



**LAB SAFETY**

**&**

**CHEMICAL HYGIENE PLAN**

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# Lab Safety & Chemical Hygiene Plan

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# Grand Rapids Community College Chemical Hygiene Plan

## 1. INTRODUCTION

### 1.1 GRAND RAPIDS COMMUNITY COLLEGE STATEMENT OF RESPONSIBILITY

It is the responsibility of Grand Rapids Community College (GRCC), as an employer, to take every reasonable precaution to provide a work environment that is free from recognizable hazards for its employees, students and guests. Because GRCC academic programs include working in laboratories, the *Lab Safety and Chemical Hygiene Plan* has been prepared in compliance with the Michigan Occupational Safety and Health Administration (MIOSHA) Hazardous Work in Laboratories standard (the Laboratory Standard – Part 431). It was written to ensure that the necessary work practices, procedures and policies are implemented to protect all employees and students working in college owned and operated laboratories from hazardous chemicals in the work area. Grand Rapids Community College 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 will serve as a Chemical Hygiene Plan for all laboratories and classrooms where hazardous materials are used.

This document will hereafter be known as the Grand Rapids Community College Lab Safety and Chemical Hygiene Plan (GRCC-CHP).

### 1.2 THE MIOSHA LABORATORY STANDARD (adopted by MIOSHA January 1, 1992, amended January 10, 2014, December 2018)

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.

### 1.3 SCOPE AND APPLICATION

This document serves as the written guide for GRCC's compliance with MIOSHA's Hazardous Work in Laboratories regulations. All employees at GRCC who are engaged in the laboratory use (as defined by this document) of hazardous materials are required to comply with this document.

The primary objective of this document is to provide a general guide for handling hazardous materials in laboratories. The GRCC-CHP 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 materials 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 is not adequately addressed by this general document, specific standard operating procedures (SOP) must be developed by the employee implementing the procedures and approved by their supervisors or assistant dean as appropriate. Documentation will be kept in the department where the SOP originated. This GRCC-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.

### 1.4 HAZARDOUS MATERIAL DEFINITIONS

#### A.) Chemical

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

**Particularly hazardous substances**, by MIOSHA definition, are select carcinogens, reproductive toxins 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/ml.
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.

The US Department of Health and Human Services National Toxicology Program provides a [Report on Carcinogens](#).

For the current list of carcinogens from OSHA: [www.osha.gov](http://www.osha.gov) (part 1990)

For the current list of carcinogens from IARC: [www.iarc.fr](http://www.iarc.fr)

**Reproductive toxicants** are defined by MIOSHA as any chemical that 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 Safety Data Sheet (SDS).

**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<sub>50</sub>) 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<sub>50</sub> is that dose at which a lethal response is observed in 50% of the test animals.

The following two 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 SDS will list the specific hazards. Use the SDS to address chronic toxicity. For further help in determining the hazard of a chemical, contact your supervisor or assistant dean as appropriate.

## **B.) Biological**

**Biological hazards** (biohazards, biohazardous materials) are exempt from coverage under the GRCC-CHP if the only hazard they pose is biological. However, if the material also possesses physical or health hazards, then an SDS is required.

## **1.5 RESPONSIBILITY**

**1.5.1 The Health & Safety Team:** The Health & Safety Team is responsible for the development and implementation of institutional procedures for the establishment and maintenance of an environmentally healthy and safe work place. The team is responsible for annual review and updates to this plan based on MIOSHA laboratory standards. Faculty and Lab Coordinators serve as resources for compliance with the Plan and have the responsibility to implement and carry-out provisions of the Plan. In the absence of a Chemical Hygiene Officer the Health and Safety Team shall fulfill those roles.

**1.5.2 Chemical Hygiene Officer:** An employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. Responsibilities include:

1. Establishes, maintains, and revises the chemical hygiene plan (CHP).
2. Creates and revises safety rules and regulations.
3. Monitors procurement, use, storage, and disposal of chemicals.
4. Conducts regular inspections of the laboratories, preparations rooms, and chemical storage rooms,
5. Maintains inspection, personnel training, and inventory records.
6. Assists laboratory supervisors in developing and maintaining adequate facilities.

**1.5.3 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 the Campus Police for reportable accidents. The Health & Safety team, supervisor, or assistant dean as appropriate, should be notified about work practices or working conditions they believe hazardous to their health or to the health of others.

**1.5.4 Student.** While students are not covered under the provisions of the

MIOSHA laboratory standard, students will be made aware of chemical health and safety hazards in classroom situations and will be provided with information and equipment to protect themselves from those hazards. Instructors 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/laboratory 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 their supervisor or Assistant Dean about potential risks in the laboratory.

## **1.7 AVAILABILITY**

The Chemical Hygiene Plan must be readily available online at [www.grcc.edu](http://www.grcc.edu) under quick reference *Chemical Hygiene*.

## **1.8 ANNUAL REVIEW**

The Health and Safety Team is responsible for reviewing the plan annually from its effective date and make any necessary modifications as programs, courses and/or projects change.

## **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.

**1.9.1 Information.** Information provided by administrators, supervisors, faculty and lab coordinators to employees must include:

1. The contents of the MIOSHA Hazardous Work in laboratories standard.
2. The location and availability of the GRCC-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 the SDS).
5. The location and availability of known reference materials on the hazards, safe handling, storage and disposal of hazardous chemicals found in the

laboratory, including, but not limited to, Safety Data Sheets received from the supplier and are readily available from [www.grcc.edu](http://www.grcc.edu) homepage under quick reference Safety Data Sheets – SDS.

**1.9.2 Method of Training.** General training will be provided by Supervisors, Assistant Deans, Department Heads, Faculty and Lab Coordinators and may take the form of individual instruction, group seminars, audiovisual presentations, on-line instruction, handout material, or any combination of the above.

**General awareness training** provided to employees *may* include:

1. Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as 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 College 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 GRCC CHP.

**Site-specific training** provided to employees or students will include:

1. Site-specific standard operating procedures.
2. Site-specific emergency procedures.
3. Specific physical and health hazards of chemicals in the work area (available on SDSs).

**1.9.3 Documentation.** Supervisors, Program Directors and Lab Coordinators must maintain records to document employee training completion and submit that information to Staff Development. Faculty are responsible to maintain student safety training documentation.

## 1.10 RECORD KEEPING

Campus wide training documents will be kept by the Staff Development. Site specific training documents will be kept by the employee's supervisor or Assistant Dean within the employee's area. Accident records for employees should be written and retained by the Human Resources. 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. STANDARD OPERATING PROCEDURES**

GRCC has developed generic standard operating procedures relevant to safety and health considerations when laboratory work involves the use of hazardous materials. Standard operating procedures must be provided to all affected laboratory employees. The Standard Operating Procedures in this document specify minimum regulations and recommendations.

Academic departments may have additional, department specific standard operation procedures and requirements for working in laboratories. Faculty and staff may create their own procedures or use publicly available resources such as reference books, internet sites (of a reliable source), or lab manuals.

### **2.1 GENERAL SAFETY PRINCIPLES**

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

1. Examine the known hazards associated with the materials being used. Never assume all hazards have been identified. Carefully read the label before using an unfamiliar chemical. When appropriate, review the Safety Data Sheet (SDS) for special handling information. Determine the potential hazards and use appropriate safety precautions before beginning any new operation.
2. Be familiar with the location of emergency equipment - fire alarms, fire extinguishers, and emergency eyewash and shower stations and know the appropriate emergency response procedures. Avoid distracting or startling other workers when they are handling hazardous materials.
3. Use equipment and hazardous materials only for their intended purpose.
4. Always be alert to unsafe conditions and actions calling attention to them so that corrective action can be taken as quickly as possible.

### **2.2 HEALTH AND HYGIENE**

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

1. Avoid direct contact with any hazardous materials. Know the types of protective equipment available and use the proper type for each job.
2. Confine long hair and loose clothing and always wear footwear that fully covers the feet.
3. Use appropriate safety equipment whenever exposure to gases, vapors,

oraerosols is suspected and ensure exhaust facilities are working properly. Wash thoroughly with soap and water after handling hazardous materials, before leaving the laboratory and before eating or drinking.

4. Replace personal protective equipment as appropriate.
5. Laboratory employees shall be familiar with the symptoms of exposure for the materials with which they work and the precautions necessary to prevent exposure.
6. Wear eye and face protection when appropriate.
7. Always inspect equipment for leaks, tears and other damage before handling a hazardous material. This includes gloves, goggles, etc.
8. Avoid tasting or smelling hazardous materials.
9. There shall be no food, drink, smoking or applying cosmetics in the laboratories.
10. No horseplay, practical jokes, or pranks are allowed in the laboratory.

### **2.3 HOUSEKEEPING**

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

1. Keep laboratories clean and uncluttered. Clean minor spills immediately and thoroughly.
2. Do not block exits, emergency equipment or controls, or use hallways and stairways as storage areas.
3. Avoid working alone whenever possible. No students should ever be allowed to work alone in a laboratory unless supervised by an appropriate faculty member or supervisor.

### **2.4 FOOD AND DRINK IN THE LABORATORY**

1. Avoid eating, drinking, smoking, or applying of commercial products in any laboratory area where hazardous chemicals or biological hazards are in use.
2. Refrigerators and microwave ovens used for chemical or biological storage or other laboratory use shall not be used for food storage or preparation.
3. Food or beverages for research or experimental purposes should be labelled as such or with the words “not for human consumption”.

## **2.5 CHEMICAL HANDLING**

The decision to use a hazardous material should be a commitment to handle and use the materials properly from initial receipt to disposal. Each department should have a specific plan, indicate where this information is stored, and the location should be made known to department employees.

1. Always purchase the minimum amount necessary of a hazardous material.
2. Information on proper handling and disposal of hazardous materials and access to related Safety Data Sheets (SDS) should be made available to all laboratory employees prior to the use of the material.
3. Hazardous materials utilized in the laboratory must be appropriate for the laboratory's ventilation system.
4. Large, glass bottles should be stored no more than two feet from floor level.
5. Storage of materials at the lab bench, or other work areas shall be kept to a minimum.
6. Any chemical mixture shall be assumed to be as toxic as its most toxic component.
7. Substances of unknown toxicity shall be assumed to be toxic.

## **2.6 TRANSFERRING OF HAZARDOUS MATERIALS**

When transporting hazardous materials outside the laboratory, precautions should be taken to avoid dropping or spilling chemicals. Use the following procedures:

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

### **2.6.1 Autoclave Protocol**

#### **Basic Procedure**

The following procedure is recommended by the Office of Radiation, Chemical and Biological Safety for the decontamination of biohazardous waste.

1. The following materials need to be autoclaved prior to disposal:
  - Culture and stocks of infectious agents

- Culture dishes and related devices
  - Contaminated solid items such as paper towels, cloth and plastic pipette tips, pipettes and vials, petri dishes and gloves.
  - Have a cart available to transport items to and from the autoclave
2. Items should be autoclaved in approved autoclave bags and a rigid secondary container with indicator tape which demonstrates if the sterilization temperature was achieved.
  3. Add one cup of water to each bag of solid waste and keep the bags OPEN-- steam cannot penetrate closed bags.
  4. After the cycle is completed, let the bag cool for several minutes before removing it from the autoclave. Securely close orange autoclave bag.
  5. Place treated autoclave bags into opaque (non see-through) black bag and close them securely before disposing. To assure that the black bag does not rupture, do not put multiple orange bags in a single black bag.
  6. Only trained employees may operate the autoclave.
  7. Once a month use a biological indicator and bury in the center of the load to validate adequate steam penetration. Keep a log of the results.
  8. Autoclave components to be inspected regularly.

## **2.7 LABORATORY SECURITY**

Laboratories must be secured using reasonable measures to prevent against theft, unauthorized entry, and misuse of chemicals or equipment, especially those that could present a risk to the public or be used for illicit purposes.

## **2.8 STORAGE AND DISPOSAL OF HAZARDOUS WASTE**

Each laboratory must have a designated space where hazardous waste is accumulated. All such waste must be collected and clearly labeled. The proper storage and disposal of hazardous wastes from laboratory operations must be documented in program specific procedures. The GRCC Facilities department will assist with facilitating waste disposal according to MIOSHA guidelines and standards.

## 3. STANDARD OPERATING PROCEDURES

### 3.1 HAZARD IDENTIFICATION

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

1. Labels on incoming containers of hazardous materials for laboratory use are not to be removed or defaced. Labels contain information on the identity of the material(s) in the container and the hazard identification of the material(s). Incoming containers must be labeled with the date of receipt.
2. Hazardous material storage areas should be labeled per the guidelines established in Section 6 of this document.
3. Employees must have access to Safety Data Sheets (SDS).

### 3.2 LABELING

**3.2.1 Container Labels.** All permanent containers of hazardous materials must be clearly and visibly labeled with the name of the material and all the hazard(s), as provided by the manufacturer. For example, acetaldehyde is flammable and a carcinogen, and must be labeled appropriately. Additionally, the subsequent guidelines shall be followed:

1. All peroxide forming chemicals must be labeled with the date the container was opened. After the recommended disposal date, test the chemical for peroxides or dispose of properly (see Appendix B for a list of peroxide forming chemicals and peroxide testing protocols).
2. Consumer products and anything available over the counter to the general public is exempt from labeling requirements as long as it has already been labeled by the manufacturer.
3. Temporary storage containers and portable containers into which hazardous materials are transferred from labeled containers are to have a temporary label identifying the chemical. The label should be affixed to or written on the container for temporary storage or transport.
4. All sample containers or prepared solutions must be labeled.

**3.2.2 Waste Containers.** All hazardous material waste should be segregated and labeled. 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. Once a chemical has been dated and labeled as a hazardous waste, it may not be accumulated for more than 90 days.

### 3.3 PROVISIONS FOR PARTICULARLY HAZARDOUS SUBSTANCES

**3.3.1 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 American Conference of Governmental Industrial Hygienists (ACGIH) has established Threshold Limit Values (TLV's) that are TWA values similar to PEL's. To keep employee exposures as low as reasonably achievable, employers will be expected to uphold the lowest exposure limit.

**3.3.2 Employee Exposure Determination.** The college will arrange for 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. The college 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.

**3.3.3 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.**

1. Use and store materials only in **designated areas**: a restricted access hood, or portion of a lab designated for use of highly toxic substances. Assure that all personnel with access are aware of the necessary safety precautions.
2. Label all containers, storage and use areas appropriately. Follow the guidelines established in this document.

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

1. Use a hood for procedures that may result in the generation of aerosols or vapors.
2. It is recommended that breakable containers be stored in chemical-resistant trays.

**Removal of Contaminated Waste.**

Follow the guidelines established for each laboratory and contact GRCC Facilities for assistance.

**Follow decontamination procedures prior to leaving the designated area.**

1. On leaving the designated area, remove any protective apparel (place it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck.
2. 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.
3. Use a wet mop or a vacuum cleaner equipped with a HEPA filter to decontaminate surfaces. **DO NOT DRY SWEEP SPILLED POWDERS.**
4. 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 materials.**

1. Consult the SDS for toxic properties and follow the specific precautions and procedures.
2. Guard against spills and splashes. Appropriate safety apparel, especially goggles and gloves, should be worn. All hoods or other essential engineering controls should be operating properly before work is started.
3. Notify the **Faculty/Supervisor /Associate Dean** and **Campus Police** of all incidents of exposure or spills. Contractors/vendors working on site should follow their appropriate employee protocol.

### 3.4 PHYSICAL HAZARDS

Materials that present a physical hazard 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 violent reaction or a reaction that generates toxic gas.

When certain hazardous materials are stored or mixed together, violent reactions may occur because the materials are unsuitable for mixing, or are incompatible. Classes of incompatible materials should be segregated from each other during storage, according to hazards of class. Use the following general guidelines for hazard class storage; flammable/combustible liquids and organic acids, flammable solids, mineral acids, caustics, oxidizers, perchloric acid, and compressed gasses.

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

<b>Flammable</b>	<b>Flash Point</b>	<b>Boiling Point</b>
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)	
<b>Combustible</b>		
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 C lists some common flammable and combustible chemicals. Appendix C pertains to the storage of flammable and combustible materials.

**When handling flammable/combustible materials, observe the following guidelines:**

1. Eliminate ignition sources such as open flames, hot surfaces, sparks from welding or cutting, operation of electrical equipment, and static electricity.
2. 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.
3. 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.

4. Assure appropriate fire extinguishers and/or sprinkler systems are in the area.

**3.4.2 Corrosives.** Corrosive 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 E.

1. Containers and equipment used for storage and processing of corrosive materials should be corrosion resistant.
2. Eye protection and rubber gloves should always be used when handling corrosive materials. A face shield, rubber apron, and rubber boots may also be appropriate, depending on the work performed.
3. **Never add water to acid.** When mixing concentrated acids with water, add the acid slowly to water.
4. 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.

**3.4.3 Oxidizers.** Oxidizers are materials that 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 F.

1. Know the reactivity of the materials involved in the experiment or process. Ensure there are no extraneous materials in the area that could become involved in a reaction.
2. If the reaction is anticipated to be violent or explosive, use shields or other methods for isolating the materials or the process.

**3.4.4 Water Reactive Materials.** Water reactive materials are those that 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.

**3.4.5 Peroxidizable Chemicals (Organic Peroxides).** Peroxides are materials that undergo auto-oxidation (a reaction with oxygen in the air) to form peroxides, which can explode upon 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 G for a list of materials that may form peroxides.

1. Date all peroxidizables upon receipt and upon opening. Dispose of or check for peroxide formation after the recommended time; 3-months or

one year depending on the chemical. See Appendix G.

2. Do not open any container that has obvious solid formation around the lid.
3. It is recommended to chemically test for peroxides periodically.
4. Follow the same basic handling procedures as for flammable materials.

**3.4.6. Light-Sensitive Materials.** Light sensitive materials degrade in the presence of light, forming new compounds that can be hazardous or result in conditions such as pressure build-up inside a container. Examples of light sensitive materials include chloroform, tetrahydrofuran, ketones, and anhydrides. Store light-sensitive materials in amber colored bottles in a cool dark place .

**3.4.7 Unstable Materials.** Unstable materials 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 G.

1. Contact the Campus Police when it is suspected that the inadvertent formation of shock-sensitive materials in chemicals being stored has occurred.
2. Date all containers of explosive or shock-sensitive materials upon receipt and when opened.
3. If there is a chance of explosion, use barriers or other methods for isolating the materials or the process.

**3.4.8 Cryogenics.** Cryogenics are 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 cryogenics are fire, pressure, weakening of materials, and skin or eye burns upon contact with the liquid.

1. Equipment should be kept clean, especially when working with liquid or gaseous oxygen.
2. Mixtures of gases or fluids should be strictly controlled to prevent formation of flammable or explosive mixtures.
3. 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.

4. Containers and systems containing cryogenics should have pressure relief mechanisms.
5. Containers and systems should be capable of withstanding extreme cold without becoming brittle.

**3.4.9 Compressed Gases.** 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. Additional programmatic and departmental procedures must be developed if required for specific gas types.

OSHA Standard for the storage of Oxygen-fuel Gases for welding and cutting:

Part Number:	1910
Part Title:	Occupational Safety and Health Standards
Subpart:	Q
Subpart Title:	Welding, Cutting and Brazing
Standard Number:	1910.253
Title:	Oxygen-fuel gas welding and cutting
GPO Source:	e-CFR

OSHA Standard for the storage of compressed gases other than those used for welding and cutting:

Part Number:	1910
Part Title:	Occupational Safety and Health Standard
Subpart:	H
Subpart Title:	Hazardous Materials
Standard Number:	1910.101
Title:	Compressed gases (general requirements)
GPO Source:	e-CFR

## 4. EMERGENCY AND NON-EMERGENCY PROCEDURES

### 4.1. BASIC STEPS IN CASE OF A SPILL

#### 4.1.1 Definitions of Emergency and Non Emergency Spills

**Emergency Situations.** 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 a 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 or health
  - 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.
5. The spill is of a reactive material.

**Non Emergency Situations.** 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 laboratory instructor, laboratory technician, or trained student-workers (under supervision) can appropriately clean up the release using authorized 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 instructors, trained student employees, or trained custodians need not be considered an emergency.

#### **4.1.2. Spill Kits.**

Ready access to the following equipment is required in laboratories that work with hazardous materials:

1. Splash resistant goggles
2. Chemical resistant gloves
3. Plastic bags
4. The following chemical sorbents (enough for a 4 L spill)
  - a. sand (organic spills)
  - b. sodium hydrogen carbonate (acid spills)
  - c. citric acid (base spills)
  - d. zinc dust (mercury spills)
5. Small broom and dust pan

#### **4.1.3 Procedures for Emergency Spills.**

If the spill is more than 4 liters and of high toxicity or flammability, or you are unsure of how to proceed, execute the following:

1. Call Campus Police, ext. 4911 or 911 if after hours.
2. Evacuate students from the spill area and alert others in the area.
3. If there are hazardous fumes, contact facilities for emergency shut down of HVAC units. Evacuation of the building is mandatory if chemicals or contaminants could enter the air circulation system of a building.

#### **4.1.4 Procedures for body and eye splashes and chemical inhalation.**

**Attend to victims for a body splash using the following procedures:**

1. If necessary, remove person(s) from spill area to fresh air only if attempts to rescue victim(s) do not present a danger to the rescuers.
2. Remove contaminated clothing, shoes, and jewelry (do not attempt to wipe the clothes) while under an emergency shower. Seconds count. Be careful not to contaminate eyes while removing clothing. It may be better to cut clothing off.
3. Flood affected area with cold water for at least 15 minutes or longer if pain persists. Try not to spread chemical on skin or eyes.

4. Contact Campus Police ASAP and assure they know the chemical(s) involved.
5. **Attend to victims for an eye splash using the following procedures:**
  - a. If necessary, remove victim(s) from spill area to fresh air only if an attempt to rescue victim(s) does not present a danger to the rescuers.
  - b. Lead the victim(s) immediately to an emergency eye wash facility.
  - c. Hold eyelids open. Have victim rotate eyes.
  - d. Flush eyes for at least 15 minutes or longer if pain persists.
  - e. Contact Campus Police (ext. 4911) ASAP and assure that they know the chemical(s) involved.

**Attend to victim of chemical inhalation using the following procedures:**

- a. Remove victim to fresh air.
- b. If symptoms, such as a headache, nose or throat irritation, dizziness, drowsiness, or tightening of the chest, contact Campus Police, 4911.

**4.1.5 Procedures for non-emergency spills (less than 4 liters).**

**Use the following procedures for non-emergency spills:**

1. Locate the spill kit.
2. Choose the proper protective equipment. Always wear gloves and protective eyewear. If necessary, use additional protective equipment such as an apron, coveralls, or boots.
3. Confine or contain the spill.
4. Cover liquid spills with spill kit absorbent and sweep into a dustpan and place in a sealed container.
5. Sweep solid materials into a dustpan and place in a sealed container.
6. Dispose of waste as normal trash as long as substance is non-volatile, non-hazardous.

**4.1.6 Mercury Spills.** GRCC suggests that staff/faculty avoid the use of mercury on campus whenever possible. Specific procedures exist and should be followed for programs requiring use (i.e. – Dental).

In case of a small spill, i.e. a broken mercury thermometer, we can clean it up in house. For a mercury spill of more than the amount contained in a normal mercury thermometer do not clean it up. Evacuate the area and call Campus Police. **Procedures are as follows:**

1. In case of a small spill, i.e. a broken mercury thermometer, use an appropriate Mercury spill kit to clean-up the spilled mercury.
2. Do not allow foot traffic in the area until the clean-up is complete.
3. Dispose of the used spill kit by placing the sealed container in your hazardous waste staging area, either yourself by appropriate means for your department to dispose of hazardous waste. Be certain that the package is clearly labeled Mercury.
4. If mercury (in any amount) gets into a drain do not allow anything including water to be sent down the drain cordon off the area and call Campus Police.

For a mercury spill of greater volume than the amount contained in a normal mercury thermometer do not clean it up.

1. Evacuate the area maintaining the furthest distance from the spill sight possible.
2. Close all access to the area and post so that no one enters.
3. If possible, without any risk of disturbing or spreading the mercury, supply fresh air ventilation.

Call Campus Police:

4911 in house phone

(616) 234-4911 by Cell or Off Campus Phone

## **4.2 BASIC STEPS IN CASE OF FIRE ALARM OR FIRE**

**4.2.1 Fire Alarms.** The following steps are basic protocol in the event of a fire alarm. These steps and exit locations should be reviewed with students.

1. When passing through a closed door, check doorframe for heat.
2. Feel the door or doorknob to the hallway with back of your hand. If it feels hot, do not open it-the fire may be on the other side of the door. If you are trapped, put a cloth or towel under the door to help prevent entry of smoke.
3. Call Campus Police, (ext.4911) stay on phone until instructed otherwise.

4. If the door is not hot, open it slowly. If the hallway is clear of smoke, drop and crawl toward an exit.
5. Identify people who can assist wheelchair users in getting to the "Handicapped Evacuation Areas". **The "Handicapped Evacuation Area" for each building has a map marking the designated location:**
  - a. Close doors and turn off lights upon leaving the room. Evacuate the building at the nearest exit.
  - b. If you are with students, take your class to the designated area and wait until "All Clear" is given by the GRCC Campus Police officers.
  - c. Do not stand on pedestrian walkways or block exits.
  - d. Do not use elevators.
  - e. Report any known missing or injured students/staff immediately to Campus Police at ext. 4911.

**4.2.2 Small Laboratory Fires.** The following steps are basic protocol for handling a small laboratory fire:

1. A fire contained in a small vessel can usually be suffocated by covering the vessel with a lid.
2. If you have been trained in the use of a fire extinguisher and are confident that you can contain the fire, fight the fire from a position where you can escape.

**4.2.3 Clothing/Body Fires.** The following steps are basic protocol in the event of a clothing/body fire:

1. If your clothing catches on fire, drop to the floor and roll. Use a fire blanket if available.
2. If a co-worker's clothing catches on fire, knock person to the floor and roll them to smother the flames. Use a fire blanket if available.
3. Use a safety shower immediately afterwards.
4. Contact Campus Police, ext. 4911.

**4.2.4 Facility Fires.** The following steps are basic protocol in the event of a facility fire:

1. Activate the emergency fire alarm and alert people in area of the need to evacuate.
2. Follow steps under Section **4.2.1 Fire Alarms**.
3. Call Campus Police at ext. 4911 from a safe location.
4. Campus Police staff shall immediately notify the Crisis Management Team when a fire emergency alarm goes off.

### **4.3. MISCELLANEOUS EMERGENCIES**

#### **4.3.1 Gas Leakage:**

1. If leakage location is identifiable, immediately shutoff at location.
2. If leakage location cannot be identified, hit the emergency shutoff.
3. Evacuate the building if leak cannot be isolated.
4. In both instances, immediately notify Campus Police, ext. 4911.

#### **4.3.2 Accidental Ingestion of Chemicals**

1. Call Campus Police, ext. 4911.
2. Do not induce vomiting unless directed to do so by medical personnel.

#### **4.3.3 HVAC: Ventilation and Electrical**

If laboratory ventilation is not functioning or there is an electrical emergency, contact **Facilities at ext. 4057**. If emergency lighting and fire alarms **ARE NOT** operable, evacuate the building after the following steps have been taken:

1. Place lids on all open containers of volatile chemicals.
2. Lower the sash on chemical fume hoods.
3. Shut down all equipment (leave cooling water and purge gases on as necessary).
4. Turn off ignition sources and gas sources.
5. Secure or isolate reactions that are underway.
6. Close all doors.
7. Take your books, coats, purse/wallet, keys, etc.

#### **In anticipation of a power outage the following provisions have been made:**

1. GRCC has emergency generators that will provide temporary lighting. The lights are primarily used for illumination to exit the facility.
2. Flashlights should be conveniently located.
3. Campus emergency numbers should be in convenient locations.

## 5. MEDICAL PROCEDURES

### 5.1 INJURY AND ACCIDENT

Use the following procedures in the event of accident or injury to a GRCC employee (not employees through temporary services) during the performance of duties for Grand Rapids Community College. If an employee is injured on the job, he/she must:

1. Report the injury promptly to Campus Police, ext. 4911 for completion of an incident report. It is imperative that **all injuries** are reported, even if medical treatment is not necessary. Employees should promptly report work-related injuries, even if the injury is discovered later or the work related injury is not rapidly apparent.
2. Complete an **[EMPLOYEE INJURY REPORT](http://www.grcc.edu/humanresources/employeeinjuryprocedures)** form which can be found on line at <http://www.grcc.edu/humanresources/employeeinjuryprocedures>
3. All injuries should be reported, even if medical treatment is not necessary.
4. Report his/her injury within 24 hours to his/her supervisor.
5. After treatment, the employee must return any after care instructions to his/her supervisor or Department Head for review of any restrictions. After review, supervisors are required to send all paperwork to the HR/Benefits Office, Admin Building.
6. If an injury occurs after regularly scheduled GRCC hours and immediate medical authorization is necessary, employees should contact Campus Police at (616) 234-4911. If the injury is life threatening, injured employees should go to the nearest emergency room.

NOTE: To be considered an employee, the person must be on the payroll for Grand Rapids Community College at the time of injury. If individuals are not paid by the College, GRCC is not responsible for their treatment. Contracted service employees and vendors should follow their organization's protocol.

### 5.2 MEDICAL CONSULTATIONS AND EXAMINATIONS

GRCC must provide all employees working with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the circumstances outlined below:

1. The employee must be provided an opportunity to receive an appropriate examination when he/she develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory
2. Where exposure monitoring reveals a 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.

3. 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.
4. All medical consultations and examinations must be performed by or under the direct supervision of a licensed physician and be provided without cost to the employee, without loss of pay and at a reasonable time and place.

**GRCC or the appropriate department** shall provide the following information to the physician:

1. The identity of the hazardous chemical(s) to which the employee may have been exposed.
2. A description of the conditions surrounding the exposure, including available quantitative exposure data.
3. A description of the signs and symptoms of exposure that the employee is experiencing, if any.

## 6. STANDARD LABORATORY FACILITY REQUIREMENTS

### 6.1. 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 and emergency equipment, exits, and to aid Campus Police.

The Michigan Right-to-Know law requires that laboratories keep Safety Data Sheets (SDS's) in a systematic and consistent manner. The system adopted must provide easy access to SDS's for hazardous chemicals used in the laboratories.

Safety Data Sheets are documents containing chemical hazard identification, safe handling information, and is prepared in accordance with the OSHA Hazard Communication Standard and the Michigan Right-to-Know law. Chemical manufacturers and distributors must provide the purchasers of hazardous chemicals an appropriate SDS for each hazardous chemical/product purchased.

GRCC SDS's are located online at [www.grcc.edu](http://www.grcc.edu) under quick reference and hard copies are located at **Campus Police and Purchasing**.

The following signs must be posted in appropriate places.

1. The Michigan Right-to-Know law poster, listing the location of SDS's for all hazardous chemicals used in the laboratories.
2. The emergency contact numbers are posted on the Right to Know Stations.
3. The Director of Purchasing updates policy and safety data sheets as the law states.
4. 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.

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 and radioisotopes. Other chemical hazards will be dealt with on a case-by-case basis, with consultation from content experts and external resources as needed.

## 6.2 STORAGE AREAS

Chemicals should be stored according to compatibility 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

Additionally, storage areas for radioisotopes should be appropriately labeled.

## 6.3 PERSONAL PROTECTIVE AND SAFETY EQUIPMENT

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.

### 6.3.1 Personal Protective Equipment

Eye and skin protection equipment must be made available to all employees or visitors to laboratories where chemicals are used or stored. This equipment must be used where there is a reasonable probability of injury from hazardous chemicals that can be prevented from such equipment.

**6.3.1.1 Eye Protection.** Many of our laboratories, non-laboratory areas, and chemical storeroom contain hazardous or corrosive liquids that may present a chemical splash hazard that could cause eye injury. The potential for eye injury from flying debris also exists in some instances. The following section describes adequate eye protection for various situations and provides guidelines for using such protection.

MIOSHA has adopted the American National Standards Institute (ANSI) consensus standards for eye protection. 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. The following types of eye protection are available for use in the laboratory:

1. Safety glasses with side shields offer minimal eye protection against flying fragments, chips, particles, sand, and dirt.
2. Safety (impact) goggles offer adequate eye protection against flying fragments, chips, particles, sand, and dirt.

3. Chemical splash goggles have indirect venting for splash proof sides and provide adequate eye protection against chemical splashes.
4. Face shields protect the face and neck from flying particles and splashes. Face shields do not protect the eyes adequately so additional eye protection should be worn.
5. Ultra-violet (UV) light face shields provide eye protection when working with UV light sources.

#### Table of Eye Protection Selection Guidelines

Operation	Eye Protection Required
When handling potentially hazardous, corrosive, or injurious chemicals	Chemical splash goggles
Entry into laboratory or area where others are working with potentially hazardous, corrosive, or injurious chemicals	Chemical splash goggles
Transferring more than one liter quantities of corrosive chemicals	Chemical splash goggles and face shield
Working with glassware under reduced or elevated pressure or with drill presses or other similar conditions.	Safety (impact) goggles
Working with UV light sources	UV light face shield

All employees and visitors should be provided protective eye-wear whenever they enter a laboratory or chemical storeroom. Guidelines for eye protection use are out lined in the table above. Refer to the SDS for assistance in determining the injurious nature of chemicals and for specific recommendations on eye protection.

**6.3.1.2 Protection of the Skin and Body.** Many chemicals cause skin irritation or burns. Further, some can be absorbed through the skin, with potentially harmful effects. Therefore, efforts must be made to reduce chemical exposure to the skin and body. Skin and body protection involves the use of protective clothing to prevent chemical exposure. The SDS may provide some information on personal protective equipment recommended for a given chemical; however, the SDS often does not provide sufficient information concerning the specific type of protective clothing required.

The most basic and effective forms of protection include:

1. Shoes – shoes that cover the entire foot should always be worn when handling liquid, hazardous, and corrosive chemicals. Opened toed shoes, sandals, and clogs are forbidden in the chemistry laboratories.
2. Long pants – Long pants should be worn to protect the skin from chemical exposure. For the best protection, pants should be loose-fitting and made from a heavy material. Shorts and skirts should not be worn while working in the lab.

3. Shirts – In order to protect the skin from chemical exposure, shirts should cover the abdomen. Shirts should not have long, flowing sleeves.
4. Laboratory coats - Laboratory coats offer additional skin protection from chemical exposure.
5. Gloves – Gloves are an excellent way to prevent chemical exposure to the hands when chemicals are transferred between containers. Protective gloves should be worn when handling hazardous materials, chemicals of unknown toxicity, and corrosive materials. Choosing the appropriate hand protection can be a challenge in a laboratory setting. Glove selection is discussed below.

In rare cases, such as when handling large quantities of strong acids or bases, acid gases, certain organic chemicals, which are classified as mutagens, or carcinogens, strong oxidizing agents, the use of specialized protective equipment that prevents skin contamination may be required. Examples of this equipment include rubber gloves, aprons, boots and protective suits.

**Gloves.** When handling chemicals in a laboratory, disposable latex, vinyl, or nitrile examination gloves are usually appropriate for most circumstances. When working with chemicals with high acute toxicity, working with corrosives in high concentrations, handling chemicals for extended periods of time or immersing all or part of a hand into a chemical, the appropriate glove material should be selected based on chemical compatibility. The following table outlines the major glove types and their general uses.

<b>Glove Material</b>	<b>General Uses</b>
Butyl	Offers the highest resistance to permeation by most gases and water vapor. Especially suitable for use with esters and ketones.
Neoprene	Provides moderate abrasion resistance but good tensile strength and heat resistance. Compatible with many acids, caustics and oils.
Nitrile	Excellent general duty glove. Provides protection from a wide variety of solvents, oils, petroleum products and some corrosives. Excellent resistance to cuts, snags, punctures and abrasions.
PVC	Provides excellent abrasion resistance and protection from most fats, acids, and petroleum hydrocarbons.
PVA	Highly impermeable to gases. Excellent protection from aromatic and chlorinated solvents. Cannot be used in water or water-based solutions.
Viton	Exceptional resistance to chlorinated and aromatic solvents. Good resistance to cuts and abrasions.
Silver Shield	Resists a wide variety of toxic and hazardous chemicals. Provides the highest level of overall chemical resistance.

Natural rubber Provides flexibility and resistance to a wide variety of acids, caustics, salts, detergents and alcohols.

There are several factors besides glove material to consider when selecting the appropriate glove. More details on glove selection can be found in the catalogs that sell these items.

1. Dexterity- Where fine dexterity is needed, consider double gloving with a less compatible material, immediately removing and replacing the outer glove if there are any signs of contamination. In some cases, such as when wearing Silver Shield gloves, it may be possible to wear a tight-fitting glove over the loose glove to increase dexterity.
2. Length- Glove length should be chosen based on the depth to which the arm will be immersed or where chemical splash is likely.
3. Size – Glove size may also be important. Gloves that are too tight tend to cause fatigue, while gloves which are too loose will have loose finger ends which make work more difficult.
4. Degradation - Degradation is the change in one or more of the physical properties of a glove caused by contact with a chemical. Degradation typically appears as hardening, stiffening, swelling, shrinking or cracking of the glove. Gloves that show signs of degradation should be discarded.
5. Breakthrough time – Breakthrough time is the elapsed time between the initial contact of the test chemical on the surface of the glove and the analytical detection of the chemical on the inside of the glove. When using mixture of chemicals, it is recommended that the glove material be selected based on the shortest breakthrough time.
6. Permeation rate – The permeation rate is the rate at which the test chemical passes through the glove material once breakthrough has occurred and equilibrium is reached.

**Glove Inspection, Use, and Care.** The following guidelines should be observed when using protective gloves:

1. All gloves should be inspected for signs of degradation or puncture before use. Test for pinholes by blowing or trapping air inside and rolling them out.
2. Disposable gloves should be changed when there is any sign of contamination. Reusable gloves should be washed frequently if used for an extended period of time and each time they are removed.

3. While wearing gloves, be careful not to handle anything but the materials involved in the procedure. Touching equipment, phones, wastebaskets or other surfaces may cause contamination. Be aware of touching the face, hair, and clothing as well.
4. To avoid accidental skin exposure, remove the first glove by grasping the cuff and peeling the glove off the hand so that the glove is inside out. Repeat this process with the second hand, touching the inside of the glove cuff, rather than the outside. Wash hands immediately with soap and water.

**Latex Gloves and Related Allergies.** Latex exposure symptoms include skin rash and inflammation, respiratory irritation, asthma, and shock. The amount of exposure needed to sensitize an individual to natural rubber latex is not known, but when exposures are reduced, sensitization decreases.

NIOSH recommends the following actions to reduce exposure to latex:

1. Whenever possible, substitute another glove material.
2. If latex gloves must be used, choose reduced-protein, powder-free latex gloves.
3. Wash hands with mild soap and water after removing latex gloves.

**Respirators.** Use of respirators in laboratories is strongly discouraged. Respirator 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 Spectrum Health Occupational Services, attend a respiratory training session, undergo a fit test and complete a respirator wearer questionnaire.

### 6.3.2 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  $\leq 2.0$  or  $\geq 12.5$  are used.
2. Showers shall be located within 100 feet of areas where chemicals with a pH of  $> 2$  and  $< 4$  or  $\geq 9$  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.
4. 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 tepid 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.

#### **6.4 VENTILATION CONTROLS**

Ventilation controls are those controls intended to minimize employee exposure to hazardous chemicals by removing air contaminants from the work site. To determine ventilation requirements for a specific chemical, assess the MSDS. There are two main types of ventilation controls:

1. General (Dilution) Exhaust: a room or building-wide system that 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 workday. 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.

**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 that 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 airflow in the hood using a continuous monitoring device or another source of visible airflow indicator. If airflow has changed, contact GRCC Facilities for an inspection.

**Ventilation Inspection.** 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.** GRCC Facilities 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) by a thermoAnemometer (a hot wire). One measurement is taken per square foot of face space and averaged. 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 contained by the hood.

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 system must be 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 that 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 Facilities to arrange for an inspection.

# Appendix A

## BIOLOGICAL AGENTS BY RISK GROUP

### ***Risk Group 1 (low individual and community risk)***

A biological agent that is unlikely to cause disease in healthy workers or animals.

### ***Risk Group 2 (moderate individual risk, limited community risk)***

A pathogen that can cause human or animal disease but under normal circumstances, is unlikely to be a serious hazard to healthy laboratory workers, the community, livestock, or the environment. Laboratory exposures rarely cause infection leading to serious disease; effective treatment and preventive measures are available and the risk of spread is limited.

### **Risk Group 2 Bacteria, Chlamydia, Mycoplasma**

Bacillus cereus

Corynebacterium diphtheriae,

Escherichia coli

Mycobacteria - all species (except M. tuberculosis, and M. bovis (non-BCG strain), which are in Risk Group 3)

Pseudomonas aeruginosa

Shigella boydii, S. dysenteriae, S. flexneri, S. sonnei

Staphylococcus aureus

Streptococcus spp. (Lancefield Groups A, B,C,D,G)

### **Risk Group 2 Fungi**

Cryptococcaceae

*Candida albicans*

### **Risk Group 3 (high individual risk, low community risk)**

A pathogen that usually causes serious human or animal disease, or which can result in serious economic consequences but does not ordinarily spread by casual contact from one individual to another, or that can be treated by antimicrobial or antiparasitic agents.

### ***Risk Group 4 (high individual risk, high community risk)***

A pathogen that usually produces very serious human or animal disease, often untreatable, and may be readily transmitted from one individual to another, or from animal to human or vice-versa directly or indirectly, or by casual contact.

# APPENDIX B

## Classes of Peroxidizable Chemicals

### A. Chemicals that form explosive levels of peroxides without concentration

Butadiene <sup>a</sup>	Divinylacetylene	Tetrafluoroethylene <sup>a</sup>	Vinylidene chloride
Chloroprene <sup>a</sup>	Isopropyl ether		

### B. Chemicals that form explosive levels of peroxides on concentration

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

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

Acrylic acid <sup>b</sup>	Chlorotrifluoroethylene	Vinyl acetate	Vinyladiene chloride
Acrylonitrile <sup>b</sup>	Methyl methacrylate <sup>b</sup>	Vinylacetylene	
Butadiene <sup>c</sup>	Styrene	Vinyl chloride	
Chloroprene <sup>c</sup>	Tetrafluoroethylene <sup>c</sup>	Vinylpyridine	

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

Acrolein	tert-Butyl methyl ether	Di(1-propynyl) ether <sup>f</sup>	4-Methyl-2-pentanone
Allyl ether <sup>d</sup>	n-Butyl phenyl ether	Di(2-propynyl) ether	n-Methylphenetole
Allyl ethyl ether	n-Butyl vinyl ether	Di-n-propoxymethane <sup>d</sup>	2-Methyltetrahydrofuran
Allyl phenyl ether	Chloroacetaldehyde diethylacetal <sup>d</sup>	1,2-Epoxy-3-isopropoxypropane <sup>d</sup>	3-Methoxy-1-butyl acetate
p-(n-Amyloxy)benzoyl chloride	2-Chlorobutadiene	1,2-Epoxy-3-phenoxypropane	2-Methoxyethanol
n-Amyl ether	1-(2-Chloroethoxy)-2-phenoxyethane	Ethoxyacetophenone	3-Methoxyethyl acetate
Benzyl n-butyl ether <sup>d</sup>		1-(2-Ethoxyethoxy)ethyl acetate	2-Methoxyethyl vinyl ether
Benzyl ether <sup>d</sup>	Chloroethylene	2-Ethoxyethyl acetate	Methoxy-1,3,5,7-cycloocta tetraene
Benzyl ethyl ether <sup>d</sup>	Chloromethyl methyl ether <sup>c</sup>	(2-Ethoxyethyl)-o-benzoyl benzoate	§-Methoxypropionitrile
Benzyl methyl ether	§-Chlorophenetole	1-Ethoxynaphthalene	m-Nitrophenetole
Benzyl 1-naphthyl ether <sup>d</sup>	o-Chlorophenetole		
1,2-Bis(2-chloroethoxy)ethane	p-Chlorophenetole	o,p-Ethoxyphenyl isocyanate	1-Octene
Bis(2-ethoxyethyl) ether	Cyclooctene <sup>d</sup>	1-Ethoxy-2-propyne	Oxybis(2-ethyl acetate)
Bis(2-(methoxyethoxy)ethyl)	Cyclopropyl methyl ether	3-Ethoxypropionitrile	Oxybis(2-ethyl benzoate)

ether	Diallyl ether <sup>d</sup>	2-Ethylacrylaldehyde oxime	§,§-Oxydipropionitrile
Bis(2-chloroethyl) ether	p-Di-n-butoxybenzene	2-Ethylbutanol	1-Pentene
Bis(2-ethoxyethyl) adipate	1,2-Dibenzyloxyethane <sup>d</sup>	Ethyl §-ethoxypropionate	Phenoxyacetyl chloride
Bis(2-ethoxyethyl)	p-Dibenzyloxybenzene <sup>d</sup>	2-Ethylhexanal	Ⓒ-Phenoxypropionyl chloride

phthalate			
Bis(2-methoxyethyl) carbonate	1,2-Dichloroethyl ethyl ether	Ethyl vinyl ether	Phenyl o-propyl ether
Bis(2-methoxyethyl) ether	2,4-Dichlorophenetole	Furan p-Phenylphenetone	
Bis(2-methoxyethyl)phthalate	Diethoxymethane <sup>d</sup>	2,5-Hexadiyn-1-ol	n-Propylether
Bis(2-methoxymethyl) adipate	2,2-Diethoxypropane	4,5-Hexadien-2-yn-1-ol	n-Propyl isopropyl ether
Bis(2-n-butoxyethyl) phthalate	Diethyl ethoxymethylenemalonate	n-Hexyl ether	Sodium 8,11,14-eicosa
Bis(2-phenoxyethyl) ether	Diethyl fumarated	o,p-Iodophenetole	tetraenoate
Bis(4-chlorobutyl) ether	Diethyl acetal <sup>d</sup> Isoamyl benzyl ether <sup>d</sup>	Sodium ethoxyacetylid <sup>e</sup>	
Bis(chloromethyl) ether <sup>e</sup>	Diethylketene <sup>f</sup>	Isoamyl ether <sup>d</sup>	Tetrahydropyran
2-Bromomethyl ethyl ether	m,o,p-Diethoxybenzene	Isobutyl vinyl ether	Triethylene glycol diacetate
§-Bromophenetole	1,2-Diethoxyethane	Isophorone <sup>d</sup>	Triethylene glycol dipropionate
o-Bromophenetole	Dimethoxymethane <sup>d</sup>	p-Isopropoxypropionitrile <sup>d</sup>	1,3,3-Trimethoxypropene <sup>d</sup>
p-Bromophenetole	1,1-Dimethoxyethane <sup>d</sup>	Isopropyl 2,4,5-trichlorophenoxy-	1,1,2,3-Tetrachloro-1,3-
3-Bromopropyl phenyl ether	Dimethylketene <sup>f</sup>	acetate	butadiene
1,3-Butadiyne	3,3-Dimethoxypropene	Limonene	4-Vinyl cyclohexene
Buten-3-yne	2,4-Dinitrophenetole	1,5-p-Methadiene	Vinylencarbonate
tert-Butyl ethyl ether	1,3-Dioxepane <sup>d</sup>	Methyl p-(n-amyloxy)benzoate	Vinylidene chlorid <sup>e</sup>

1. When stored as a liquid monomer
2. Although these chemicals form peroxides, no explosions involving these monomers occur.
3. 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.
4. These chemicals easily form peroxides and should probably be considered under part B.
5. OSHA-regulated carcinogen
6. Extremely reactive and unstable compound.

## Safe Storage Period for Peroxide Forming Chemicals

Description	Period
Unopened chemicals from manufacturer	18 months
<b>Opened containers</b>	
Chemicals in Part A	3 months
Chemicals in Parts B and D	12 months
Uninhibited chemicals in Part C	24 hours
Inhibited chemicals in Part C	12 months <sup>a</sup>

<sup>a</sup> Do not store under inert atmosphere, oxygen required for inhibitor to function.

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

## DETECTION AND INHIBITION OF PEROXIDES BASIC PROTOCOLS

### Ferrous Thiocyanate Detection Method

Ferrous thiocyanate will detect hydroperoxides with the following test:

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

Shake with an equal quantity of the solvent to be tested

If peroxides are present, a red color will develop

### Potassium Iodide Detection Method

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)

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<sup>R</sup> has been reported effective for inhibiting peroxide formation in ethyl ether.
4. 100 ppm of 1-naphthol is effective for peroxide inhibition in isopropyl ether.
5. Hydroquinone is effective for peroxide inhibition in tetrahydrofuran.
6. Stannous chloride or ferrous sulfate is effective for peroxide inhibition in dioxane.

### **Peroxides Test Strips**

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

***Please note that these methods are BASIC protocols. If one of these methods is performed, all safety precautions should be thoroughly researched.***

Sources:

1. Furr, Keith Handbook of Lab Safety, 4<sup>th</sup> 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 C**

### **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  
documen  
"NFPA 321:  
Classification  
of Flammable  
and  
Combustible  
Liquids, 1991  
Edition."

## APPENDIX D

### FLAMMABLE AND COMBUSTIBLE LIQUID CONTAINMENT AND STORAGE REQUIREMENTS

#### Containment

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

Container	Flammable Class			Combustible Class	
	IA	IB	IC	II	III
Glass	1 pt*	1 qt*	1 gal	1 gal	5 gal
Metal or Approved Plastic	1 gal	5 gal	5 gal	5 gal	5 gal
Safety Cans	2 gal	5 gal	5 gal	5 gal	5 gal
Metal Drums	60 gal	60 gal	60 gal	60 gal	60 gal
Approved Metal Portable Tanks	660 gal	660 gal	660 gal	660 gal	660 gal
Polyethylene	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.

#### Storage

Only NFPA 45 approved amounts of flammable liquids shall be stored in laboratory units outside of flammable liquid storage rooms.

Flammable / Combustible Class	Maximum Quantity per 100ft <sup>2</sup> of Laboratory Unit	Maximum Quantity per Laboratory Unit	
		Unsprinklered	Sprinklered
List as Class A Lab			
I	20 gallons	600 gallons	1200 gallons
I, II and IIIA	40 gallons	800 gallons	1600 gallons
List as Class B Lab			
I	10 gallons	300 gallons	600 gallons
I, II and IIIA	20 gallons	400 gallons	800 gallons
List as Class C Lab			
I	4 gallons	150 gallons	300 gallons
I, II and IIIA	8 gallons	200 gallons	400 gallons

The amounts above include quantities stored in approved storage cabinets and safety cans. Allowable quantities stored outside of approved storage cabinets and safety cans are 50% of the quantities listed above.

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.

Should Class B or C laboratories be used for instructional purposes, quantities of flammable and combustible liquids shall be **50%** of those listed in the above table.

# APPENDIX E

## COMMON LABORATORY CORROSIVES

ORGANIC ACIDS	ORGANIC BASES	INORGANIC ACIDS
Formic Acid	Ethylenediamine	Hydrofluoric Acid
Acetic Acid (Glacial)	Ethylimine	Hydrochloric Acid
Propionic Acid	Tetramethylethylenediamine	Hydrobromic Acid
Butyric Acid	Hexamethylenediamine	Hydriotic Acid
Chloroacetic Acid	Trimethylamine aq. soln.	Sulfuric Acid
Trichloroacetic Acid	Triethylamine	Chromerge™
Acetyl Chloride	Phenylhydrazine	No-Chromix™
Acetyl Bromide	Piperazine	Chlorosulfonic Acid
Chloroacetyl Chloride	Hydroxylamine	Sulfuryl Chloride
Oxalic Acid	Tetramethylammonium Hydroxide	Bromine Pentafluoride
Propionyl Chloride		Thionyl Chloride
Propionyl Bromide	<b>ELEMENTS</b>	Tin Chloride
Acetic Anhydride	Fluorine (gas)	Tin Bromide
Methyl Chloroformate	Chlorine (gas)	Titanium Tetrachloride
Dimethyl Sulfate	Bromine (liquid)	Perchloric Acid
Chlorotrimethylsilane	Iodine (crystal)	Nitric Acid
Dichlorodimethylsilane	Phosphorus	Phosphoric Acid
Phenol		Phosphorus Trichloride
Benzoyl Chloride		Phosphorus Tribromide
Benzoyl Bromide	<b>INORGANIC BASES</b>	Phosphorus Pentachloride
Benzyl Chloride	Ammonium Hydroxide	Phosphorus Pentoxide
Benzyl Bromide	Calcium Hydroxide	
Salicylic Acid	Sodium Hydroxide	
	Potassium Hydroxide	<b>ACID SALTS</b>
	Calcium Hydride	Aluminum Trichloride
	Sodium Hydride	Antimony Trichloride
	Hydrazine	Ammonium Bifluoride
	Ammonium Sulfide	Calcium Fluoride
	Calcium Oxide	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 F

## COMMON LABORATORY OXIDIZERS

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

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

# APPENDIX G

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

hexanitrostilbene	trimethylolethane
hexogen	trimonite
hydrazoic acid	trinitroanisole
lead azide	trinitrobenzene
lead mononitroresorcinate	trinitrobenzoic acid
lead styphnate	trinitrocresol
mannitol hexanitrate	trinitroresorcinol
sodium picramate	tritonol
tetranitrocarbazole	urea nitrate

References: Safety Data Sheets, various chemical companies

# APPENDIX H

## 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<sup>3</sup>) 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.

For a 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 ( $\text{mg}/\text{m}^3$ ). 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 ( $< 0.2 \mu\text{m}$ ) 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
- ozone
- hydrogen fluoride
- alkaline dusts and mists
- 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

- acrolein
- formic acid
- acetic acid

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 and chromic acid
- sodium and potassium hydroxide

**Asphyxiants** have the ability to deprive tissue of oxygen.

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

- nitrogen
- nitrous oxide
- carbon dioxide
- hydrogen

**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
- hydrogen sulfide
- cyanides

**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
- methyl mercury
- organic phosphorus insecticides
- manganese
- tetraethyl lead
- carbon disulfide
- thallium

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

- nitrites
- aniline
- toluidine
- nitrobenzene
- benzene

**Pulmonary tissue (lungs) agents** can be toxic, through other means 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
- wood dust
- cotton 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
- dibromodichloropropane

A **mutagen** is a chemical agent which may react with nucleophilic structures such as DNA. Mutations can occur on the gene level (gene mutations) when, for example, one nucleotide base-pair is changed 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, dibromodichloropropane.
  
- **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 I

## 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 employer 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 a department, school, or company 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 100deg.F (37.8deg.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 100deg.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, 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 type of ventilation is not

recommended 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 140deg.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 slowdown 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 Concentrations<sub>50</sub>** -- The concentration of an air contaminant (**LC<sub>50</sub>**) that will kill 50 percent of the test animals in a group during a single exposure.

**Lethal Dose<sub>50</sub>** -- The dose of a substance or chemical that will (**LD<sub>50</sub>**) 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 duct work.

**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.

**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 an atom loses electrons.

**Oxidizer** -- 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** -- 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 action, 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 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 10mg/ml<sup>3</sup>
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** -- Airborne concentrations of substances devised by the ACGIH that represents conditions under which it is believed that nearly all workers may be exposed day after day with no adverse effect. TLV's are advisory exposure guidelines, not legal standards, which 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** -- 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 5 ppm, then the explosive range of the chemical is 1ppm to 5ppm. (See also LEL).

**Vapor** -- The gaseous state of substances that 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.