number for the metal is given-not the CAS number for the individual compounds.
B	Parts of vapor or gas per million parts of comtaminated air by volume at 25° 760 torr.
C	Approximate milligrams of substance per cubic meter of air.
D	Duration is for 15 minutes, unless otherwise noted.
E	The final benzene standard in R 325.77101 et seq. applies to all occupational exposures to benzene, except some subsegments of industry where exposures are consistently under the action level. These subsegments include the distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures. For the excepted subsegments, the benzene limits in table G-2 apply.
F	Caution—this rule contains extensive requirements for exposure to these substances.

TABLE G-2
EXPOSURE LIMITS FOR AIR CONTAMINATES

Substances	8-hour, time-weighted average	Acceptable ceiling concentration	Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour workshift.	
			Concentration	Maximum duration
S Benzene	10 ppm	25 ppm	50 ppm	10 minutes
Beryllium and beryllium compounds	2 $\mu g/m^3$	5 $\mu g/m^3$	25 $\mu g/m^3$	30 minutes
S Ethylene dibromide	20 ppm	30 ppm	50 ppm	5 minutes

Note: **S** above signifies that skin contact shall not be allowed.

NOC Not otherwise classified
f/cc fibers/cubic centimeter
(C) TLV-ceiling - the concentration that should not be exceeded during any part of the working exposure.
Skin Substances that pass through the skin at a significant rate. Exposure assesment must take into account any exposure via the inhalation route and skin route.
TWA Time–Weighted–Average = The time weighted averagean employee's exposure divided by the length of the work shift. Most commonly calculated with a continuous monitoring device worn by the employee over the entire work-day. If, for example, the employee is exposed to 8 ppm chloroform vapor in an 1 hour period, with no exposure the rest of the workshift (7-hrs), their TWA is 1 ppm chloroform for the day.
STEL Short Term Exposure Limit = the maximum concentration to which workers can be exposed in 15 minutes, limited to four times a day, with at least 60 minutes between each exposure period.

APPENDIX L

HAZARDOUS MATERIALS SUBJECT TO PRIOR APPROVAL FROM ORCBS

Biological Materials - please contact the Biological Safety Officer from the ORCBS

Radioactive Materials - please contact the Radiation Safety Officer from the ORCBS

Contact the ORCBS 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 the ORCBS 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 M

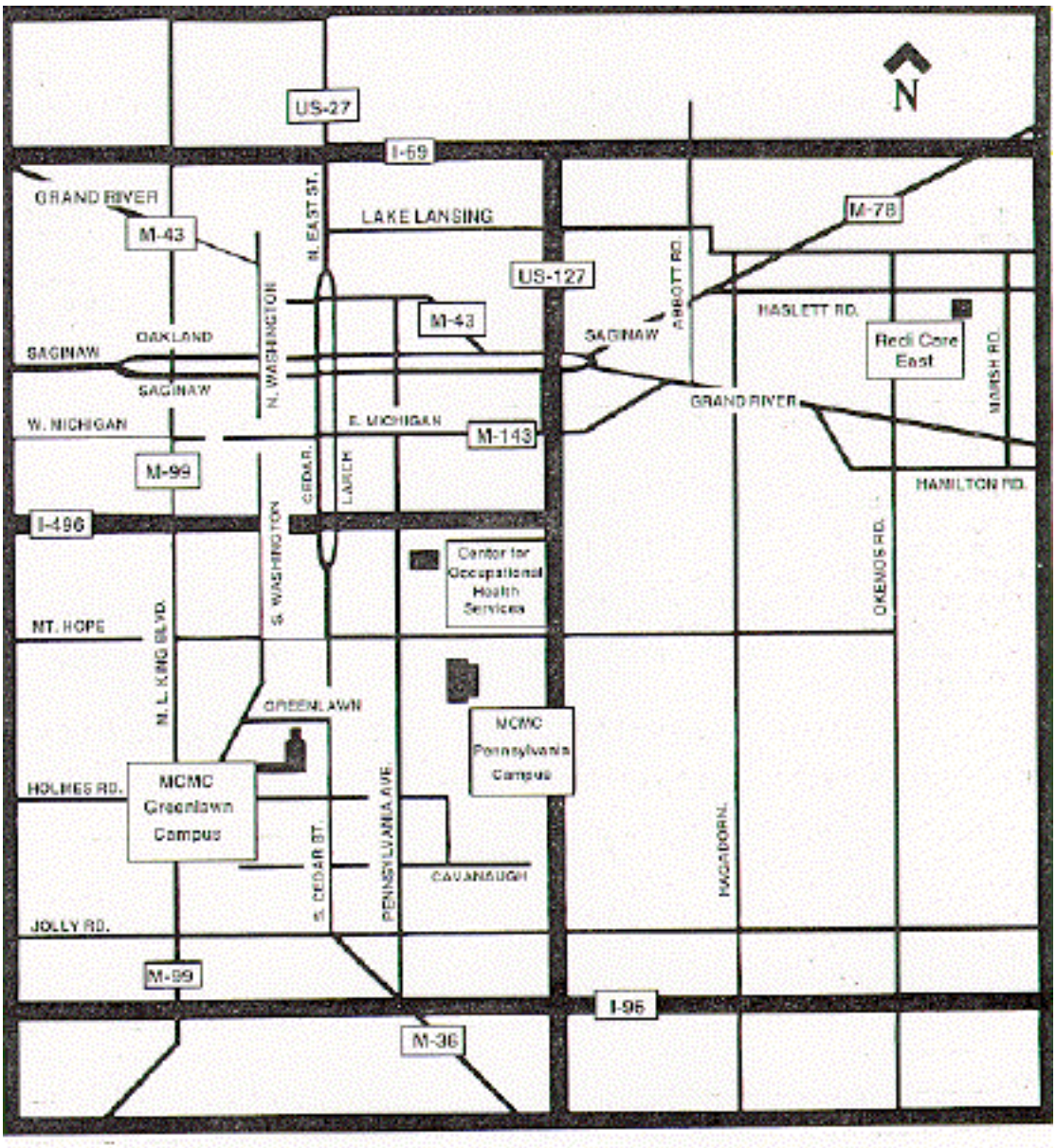
See Human Resources Web link for most updated forms.
http://www.hr.msu.edu

1. **Michigan State University Exposure To Health Risk Information**

2. **Authorization to Invoice MSU**

3. **Report Of Claimed Occupational Injury Or Illness**

Map of Lansing



APPENDIX N - MSU CHEMICAL SAFETY LABORATORY 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 sharp objects labeled, puncture-proof containers.
○ 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 DPPS 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.**	Flammable and corrosive 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 O

POLICY FOR TERMINATION OF LABORATORY AND CONTAINMENT AREA USE OF HAZARDOUS MATERIALS

Whenever a Principal Investigator or Laboratory Supervisor (or a person under their charge performing work with hazardous materials in their laboratory) leaves the university or is transferred to a different location, proper disposition of hazardous materials is required. This includes faculty, staff, post-doctoral and graduate students.

If improper management of hazardous materials at close-out requires removal services from an outside contractor, the responsible department will be charged for this service.

Hazardous Chemical Disposal in Laboratories and Containment Areas

The following procedures should be completed before the responsible individual leaves the university or transfers to a different location on campus.

- Assure that all containers of chemicals are labeled with the name of the chemical. All containers must be securely closed. Beakers, flasks, evaporating dishes, etc., should be emptied. Hazardous chemical wastes must not be sewered or trashed; they must be collected for disposal.

- Clean chemicals from glassware and assure proper waste disposal guidelines are followed. Never pour chemical residues down the sink unless it is specified by the MSU Hazardous Waste Disposal Guide that this is the safe and preferred method of disposal.

- Check refrigerators, freezers, fume hoods, storage cabinets and bench tops for chemical containers and thoroughly clean these locations.

- If another room or facility (such as a freezer or refrigerator, stock rooms, etc.) is shared with other researchers, remove, transfer or dispose of items used by the departing researcher.

- Contact the ORCBS for pick-up of hazardous waste at least one week prior to vacating the lab.

- For gas cylinders, remove regulators, replace cap and return to supplier. If cylinders are non-returnable, refer to the MSU Hazardous Waste Disposal Guide. Gas cylinders used in the containment area must be decontaminated prior to return.

As an alternative to disposal, if the chemical is still usable, transfer the responsibility of the chemical to another P.I. or supervisor who is willing to take charge of the chemical.

Follow all guidelines in the MSU Hazardous Waste Disposal Guide for disposal of unwanted chemicals. The ORCBS will pick up all hazardous waste provided:

- All chemical containers are properly labeled as "hazardous waste" and are accompanied with a completely filled out hazardous waste tag.

- All containers are securely closed.

Notify the department when laboratories or containment area/rooms have been cleared.

Transportation of Chemicals on Campus

The following procedures should be completed by individuals who have usable chemicals which are to be moved to a different laboratory.

- Assure that all containers of chemicals are labeled with the name of the chemical. All containers must be securely closed. Beakers, flasks, evaporating dishes, etc., should be emptied. Stock solutions should be transferred to containers intended for use in transportation such as screw cap bottles. Transportation requirements for usable chemicals is the same as that for hazardous waste.

- Chemicals offered for shipment must be grouped together on lab benches or on shelves to facilitate removal.

- For gas cylinders, remove regulators and replace cap. Attach a tag with the name of the person responsible for the material, a contact person, and a phone number.

- A licensed transporter should be contacted to package and deliver the materials to the new location. ORCBS will help in making a proper selection.

- Persons intending to transport chemical materials themselves should contact ORCBS.

Disposal of Controlled Substances

The United States Drug Enforcement Agency (DEA) issues permits for controlled substances. There are several considerations when disposing of controlled substances.

- Abandonment of a controlled substance is a violation of the DEA permit under which it is held.

- Permission to transfer ownership of a controlled substance must be received from the DEA.

- Controlled substances being held by a licensed individual and to be surrendered for destruction must be inventoried on DEA Form 41 and mailed to:

    Drug Enforcement Administration
    231 West Lafayette
    357 Federal Building
    Detroit, Michigan 488226

For copies of DEA Form 41 please contact the ORCBS.

- If controlled substances for which the licensee is unknown are found, contact ORCBS immediately.

Disposal of Biological Materials

Animal Tissue

- If tissue is held in a liquid preservative, the tissue and liquid should be separated.

- Large animal parts or whole animals will be picked up by ULAR and incinerated. Small animal parts and tissues should be placed in a biohazard waste bag for incineration.

- Liquid preservative usually needs to be disposed as a hazardous waste. Contact the ORCBS for assistance. Do not assume that the preservative can be sewered.

- If appropriate disposal is uncertain, contact the ORCBS at 355-0153.
- Defrost and clean refrigerators and freezers if they are empty.
- If samples need to be saved, locate the PI or supervisor to take responsibility for them.

Microorganisms And Cultures

- Use an autoclave to decontaminate all liquid culture waste, and dispose of it as outlined in the MSU Hazardous Waste Disposal Guide.
- If the material cannot be decontaminated, place it in a biohazard bag for incineration.
- Clean and disinfect incubators, drying or curing ovens, refrigerators and freezers.
- If samples need to be saved, locate the PI or supervisor to take responsibility for them.

Transportation of Biological Materials on Campus

All biological materials* that are of potential risk to humans and/or animals must be stored and transported in a primary and secondary container. Primary containers can be culture tubes, flasks, vials etc. All containers must meet the following requirements:

- Rigid
- Puncture resistant
- Leak proof
- Impervious to moisture
- Of sufficient strength to prevent tearing or bursting under normal conditions of use and handling
- Sealed to prevent leakage during transport
- Labeled with a biohazard or infectious substance label

All containers should be accompanied by a list of content, the person responsible for this material, a contact person and phone number.

If materials are to be transported in liquid nitrogen or with other protection from ambient or higher temperatures, all containers and packaging should be capable withstanding very low temperatures, and both primary and secondary packaging must be able to withstand a pressure differential of at least 95 kPa and temperatures in the range of - 40˚C to + 50˚C. If the material is perishable, warnings should appear on accompanying documents, e.g., "Keep cool, between + 2˚C and + 4˚C."

For all shipment requirements of biological materials off campus contact the ORCBS at 355-0153.

*** Infectious substances**: viable microorganisms, including a bacterium, virus, rickettsia, fungus, or a recombinant, hybrid or mutant, that are known or reasonably believed to cause disease in animals or humans.
*** Diagnostic specimens**: any human or animal material including but not limited to, excreta, secreta, blood and its components, tissue and tissue fluids.

Radioisotopes

Close Out Procedures for Radioactive Materials Use Areas

Prior to close-out of radioactive materials use areas, release of radioactive use equipment and/or radioactive materials approvals, it is the responsibility of the approved principal investigator and the department to assure that the following steps have been completed.

1. Contact a Health Physicist to notify ORCBS of the intended transfer or close out. At that time, the materials to be moved will be reviewed. If necessary, a visit will be scheduled for ORCBS to go to the laboratory and provide guidance for segregating, labeling and packing the materials to be relocated. It is helpful to request a copy of the most recent inventory of radioactive materials possessed by the principal investigator to facilitate the close-out, transfer and waste disposal process.

2. The ORCBS must authorize any transfers to other principal investigators or to off campus licensees prior to the transfer. The receiving principal investigator must be approved for the nuclide and quantity of activity, and must not exceed the authorized amount after receipt of the transferred material. The shipments must be transferred in the ORCBS inventory database tracking system.

3. An inventory of the materials to be transferred must be supplied to the ORCBS prior to the transfer.

4. Package the radioactive materials in strong tight containers. Each container must be contained and segregated properly according to the nuclide and amount of activity in the material, whether it is waste, stock vials, sealed sources, contaminated equipment, samples, etc.

5. Schedule a pickup of the radioactive materials with the ORCBS. **All radioactive materials must be transported by the ORCBS; transfer by the laboratory staff is prohibited if the materials are to be moved in a vehicle.**

6. After the removal of all radioactive materials, sources and waste, perform a survey of the entire laboratory, including all use, storage and disposal areas. (Note: refrigerators and freezers, community use areas, incubators, fume hoods and all other areas which may potentially be contaminated must be included in the survey). Document this survey in the safety records. If contamination is found, it must be decontaminated prior to release to new occupants. No further use of radioactive materials in the room is allowed until the close-out is finalized and the room or areas is released by ORCBS.

7. Contact a Health Physicist and arrange for a formal ORCBS close-out survey. This must be completed, with records maintained, before new occupants may move into the area. Warning labels may then be removed. Records of decommissioning radiation surveys will be sent to the principal investigator, and will be available upon request for new occupants.

8. Prior to moving radioactive materials into a new use area, principal investigators must obtain prior approval from the Radiation Safety Officer. New rooms to be occupied must be approved for radioactive materials use, and facilities must be appropriate for the types and quantities of radioactive materials to be used.

9. Equipment used for or with radioactive materials must be surveyed and released by the ORCBS prior to transfer to other locations or users.

10. Note that all contaminated areas, equipment, materials etc., must be decontaminated to the **unrestricted area release limits** before release or must be treated as radioactive and managed accordingly.

Some other tips which will help with planning relocation of radioactive materials, or release of equipment and other items used for radioactive materials are:

- Materials must be in containers which are tightly sealed or capped.
- For liquids, it is recommended that parafilm be wrapped around the caps to prevent volatilization or leakage if caps loosen.
- Each container must be labeled clearly with the nuclide, date, quantity and chemical form.
- Put smaller bottles and containers in secondary containers which are lined with plastic, and place absorbent material between containers to prevent breakage.
- Use strong boxes with strong bottoms which will not tear or break. (DOT approved boxes are the most effective.)
- Do not pack boxes and containers with more than 50 pounds of material.
- For materials which must be kept at frozen or ultra-frozen temperatures, pack the materials in dry ice just prior to pick up by ORCBS. We do not have cold temperature maintenance capabilities in our transport vehicles.
- Have storage facilities ready at the receiving location, and radiation workers present to receive and properly store radioactive materials.
- Materials found leaking or contaminated on the outside will not be moved. Check each package in advance (wipe the package and monitor with the correct radiation detection instrument) to assure the integrity of the package.
- Equipment which has been used for radioactive materials, such as refrigerators, incubators or any other equipment, must be surveyed prior to relocation and released by the ORCBS.
- An equipment release form must be affixed to each piece or package of equipment which will be moved by Physical Plant or intended to go to Salvage. (This documents that the equipment has been checked and is safe for release to the general public.)
- If materials or equipment are going to be routed out as regular trash, it must be surveyed prior to dumping and certified free of radioactive contamination.

Mixed Hazards

Occasionally it is necessary to dispose of materials that contain more than one of the above hazards. Contact the ORCBS (355-0153) for chemical, radioactive or biological agent assistance.

Equipment

If laboratory equipment is to be left for the next occupant, clean or decontaminate it before departing the laboratory. Attached is an Equipment Release Form that should be used to certify that the equipment was decontaminated. If exhaust or filtration equipment has been used with extremely hazardous substances or organisms, alert the ORCBS.

If laboratory equipment is to be discarded, be aware that capacitors, transformers, mercury switches, mercury thermometers, radioactive sources and chemicals must be removed before disposal. Contact the ORCBS for assistance.

Equipment potentially contaminated with radioisotopes must be surveyed by the ORCBS prior to release or use by other persons.

Shared Storage Areas

One of the most problematic situations is the sharing of storage units such as refrigerators, freezers, cold rooms, stock rooms, waste collection areas, etc., particularly if no one has been assigned to manage the unit. Departing researchers must carefully survey any shared facility in order to locate and appropriately dispose of their hazardous materials.

Regulatory Impact

Mishandling of hazardous materials can result in citations, fines and/or loss of right to use hazardous materials. Adverse publicity is also a frequent result.

APPENDIX P

EQUIPMENT RELEASE FORM

Date: _____ Location of Origin: _____

Principal Investigator: _____

Destination/Service Department: _____

Service to be Performed: _____

_____

_____

Type of Equipment: _____

_____

_____

Contaminated (Yes/NO): _____

Contaminants Identified/Suspected: _____

_____

_____

Method of Decontamination: _____

_____

_____

_____

Name of Person Decontaminating: _____
Please Print

I certify that the above listed equipment is free of contamination or hazardous agents and that it is safe to release to unrestricted areas and/or perform the work described above on this equipment.

_____
Signature of Responsible Person

APPENDIX Q

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) 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 editions 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 effect 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 Affects 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 (chromosomal mutations) 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 R

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 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.

Asphyxiant -- 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, in a container, 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.

Erythema -- 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 MSDS 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) -- A 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 MSDS.

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 S

MIOSHA Hazardous Work in Laboratories Standard

Department of Public Health

Occupational Health Standards Commission

Hazardous Work in Laboratories

Filed with the Secretary of State on **JANUARY 9, 1992(as amended July 28, 2003)**

These rules take effect 7 days after filing with the Secretary of State

(By authority conferred on the director of the department of consumer and industry services by sections 14 and 24 of 1974 PA 154 and Executive Reorganization Orders Nos. 1996-1 and 1996-2, MCL 408.1014, 408.1024, 330.3101, and 445.2001)

R 325.70101 Scope; effective date of subrule (2)

Rule 1. (1) These rules set forth the requirements for laboratory use of hazardous chemicals. Subjects to which these rules apply include all of the following:

(a) Exposure limits.
(b) Exposure monitoring.
(c) Written chemical hygiene plan.
(d) Employee information and training.
(e) Medical surveillance.
(f) Hazard identification.
(g) Use of respiratory protection.
(h) Recordkeeping.

(2) These rules, where they apply as specified in R 325.70102, supersede all Michigan occupational safety and health act (MIOSHA) occupational health standards that govern the use of specific chemical substances,except as provided in R 325.70104, R 325.70105, and R 325.70108. Also, where they apply, these rules supersede the requirements of the occupational safety and health administration (OSHA) hazard communication standard, being 29 C.F.R. §1910.1200, which is incorporated by section 14a of 1974 PA 154, MCL 408.1014a. This subrule takes effect when an employer has developed and implemented a written chemical hygiene plan as prescribed by R 325.70106.

(3) All occupational health standards that do not deal with a specific chemical substance apply to laboratory operations as do any occupational safety standards administered by the Michigan department of consumer and industry services. Such non-chemical substance standards that apply to laboratory operations include all of the following rules:

(a) Occupational noise exposure, Part 380., R 325.60101 et seq.
(b) Ionizing radiation, Part 381., O.H. 2410 et seq.
(c) Nonionizing radiation, Part 382., R 325.60701 et seq.
(d) Ventilation control, Part 520., O.H. 3101 et seq.
(e) Permit-required confined spaces, Part 490., R 325.63001 et seq.
(f) Respiratory protection, Part 451., R 325.60051 et seq.
(g) Illumination, Part 478., R 325.47801 et seq.
(h) Sanitation, Part 474., O.H. 4201 et seq.
(i) Medical services and first aid, Part 472., R 325.47201 et seq.
(j) Employee medical records and trade secrets, Part 470., R 325.3451 et seq.

R 325.70102 Application

Rule 2. (1) These rules apply to all employers who have an employee or employees involved in the laboratory use of hazardous chemicals as defined in R 325.70103.

(2) These rules do not apply to either of the following

(a) 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.

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

R 325.70103 Definitions

325.70103 Definitions

Rule 3. As used in these rules:

(a) **"Action level"** means a concentration which is designated in established MIOSHA health standards for a specific substance, calculated as an 8-hour, time-weighted average, and which initiates certain required activities, such as exposure monitoring and medical surveillance.

(b) **"Chemical hygiene officer"** means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the 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.

(c) **"Chemical hygiene plan"** means a written program which is developed and implemented by the employer, which sets forth procedures, equipment, personal protective equipment, and work practices that are capable of protecting employees from the health hazards presented by the hazardous chemicals used in a particular workplace, and which is in compliance with the requirements of R 325.70106.

(d) **"Director"** means the director of the Michigan department of consumer and industry services or his or her designee.

(e) **"Emergency"** means any occurrence, such as equipment failure, the rupture of containers, or the failure of control equipment, that results in an uncontrolled release of a hazardous chemical into the workplace.

(f) **"Employee"** means a person who is assigned to work in a laboratory workplace and who may be exposed to hazardous chemicals in the course of his or her assignments.

(g) **"Hazardous chemical"** means a chemical for which there is statistically significant evidence, based on at least 1 study that is conducted in accordance with established scientific principles, that acute or chronic health effects may occur in employees who are exposed to the chemical. These health effects include those that result from exposure to chemicals which are any of the following:

(i) Carcinogens

(ii) Toxic or highly toxic agents.

(iii) Reproductive toxins.

(iv) Irritants.

(v) Corrosives.

(vi) Sensitizers.

(vii) Hepatotoxins.

(viii) Nephrotoxins.

(ix) Neurotoxins.

(x) Agents that act on the hematopoietic systems.

(xi) Agents that damage the lungs, skin, eyes, or mucous membranes.

Appendices A and B of the OSHA hazard communications standard, being 29 C.F.R. §1910.1200 and referenced in R 325.70101(2), provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of these rules.

(h) **"Laboratory"** means a facility where the laboratory use of hazardous chemicals occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.

(i) **"Laboratory-type hood"** means a work chamber which is used in a laboratory, which is enclosed on 5 sides and has a moveable sash or fixed partial closure on the remaining side, which is constructed and maintained to draw air from the laboratory and prevent or minimize the escape of air contaminants into the laboratory, and which allows chemical manipulations to be conducted in the enclosure

without inserting any portion of the employee's body other than hands and arms. The term includes walk-in hoods with adjustable sashes if the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and so that employees do not work inside the enclosure during the release of airborne hazardous chemicals.

(j) **"Laboratory use of hazardous chemicals"** means the handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a laboratory scale.

(ii) Multiple chemical procedures or chemicals are used.

(iii) The procedures that are involved are not part of production process, nor in any way simulate a production process.

(iv) Protective laboratory practices and equipment are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

(k) **"Medical consultation"** means a consultation that takes place between an employee and a licensed physician to determine what medical examinations or procedures, if any, are appropriate.

(l) **"Physical hazard"** means a chemical for which there is scientifically valid evidence that it is any of the following:

(i) A combustible liquid.

(ii) A compressed gas.

(iii) Explosive.

(iv) Flammable.

(v) An organic peroxide.

(vi) An oxidizer.

(vii) Pyrophoric.

(viii)Unstable (reactive).

(ix) Water-reactive.

These terms are defined in appendix B of these rules.

(m) **"Production"** means the manufacturing processes that use hazardous chemicals and result in a product.

(n) **"Protective laboratory practices and equipment"** means those laboratory procedures, practices, and equipment that are accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

(o) **"Reproductive toxins"** means chemicals that affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

(p) **"Select carcinogen"** means any substance that meets 1 or more of the criteria set forth in the definition of select carcinogen in paragraph (b) of OSHA standard 29 C.F.R. §1910.1450, which is adopted herein by reference. The cited provision of 29 C.F.R. §1910.1450 is available from the Michigan Department of Consumer and Industry Services, Standards Division, P.O. Box 30643, Lansing, Michigan 48909, at no cost, or from the U.S. Department of Labor, OSHA, 801 S. Waverly, Suite 306, Lansing, Michigan 48917, at no cost. The cited definition is printed as appendix C to these rules.

R 325.70104 Permissible exposure limits

Rule 4. For laboratory uses of MIOSHA-regulated substances, an employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in MIOSHA occupational health standards.

R 325.70105 Exposure monitoring

Rule 5. (1) An employer shall measure an employee's exposure to any substance that is regulated by a standard that requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level or, in the absence of an action level, the permissible exposure limits (PEL).

(2) If the initial monitoring prescribed by subrule (1) of this rule discloses employee exposure over the action level or, in the absence of an action level, the PEL, an employer shall comply with the exposure monitoring provisions of the relevant standard.

(3) Monitoring may be terminated in accordance with the relevant standard.

(4) An employer shall, within 15 working days after the receipt of any monitoring results, notify an employee of these results, in writing, either individually or by posting the results in an appropriate location that is accessible to employees.

R 325.70106 Chemical hygiene plan

Rule 6. (1) Where hazardous chemicals as defined by these rules are used in the workplace, an employer shall develop and carry out the provisions of a written chemical hygiene plan that provides for both of the following:

(a) Protecting employees from health hazards that are associated with hazardous chemicals in that laboratory.

(b) Keeping exposures below the limits specified in R 325.70104.

(2) The chemical hygiene plan shall be readily available to employees, employee representatives, and, upon request, to the director.

(3) The chemical hygiene plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

(a) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals.

(b) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals, including engineering controls, the use of personal protective equipment, and hygiene practices. Particular attention shall be given to the selection of control measures for chemicals that are known to be particularly hazardous.

(c) A requirement that laboratory-type hoods and other protective equipment are functioning properly and the specific measures that shall be taken to ensure the proper and adequate performance of such equipment.

(d) Provisions for employee information and training as prescribed in R 325.70107.

(e) The circumstances under which a particular laboratory operation, procedure, or activity shall require prior approval from the employer or the employer's designee before implementation.

(f) Provisions for medical consultation and medical examinations in accordance with R 325.70108.

(g) Designation of personnel who are responsible for implementing the chemical hygiene plan, including the assignment of a chemical hygiene officer and, if appropriate, establishment of a chemical hygiene committee.

(h) Provisions for additional employee protection for work with particularly hazardous substances, such as select carcinogens, reproductive toxins, and substances that have a high degree of acute or chronic toxicity. Specific consideration shall be given to the following provisions, which shall be included where appropriate:

(i) The establishment of a designated area or areas that indicate the physical limits of exposure to particularly hazardous substances.

(ii) The use of containment devices, such as laboratory-type hoods or glove boxes.

(iii) Procedures for the safe removal of contaminated waste.

(iv) Decontamination procedures.

(4) An employer shall review and evaluate the effectiveness of the chemical hygiene plan at least annually and update it as necessary.

R 325.70107 Employee information and training

Rule 7. (1) An employer shall provide employees with information and training to ensure that they are apprised of and understand the hazards of chemicals present in their work areas.

(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and before assignments that involve new exposure situations. Refresher information and training shall be provided by the employer to ensure that an employee is aware of the risks of exposure to hazardous chemicals.

(3) Employees shall be informed of all of the following:

(a) The contents of these rules and appendices, which shall be made available to employees.

(b) The location and availability of the employer's chemical hygiene plan.

(c) The permissible exposure limits for MIOSHA-regulated substances or the recommended exposure limits for other hazardous chemicals if there are no applicable MIOSHA rules.

(d) Signs and symptoms associated with exposures to hazardous chemicals that are used in the laboratory.

(e) The location and availability of known reference material on the hazards, safe handling, storage, and disposal of hazardous chemicals found in the laboratory, including material safety data sheets (MSDS) received from a chemical supplier.

(4) Employee training shall include all of the following:

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

(b) The physical and health hazards of chemicals in the work environment.

(c) The measures employees can take to protect themselves from health hazards, including specific procedures that the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

(5) The employee shall be trained about the applicable details of the employer's written chemical hygiene plan.

R 325.70108 Medical surveillance

Rule 8. (1) An employer shall provide all employees who work with hazardous chemicals an opportunity to receive the following medical attention, including any follow-up examinations which the examining physician determines to be necessary:

(a) When an employee develops signs or symptoms that are associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

(b) If exposure monitoring reveals an exposure level that is routinely above the action level or, in the absence of an action level, the PEL for a MIOSHA-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) When an event takes place in the work areas, such as a spill, leak, explosion, or other occurrence that results in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician who is familiar with the general health effects of hazardous chemicals and sources of specific information on such effects and shall be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

(3) An employer shall provide all of the following information to the physician:

(a) The identity of the hazardous chemical or chemicals to which the employee may have been exposed.

(b) A description of the conditions under which the exposure occurred, including quantitative exposure data, if available.

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

(4) For examination or consultation that is required under this rule, an employer shall obtain a written opinion from the examining physician. The opinion shall include all of 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 revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical that is 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.

(5) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

R 325.70109 Hazard identification

Rule 9. (1) With respect to labels and material safety data sheets (MSDS) for hazardous chemicals, both of the following provisions apply:

(a) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

(b) Employers shall maintain any MSDS that are received with incoming shipments of hazardous chemicals and ensure that MSDS are readily accessible to laboratory employees.

(2) All of the following provisions shall apply to chemical substances that are developed in the laboratory:

(a) If the composition of the chemical substance that is produced exclusively for the laboratory's use is known, an employer shall determine if it is a hazardous chemical. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required by R 325.70107.

(b) If the chemical produced is a by-product of unknown composition, an employer shall assume that the substance is hazardous and shall implement the provisions of R 325.70106.

(c) If the chemical substance is produced for another user outside of a laboratory, an employer shall comply with the OSHA hazard communication standard, being 29 C.F.R. §1910.1200, which is referenced in R 325.70101.

R 325.70110 Use of respiratory protection

Rule 10. If, after appropriate application of feasible engineering and work practice controls, the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory protection equipment.

Respirators shall be selected and used in accordance with the requirements of respiratory protection, Part 451., R 325.60051 et seq.

R 325.70111 Recordkeeping

Rule 11. (1) An employer shall establish and maintain, for each employee, an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations, including tests or written opinions required by these rules.

(2) An employer shall assure that such records are kept, transferred, and made available in accordance with the provisions of employee medical records and trade secrets, Part 470., R 325.3451 et seq., and are protected from unauthorized disclosure.

R 325.70112 Rescinded

R 325.70113 Appendices

Rule 13. Appendices A, B, C, and D to these rules are informational only and are not intended to create any additional obligations or requirements not otherwise imposed by these rules or to detract from any established obligations or requirements.

R 325.70114 Availability of rules and appendices; permission to copy

Rule 14. (1) A copy of these rules and appendices are available at no cost from the Michigan Department of Consumer and Industry Services, Standards Division, P.O. Box 30643, Lansing, Michigan 48909.

(2) Permission to copy any of these documents in full is granted by the director.