Chemical Safety Guide for Laboratories

Emergency reference numbers:

Police, Fire, or Ambulance ......................................... 9-911
Chemical Safety .............................................................. 333-2755

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Preface

Safety can be defined as the undertaking to protect people, property and the environment. But how do we know if we have provided enough protection? If we underprotect then we needlessly place people in harm’s way; if we overprotect then we expend precious resources with no added benefit. Invariably, the practical questions about the priority of safety and how much is too much (or how much is too little) lead us into questions about risk.

We all take risks. We all choose to accept certain risks and refuse to accept other risks. Consider driving, or crossing a street, or choosing to go in public during the flu and cold season. We may intuitively find ways to reduce our risks. We learn safe driving habits. We learn to look both ways before crossing the street. We learn to wash hands before eating. But these risks are never reduced to zero, no matter how hard we work at this.

In a research environment, the risks around us are different than those at home or in other lines of work. In fact, risks vary greatly from one laboratory to another, from a laboratory to a workshop, and from a laboratory to research in the field or at a pilot plant. Faced with such complications, we can become on the one hand overly cautious or conversely too cavalier in our daily work. The challenge is to think intelligently about these things, so that we properly respect the risks we choose to accept.

But what is acceptable risk? The question is complicated, and there are various ways to address it. Some may be familiar with terminology from the insurance industry: risk can be defined as a combination of severity and frequency, so that for a high severity scenario, we want to see the frequency driven to a low value. For our purposes, we will consider research risks as a combination of hazards and control measures. A risk is considered an acceptable risk when there are control measures sufficient for the hazards present. In other words, the greater the hazard, the greater the control measures in order to achieve acceptable risk.

This leads us into our five-point safety strategy, around which the chapters of the Chemical Safety Guide are arranged:

(1) Hazard Awareness
(2) Engineering Controls
(3) Administrative Controls
(4) Personal Protective Equipment
(5) Emergency Planning

This strategy should help you make educated risk-benefit decisions in the course of research in University labs.
Acknowledgements

The Illinois DRS staff would like to acknowledge Cornell University, Michigan State University, and the University of Michigan, from whom we have adopted portions of this Chemical Hygiene Plan.

Notice and Disclaimer

Information concerning environmental health and safety programs of the University of Illinois at Urbana-Champaign is intended as guidance for University of Illinois at Urbana-Champaign students, staff, and faculty engaged in activities related to their education, research, and/or employment. The information is subject to change and updating at any time.

NOTE: This is a major revision of the content and organization of this document. Please take some time to review the changes and additions.
Chapter 1: Introduction

Chapter Overview

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Revision Date: 10/02/09

1.1 Purpose

The purpose of this document is to educate research investigators about consensus standards of good laboratory practice, and to promote conformance with the OSHA Laboratory Standard (29 CFR 1910.1450).

The Chemical Safety Guide is intended to be part of a laboratory’s safety references, which would sensibly include such classic publications as the National Research Council’s Prudent Practices in the Laboratory and the American Chemical Society’s Safety in Academic Chemistry Laboratories. These and other resources together form the backbone for a laboratory’s local Chemical Hygiene Plan (CHP).

This document is to be used and supplemented, as needed, by each Principal Investigator (PI) or lab-related research at the University of Illinois, Urbana-Champaign. It is the responsibility of the PI to review the Chemical Safety Guide and to use it in the development of a complete CHP specific to their laboratories. Each PI is responsible for the implementation and documentation of his or her own Chemical Hygiene Plan and for providing safety information and training to their employees.

Colleges, department, other units, and individual laboratories are free to establish the guidelines found within this document as required policies for their units or laboratories.
1.2 Laboratory Safety Manual

Each Principal Investigator (PI) shall develop and maintain a Laboratory Safety Manual for their laboratory. A lab safety manual (1) contains safety information relevant to the laboratory's specific hazards and research materials, (2) serves as a training tool for lab personnel and should include documentation of such training, and (3) must be readily available to all research personnel in the lab.

A lab safety manual shall include:
- Lab safety policies and Standard Operating Procedures (SOPs)
- Lab safety program key personnel
- Lab contact information
- Lab security procedures
- Hazard assessment information and Personal Protective Equipment (PPE) selection
- Lab emergency procedures
  - Spill response
  - Medical response
  - Lab- and building-specific evacuation information
- Descriptions of lab incidents, injuries, and corrective actions
- Safety training records for lab personnel
- Safety program correspondence

The lab safety manual shall also include a Biosafety Manual for biological materials, a Chemical Hygiene Plan (CHP) for chemicals, a Radiation Permit for radioactive materials, and a Laser Safety Plan for Class 3b and 4 lasers. For more information please contact the Division of Research Safety (333-2755 or via e-mail) or visit our website: [http://www.drs.illinois.edu/]

1.3 Chemical Hygiene Plans

Each Principal Investigator (PI) is responsible to develop and maintain the Chemical Hygiene Plan (CHP) for his or her laboratory. In broad terms, a CHP is a detailed strategy for controlling hazards in a given location. A laboratory’s CHP shall (1) identify all the hazards present at that location, and (2) describe specific measures for effectively controlling those hazards. Furthermore, a laboratory’s CHP shall be considered as a combination of two broad sections:

- **General Safety Information**
  The *Chemical Safety Guide* is intended as general-level information, a starting point in assembling a laboratory-specific CHP.

- **Laboratory-Specific Safety Information**
  This includes written documents or records such as Standard Operating
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Procedures (SOPs), laboratory safety policies, or completed inventory reports. Details concerning the Unit, Personnel, Facility, Equipment, Procedures and Chemicals shall be included in such information. For assistance in compiling lab-specific safety information, CHP Forms are available at [http://www.drs.illinois.edu/css/](http://www.drs.illinois.edu/css/).

It is the responsibility of the PI to review the Chemical Safety Guide and to use it in the development of a complete plan specific to each laboratory.

1.3.1 Regulatory Introduction

In January 1991, the Occupational Safety and Health Administration (OSHA) promulgated a final rule for occupational exposure to hazardous chemicals in laboratories (29 CFR 1910.1450, also known as the OSHA Lab Standard, available at [http://www.osha.gov/](http://www.osha.gov/)). Included in the standard is the requirement that all employees covered by the standard must carry out the provisions of a Chemical Hygiene Plan (CHP).

1.3.1.1 Requirements for CHPs

As defined in the OSHA Lab Standard, a CHP is a written program which must:

- Be capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular laboratory
- Be capable of keeping exposures below Permissible Exposure Limits (PELs)
- Indicate specific measures that the employer will take to ensure laboratory employee protection
- Include the following elements:
  1. Designation of personnel responsible for implementation of the CHP.
  2. Standard Operating Procedures (SOP) relevant to safety and health to be followed whenever laboratory work includes the use of hazardous chemicals and other agents.
  3. Provisions for employee information and training to be provided before the assignments to work areas where hazardous chemicals are present and prior to assignments involving new exposure situations. Information to be provided includes:
     - Contents of Standard 29 CFR 1910.1450
     - Location of Principal Investigator's (PI's) CHP
     - Inventory of laboratory chemicals
     - Methods and means to evaluate potential hazards, including discussion of permissible exposure limits
  4. Employee training including, as a minimum:
     - Physical and health hazards associated with the hazardous chemicals in the work area
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- Measures employees can take to protect themselves from these hazards
- Methods and observations to help detect the presence or release of hazardous chemicals
- Signs and symptoms associated with overexposures to hazardous materials used in the laboratory

The frequency for refresher training for employees trained under the OSHA Laboratory Standard is left to the discretion of the employer. At the University the frequency of refresher training is determined by principal investigators. DRS recommends that refresher training be performed annually.

5. Determination and implementation of control measures to reduce employee exposures to hazardous chemicals by using:
  - Engineering controls
  - Personal protective equipment (PPE)
  - Safe work practices and personal hygiene

6. Requirements that fume hoods and other protective equipment are functioning properly and for maintaining adequate performance of such equipment.

7. Availability of Material Safety Data Sheets (MSDS) and other sources of information, to describe potential hazards and safety precautions for specific chemicals.

8. Provisions, as may be needed, for additional employee protection for work involving particularly hazardous substances and conditions, including situations which may require special approval from the PI prior to implementation.

1.3.1.2 Responsibility to Develop and Maintain a CHP

The Principal Investigator (PI) is responsible to develop and maintain the Chemical Hygiene Plan (CHP) for his or her laboratory. According to the OSHA Lab Standard (29 CFR 1910.1450), a Chemical Hygiene Plan (CHP) applies to all employers engaged in the laboratory use of hazardous chemicals.

- The University of Illinois is the employer of all laboratory personnel at the University of Illinois at Urbana-Champaign. On this campus, Principal Investigators are University personnel with local authority and responsibility to comply with applicable regulatory requirements and promote health and safety in their areas of influence. Thus "employer" is understood by University of Illinois at Urbana-Champaign to denote a Principal Investigator (PI) in a University of Illinois at Urbana-Champaign research laboratory.
- A "laboratory" is defined as a facility where the laboratory use of hazardous chemicals occurs.
- A "hazardous chemical" is defined as a chemical for which there is evidence that acute or chronic health effects may occur in exposed
employees. Such chemicals include carcinogens, toxic agents, irritants, and agents which damage the lungs, skin, eyes or mucous membranes.

- "Laboratory use of hazardous chemicals" is defined as handling or use of such chemicals in which all of the following conditions are met:
  1. Chemical manipulations are carried out on a "laboratory scale", or work with substances in which the containers used are designed to be easily and safely manipulated by one person;
  2. Multiple chemical procedures or chemicals are used;
  3. The procedures involved are not part of a production process, nor in any way simulate a production process;
  4. "Protective laboratory practices and equipment" is available and in common use to minimize the potential for employee exposure to hazardous chemicals.

1.3.2 Reasons to Have and Use a CHP

- Quality Assurance
  A Chemical Hygiene Plan is essentially a quality assurance document and represents consensus standards from the "research" industry. The lab standard is based on good lab practices which have been established by funding agencies.

- Comprehensive Curriculum
  Practicing and teaching safety is a vital part of any laboratory curriculum. In a school of diverse backgrounds, it cannot be assumed that safe practices will always be known or automatically be followed.

- Legal Requirement
  A Chemical Hygiene Plan is required by Federal law (29 CFR 1910.1450) and by State law (IDOL) in any laboratory where employees use hazardous chemicals.

- Potential Grant Requirement
  It is anticipated that in the future, governmental agencies, such as the NIH, may require proof of compliance with Federal statutes before making grants.

- Continuing Grant Funding
  Being officially cited as not in compliance with Federal or State statutes may also make it more difficult to obtain funding for research.

- Improved Safety
  Development and implementation of a CHP will result in greater safety in our laboratories.

1.3.3 Five Steps to a Lab-Specific CHP

Getting started can be difficult, but it does not need to be. Do the following, and you will be well on your way to an effective CHP for your laboratory.
1. **Review** the *Chemical Safety Guide*.

2. **Complete** the contact information and emergency procedures (Sections 1 through 3) in the *CHP Forms*.

3. **Inventory** all chemicals (see Section 4 of the *CHP Forms*) in the rooms indicated. Approximate quantity should be adequate for most chemicals. Exceptions include DEA Controlled Substances (see also [http://www.drs.illinois.edu/css/guidesplans/dea](http://www.drs.illinois.edu/css/guidesplans/dea)), highly toxic chemicals, and extraordinarily expensive or valuable materials.

4. **Evaluate** the chemical inventory (see Section 5 of the *CHP Forms*). Consider particularly hazardous chemicals (carcinogens, reproductive toxins, acute toxins). Consider the hazards present as a result of the chemicals present in their respective quantities. What controls should be in place to appropriately address all hazards? Which hazards are your top priority?

5. **Compose** safety information to supplement the *Chemical Safety Guide* in order to sufficiently communicate how you address the hazards present in your laboratory space. These written materials may be as simple as posted reminders or tip sheets for a process, or as complicated as formal SOPs or step-wise work instructions with safety instructions included. See Section 6 of the *CHP Forms* for more guidance.

### 1.4 Safety Responsibilities

Everyone working at the University of Illinois has the right to a safe work environment and has the responsibility to help assure safety for themselves and others. Everyone has an important role in safety. The following illustrates areas of responsibility for safety at the University of Illinois. These responsibilities are also found in the Campus Administrative Manual (available on the web at [http://www.fs.illinois.edu/cam](http://www.fs.illinois.edu/cam)).

Periodically inspectors from regulatory agencies (such as the IEPA and IDOL) visit campus for regulatory compliance inspections. When this happens, it is possible that they may visit your work place and speak with you. If this occurs, please call DRS immediately at 333-2755. DRS will provide assistance in addressing the concerns of the inspector.

#### 1.4.1 Deans, Directors and Heads of Academic and Administrative Units

Deans, Directors and Heads of Academic and Administrative Units have a primary responsibility in providing for the health and safety of their faculty, staff, students, and visitors, and ensuring that work activities do not violate environmental standards. Unit head responsibilities include:

- Establishing environmental, safety, and regulatory compliance as a unit priority. (In some instances departmental or college safety committees may be helpful. Experience has indicated that such committees can provide an effective means of implementing safety programs.)
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- Striving to provide adequate resources to meet safety and regulatory needs.
- Implementing programs to assure compliance with applicable environmental, health, and safety rules, regulations and standards.
- Ensuring that General Laboratory Safety training is completed by all incoming faculty, staff and students who will work in laboratory space, belonging to the unit, where biological, chemical or radiological materials are used. (This training is available online at [http://www.drs.illinois.edu/training/](http://www.drs.illinois.edu/training/)).

### 1.4.2 Principal Investigators (PIs)

Principal Investigators (PIs) have specific responsibilities toward providing a work environment free from environmental, health and safety hazards for those supervised. PI responsibilities include:

- Providing information about relevant environmental, health, and safety rules, regulations, standards, or practices.
- Assuring that required safety-related equipment and personal protective devices are provided, maintained, and used.
- Taking prompt action when unsafe acts or hazardous conditions are reported or noted.
- Providing or arranging for environmental, health, and safety training and education as needed. Training available from DRS is designed to support but not fully meet this requirement.
- Promptly investigating and reporting all on-the-job accidents and/or job-related health problems and requesting medical treatment, if needed.
- Promptly reporting any spills or releases to the environment or any observed illicit environmental actions.
- Taking prompt action to prevent and clean up spills to the environment. Encouraging and training employees to use recommended best management practices to prevent and reduce pollution on campus.
- Requesting the assistance of the next higher level of supervision regarding budget requests for environmental, health, and safety improvements.

### 1.4.3 Laboratory Personnel

Laboratory Personnel, as employees or students, are responsible for complying with existing environmental, health and safety rules, regulations and standards. Employee responsibilities include:

- Following all applicable environmental, health, and safety regulations, standards, campus plans, or policies.
- Wearing or using required safety-related equipment and personal protective devices.
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- Refraining from operating any mechanical equipment that has the potential to harm personnel or the environment without proper instruction, training or authorization to safely use the equipment.
- Reporting unsafe acts or hazardous conditions to the supervisor.
- Attending prescribed environmental, health, and safety training and education.
- Reporting all on-the-job accidents and/or job-related health problems to the supervisor and requesting medical treatment, if needed.
- Reporting any spills or releases to the environment or any observed illicit environmental actions.
- Using recommended best management practices to prevent and reduce pollution to the environment.

1.4.4 The Division of Research Safety (DRS)

The Division of Research Safety (DRS) is committed to assisting campus units to identify and manage biological, chemical and radiological hazards. DRS responsibilities include:

- Providing advice and technical assistance in using these materials safely.
- Facilitating the campus community’s understanding of and compliance with required regulations.
- Developing, implementing, and overseeing comprehensive safety programs and policies, in partnership with campus safety oversight committees. **Unit heads and supervisors remain responsible for promoting safety and ensuring regulatory compliance in their research area.** Such programs are designed to:
  - Ensure the health and safety of faculty, staff, students, and visitors.
  - Protect the environment.
  - Facilitate compliance with regulatory requirements.

1.4.4.1 Overview of the DRS Chemical Safety Section

As part of DRS, the mission of the Chemical Safety Section (CSS) is to work with the campus community to develop and implement an efficient, convenient, comprehensive, and forward-looking chemical safety program. Priorities are as follows:

- Develop chemical safety programs that protect the health and well being of students, faculty, staff, and visitors at the University of Illinois.
- Develop programs to minimize chemical hazards and chemical wastes.
- Provide guidance for the safe handling, storage, and disposal of chemicals used on campus.
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- Dispose of chemical wastes in an environmentally sound and cost-effective manner.
- Assist the campus community in complying with federal, state, and local regulations.

1.4.4.2 Chemical Hygiene Officer

The Director of DRS or a Division staff person designated by the Director is designated as the Chemical Hygiene Officer for the University of Illinois at Urbana-Champaign.

The Chemical Safety Committee will be advisory on matters relating to the safe handling, transport, use, and disposal of chemicals on the Urbana-Champaign campus. The committee will report to the Vice Chancellor for Research through DRS.

Academic units that have chemistry laboratories are encouraged to have their own chemical safety officers to help implement their chemical hygiene plans. Likewise, individual research groups or users of significant amounts of chemicals in non-laboratory settings are encouraged to designate chemical safety liaisons to facilitate the flow of safety information throughout the campus community.
Chapter 2: Hazard Awareness

This chapter provides an introduction to the types of hazards, labeling systems and common sources of hazards information in research labs on campus. This information will help you to identify hazards in your laboratory and will provide resources to increase your understanding of those hazards. Additionally, this chapter provides information to researchers to assist in labeling in-house chemical containers and equipment to identify their unique hazards.

Chapter Overview

2.1 Types of Hazards
2.1.1 Health hazards
2.1.1.1 Toxicity
2.1.1.2 Routes of exposure
2.1.2 Physical hazards of chemicals
2.2 Labeling
2.2.1 Handwritten (in-house) labels
2.2.2 Manufacturers’ labels
2.2.3 Common labeling systems
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2.2.3.3 DOT
2.2.3.4 GHS
2.3 Safety Data Sheets (MSDS)
2.4 Controlling Chemical Hazards
2.5 Other Hazard Information Sources

Revision Date: 03/22/10

2.1 Types of Hazards
2.1.1 Health Hazards

According to the OSHA Lab Standard,

"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system and agents which damage the lungs, skin, eyes, or mucous membranes. Appendix A provides further definitions and explanations of the scope of health hazards.
Working with chemicals in a research laboratory can expose researchers to health hazards through inhalation, ingestion, skin, eye, or mucous membrane contact or absorption, or injection of chemicals. Chemical exposures may be acute (short term), intermittent, or chronic (long term), they may be reversible or irreversible, and may have local or systemic effects.

The following are brief descriptions of the classes of health hazards included in the Lab Standard definition of “health hazard” above. Complete definitions are found in the OSHA Lab Standard (29 CFR 1910.1450).

- **Carcinogen:** A chemical which causes or potentially causes cancer according to the International Research on Cancer, or is listed as such in the National Toxicology Program Annual Report on Carcinogens [http://ehis.niehs.nih.gov/roc/](http://ehis.niehs.nih.gov/roc/).
- **Corrosive:** A chemical that causes visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.
- **Irritant:** A chemical, which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact.
- **Mutagen:** A chemical that damages chromosomes.
- **Sensitizer:** A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.
- **Target Organ Effects:**
  - *Hepatotoxins* damage the liver.
  - *Nephrotoxins* damage the kidneys.
  - *Neurotoxins* adversely affect the nervous system.
  - *Hematopoietic Agents* decrease hemoglobin function and deprive the body tissues of oxygen.
  - *Agents which damage the lung* irritate or damage pulmonary tissue.
  - *Reproductive toxins* affect reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).
  - *Cutaneous hazards* affect the skin, or dermal layer, of the body.
  - *Eye hazards* affect the eye or visual capacity.
- **Teratogen:** A chemical that causes birth defects.
- **Toxic:** A chemical falling within any of the following categories:
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- A chemical that has a median lethal dose (LD$_{50}$) of more than 50 mg/kg but not more than 500 mg/kg when administered orally to albino rats weighing between 200 and 300 grams each.

- A chemical that has a median lethal dose (LD$_{50}$) of more than 200 mg/kg but not more than 1,000 mg/kg when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

- A chemical that has a median lethal concentration (LC$_{50}$) in air of more than 200 parts per million (ppm) but not more than 2,000 ppm by volume of gas or vapor, or more than 2000 mg/m$^3$ but not more than 20,000 mg/m$^3$ of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

**Highly Toxic:** A chemical falling within any of the following categories:

- A chemical that has a median lethal dose (LD$_{50}$) of not more than 50 mg/kg when administered orally to albino rats weighing between 200 and 300 grams each.

- A chemical that has a median lethal dose (LD$_{50}$) of not more than 200 mg/kg when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.

- A chemical that has a median lethal concentration (LC$_{50}$) in air of 200 ppm by volume or less of gas or vapor, or 2000 mg/m$^3$ or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

<table>
<thead>
<tr>
<th>LD$_{50}$ (oral, rat)</th>
<th>LD$_{50}$ (skin, rabbit)</th>
<th>LC$_{50}$ (rat)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(mg/kg)</td>
<td>(mg/kg)</td>
<td>(ppm for 1 hr)</td>
</tr>
<tr>
<td>High Toxic</td>
<td>≤ 50</td>
<td>≤ 200</td>
</tr>
<tr>
<td></td>
<td>≤ 200</td>
<td>≤ 200</td>
</tr>
<tr>
<td>Toxic</td>
<td>50 to 500</td>
<td>200 to 1000</td>
</tr>
<tr>
<td></td>
<td>200 to 1000</td>
<td>200 to 2000</td>
</tr>
</tbody>
</table>

Table 2.1 Toxic and Highly Toxic definitions

2.1.1.1 Toxicity

The following is an excerpt from *Safety in Academic Chemistry Laboratories* (American Chemical Society, 2003: pp. 10-11):

Any substance could be harmful to living things. But complex relationships exist between a substance and its physiological effect in humans. The major factors include the dose (the amount of a substance to which one is exposed and
the length of time of exposure to the substance), the route of exposure (by inhalation, ingestion, absorption through the skin or eyes, or injection), and myriad other factors such as gender, stage in the reproductive cycle, age, lifestyle, previous sensitization, allergic factors, genetic disposition, and even whether it has been a “good day” or a “bad day” for the victim. These and other factors can affect the severity of an exposure. If you don’t know these details, as is often the case, it is prudent to act as though you could be susceptible to serious toxic consequences and to therefore follow the necessary precautions when working with chemicals in the laboratory.

The toxic effects can be immediate or delayed, reversible or irreversible, local or systemic. The toxic effects vary from mild and reversible (e.g., a headache from a single episode of inhaling the vapors of ethyl acetate that disappears when the victim inhales fresh air) to serious and irreversible (e.g., birth defects from excessive exposure to a teratogen during pregnancy or cancer from excessive exposure to a carcinogen).

Some important details about toxic effects:

- **Acute poisoning** is characterized by rapid assimilation of the substance. Often, but not always, the effect is sudden and can be painful or severe and even fatal. Normally, a single exposure is involved. Examples: carbon monoxide or cyanide poisoning.

- **Chronic poisoning** is characterized by repeated exposures with a duration measured in months, or years. Symptoms may not be immediately apparent. Examples: lead or mercury poisoning, pesticide exposures.

- **Substances in combination** may result in the synergistic effect. When two or more hazardous materials are present, the resulting effect can be greater than the effect predicted for the individual substances. Example: exposure to alcohol and chlorinated solvents. The opposite is also possible; two poisonous substances can lessen each other’s effects, called the antagonistic effect. Example: cyanide and amyl nitrite.

- **Allergens** are agents that produce an immunologic reaction, and you may encounter them in the laboratory. Asthma-like symptoms or dermatitis are typical allergic reactions. Not everyone is susceptible to allergens. A susceptible individual will not suffer an allergenic reaction unless he or she has been sensitized by at least one previous exposure. For some allergens, an individual must be exposed several times before suffering an allergenic response. Tell your instructor if you know or
suspect that you are allergic to a chemical in your laboratory.

Except for allergenic exposures, the toxic effects from exposure to a chemical depend on the severity of the exposures. Generally, the larger or more frequent the exposure, the more severe the result. Consequently, you can reduce or even avoid harm by keeping exposures to a minimum.

2.1.1.2 Routes of Exposure

There are four main routes of exposure for chemicals: inhalation; direct contact (to skin, eyes and or mucous membranes); ingestion; and injection. An understanding of these routes of entries enables one to develop procedures or controls to prevent hazardous exposures to chemicals.

- **Inhalation:** Inhalation of gases, vapors, dusts, fumes or mists is a common route of exposure. Chemicals can enter and irritate the nose, airways and lungs. They can become deposited in the airways or be absorbed through the lungs into the bloodstream. The blood can then carry these substances to the rest of the body.

- **Direct (skin/eye) contact and/or absorption:** Many chemicals can injure the skin directly (corrosives), while others may cause irritation or an allergic reaction. In addition to causing local effects, many chemicals may be absorbed through the skin and/or eyes in sufficient quantity to cause systemic effects. The main avenues by which chemicals enter the body through the skin are hair follicles, sebaceous glands, sweat glands, and cuts or abrasions of the skin. Direct contact effects and absorption of chemicals through the skin depend on a number of factors, including:
  - Chemical concentration
  - Chemical reactivity
  - Solubility of the chemical in fat and water
  - Condition of the skin
  - Duration of contact

- **Ingestion:** Chemicals that get in or on food, cigarettes, utensils or hands can be swallowed. Substances can be absorbed into the blood and then transported to the rest of the body.

- **Injection:** Injections can occur through high pressure streams of liquids or gases, needles or broken contaminated glassware.

2.1.2 Physical Hazards

The Lab Standard defines physical hazard as:

Physical hazard means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas,
explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) or water-reactive.

The following are brief descriptions of the classes of physical hazards included in the Lab Standard definition of “physical hazard” above. Complete definitions are found in the OSHA Lab Standard (29 CFR 1910.1450).

- **Combustible liquid**: Any liquid having a flashpoint at or above 100° F (37.8°C), but below 200° F (93.3°C), except any mixture having components with flashpoints of 200° F (93.3°C), or higher, the total volume of which make up 99% or more of the total volume of the mixture.

- **Compressed gas**: A gas or gas mixture with an absolute pressure exceeding 40 psi at 70°F (21.1°C), or exceeding 104 psi at 130°F (54.4°C), or a liquid having a vapor pressure exceeding 40 psi at 100°F (37.8°C).

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

- **Flammable**:
  - *Aerosol*: A chemical that can produce a flame or flashback from a valve opening.
  - *Gas*: Any gas at ambient conditions that will cause a flammable mixture with air in concentrations of 13% or less.
  - *Liquid*: Any liquid having a flashpoint below 100° F (37.8°C), except any mixture having components with flashpoints of 100° F (37.8°C) or higher, the total of which make up 99% or more of the total volume of the mixture.
  - *Solid*: A solid that is liable to cause fire through friction, contact with moisture, spontaneous reaction, or retained heat, or which can be readily ignited and burns with enough persistence or violence to cause a serious health hazard.

- **Organic peroxides**: An organic compound with a bivalent O-O structure, which may be considered a peroxide derivative with one or both of the hydrogen atoms replaced with an organic molecule. They present dangerous fire and explosion risks; many are strong oxidizers.

- **Oxidizer**: A chemical that initiates or supports combustion of other materials, causing fire by itself or by the release of oxygen or other gases.

- **Pyrophoric**: A chemical that will ignite spontaneously in air at or below 130°F (54.4°C).

- **Unstable**: Any chemical, which will vigorously decompose, polymerize, condense, or will become self reactive when exposed to conditions of shock, pressure, or temperature.

- **Water-reactive**: A chemical which can react with water or steam to produce a gas which is either toxic or flammable.
2.2 Labeling

Each chemical container must be labeled as to its contents and any applicable hazard categories. Even non-hazardous chemicals should be identified as such to remove any confusion.

2.2.1 Handwritten or In-House Labels

Temporary containers should be labeled so that if an emergency arises, another person can identify what is in the container. For chemical waste, the container should describe the contents with the word “waste” (e.g., “waste acetone,” “waste halogenated solvents,” etc.). If a label begins to fall off a container or becomes degraded, the container must be immediately relabeled with tape and permanent marker, printed labels, etc.

Chemical names may be abbreviated (such as Ethanol – EtOH) if everyone in the lab is knowledgeable of the abbreviation. Creating a table of common chemical abbreviations for the lab is strongly advised.

2.2.2 Manufacturers’ Labels

The label(s) affixed to the container will have information regarding the hazards of a material.

To start with, the original manufacturer’s container label must include the following:

- Product Name
- Manufacturer’s Name and Address
- Hazards Identification

Some manufacturers use easily recognizable symbols to communicate the hazard(s) of a product.

```
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Corrosive" /></td>
<td>Corrosive</td>
</tr>
<tr>
<td><img src="image2" alt="Explosive" /></td>
<td>Explosive</td>
</tr>
<tr>
<td><img src="image3" alt="Flammable" /></td>
<td>Flammable</td>
</tr>
<tr>
<td><img src="image4" alt="Irritant" /></td>
<td>Irritant</td>
</tr>
<tr>
<td><img src="image5" alt="Oxidizer" /></td>
<td>Oxidizer</td>
</tr>
<tr>
<td><img src="image6" alt="Poisonous" /></td>
<td>Poisonous</td>
</tr>
</tbody>
</table>
```

Figure 2.1: Examples of hazard warnings commonly found on labels

2.2.3 Common Labeling Systems

In addition to the icons shown in Figure 2.1, there could be markings from various labeling systems, such as National Fire Protection Association (NFPA), Hazardous Materials Identification System (HMIS) III, Department of Transportation (DOT), or Globally Harmonized Systems (GHS).
2.2.3.1 National Fire Protection Administration (NFPA)

NFPA 704 Standard System for the Identification of the Hazards of Materials for Emergency Response provides a readily recognized, easily understood system for identifying specific hazards and their severity using spatial, visual, and numerical methods to describe in simple terms the relative hazards of a material. It addresses the health, flammability, instability, and related hazards that may be presented as short-term, acute exposures that are most likely to occur as a result of fire, spill, or similar emergency.

The system is characterized by the diamond shape (Figure 2.2). It identifies the hazards of a material and the degree of severity of the health, flammability, and instability hazards. Hazard severity is indicated by a numerical rating that ranges from zero (0) indicating a minimal hazard, to four (4) indicating a severe hazard. The hazards are arranged spatially as follows: health at nine o’clock position (blue), flammability at twelve o’clock position (red), and instability at three o’clock position (yellow).

<table>
<thead>
<tr>
<th>Health</th>
<th>Flammability</th>
<th>Instability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials that, <em>under emergency conditions</em>…</td>
<td>Materials that will not burn under typical fire conditions, including intrinsically noncombustible materials such as concrete, stone and sand</td>
<td>…in themselves are normally stable, even under fire conditions</td>
</tr>
<tr>
<td>0</td>
<td>…would offer no hazard beyond that of ordinary combustible materials</td>
<td>Materials that must be preheated before ignition can occur</td>
</tr>
<tr>
<td>1</td>
<td>…can cause significant irritation</td>
<td>Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur</td>
</tr>
<tr>
<td>2</td>
<td>…can cause temporary incapacitation or residual injury</td>
<td>Liquids and solids that can be ignited under almost all ambient temperature conditions</td>
</tr>
<tr>
<td>3</td>
<td>…can cause serious or permanent injury</td>
<td>Materials that rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or that are readily dispersed in air and burn readily</td>
</tr>
<tr>
<td>4</td>
<td>…can be lethal</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2: Explanation of the NFPA numbering system, adapted from NFPA 704.
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The six o'clock position on the symbol represents special hazards and has a white background. The special hazards in use are **W**, which indicates unusual reactivity with water and is a caution about the use of water in either fire fighting or spill control response; **OX**, which indicates that the material is an oxidizer; and **SA**, which indicates that the material is a simple asphyxiant, limited to the gases nitrogen, helium, neon, argon, krypton and xenon.

2.2.3.2 Hazardous Materials Identification System (HMIS)

The National Paint & Coatings Association, Inc. (NPCA) developed the HMIS to aid employers in the implementation of an effective Hazard Communication Program. The current version, HMIS III, defines the Health, Flammability and Physical Hazards of different chemicals with a label that incorporates color-coded fields along with a recommendation for personal protective equipment.

As with the NFPA system, the relative hazard of each category is identified by using a numerical rating that ranges from zero (0) indicating a minimal hazard, to four (4) indicating a severe hazard. Where applicable, the Target Organs (Figure 2.4) and Physical Hazards (Figure 2.5) will be identified by icons surrounding the label.

In addition to the hazards being identified, appropriate PPE is defined in the last section, by using a single letter (Figure 2.6). For example, the letter “A” corresponds to safety glasses, while the letter “C” would indicate that safety glasses, gloves and a protective apron should be worn.
2.2.3.3 **Department of Transportation (DOT)**

The US DOT uses hazard classes (1-9). These classes are based on physical and health hazards. When a hazardous material is in transport, it must bear the appropriate label(s). These labels must remain in place until the container is empty.

The nine hazard classes are:
Class 1: Explosives
An explosive is a substance or article, including a device, that is designed to function by explosion (i.e., an extremely rapid release of gas and heat) or which, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion, unless the substance or article is otherwise classified under the provision of the regulations.

Class 2: Gases

Division 2.1: Flammable Gas
A flammable gas is any material that is a gas at 20°C (68°F) or less and 101.3 kPa (14.7 psi) of pressure and:

- Is ignitable at 101.3 kPa (14.7 psi) when in a mixture of 13% or less by volume in air.
- Or has a flammable range at 101.3 kPa (14.7 psi) with air of at least 12% regardless of the lower limit.

Division 2.2: Non-flammable, Non-poisonous Compressed Gas
Any material or mixture (including compressed gas, liquefied gas, compressed gas in solution, asphyxiant gas and oxidizing gas) that exerts in the packaging an absolute pressure of 280 kPa (40.6 psi) or greater at 20°C (68°F), or is a cryogenic liquid, and does not meet the definition of Division 2.1 or 2.3.

Division 2.3: Gas Poisonous by Inhalation
A gas poisonous by inhalation is a material that is a gas at 20°C (68°F) or lower and a pressure of 101.3 kPa (14.7 psi) and either:

- Is known to be so toxic to humans as to pose a hazard to health during transportation.
- In the absence of adequate data on human toxicity, is presumed to be toxic to humans because when tested on laboratory animals it has an LC$_{50}$ value of not more than 5,000 ml/m$^3$.

Class 3: Flammable and Combustible Liquids
A flammable liquid is either:

- A liquid having a flash point of not more than 60°C (140°F).
- Any material in a liquid phase with a flash point at or above 37.8°C (100°F) that is intentionally heated and offered for transportation or transported at or above its flash point in a bulk package.
A *combustible liquid* is a liquid that does not meet the definition of any other hazard class and has a flash point above 60°C (140°F) and below 93°C (200°F).

**Class 4: Flammable Solids**

**Division 4.1**
- *Wetted Explosives*: Class 1 explosives when dry, other than those of compatibility group A, that are sufficiently wetted to suppress explosive properties.
- *Self-reactive materials*: Materials that are thermally unstable and can undergo a strongly exothermic decomposition even in the absence of oxygen (air).
- *Readily combustible solids*: Solids that can cause fire through friction, such as matches.

**Division 4.2: Spontaneously Combustible**
- *Pyrophoric materials*: Liquids or solids that can, without an external ignition source, ignite with five minutes after coming in contact with air when tested according to the “UN Manual of Tests and Criteria.”
- *Self-heating materials*: Substances that are liable to self-heat when in contact with air and without an energy supply. Materials are classified as Division 4.2 if they exhibit spontaneous ignition or if the temperature exceeds 200°C (392°F) during the 24-hour test period when tested in accordance with “UN Manual of Tests and Criteria.”

**Division 4.3: Dangerous When Wet**
Materials, that by contact with water, are liable to become spontaneously flammable or to give off flammable or toxic gas at a rate greater than 1L/kg of the material per hour, when tested in accordance with the “UN Manual of Tests and Criteria.”

**Class 5: Oxidizers and Organic Peroxides**

**Division 5.1: Oxidizers**
A material that can, generally by yielding oxygen, cause or enhance the combustion of other materials.

**Division 5.2: Organic Peroxides**
Any organic compound containing oxygen (O) in the bivalent –O–O– structure and that may be considered a derivative of
hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals.

Class 6: Poisonous Materials and Infectious Substances

Division 6.1: Poisonous Materials
A material, other than a gas, known to be so toxic to humans to pose a health hazard during transportation.

Division 6.2 Infectious Substances
Includes materials known to contain or suspected to contain a pathogen. A pathogen is a microorganism (including viruses, bacteria, parasites, fungi, and rickettsiae) or other agent, such as a proteinaceous infectious particle (prion), that has the potential to cause disease in humans or animals.

Class 7: Radioactive Material
Any material containing radionuclides in which both the activity concentration and the total activity in the consignment exceed the values specified in the table at 49 CFR 173.436 or values derived according to the formula at 49 CFR 173.433.

Class 8: Corrosive Material
Liquids or solids that cause full thickness destruction of human skin at the site of contact within a specified period of time. There is no correlation to pH.

Class 9: Miscellaneous Hazardous Materials
Materials that present a hazard during transportation but do not meet the definition of any other hazard class. This class includes:

- Any material that has an anesthetic, noxious, or similar property that could cause extreme annoyance or discomfort to a flight crew member so as to prevent the correct performance of assigned duties.
- Any material that meets the definition in 49 CFR 171.8 of an elevated temperature material, a hazardous substance, a hazardous waste, or a marine pollutant.

2.2.3.4 Globally Harmonized System (Reserved for future use.)

2.3 Safety Data Sheets (MSDS)
Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are common sources of information on hazardous chemicals, as manufacturers are required to provide one for each chemical product sold. For any chemical you receive, the
MSDS or SDS must be maintained. To assist with this requirement, DRS maintains a repository of many MSDS and SDS received by the campus. DRS recommends that each lab obtain hard copies of MSDS and SDS from the manufacturer for the products most commonly used. Instructions for electronic access to the DRS repository (for the campus community only) and connections to MSDS and SDS available through the Web can be found on the [DRS website](#).

**Reading a Safety Data Sheet**
MSDS and SDS are divided into sections. While the actual format used will vary from one manufacture to another, the MSDS/SDS must include the following:

- **Product Information**
  - Product Name (as on the label)
  - Manufacturer’s name, address, and phone number
  - Date of MSDS/SDS

- **Composition/Information on Hazardous Ingredients**
  - Chemical Name and CAS Number
  - Percentage (if mixture)
  - Exposure Limits (if applicable)

- **Physical and Chemical Properties**
  - Boiling Point
  - Vapor Pressure
  - Vapor Density
  - Appearance and Odor

- **Fire and Explosion Hazard Data**
  - Flash Point
  - Extinguishing Media

- **Reactivity Data**
  - Stability
  - Incompatibilities
  - Hazardous Decomposition Products
  - Conditions to Avoid

- **Health Hazard Data**
  - Routes of Entry
  - Health Hazards
  - Signs and Symptoms of Exposure
  - First Aid

- **Precautions for Safe Handling and Use**
  - Spill and Accidental Release Measures
  - Waste Disposal

- **Control Measures**
  - Engineering Controls
In addition to the required information, MSDS/SDS may include the following:

- Toxicological Information
- Ecological Information
- Disposal Considerations
- Transportation Information
- Regulatory Information
- Other Information

2.4 Controlling Chemical Exposures

Using the information presented in the earlier sections of this chapter and knowing the specific hazards of the chemicals to be used, one can design procedures to minimize hazards.

The OSHA Permissible Exposure Limit (PEL) or Short Term Exposure Limit (STEL) should not exceeded. These are legal limits established by OSHA to protect all workers. Similarly, Threshold Limit Values (TLVs) from the American Conference of Governmental Industrial Hygienists (ACGIH) should not be exceeded. These values are updated more frequently and are more reflective of the best knowledge available. You may request assistance from DRS at 333-2755 in developing or reviewing procedures to control chemical exposures.

Control techniques fall into three broad classes in order of preference: engineering controls, administrative controls, and personal protective equipment (PPE).

- **Engineering controls:** Options for engineering controls are those that eliminate the hazard through methods such as changing the procedures or substituting less hazardous materials for more hazardous materials. Conducting work with hazardous chemicals in a fume hood or glove box, and providing secondary containment in the event of spills are examples of engineering controls.

- **Administrative controls:** Whereas engineering controls are controls that work passively once they are established, administrative controls require that workers take active steps. Examples of administrative controls are posting hazard signs on laboratory doors, minimizing exposure time when working with hazardous chemicals, restricting access to areas where hazardous chemicals are used, working in a chemical fume hood with highly odorous chemicals during non-office hours, and adopting standard operating procedures.

- **Personal protective equipment:** Personal protective equipment includes items such as gloves, eye protection, suitable clothing, and respirators. Because such equipment is the last line of defense against exposure to
hazardous chemicals, these are the options last employed. Note that selection of appropriate PPE is not always straightforward. In the case of gloves, there are a wide variety of types depending on the specific application. Although some types of PPE may be suitable for a wide range of applications, each operation should be assessed individually.

Exposure controls will be examined in subsequent Chapters of this guide.

2.5 Other Information Sources

As sources of information change, look for the most recent update to or edition of the resources below. These are select examples; there are many other valuable resources available.

*Handbook of Reactive Chemical Hazards*, Edited by L. Bretherick, Butterworths.

*Patty’s Industrial Hygiene and Toxicology*, Edited by George D. Clayton and Florence E. Clayton, Wiley-Interscience.


*Safety in Academic Chemistry Laboratories*, Committee on Chemical Safety, American Chemical Society: Washington, D.C.

*TLVs and BEIs: Threshold Limit Values and Biological Exposure Indices for Chemical Substances and Physical Agents*, American Conference of Governmental Industrial Hygienists.
Chapter 3: Standard Operating Procedures

This document represents a minimum set of guidelines for the handling of toxic chemicals on campus. Individual administrative units, laboratories, or research groups are expected to develop more detailed procedures as their situations warrant. Safety references such as those listed in Appendix 3 of this document may be useful in developing additional procedures. As outlined in the Campus Administrative Manual, supervisors and principal investigators are responsible for complying with and/or enforcing appropriate safety and hygiene measures in the work areas they supervise. The Division of Research Safety (DRS) is available for consultative assistance to develop safe procedures for situations not covered in this guide.

Some rules or standard operating procedures, which apply to all work areas on campus, include the following:

3.1 General Procedures

Respect and understand the safety and health hazards associated with the chemicals and equipment you use, and practice the following general safety guidelines at ALL times:

- **Accident response:** If an injury requiring emergency medical assistance has occurred, call 9-911. You may obtain 9-911 stickers from the Division of Public Safety at 333-1216. See Chapter 5 for more information.

- **Chemical spills:** If a toxic/hazardous chemical has made contact with the skin, start flushing the area immediately. If emergency assistance is required, call 9-911. Cleanup procedures for chemical spills are presented in Chapter 6.

- **Children and unauthorized persons:** Children and other unauthorized persons should not be in laboratories where hazardous materials or hazardous equipment are being used.

- **Disposal of chemicals:** Requests for collection of chemical waste must be submitted in writing as outlined in the UIUC Chemical Waste Management Guide. Questions about chemical waste management should be directed to the Chemical Safety Section of DRS at 333-2755. A list of DRS-prepared resource materials that address common chemical waste issues is found in Appendix 2.

- **Electrical:** Access to electrical equipment (e.g. plugs, switches and electrical panels) should be maintained free from obstructions to allow immediate access in an emergency. All receptacle outlets in laboratory spaces should be the polarized grounding type. Ground Fault Circuit Interrupters (GFCI’s) should be used in those locations involving wet processes or outdoor work, including electrical outlets within six feet of sinks. All electrical hand tools used inside laboratories should be grounded or double insulated.
All electrical extension cords used should be visible and inspected on a periodic basis for damage and/or defects. Cords should not run in aisles or corridors where they might be damaged or create a tripping hazard. Cords should not be run through doors, walls or partitions, under rugs, or above dropped ceilings. They should not be wrapped around fixtures, tied in knots, or draped over pipes, lights, or ventilation ductwork.

Extension cords should not be used as substitution for fixed receptacle outlets. Cords used for 110-120 volt service should be UL listed standard heavy-duty three-wire equipped with a polarized three prong plug. Two-wire type extension cords should not be used.

- **Emergency eye wash/safety showers:** Be certain safety showers/emergency eye washes are properly located and maintained. These units should be located in areas which will be immediately accessible (reachable within 10 seconds). There should be no obstructions that might inhibit the use of this equipment.

Eye washes and safety showers should be flushed on a regular basis to verify that the units are working and to clear the lines of stale water and debris. Whenever these emergency units are checked for proper functioning, written documentation showing the date and person’s initials performing the check, should be maintained.

- **Equipment:** Use proper equipment that is in good condition. For example, never use chipped or cracked glassware. Shield pressurized or vacuum apparatus and safeguard against bumping or overheating.

- **Fire extinguishers:** Fire extinguishers must be available, charged, and hung in a location which is immediately accessible (reachable within 10 seconds). There should be no obstructions that might inhibit the use of this equipment. Make sure that all extinguishers are checked annually. Each extinguisher should have a tag indicating the date it was last checked. Contact Fire Safety (217) 333-9711 for assistance.

- **Food, drink, cosmetics:** Eating, drinking and the application of cosmetics are forbidden in areas where hazardous chemicals are used and should be done only in well-defined, designated non-chemical areas. Do not store food in the same refrigerator with chemicals, biohazards or radioactive materials.

- **Horseplay:** Practical jokes or other behavior which might confuse, startle, or distract, another worker is forbidden when hazardous chemicals are present.

- **Housekeeping:** Exits, aisles and safety equipment must NOT be obstructed in any way with equipment, furniture, or other items. Aisles within the laboratory should be 36 inches in clear width. Work areas and floors are not to be used for excessive storage. Doors which are not in use but which are accessible from a corridor or adjacent room should be appropriately labeled if they are blocked on the interior of the room. Hallways are not to be used as storage areas. Refer to Campus Administrative Manual (CAM) V/B - 6.2, Departmental Use of Corridors. Items may be stored in corridors only if prior
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Approval is obtained from the Office of Project Planning and Facilities Management (333-1232).

- **Mercaptans:** To avoid false reporting of natural gas leaks, mercaptans should not be used in such a manner (e.g. scrubbers for effluent) that persons outside of the laboratory could smell the mercaptan and suspect a natural gas leak in the building. All persons using mercaptans should report these uses to the campus telecommunicators (3-1216) prior to actual use.

- **Mouth pipetting:** Mouth pipetting is forbidden.

- **Perchloric acid:** If perchloric acid is heated above ambient temperature it may evaporate and condense on ductwork in the form of explosive perchlorates. Hence, when heating perchloric acid above ambient temperature, a perchloric acid fume hood with a water wash down system or a local scrubbing or trapping system must be used.

- **Signs:** Laboratories where hazardous materials or operations are present must follow the UIUC Laboratory Signage Guideline. An emergency contact card, updated at least annually, should be posted on each laboratory entrance. A recommended form with the information needed by emergency responders is available in [CHP Forms](#).

- **Smoking:** No smoking in laboratories. If you have been using chemicals, be sure to wash your hands before smoking.

- **Spill preparedness:** Before working with chemicals, assess potential spill hazards. Each laboratory worker should be familiar with general spill response procedures. Written protocols should be developed when extremely hazardous or large quantities of chemicals are used. Have readily available all necessary personal protective equipment and spill cleanup materials. See Chapter 6 for more detailed information.

- **Unattended experiments:** If operations involving hazardous substances are carried out with no one present, it is the responsibility of the worker to design procedures to prevent the release of hazardous substances in the event of interruptions in utility services such as electricity, cooling water, and inert gas. Lights should be left on, and signs should be posted identifying the nature of the operation and the hazardous substances in use. If appropriate, arrangements should be made for other workers to periodically inspect the operation.

Similarly, if unattended experiments require the use of running water, the worker should develop procedures to make sure the experiment is checked periodically for water leaking from the system. Unattended experiments involving the use of running water have caused flooding damage at UIUC.

- **Working alone:** When working with hazardous materials, it is advisable to have a second person present, or at a minimum, maintain contact via telephone.
3.2 Pollution Prevention and Waste Minimization

Waste minimization strategies usually have the dual benefits of improving safety and reducing chemical purchase and disposal costs.

It is recommended that each unit evaluate its procedures periodically to consider the possible usage of less hazardous or smaller quantities of chemicals. This evaluation may include the following issues:

- Is there good housekeeping where chemicals are used and stored?
- Are all containers properly labeled?
- If appropriate, is there an inventory of all chemicals in the unit?
- Do the chemicals in use present significant hazards to those working with them? (e.g. highly reactive, highly toxic, carcinogenic, and/or corrosive chemicals should be discouraged)
- If applicable, consider substitutes for all uses of mercury and chromic acid cleaning solutions.

For further information, see the waste minimization Fact Sheets listed in Appendix 2. Additional technical information on ways to implement waste minimization is available from DRS at (217) 333-2755 or via email [via email].

3.3 -- Reserved for Future Use --

3.4 -- Reserved for Future Use --

3.5 Handling and Storage of Chemicals

Hazards associated with various chemicals and gases vary widely. Understanding the hazards associated with a compound and minimizing the quantity used and stored in the lab will decrease chance of injury.

- **Compressed gases**: Use appropriate hand carts to move compressed gas cylinders. Gas cylinders should be capped and secured to a cart during transport. Highly toxic gases should not be moved through the corridors, particularly during business hours. Always consider cylinders as full and handle them with corresponding care.

- Gas cylinders should be stored in well-ventilated areas with their protective caps on. Gas cylinders should be secured (e.g., strapped or chained in place) to reduce the chance of being knocked over. Do not store cylinders near heat or high traffic areas. Do not store flammables and oxidizers together. Do not store empty and full cylinders together. Storage of large quantities of cylinders should be in an approved gas cylinder storage area. Refer to the [Compressed Gas Safety Fact Sheet](#).
• **Containers:** Make sure all containers are of good integrity. If deteriorated containers are found, dispose of the chemical or transfer it to a new container. Make sure that the container is appropriate for the chemical stored; for example, hydrofluoric acid must not be stored in glass and some oxidizers should not be stored in plastic containers. Waste halogenated solvents may not be stored in metal safety cans due to the potential for corrosion. Flammable materials, if removed from their original containers, should be stored in appropriate containers, such as safety cans or other Department of Transportation (DOT) approved containers. If in a substantial amount (>4 liters, but less than 20), waste solvents should be stored in poly jerricans (Central Stores stock number 37-38-1800 for the 10 liter size).

• **Cryogenic liquids:** These items present the potential hazards of fire or explosion, pressure buildup, embrittlement of structural materials, frostbite, and asphyxiation. Work areas must be well ventilated. Cryogenic liquids must be stored, shipped, and handled in containers that are designed specifically for this purpose. Because of the extreme cold and splash hazards, skin protection and eye protection - preferably a face shield - should be worn when handling cryogenic liquids. First time users of cryogenic liquids should have direct supervision and instruction from an experienced user when attempting transfers from one container to another.

• **Handling:** Encourage the use of poly coated bottles or use bottle carriers for transporting chemicals which are in glass containers. Close caps securely. Pour chemicals carefully. Never add water to concentrated acid; rather prepare dilute solutions by adding acid to water. Containers holding more than five gallons should be grounded when transferring flammable liquids.

• **Labels:** Make sure all labels are legible. Label all containers with the chemical name and appropriate health hazard warning(s). A chemical is considered to pose a health hazard if it is in one or more of the following classes: carcinogen, corrosive, irritant, sensitizer, toxic, or highly toxic. Information on whether a chemical poses a health hazard may be found on the Material Safety Data Sheet.

• Date all peroxidizable and other chemicals which may become unstable over time; test and/or dispose of them when appropriate. Common examples of chemicals that form peroxides upon aging are: ethyl ether, isopropyl ether, tetrahydrofuran, and dioxane. See [DRS Chemical Safety Factsheets](#) for a more complete listing of chemicals that can form peroxides upon aging.

• **Storage:** Avoid storing chemical containers in hard to reach areas. Chemicals should be segregated by hazard classification. Once segregated by hazard class, chemicals may be stored alphabetically. Basic segregations should keep:
  o oxidizers away from organics
  o air/water reactives away from air and water
  o caustics away from acids
  o cyanides, sulfides away from acids
• Laboratories with large numbers of hazard classifications may choose to further segregate chemicals.

• Volatile chemicals should be stored in volatile storage cabinets, or temporarily in fume hoods when cabinets are unavailable. If volatile substances are stored in a hood, other uses of the hood should be restricted to activities compatible with the chemical and physical properties of the stored or used chemicals. When volatiles must be stored in a cooled atmosphere, flammable material refrigerators, explosion-proof refrigerators or cold rooms designed for this purpose must be used. Refer to [Chemical Safety Factsheets](#).

### 3.6 Chemical Fume Hoods and Other Engineering Controls

All users of chemical fume hoods at the University of Illinois at Urbana-Champaign (UIUC) campus should comply with the Division of Research Safety (DRS) [Work Practices for Chemical Fume Hoods](#). Chemical fume hoods and other engineering controls, such as vented gas cabinets, should be surveyed annually by a qualified person (from Facilities & Services or an outside contractor) with a written report of the results maintained by the unit in charge of the laboratory.

Chemical fume hood velocities for all hoods on campus are currently evaluated on an annual basis by F&S Safety & Compliance at no charge to the users. The face velocity of the hoods should fall between 80 and 120 feet per minute (fpm) with the sash positioned at approximately half open, unless specified otherwise. (In general, fume hoods should not be used with the sash fully open.) If the face velocity is between 80 and 120 fpm on the day of the evaluation, the fume hood will bear a green sticker on the fume hood cabinet with an arrow pointing to the appropriate sash position. If the face velocity is between 60 and 79 fpm or above 120 fpm, the hood will have a red sticker with an arrow indicating sash position. This indicates that the hood is "Restricted" and should not be used for protection from highly toxic substances. Finally, if the face velocity of the fume hood is below 60 fpm, the hood will display a 5" x 7" DANGER sign, which states that the fume hood should be used for storage only.

Users should be certain that their fume hood has a sticker on it and that the date on the sticker is less than a year old. If the sticker is not green, indicating that the chemical fume hood was not functioning properly when last tested, users should work with their departmental business manager to have the chemical fume hood repaired. For maintenance of fume hoods, users should contact the (PC&M) Service Office at 3-0340. (In most cases, academic units are financially responsible for the maintenance of chemical fume hoods.)

Because the status of the chemical fume hood can change within one year, continuous air flow indicators are recommended. New chemical fume hoods should be equipped with air flow monitoring devices which will alert the user if there is a problem with air flow. For older hoods without air flow monitoring devices, a simple visible test to ensure flow into chemical fume hoods and other ventilating devices is
to tape a tissue to the hood and note its movement when the exhaust fan is turned on.

Protective equipment other than chemical fume hoods should be checked periodically by the laboratory supervisor to ensure that the equipment is functioning properly. DRS will assist upon request. Any questions or requests for assistance in evaluation of chemical fume hoods and other engineering controls may be directed to DRS (217) 333-2755 or the PC & M Service Office (217) 333-0340.

3.7 Prior Approval for Use of Certain Hazardous Materials

The responsibility for approval of the acquisition and use of toxic chemical agents rests with the laboratory supervisor. Certain materials including radioactive materials, recombinant DNA and certain biohazardous materials require prior internal (campus) or external approval. Wastes of hazardous materials with multiple hazards (chemical, radioactive and/or biohazardous) often complicate disposal. The Division of Research Safety (DRS) cannot guarantee that there are outlets for wastes exhibiting multiple hazards and we therefore recommend that you contact us prior to conducting experiments that might generate such wastes. Questions concerning the need for approval should be directed to DRS (217) 333-2755.

3.8 Medical Attention and Medical Surveillance

In addition to reporting of any physical injury sustained while working in a laboratory, chemical exposures should be reported immediately, and may require medical attention. OSHA sets enforceable permissible exposure limits (PELs) to protect workers against the health effects of exposure to hazardous substances. PELs are regulatory limits on the amount or concentration of a substance in the air. More information on action levels and Permissible Exposure Limits can be found on the OSHA Health and Safety topics page Permissible Exposure Limits.

3.8.1 Medical Attention

When a chemical exposure occurs, medical consultations and medical examinations will be made available to laboratory workers who work with hazardous chemicals as required. All work related medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided at no cost to the employee without loss of pay, and at a reasonable time.

The opportunity to receive medical attention, including any follow up examinations, will be provided to employees who work with hazardous chemicals under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.
Where airborne exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the Permissible Exposure Limit) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements. (For more information on medical surveillance see 3.8.2.)

Whenever an event such as a spill, leak, explosion or other occurrence takes place and results in the likelihood of a hazardous exposure. Upon such an event, the affected employee shall be provided an opportunity for a medical consultation. The consultation shall be for the purpose of determining the need for a medical examination.

3.8.1.1 Information Provided to the Physician
The physician shall be provided with the following information:

- The identity of the hazardous chemical(s) to which the employee may have been exposed. Such information can be found in the Material Safety Data Sheet (MSDS) for the chemical(s).
- A description of the conditions under which the exposure occurred including quantitative exposure data, if available.
- A description of the signs and symptoms of exposure that the employee is experiencing, if any.

3.8.1.2 The Physician’s Written Opinion
The physician’s written opinion for the consultation or examination shall include:

- The results of the medical examination and any associated tests.
- Any medical condition that may be revealed in the course of the examination, which may place the employee at increased risk as a result of exposure to a hazardous workplace.
- A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
- The written opinion shall not reveal specific findings of diagnoses unrelated to the occupational exposure.

All records of medical consultations, examinations, tests, or written opinions shall be maintained in accordance with 29 CFR 1910.1020 - Access to employee exposure and medical records.

3.8.2 Medical Surveillance
Regulations from OSHA, NIH, IDPH, and other agencies require that employees, who may be exposed to harmful substances through their job duties, be enrolled in a medical surveillance program. Employee health screenings are conducted by the Occupational Medicine Department of the currently contracted medical provider.
3.9 Special Provisions for Select Carcinogens, Reproductive Toxins and Acutely Toxic Chemicals

In addition to the general safety guidelines mentioned above, special precautions are needed when handling particularly toxic chemicals - such as select carcinogens, reproductive toxins, and chemicals with a high degree of acute toxicity. The laboratory supervisor should ensure that these and other precautions designed to minimize risk of exposure to these substances are taken. The following are minimum guidelines:

- Quantities of these chemicals used and stored in the laboratory should be minimized, as should their concentrations in solution or mixtures. Work with carcinogens, reproductive toxins and acutely toxic chemicals should be performed within a functioning fume hood, ventilated glove box, sealed system, or other system designed to minimize exposure to these substances. (The exhaust air from the ventilation systems may require scrubbing before being released into the atmosphere.) In all cases, work with these types of chemicals should be done in such a manner that the Occupational Safety and Health Administration's (OSHA) permissible exposure limits or similar standards are not exceeded.

- Compressed gas cylinders that contain acutely toxic chemicals, such as arsine and nitrogen dioxide, should be kept in ventilated gas cabinets.

- The ventilation efficiency of the designated chemical fume hood, glove box, or gas cabinet, and the operational effectiveness of mechanical and electrical equipment used to contain or manipulate these special substances should be evaluated periodically by the laboratory personnel at intervals determined by the laboratory supervisor. The interval of evaluating systems may vary from weekly to biannually depending upon the frequency of usage, quantities employed and level of hazard.

- Each laboratory utilizing these substances must designate an area for this purpose and sign or mark this area with an appropriate hazard warning. The designated area may be an entire laboratory, an area of the laboratory, or a device such as a fume hood or glove box. The designated area should be marked with a sign stating "DANGER, specific agent, AUTHORIZED PERSONNEL ONLY" or comparable warning sign.

- All laboratory workers who work in a laboratory which has an area designated for use with carcinogens, reproductive toxins and/or acutely toxic chemicals must be trained about the deleterious effects of these substances plus signs and symptoms regarding exposure to these substances. This training is required even for those who do not actually work with the substances. Training to ensure the safe handling and storage of these substances is required for those who use these materials. This training is the
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responsibility of the laboratory supervisor and must be done prior to the use of any of these materials.

- Laboratory workers using these chemicals must have access to appropriate personal protective equipment (available at no expense to the workers) and must be trained on how to properly utilize this equipment.

- Detection equipment may be required in laboratories where highly toxic chemicals (especially poisonous gases) are used.

- All wastes contaminated with these substances should be collected and disposed of promptly as outlined in the UIUC Chemical Waste Management Guide. For disposal assistance, call the DRS Chemical Safety Section (217) 333-2755 contact [via email]. Treatment of waste products to lessen or eliminate their toxicity as part of the experimental protocol is encouraged as a way of minimizing health hazards and the amount of waste, only if such treatment can be performed safely.

- The designated working area shall be thoroughly decontaminated and cleaned at regular intervals determined by the laboratory supervisor. The interval may be as short as one day or as long as six months depending upon the frequency of usage and level of hazard.

- Special precautions to avoid release and exposure to carcinogens, highly toxic chemicals and reproductive toxins must be utilized. For instance, volatile substances should be kept cool and contained. Gas cylinders should have properly functioning valves, check valves, regulators, containment which can withstand pressure buildup, and appropriate piping; and dispersive solids should be kept in closed containers, used in places with minimal air currents, and appropriate contact materials should be used to avoid static charging.

- Emergency response planning for releases or spills should be prepared by the laboratory supervisor and included in the training of the laboratory workers and others who may be affected in the building. DRS and the appropriate Fire Department should be involved in this planning.
Chapter 4  -- Reserved for Future Use --
Chapter 5: Personal Protective Equipment (PPE)

The following is an excerpt from *Fundamentals of Industrial Hygiene* (National Safety Council, 4th Ed., 1996: p. 546) provides a basic introduction to the topic:

...The use of personal protective equipment should be considered a last resort, when engineering or administrative controls are not possible or when they are not sufficient to achieve acceptable limits of exposure... The primary disadvantage of personal protective devices is that they do not eliminate the hazard from the workplace, and thus their failure results in immediate exposure to the hazard. A protective device may become ineffective without the wearer’s knowledge, resulting in serious harm. The integrity and fit of a personal protective device is vital to its effectiveness.

**Chapter Overview**

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**Revision Date: 07/16/10**

5.1 Laboratory Responsibilities for PPE

PPE must be made available to laboratory workers to reduce exposures to hazardous chemicals in the lab. Proper PPE includes items such as gloves, eye protection, lab coats, face shields, aprons, boots, hearing protection, etc. **PPE must be readily available and most equipment is provided at no cost to the employee.**

The OSHA Personal Protective Equipment standard, [29 CFR 1910 Subpart I](#), includes the following requirements:

- Hazard assessment and equipment selection
- Employee training
5.1.1 Hazard Assessment and Equipment Selection

Laboratory personnel need to conduct hazard assessments of the specific operations occurring in their laboratories to determine what PPE is necessary to safely carry out the operation. (See the PPE Selection Worksheet for blank forms.)

When deciding on the appropriate PPE to wear when performing any operations or experiments, a number of factors must be taken into consideration such as:

- The chemicals being used, including concentration and quantity.
- The hazards the chemicals pose.
- The routes of exposure for the chemicals.
- The material the PPE is constructed of.
- The permeation and degradation rates specific chemicals will have on the material.
- The length of time the PPE will be in contact with the chemicals.

Careful consideration should be given to the comfort and fit of PPE to ensure that it will be used by laboratory personnel.

All personal protective clothing and equipment must be maintained in a sanitary and reliable condition. Only those items that meet NIOSH (National Institute of Occupational Safety and Health) or ANSI standards should be purchased or accepted for use.

There are a number of safety equipment suppliers who sell a wide variety of personal protective equipment. If you have questions about what PPE is most appropriate for your applications, contact DRS at 333-2755.

PLEASE NOTE: Principal Investigators, laboratory supervisors, departments and colleges are free to set policies that establish minimum PPE requirements for personnel working in and entering their laboratories.

5.1.2 Training for Personal Protective Equipment

Laboratory personnel must be trained in the selection, proper use, limitations, care, and maintenance of PPE. Training requirements can be met in a variety of ways including videos, group training sessions, and handouts. Periodic retraining should be offered to both the employees and supervisors as appropriate. Examples of topics to be covered during the training include:

- When PPE must be worn.
- What PPE is necessary to carry out a procedure or experiment.
- How to properly put on, take off, adjust, and wear PPE.
The proper cleaning, care, maintenance, useful life, limitations, and disposal of the PPE.

As with any training sessions, PPE training must be documented, including a description of the information covered during the training session and a copy of the sign-in sheet. Written records must be kept of the names of the persons trained, the type of training provided, and the dates when training occurred. (See the Laboratory Safety Training – Session Record for blank forms.)

Please note: while DRS can provide information, training, and assistance with training on conducting hazard assessments, and on the selection and use of proper PPE, the ultimate responsibility lies with the Principal Investigator or laboratory supervisor.

It is the responsibility of the Principal Investigator or laboratory supervisor to ensure laboratory staff have received the appropriate training on the selection and use of proper PPE, that proper PPE is available and in good condition, and laboratory personnel use proper PPE when working in laboratories under their supervision.

5.2 Eye / Face Protection

Wearing eye protection is required by OSHA regulation whenever and wherever potential eye hazards exist. Laboratory personnel should use eye protection for many of the chemical and physical hazards found in laboratories including airborne particulates, aerosols, flying particles, molten metal, acids or caustic liquids, chemical liquids, chemical gases or vapors, or potentially injurious light radiation.

DRS strongly encourages Principal Investigators and laboratory supervisors to make use of eye protection a mandatory requirement for all laboratory personnel, including visitors, working in or entering laboratories under their control.

All laboratory employees and visitors should wear protective eyewear while in laboratories where chemicals are being handled or stored, at all times, even when not working directly with chemicals.

5.2.1 Selection of Eye / Face Protection

All protective eye and face devices must comply with ANSI Z87.1-1989, "American National Standard Practice for Occupational and Educational Eye and Face Protection" and be marked to identify the manufacturer. When choosing proper eye protection, be aware there are a number of different styles of eyewear that serve different functions.

- Prescription Safety Eyewear
  OSHA regulations require that employees who wears prescription lenses while engaged in operations that involve eye hazards shall wear eye protection that incorporates the prescription in its design, or must wear eye
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protection that can be worn over the prescription lenses (goggles, face shields, etc.) without disturbing the proper position of the prescription lenses or the protective lenses. Any prescription eyewear purchase must comply with ANSI Z87.1-1989.

- **Safety Glasses**
  Safety glasses provide eye protection from moderate impact and particles associated with grinding, sawing, scaling, broken glass, and minor chemical splashes, etc. Side protectors are required when there is a hazard from flying objects. Safety glasses are available in prescription form for those persons needing corrective lenses. Safety glasses do not provide adequate protection for processes that involve heavy chemical use such as stirring, pouring, or mixing. In these instances, splash goggles should be used.

- **Splash Goggles**
  Splash goggles provide adequate eye protection from many hazards, including potential chemical splash hazards, use of concentrated corrosive material, and bulk chemical transfer. Goggles are available with clear or tinted lenses, fog proofing, and vented or non-vented frames. Be aware that goggles designed for woodworking are not appropriate for working with chemicals. These types of goggles can be identified by the numerous small holes throughout the facepiece. In the event of a splash, chemicals could enter into the small holes, and result in a chemical exposure to the face. Ensure the goggles you choose are rated for use with chemicals.

- **Welder’s/Chippers’ Goggles**
  Welder’s goggles provide protection from sparking, scaling, or splashing metals and harmful light rays. Lenses are impact resistant and are available in graduated lens shades. Chippers'/Grinders' goggles provide protection from flying particles. A dual protective eyecup houses impact resistant clear lenses with individual cover plates.

- **Face Shields**
  Face shields provide additional protection to the eyes and face when used in combination with safety glasses or splash goggles. Face shields consist of an adjustable headgear and face shield of tinted or clear lenses or a mesh wire screen. They should be used in operations when the entire face needs protection and should be worn to protect eyes and face from flying particles, metal sparks, and chemical/biological splashes. Face shields with a mesh wire screen are not appropriate for use with chemicals. Face shields must **not** be used alone and are **not** a substitute for appropriate eyewear. Face shields should always be worn **in conjunction with** a primary form of eye protection such as safety glasses or goggles.

- **Welding Shields**
  Welding shields are similar in design to face shields but offer additional protection from infrared or radiant light burns, flying sparks, metal splatter, and slag chips encountered during welding, brazing, soldering, resistance welding, bare or shielded electric arc welding, and oxyacetylene welding and cutting operations.
Equipment fitted with appropriate filter lenses must be used to protect against light radiation. Tinted and shaded lenses are not filter lenses unless they are marked or identified as such.

- **LASER Eye Protection**
  A single pair of safety glasses is not available for protection from all LASER outputs. The type of eye protection required is dependent on the spectral frequency or specific wavelength of the laser source. If you have questions on the type of eyewear that should be worn with your specific LASER, contact DRS at 333-2755.

### 5.3 Hand Protection (Gloves)

Most accidents involving hands and arms can be classified under four main hazard categories: chemicals, abrasions, cuts, and heat/cold. Gloves must be worn whenever significant potential hazards from chemicals, cuts, lacerations, abrasions, punctures, burns, biologicals, or harmful temperature extremes are present. The proper use of hand protection can help protect from potential chemical and physical hazards. Gloves must be worn when using chemicals that are easily absorbed through the skin and/or particularly hazardous substances (such as “select carcinogens”, reproductive toxins, and substances with a high degree of acute toxicity).

**Keep in mind there is no one type of glove that offers the best protection against all chemicals or one glove that totally resists degradation and permeation to all chemicals. All gloves must be replaced periodically, depending on the type and concentration of the chemical, performance characteristics of the gloves, conditions and duration of use, hazards present, and the length of time a chemical has been in contact with the glove.**

All glove materials are eventually permeated by chemicals; however, they can be used safely for limited time periods if specific use and other characteristics (i.e., thickness, permeation rate, and time) are known. DRS can provide assistance with determining the resistance to chemicals of common glove materials and determining the specific type of glove material that should be worn for use with a particular chemical.

Some general guidelines for glove use include:
- Wear appropriate gloves when the potential for contact with hazardous materials exists. Laboratory personnel should inspect gloves for holes, cracks, or contamination before each use. Any gloves found to be questionable should be discarded immediately.
- Gloves should be replaced periodically, depending on the frequency of use and permeability to the substance(s) handled. Reusable Gloves should be rinsed with soap and water and then carefully removed after use. Discard disposable gloves after each use and whenever they become contaminated.
Due to potential chemical contamination, which may not always be visible, remember to remove gloves before leaving the laboratory. Do not wear gloves while performing common tasks such as answering the phone, grabbing a door handle, using an elevator, etc.

To properly remove disposable gloves, grab the cuff of the left glove with the gloved right hand and remove the left glove. While holding the removed left glove in the palm of the gloved right hand, insert a finger under the cuff of the right glove and gently invert the right glove over the removed left glove and dispose of them properly. Be sure to wash your hands thoroughly with soap and water after the gloves have been removed.

5.3.1 Selection of Proper Gloves

Before working with any chemical, always read manufacturer instructions and warnings on chemical container labels and MSDSs. Recommended glove types can sometimes be listed in the section for PPE on MSDSs. If the recommended glove type is not listed on the MSDS, then laboratory personnel should consult with glove manufacturers’ selection charts. These charts typically include commonly used chemicals that have been tested for the manufacturers’ different glove types. Keep in mind that different manufacturers use different formulations so check the glove chart of the specific manufacturer for the glove you plan to use.

If the manufacturers’ glove chart does not list the specific chemical you will be using, then call the manufacturer directly and speak with their technical representatives to determine which glove is best suited for your particular application.

It is important to know that not all chemicals or mixtures have been tested by glove manufacturers. It is especially important in these situations to contact the glove manufacturer directly.

5.3.2 Types of Gloves

As with protective eyewear, there are different types of gloves that serve different functions.

- **Fabric Gloves**
  Fabric gloves are made of cotton or fabric blends and are generally used to improve grip when handling slippery objects. They also help insulate hands from mild heat or cold. These gloves are not appropriate for use with chemicals because the fabric can absorb and hold the chemical against a user’s hands, resulting in a chemical exposure.

- **Leather Gloves**
  Leather gloves are used to guard against injuries from sparks, scraping against rough surfaces, or cuts from sharp objects like broken glass. They are also used in combination with an insulated liner when working with electricity. These gloves are not appropriate for use with chemicals because
the leather can absorb and hold the chemical against a user’s hands, resulting in a chemical exposure.

- **Metal Mesh Gloves**
  Metal mesh gloves are used to protect hands from accidental cuts and scratches. They are most commonly used when working with cutting tools, knives, and other sharp instruments.

- **Cryogenic Gloves**
  Cryogenic gloves are used to protect hands from extremely cold temperature liquids. These gloves should be used when dispensing or working with liquid nitrogen and other cryogenic liquids.

- **Chemically Resistant Gloves**
  Chemically resistant gloves come in a wide variety of materials. The recommendations given below for the specific glove materials are based on incidental contact. Once the chemical makes contact with the gloved hand, the gloves should be removed and replaced as soon as practical. Often a glove specified for incidental contact is not suitable for extended contact, such as when the gloved hand can become covered or immersed in the chemical in use. Before selecting chemical resistant gloves, consult the glove manufacturers' recommendations or their glove selection charts, or contact DRS at 333-2755 for more assistance.

Some general guidelines for different glove materials include:

- **Natural Rubber Latex** - Resistant to ketones, alcohols, caustics, and organic acids. (*See note below.*)
- **Neoprene** - Resistant to mineral acids, organic acids, caustics, alcohols, and petroleum solvents.
- **Nitrile** - Resistant to ketones, alcohols, caustics, and organic acids.
- **Norfoil** - Rated for chemicals considered highly toxic and chemicals that are easily absorbed through the skin. These gloves are chemically resistant to a wide range of materials that readily attack other glove materials. These gloves are not recommended for use with Chloroform. Common brand names include: Silver Shield by North Hand Protection, 4H by Safety4, or New Barrier by Ansell Edmont.
- **Polyvinyl chloride (PVC)** - Resistant to mineral acids, caustics, organic acids, and alcohols.
- **Polyvinyl alcohol (PVA)** - Resistant to chlorinated solvents, petroleum solvents, and aromatics.

**SPECIAL NOTE: Latex Gloves**

The use of latex gloves, especially thin, disposable exam gloves, for chemical handling is discouraged because latex offers little protection from commonly used chemicals. Latex gloves can degrade severely in minutes or seconds, when used with common lab and shop chemicals. Latex gloves also can cause an allergic reaction in a percentage of the population due to several proteins found in latex.
Symptoms can include nasal, eye, or sinus irritation, hives, shortness of breath, coughing, wheezing, or unexplained shock. If any of these symptoms become apparent in personnel wearing latex gloves, discontinue using the gloves and seek medical attention immediately.

The use of latex gloves is only appropriate for:

- Chemicals which have been verified as appropriate for the gloves in question according to glove manufacturer guidance
- Most biological materials
- Medical or veterinary applications.
- Non-hazardous chemicals
- Applications where “product protection” is the only reason for glove use (e.g., clean room environments)

Staff required to wear latex gloves should receive training on the potential health effects related to latex. Hypoallergenic, non-powdered gloves should be used whenever possible. Nitrile typically offers better chemical protection than latex – but always check with the glove manufacturer to be sure it protects against the chemicals you use.

**5.3.3 Double Gloving**

A common practice to use with disposable gloves is “double-gloving”. This is accomplished when two pairs of gloves are worn over each other to provide a double layer of protection. If the outer glove becomes contaminated, starts to degrade, or tears open, the inner glove continues to offer protection until the gloves are removed and replaced. The best practice is to check outer gloves frequently, watching for signs of degradation (change of color, change of texture, tears, etc.). At the first sign of degradation or contamination, always remove and dispose of the contaminated disposable gloves immediately and double-glove with a new set of gloves. If the inner glove appears to have any contamination or degradation, remove both pairs of gloves, and double glove with a new pair.

Another approach to double gloving is to wear a thin disposable glove (4 mil Nitrile) under a heavier glove (8 mil Nitrile). The outer glove is the primary protective barrier while the under glove retains dexterity and acts as a secondary barrier in the event of degradation or permeation of the chemical through the outer glove. Alternately, you could wear a heavier (and usually more expensive and durable) 8 mil Nitrile glove as an under glove and wear thinner, disposable 4 mil Nitrile glove as the outer glove (which can help improve dexterity). However, remember to change the thinner outer gloves frequently.

When working with mixtures of chemicals, it may be advisable to double glove with two sets of gloves made from different materials. This method can offer protection in case the outer glove material becomes permeated by one chemical in the mixture, while allowing for enough protection until both gloves can be removed. The type of glove materials selected for this type of application will be based on the
specific chemicals used as part of the mixture. Check chemical manufacturers glove selection charts first before choosing which type of glove to use.

### 5.4 Protective Clothing

Protective clothing includes lab coats or other protective garments such as aprons, boots, shoe covers, Tyvek coveralls, and other items, that can be used to protect street clothing from biological or chemical contamination and splashes as well as providing additional body protection from some physical hazards.

**DRS strongly encourages Principal Investigators and laboratory supervisors to require long pants and clothing which effectively covers the torso for all laboratory personnel, including visitors, working in or entering laboratories and laboratory support areas under their supervision.**

The following characteristics should be taken into account when choosing protective clothing:

- The specific hazard(s) and the degree of protection required, including the potential exposure to chemicals, radiation, biological materials, and physical hazards such as heat.
- The type of material the clothing is made of and its resistance to the specific hazard(s) that will be encountered.
- The comfort of the protective clothing, which impacts the acceptance and ease of use by laboratory personnel.
- Whether the clothing is disposable or reusable - which impacts cost, maintenance, and cleaning requirements.
- How quickly the clothing can be removed during an emergency. It is recommended that lab coats use snaps or other easy to remove fasteners instead of buttons.

Laboratory personnel who are planning experiments that may require special protective clothing or have questions regarding the best protective clothing to choose for their experiment(s) should contact DRS at 333-2755 for recommendations.

### 5.5 Respirators

Respiratory protection includes disposable respirators (such as N95 filtering facepieces, commonly referred to as “dust masks”), air purifying, and atmosphere supplying respirators. **Respirators are generally not recommended for laboratory workers.** Engineering controls, such as dilution ventilation, fume hoods, and other devices, which capture and remove vapors, fumes, and gases from the breathing zone of the user are preferred over the use of respirators in most laboratory environments.
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The use of all types of respiratory protection at UIUC is governed by OSHA standards and the UIUC Respiratory Protection Program. Contact Safety and Compliance at 265-9828, http://safetyandcompliance.fs.illinois.edu/ for more information.

5.6 Hearing Protection

Hearing protective devices include earplugs, earmuffs, or similar devices designed to protect your hearing. In situations where occupational noise exposures exceed permissible levels and cannot be reduced through engineering or other controls, hearing protective devices must be worn. The UIUC Hearing Protection Program protects employees who during their normal duties experience an occupational noise exposure as defined by the Occupational Safety and Health Administration (OSHA) General Industry Standard 29 CFR 1910.95—Occupational noise exposure and the Hearing Conservation Amendment. Contact Safety and Compliance at 265-9828, http://safetyandcompliance.fs.illinois.edu/ for more information, especially if you have questions about whether you are receiving an occupational noise exposure, or you would like to request workplace monitoring.

5.7 Foot Protection

Laboratory personnel (and other personnel) must wear foot protection at all times in laboratories, laboratory support areas, and other areas with chemical, biological and physical hazards present. Laboratory personnel should not wear sandals or similar types of perforated or open toes shoes whenever working with or around hazardous chemicals. This is due to the potential exposure to toxic chemicals and the potential associated with physical hazards such as dropping pieces of equipment or broken glass being present. In general, shoes should be comfortable, and leather shoes are preferable to cloth shoes due to the better chemical resistance of leather compared to cloth. Leather shoes also tend to absorb fewer chemicals than cloth shoes. However, leather shoes are not designed for long term exposure to direct contact with chemicals. In such instances, chemically resistant rubber boots are necessary.

DRS strongly encourages Principal Investigators and laboratory supervisors to require the use of closed toed shoes for all laboratory personnel, including visitors, working in or entering laboratories and laboratory support areas under their supervision.

In some cases, the use of steel-toed shoes may be appropriate when heavy equipment or other items are involved. Chemically resistant boots or shoe covers may be required when working with large quantities of chemicals and the potential exists for large spills to occur. Contact DRS at 333-2755 if you would like more information about foot protection.
Chapter 6: Emergency Planning

**IN CASE OF AN EMERGENCY, call 911 (9-911 from a campus phone),**
including the following emergencies:
- Medical Emergencies
- Fires
- Explosions
- Complicated Spills (See 6.4.3.3)

Be prepared to provide the following information:
- Type of emergency
- Location
- Phone number

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**Chapter Overview**

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6.2 Exit Routes
6.3 Emergency Equipment
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*Revision Date: 04/28/10*

Accidents happen unexpectedly. They can result in personal injury, property damage, environmental impact, and disruption of research. Accordingly, emergency procedures are required components of a Laboratory Safety Manual, which shall be relevant to the laboratory’s specific hazards and research materials, and which shall be reviewed and understood by all laboratory personnel.
Chemical Safety Guide for Laboratories

A laboratory’s emergency procedures are a combination of the following three:

- **Chapter 6: Emergency Planning** of the Chemical Safety Guide
- **CHP Forms** (see especially Sections 1-3) – completed by laboratory personnel for a given location.
- **Building Emergency Action Plan** completed by your facility manager with the Division of Public Safety.

### 6.1 Emergency Contact Signs

Emergency responders (e.g., Fire Department, Paramedics, Police) need information on the hazards present before entering a room. Post the sign at each entrance into a hazardous work area or laboratory, and in a way that emergency personnel can view the back side for hazards.

Specifically, list the names and phone numbers (office and home) of the principal investigator and other knowledgeable employees/students on the front of the sign, and complete hazard information on both front and back of the sign. Update contact or hazard information as it changes. Annually check all door signs for accuracy. Date all signs when posted or when checked.

Contact the Chemical Safety Sectoin of DRS for blank copies of door signs, or see: [http://www.drs.illinois.edu/gls/forms/pdf/emergencycontactsign.pdf](http://www.drs.illinois.edu/gls/forms/pdf/emergencycontactsign.pdf) to complete one electronically.

### 6.2 Exit Routes

Do not allow objects to block movement through aisles or exits. Laboratory personnel must have a clear route out of the room. Emergency personnel must be able to access all areas of the laboratory, and be able to move freely in the aisles, particularly if smoke is present.

Do no clutter floor space with storage. Minimize physical hazards (e.g., tripping hazards, items that could fall on someone, etc.). Properly store combustible / flammable materials in amounts that do not exceed Fire Code thresholds (see the DRS factsheet on [Flammable Liquid Storage Cabinets](http://www.drs.illinois.edu/gls/forms/pdf/flammables.pdf)), and away from exits. Do not store materials in such a way that they will slide, collapse, fall or spill.

If the laboratory door is outfitted with a window, it needs to remain unobstructed for emergency responders to see freely into the room.

### 6.3 Emergency Equipment

#### 6.3.1 First Aid Kits

First aid kits should be available and unobstructed. Consider the various injuries that could happen in the laboratory, and assemble the first aid kit accordingly. For
example, if hydrofluoric acid is used in the laboratory, then make calcium gluconate gel available for the first aid treatment of skin exposure.

Personnel should be trained on the proper use of the kit’s contents. Periodically check expirations on any ointments or over-the-counter pharmaceuticals. Periodically evaluate the hazards present in the laboratory, and adjust the first aid kit contents as needed.

6.3.2 Emergency Eyewashes and Showers

Per campus policy, emergency showers shall be available in labs where there is the potential for injury to the skin due to contact with a corrosive, severely irritating or toxic chemical. Eyewashes shall be available in labs where there is the potential for injury to the eye due to contact with a chemical, or where there is the potential for exposure to biological materials that are Risk Group 2 or greater. For more information see the UIUC Emergency Eyewash and Shower Program at [http://www.drs.illinois.edu/gls/eyewashes](http://www.drs.illinois.edu/gls/eyewashes).

Emergency eyewashes and showers shall be in accessible, unobstructed locations that require no more than 10 seconds to reach. They shall be identified with a sign that is visible within the area served. Emergency showers shall be activated and tested at least annually to verify the plumbing supply has not been disrupted to any shower. Eyewashes shall be activated and tested weekly. Regular activation (weekly flushing) ensures the eyewashes are operating properly, helps to keep them free of clutter, and helps prevent the growth of bacteria within the plumbing lines, which can cause eye infections. Initial and date tags (available from DRS) to record these tests.

Due to the flow requirements outlined in the campus policy, hand-held bottles do not qualify as approved eyewashes. Hand-held eyewash bottles are acceptable to use in conjunction with an eyewash, such as sink mounted or portable units.

Laboratories are responsible for ensuring that access to emergency showers and eyewashes are kept free of clutter and ensuring the eyewash nozzle dust covers are kept in place. If nozzle dust covers are not kept on the eyewash nozzles, dust or other particles can clog the nozzles and result in poor or no water flow. This can also result in dust or other particles being forced into the eyes when the eyewash is used.

If you discover your emergency shower or eyewash is not functioning properly, then contact your facility management or department to have the unit repaired.

6.3.2.1 Using an Emergency Eyewash

1) If you get a chemical in your eyes, yell for help if someone else is in the lab.

2) Immediately go to the nearest eyewash and push the activation handle all the way on.
3) Put your eyes or other exposed area in the stream of water and begin flushing.

4) Open your eyelids with your fingers and roll your eyeballs around to get maximum irrigation of the eyes.

5) Keep flushing for at least 15 minutes or until help arrives. The importance of flushing the eyes first for at least 15 minutes cannot be overstated! For accidents involving Hydrofluoric acid, follow the special precautions.

6) If you are alone, call 911 after you have finished flushing your eyes for at least 15 minutes.

7) Seek medical attention. (See Section 6.4.1.)

8) Complete an accident report.

If someone else in the lab needs to use an eyewash, assist them to the eyewash, activate the eyewash for them, and help them get started flushing their eyes using the procedures above and then call 911. After calling 911, go back to assist the person using the eyewash and continue flushing for 15 minutes or until help arrives and have the person seek medical attention.

### 6.3.2.2 Using an Emergency Shower

1) If you get chemical contamination on your skin resulting from an accident, yell for help if someone else is in the lab.

2) Immediately go to the nearest emergency shower and pull the activation handle.

3) Once under the stream of water, begin removing your clothing to wash off all chemicals.

4) Keep flushing for at least 15 minutes or until help arrives. The importance of flushing for at least 15 minutes cannot be overstated! If you spill Hydrofluoric acid on yourself, follow the special precautions.

5) If you are alone, call 911 after you have finished flushing for at least 15 minutes.

6) Seek medical attention. (See Section 6.4.1.)

7) Complete an accident report.

If someone else in the lab needs to use an emergency shower (and it is safe for you to do so), assist them to the emergency shower, activate the shower for them, and help them get started flushing using the procedures above and then call 911. After calling 911, go back to assist the person using the shower and continue flushing for 15 minutes or until help arrives and have the person seek medical attention.

**NOTE:** Although an emergency is no time for modesty, if a person is too modest and reluctant to use the emergency shower, you can assist them by using a lab
coat or other piece of clothing or barrier to help ease their mind while they undress under the shower. If you are assisting someone else, you should wear gloves to avoid contaminating yourself. When using an emergency shower, do not be concerned about the damage from flooding. The important thing to remember is to keep flushing for 15 minutes.

6.3.3 Fire Extinguishers

In the event of a fire, call 911 immediately.

Fire extinguishers must be available, charged, and hung in a location which is immediately accessible (reachable within 10 seconds). There should be no obstructions that might inhibit the use of this equipment. Check all extinguishers monthly. Make sure that all extinguishers are inspected by Fire Safety annually. Each extinguisher should have a tag indicating the date it was last checked or inspected. Know the location of extinguishers in your immediate area, and know how to use them (i.e., get training and read the instructions) before an emergency occurs.

If you would like more information or would like to schedule a presentation on the correct use of fire extinguishers, call the Fire Prevention Officer within Campus Code Compliance & Fire Safety at 265-5268. Report missing extinguishers to Campus Code Compliance & Fire Safety at 265-6552.

6.3.3.1 Types of Extinguishers

- Class A: Ordinary combustibles such as wood, paper, cloth, trash and plastics
- Class B: Fires in flammable liquids (such as gasoline, petroleum and paint) and flammable gases (propane, butane, etc.)
- Class C: Energized electrical equipment, such as motors, transformers and appliances
- Class D: Combustible metals, such as potassium, sodium, aluminum and magnesium
- Class K: Cooking oil fires

6.3.3.2 Using an Extinguisher – Remember PASS:

- Pull the pin from the handle.
- Aim the nozzle at the base of the fire. Hold the nozzle firmly and stand 8-10 feet from the fire (movement closer may be necessary for complete coverage).
- Squeeze the handle to activate the extinguisher.
- Sweep the base of the fire from side to side and proceed upward until the fire is extinguished.
For further information about the use of extinguishers please contact: Campus Code Compliance & Fire Safety at 265-5268 or ccandfs@illinois.edu

6.3.4 Chemical Spill Kits
A spill clean-up kit should be available and unobstructed. Consider the spills that could happen in the laboratory, and assemble the spill clean-up kit accordingly. Materials should be evaluated for compatibility with the hazards in the laboratory that could be spilled. Universal sorbents, such as 3M Powersorb, and spill pads are recommended for spill kits. If any materials are used, they should be re-stocked immediately. Periodically evaluate the spill clean-up kit, and adjust the kit contents as needed. (See Section 6.4.3 for more information.)

6.4 Emergency Procedures

IN CASE OF AN EMERGENCY, call 911 (9-911 from a campus phone).

For more information see the Emergency Response Guide from Public Safety at:

http://www.ocep.uiuc.edu/emergencyplanning/emergresponseguide.pdf

6.4.1 Medical Emergencies

6.4.1.1 University Employees
To report work-related incidents:

1. **Immediately report accident/incident to supervisor.**
   An employee who is injured on the job must inform the employer promptly. Any delay in notifying the employer can delay the payment of benefits. A delay of more than 45 days may result in the loss of all benefits. Notice to a fellow worker who is not a supervisor or otherwise a part of management is not considered notice to the employer.

2. **Promptly seek medical care as needed at one of the following:**

<table>
<thead>
<tr>
<th>Christie Occupational Medicine (Main Clinic - 4th floor)</th>
<th>After hours and weekends: Provena Covenant Hospital Emergency Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekdays 8:00 am – 5:00 pm</td>
<td>1400 W. Park Street</td>
</tr>
<tr>
<td>101 W. University Avenue</td>
<td>Urbana, IL 61801</td>
</tr>
<tr>
<td>Champaign, IL 61820</td>
<td>(217) 366-1310</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAFEWORKS ILLINOIS</th>
<th>After hours and weekends: Provena Covenant Hospital Emergency Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekdays 8:00 am – 5:00 pm</td>
<td>1400 W. Park</td>
</tr>
<tr>
<td>1806 N. Market Street</td>
<td>Urbana, IL 61801</td>
</tr>
<tr>
<td>Champaign, Illinois 61820</td>
<td>(217) 337-2131</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carle Occupational Medicine</th>
<th>After hours and weekends: Carle Hospital Emergency Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekdays 8:00 am – 5:00 pm</td>
<td>810 W. Anthony Drive</td>
</tr>
</tbody>
</table>
To assist medical personnel in your treatment, bring the Material Safety Data Sheet (MSDS) of any chemical involved. However, do not delay seeking medical attention if you cannot locate the MSDS.


An employee must thoroughly complete and sign the First Report of Injury/Illness form within 24 hours and fax (217-244-5152) or email (WorkComp@uillinois.edu) to the Office of Workers’ Compensation and Claims Management. A link to the form is found below:


For more information see University of Illinois Workers’ Compensation and Responsibilities at http://www.obfs.uillinois.edu/risk/workers_compensation/procedures_and_responsibilities/

6.4.1.2 Students, Visitors, and Other Non-Employed Personnel

Campus persons, who are involved in activities for which they are not paid and suffer an injury requiring emergency medical treatment (e.g. chemical exposure), should seek treatment at either the Provena Covenant Medical Center or Carle Foundation Hospital emergency rooms. Students may also seek basic medical care at the McKinley Health Center or with their personal physician. However, all unpaid persons may also go to the emergency rooms in this case. Costs associated with most injuries incurred during these activities are the responsibility of the individual through their personal insurance or student insurance.

If a person suffers an injury during activities for which they are not paid, a Public Injury / Property Damage Report should be completed. These reports should be completed regardless of where the injury occurred or whether the person received medical follow-up.

A report can be filed by filling out the Public Injury / Property Damage Report located at: http://www.obfs.uillinois.edu/common/pages/DisplayFile.aspx?itemId=917317

For more information see the University Office of Risk Management: http://www.obfs.uillinois.edu/risk/

6.4.2 Fires

Each person should be continually on the alert for fire safety hazards. Please report any observed hazards to Code Compliance & Fire Safety at 265-5268.
Some examples of the most frequent fire safety hazards are:

- Permitting aisles, corridors, and routes of egress to become obstructed.
- Using extension cords, ungrounded plugs, and unfused multiple outlet adapters for various small appliances. These are NOT PERMITTED and will only overload the electrical circuit.
- Illegal storage in corridors, fan rooms, equipment rooms, under stairways, etc. THESE AREAS MUST BE KEPT CLEAR AT ALL TIMES.
- Improper handling and storage of chemicals and flammable liquids. These must be limited to acceptable quantities and stored only in approved cabinets.
- Wedging open of fire resistive doors. These doors are designed to slow the spread of fire. Keep them closed at all times.
- Improper smoking habits. Smoke only in permitted areas, and discard ashes in approved ashtrays only.

**Be Prepared**

Know the exit routes from your office, floor, and building. Study these in advance. It is easy to get disoriented during an actual emergency.

Know the location of fire extinguishers and how to use them. Read the directions before an emergency. Report missing extinguishers immediately.

Make sure that emergency numbers are posted on your telephone. If these numbers are not posted on your phone, call the building RA/RD, office manager, or telecommunications.

Report any unsafe conditions to CC & FS at 265-5268.

**If a Fire Occurs**

Notify anyone in the immediate area.

- Activate the nearest fire alarm box.
- Call 911.
- Confine the fire by closing doors and windows.
- Attempt to extinguish the fire only if it is safe to do so.
- If there is smoke or heat, stay low.
- DO NOT USE ELEVATORS.
Before opening any door, feel it near the top. If it is hot, do not open, but:

Call 911 and tell them your exact location and situation.

- Place a blanket or similar article along the bottom of your door to keep out smoke. If possible, wet the material first.
- Retreat. Close as many doors between you and the fire as possible.
- Hang a light colored material out the window to attract attention from below. DO NOT JUMP.

If the door is not hot:

- Open the door cautiously—stand behind the door and be prepared to close if quickly if there is excessive smoke.
- Conduct a final search before leaving, if safe to do so.
- If your mobility is limited by wheelchair, crutches, etc., and you have a telephone, stay where you are and call 911 for help. If you do not have a telephone, leave the area and position yourself in the stairwell landing (if applicable), if it is clear, and wait for responding agencies.
- Assemble outside. Do not re-enter the building until notified.

Fire Do's and Don'ts

- **Do** Report the fire—don't assume someone else will call. Call the Fire Department at 911.
- **Do** Activate the nearest alarm box. Know their locations.
- **Do** Close doors—they will slow the spread of fire.
- **Do** Use stairs to vacate the building. Assemble outside.
- **Do** Evacuate your floor, when there is smoke visible or you are instructed to leave by the floor fire marshals, the RA/RD's or Fire Department personnel.
- **Don't** Use elevators—elevators can be very dangerous in a fire, even when they appear safe. Always use the stairs instead of an elevator.
- **Don't** Arbitrarily break windows—falling glass is a serious threat to both pedestrians and fire fighting personnel.
- **Don't** Exit until you have felt the top of the exit door and the door knob. If either are hot, or if excessive smoke prevents your exit, keep the door closed. Fire of the other side will blast through the slightest opening with tremendous force.
- **Don't** Go back for your things if you are ordered to leave.
- **Don't** Congregate in the stairways—keep to the right and keep going until it is safe to exit. Always move down and out.
- **Don't** Panic—remain calm. Help is on the way.
6.4.3 Chemical Spills

6.4.3.1 Preventing Spills

Listed below are some basic spill prevention steps that apply to storage, transportation, and transfer of chemicals.

General Precautions

- Reduce clutter and unnecessary materials in your work areas.
- Eliminate tripping hazards and other obstructions.
- Have all needed equipment readily available before starting work.

Storage Precautions

- Use sturdy shelves.
- Larger containers should be stored closer to the floor.
- Containers on shelves should be stored back from the edge to reduce the danger of falling.
- Storage shelves should have lips to further reduce the danger of falling.
- Chemicals should be stored by compatibility class first, then alphabetically.
- Inspect the storage area regularly for leaking or defective containers.
- Use appropriate storage containers.
- Periodically check containers under laboratory chemical hoods, sinks and lab benches for signs of deterioration.

Transportation Precautions:

- Use carts, where appropriate.
- Use safety containers, where appropriate.
- Use bottle carriers for any glass bottle greater than 250 ml.
- Use straps to secure gas cylinders, where appropriate.
- Think about potential hazards before transporting chemicals.
- Consider purchasing plastic coated "shatter resistant" bottles.

Precautions in Transferring Chemicals

- Pay careful attention to the size of container to avoid overfilling.
- Use pumps or other mechanical devices rather than simple pouring.
- Provide containment to capture leaks and spills.

6.4.3.2 Preparing for Spills
Evaluating potential hazards and establishing protocols and in advance is a required component of your Laboratory Safety Manual (see Section 1.2). It is best to proceed in an organized manner for spill response.

Evaluating Hazards

When spills occur, a quick appropriate response can prevent serious consequences. However, the wrong response can make things worse. In order to respond promptly and appropriately, you should evaluate the potential hazards in advance of using the chemicals. The first source of information to consult would be your Material Safety Data Sheets (MSDSs). [If you need an MSDS, consult DRS Chemical Safety Section website or call 333-2755.] Of most concern in spill situations are chemicals which are:

- air reactive
- water reactive
- flammable
- polymerizable
- corrosive
- highly toxic

Based on these hazards, you can then determine:

- appropriate personal protective equipment for spill response (e.g. gloves, respirators, etc.)
- types of fire suppression equipment
- appropriate clean up materials
- first aid procedures

Establishing Spill Response Protocols

Before working with chemicals you should determine what could go wrong and how you might respond to a spill. As a result of this evaluation, you should prepare written protocols for use in the event of a spill. These protocols need to be communicated to all persons who might be affected by a spill. The best place to document spill response protocols in the laboratory is in your Chemical Hygiene Plan (CHP). [For guidance on developing your lab’s CHP please see Section 1.3.] In addition, you should have basic spill clean-up materials readily available should anything go wrong. More information on spill clean-up materials is listed below. Always create written spill protocols before using a chemical.

Assembling a Spill Kit

Prior to starting any work with chemicals, make sure that you have all the necessary personal protective devices, safety equipment, and containment/clean up materials readily available. Each individual who may be involved in spill response or clean up must know the purpose and limitations of all personal protective
equipment, safety equipment and clean up materials. Prepackaged spill kits are available from various vendors. The prepackaged kits tend to be expensive, so campus units typically make their own kits. To make your own kit, include the following items at a minimum:

- Disposable nitrile gloves (1 box)
- Neoprene gloves (1 set)
- Safety goggles
- Hand broom
- Plastic dustpan
- 4-mil plastic zippered bags
- Appropriate absorbent material (such as spill pads, spill pillows or loose sorbents)

If mercury containing devices must be used in the lab (please replace all devices, if possible with non-mercury alternatives), the spill clean-up kit should also contain Hg Absorb™ (available from Lab Safety Supply).

The location of spill control kits should be clearly marked and highly visible. Make sure all personnel know the kit's location, are familiar with the kit's contents, and understand its limitations.

6.4.3.3 Spill Response Procedures

Chemical spills and leaks can be broken down into two basic types: complicated spills, which require outside assistance, and simple spills, which you can clean up yourself.

Definition of Complicated Spills

If your spill meets any of the following conditions, it is a COMPLICATED SPILL – immediately call 9-911 from a campus phone.

- A person is injured; or
- The identity of the chemical is unknown; or
- Multiple chemicals are involved; or
- The chemical is highly toxic, flammable or reactive; or
- The spill/leak occurs in a "public space" such as corridors; or
- The spill/leak has the potential to spread to other parts of the building such as through the ventilation system; or
- The clean up procedures are not known or appropriate materials are not readily available; or
- The clean up requires a respirator (including cartridge respirators) to be worn and no personnel have been trained and fit-tested in accordance to the campus Respiratory Protection Program; or
The spill/leak may endanger the environment by reaching waterways or outside ground, or by going down a drain.

Complicated Spill Procedures

1. Evacuate the area, alerting others in the area to follow.
2. If possible, close doors and windows to prevent the spread of fumes and vapors.
3. **From a safe location, call 9-911 immediately.** Be ready to answer the following questions:
   - What is the name of the chemical spilled?
   - What quantity of the chemical is spilled?
   - Where is the spill (building name and room number)?
   - Is anyone injured or splashed with the chemical?
   - Is a fire or explosion involved in the spill?
   - What is your name and phone number?
4. Secure the area so no one will enter until the emergency responders arrive.
5. Send someone with knowledge of the chemical spilled to meet the fire department at your building’s main entrance. If a Material Safety Data Sheet (MSDS) is readily available, the contact should take a copy to provide to the responders.

Simple Spill Procedures

If the spill does not meet any of the conditions for a complicated spill, the spill is defined as simple. You may clean up simple spills as described below.

1. If possible, close doors and windows to prevent the spread of fumes and vapors.
2. Turn off all potential sources of ignition (Bunsen burners, pumps, mechanical equipment not designed to be spark-proof, etc) if the spilled material is flammable (it may be necessary to turn off power from a remote circuit breaker).
3. Put on gloves, lab coat, apron, eye protection, and other PPE, as necessary.
4. Absorb liquids using appropriate absorbent material (such as spill pads, spill pillows or loose sorbents)
   - Do not attempt to neutralize acids or bases - absorb each liquid spill as is.
   - Do not use silica products to clean up hydrofluoric acid.
   - Do not use combustible materials to clean up oxidizers. For instance, do not use paper towels for nitric acid spills.
5. Carefully sweep powder spills to avoid contaminating the air with chemical dust.
6. Collect and contain clean-up materials in a plastic container or thick plastic bag and affix descriptive labels.

7. Decontaminate the affected area and equipment (soap and water can be used to clean most surfaces) and ventilate the area, if necessary.

8. Follow the Procedures for Requesting Chemical Waste Disposal in *Chemical Waste Management Guide*. If you have questions, contact the DRS Chemical Safety Section via e-mail or call 333-2755.

**SPECIAL CASE: Mercury Spill Procedures**

The best method of dealing with mercury spills is to prevent them in the first place. Examine all uses of mercury to see if substitutes are available. If not, use trays or other equipment to provide containment in the event of a spill.

1. In the event a spill, cordon off the area to prevent mercury from being spread by foot traffic.

2. For broken mercury thermometers use mercury-absorbing sponges. After cleaning up the mercury, place the used sponge and the broken thermometer (with heavy tape over the broken ends) in a sturdy plastic bag. Close and label the bag "Waste—broken mercury thermometer." Request a chemical waste pickup using the ChemTrak form **CWM-TRK-01**.

3. For small spills of mercury use a mercury absorbing powder. The powder creates an amalgam that does not emit mercury vapor. Close and label the bag “Waste-mercury debris.” Request a chemical waste pickup using the ChemTrak form **CWM-TRK-01**.

4. For large spills, follow department/building procedures to arrange mercury clean-up service with F&S.

**Do not** use a regular vacuum cleaner or Shop-Vac® to clean up mercury spills. Doing so will produce toxic mercury vapor in the immediate area and contaminate the vacuum cleaner.

**Do not** use nitric acid to clean up spills. Mercury and nitric acid will react, creating toxic NOx gases, and a mercury nitrate waste.
Appendix 1: OSHA Laboratory Standard

29 CFR 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories

a. Scope and application.
   1. This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.
   2. Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR, part 1910, subpart Z, except as follows:
      i. For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.
      ii. Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.
      iii. Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements, paragraphs (d) and (g)(1)(ii) of this section shall apply.
   3. This section shall not apply to:
      i. Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR, part 1910, subpart 2, even if such use occurs in a laboratory.
      ii. Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:
         a. Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and
         b. Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

b. Definitions:
   1. Action level means 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.
   2. Assistant Secretary means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.
   3. Carcinogen (see "select carcinogen").
   4. Chemical Hygiene Officer means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not

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intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

5. **Chemical Hygiene Plan** means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

6. **Combustible liquid** means any liquid having a flashpoint at or above 100°F (37.8°C), but below 200°F (93.3°C), except any mixture having components with flashpoints of 200°F (93.3°C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

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

8. **Designated area** means an area which may be used for work with "select carcinogens," reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory, or a device such as a laboratory hood.

9. **Emergency** means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

10. **Employee** means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

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

12. **Flammable** means a chemical that falls into one of the following categories:
   i. **Aerosol, flammable** means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;
   ii. **Gas, flammable** means:
      a. A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or
      b. A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
   iii. **Liquid, flammable** means any liquid having a flashpoint below 100°F (37.8°C), except any mixture having components with
flashpoints of 100°F.(37.8°C.) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

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

13. **Flashpoint** means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

i. Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24-1979 (ASTMD 56-79))- for liquids with a viscosity of less than 45 Saybold Universal Seconds (SUS) at 100°F. (37.8 °C.), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

ii. Pensky-Martens Closed Tester (see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7-1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or greater than 45 SUS at 100°F. (37.8°C.), or that contain suspended solids, or that have a tendency to form a surface film under test; or

iii. Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78))

iv. Organic peroxides, which undergo auto accelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

14. **Hazardous chemical** means a chemical for which there is statically 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. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes. Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

15. **Laboratory** means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

16. **Laboratory scale** means 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.

17. **Laboratory scale** excludes those workplaces whose function is to produce commercial quantities of materials.
18. **Laboratory-type hood** means a device located in a laboratory, enclosure on five sides with a moveable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms. Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

19. **Laboratory use of hazardous chemicals** means handling or use of such chemicals in which all of the following conditions are met:
   i. Chemical manipulations are carried out on a "laboratory scale;"
   ii. Multiple chemical procedures or chemicals are used;
   iii. The procedures involved are not part of a production process, nor in any way simulate a production process; and
   iv. "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

20. **Medical consultation** means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

21. **Organic peroxide** means an organic compound that contains the bivalent \(-\text{O-O-}\) structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

22. **Oxidizer** means a chemical other than a blasting agent or explosive as defined in §1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

23. **Physical hazard** means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, or an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

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

25. **Reproductive toxins** means chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

26. **Select carcinogen** means any substance which meets one of the following criteria:
   i. It is regulated by OSHA as a carcinogen; or
   ii. It is listed under the category, "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or
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iii. It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or

iv. It is listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
   a. After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3;
   b. After repeated skin application of less than 300 (mg/kg of body weight) per week; or
   c. After oral dosages of less than 50 mg/kg of body weight per day.

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

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

c. Permissible exposure limits
   1. For laboratory users of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR, part 1910, subpart Z.

d. Employee exposure determination.
   1. Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).
   2. Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.
   3. Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.
   4. Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

e. Chemical Hygiene Plan - General
   1. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan.)
   2. Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:
      i. Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and
ii. Capable of keeping exposures below the limits specified in paragraph c of this section.

3. The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

4. The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:
   i. Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;
   ii. Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;
   iii. A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;
   iv. Provisions for employee information and training as prescribed in paragraph (f) of this section;
   v. The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;
   vi. Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;
    vii. Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee; and
   viii. Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:
      a. Establishment of a designated area:
      b. Use of containment devices such as fume hoods or glove boxes;
      c. Procedures for safe removal of contaminated waste; and
      d. Decontamination procedures.

5. The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

f. Employee information and training
1. The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work areas.
2. Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.
3. Information. Employees shall be informed of:
   i. The contents of this standard and its appendices which shall be made available to employees;
   ii. The location and availability of the employer's Chemical Hygiene Plan;
   iii. The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;
   iv. Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and
   v. The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to,
   vi. Material Safety Data Sheets received from the chemical supplier.
4. Training
   i. Employee training shall include:
   ii. Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);
   iii. The physical and health hazards of chemicals in the work area; and
   iv. The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.
   v. The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

g. Medical consultation and medical examinations  
   1. The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:
      i. Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.
      ii. Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) 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.
      iii. 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 consultation shall be for the purpose of determining the need for a medical examination.
   2. All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.
3. Information provided to the physician. The employer shall provide the following information to the physician:
   i. The identity of the hazardous chemical(s) to which the employee may have been exposed;
   ii. A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and
   iii. A description of the signs and symptoms of exposure that the employee is experiencing, if any.
4. Physician's written opinion.
   i. For examination of consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:
      a. Any recommendation for further medical follow-up;
      b. The results of the medical examination and any associated tests;
      c. Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace;
      d. A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.
   ii. The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

h. Hazard identification
   1. With respect to labels and material safety data sheets:
      i. Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
      ii. Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.
   2. The following provisions shall apply to chemical substances developed in the laboratory:
      i. If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph f of this section.
      ii. If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph e of this section.
      iii. If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.
   i. Use of respirators.
      1. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators
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shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

j. Recordkeeping
   1. The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examination including tests or written opinions required by this standard.
   2. The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

k. Dates
   1. Effective date. This section shall become effective May 1, 1990.
   2. Start-up dates.
      i. Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.
      ii. Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

l. Appendices

The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.
Appendix 2: Campus Policies and Guidance Materials

**Campus Administrative Manual**

**Policy Number and Title**
1. Organization and Responsibilities (1.0 - 1.4)
3.1 Storm Sewer Usage
4.1 Chemical Waste Management
5.2 Fire Doors
5.4 Fire Safety
6.1 Working Alone
6.2 Departmental Use of Corridors
6.3 Safety Shoes
6.4 Eye Protection
6.5 Emergency Eyewashes and Showers
6.6 Refrigerators
6.8 First Aid Supplies
6.9 Electrical Safety - Medical Instrumentation and Biological Monitoring Devices
6.10 Chemical Hygiene Plan
7. Radiological Health (7.1 - 7.3)
8. Biohazards (8.1 - 8.4)
11.5 Safety Showers, Emergency Eyewash Stations & Drench Hoses

**F&S Health and Safety Guides**
Asbestos
Electrical Safety
Ergonomics
Fire Extinguishers
Fire Safety
Flammable Storage Cabinets
Gas Cylinder Safety
Laboratory Fume Hood Work Practices
Lead
Respiratory Protection

**Chemical Safety Section Fact Sheets**

**Chemical Safety Fact Sheets:**
Piranha Waste Generation, Collection and Disposal Procedures
Work Practices for Chemical Fume Hoods
Compressed Gas Cylinder Safety, Management and Disposal
Material Safety Data Sheets (MSDS)
Safe Storage and Use of Perchloric Acid

**Chemical Waste Fact Sheets:**
Piranha Waste Generation, Collection and Disposal Procedures
Screening Procedures by Labs for Unlabeled Chemicals
Odor Control Procedures for Campus Facilities
Compressed Gas Cylinder Safety, Management and Disposal
Procedures for Handling Chemical Spills and Leaks

**Chemical Waste Minimization Fact Sheets:**
101 Ways to Reduce Hazardous Waste in the Lab
Alternatives to Chromic Acid Cleaning Solutions
Alternatives to Mercury and Mercury Compounds
Alternatives to DNA Prep with Chloroform Extractions
Reducing or Eliminating the Use of Heavy Metals
Pollution Prevention in Laboratories - The How-to Guide
Waste Reduction Techniques for Paint Application
Used Battery Reductions, Recycling and Management

Videos
List of videos available upon request.
## Appendix 3: Chemical Resistivity Chart for Glove

### Chemicals and Gloves

| Chemical | Sulfuric Acid | Nitric Acid | Hydrochloric Acid | Hydrofluoric Acid | Formaldehyde | Acetic Acid | Acrolein | Ethanol | Methanol | Ethyl Alcohol | Ammonia | Benzene | Ethylene Oxide | Acrylonitrile | Butadiene | Vinyl Chloride | Acrylamide | Formaldehyde |
|----------|---------------|-------------|-------------------|-------------------|--------------|-------------|-----------|---------|---------|-------------|---------|---------|--------------|-------------|-----------|-------------|------------|-------------|----------------|
|          |               |             |                   |                   |              |             |           |         |         |              |         |         |              |             |           |              |           |             |----------------|

### Breakthrough Time

- The breakthrough time under laboratory test conditions is defined as the elapsed time between initial contact of chemical on glove surface and analytical detection of chemical (inside glove).

### Chart

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Breakthrough Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Acrolein</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Acrylamide</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Butadiene</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Chloroform</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Ethylene Oxide</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Hydrochloric Acid</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Hydrofluoric Acid</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Nitric Acid</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Vinyl Chloride</td>
<td>&gt;1h</td>
</tr>
<tr>
<td>Xylene</td>
<td>&gt;1h</td>
</tr>
</tbody>
</table>

### Note

- This chemical compatibility chart shows how each type of glove resists chemicals. Some combinations have been not tested, and others have been tested in non-representative conditions. The results are not definitive; always consult with an expert before using any chemical on a specific type of glove. This chart cannot be used for medical devices.