
Laboratory & Research Safety Plan:

1. General Safety Plan
 2. Waste Management Logbook
 3. Rules and Procedures for the Use of Radioactive Material at The Pennsylvania State University
 4. Unit Specific Plan
-

The Pennsylvania State University

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Acknowledgement

Penn State would like to thank Northwestern University for their help and generous donation of the template for this document.

Plan developed in 2009

| Revision Date | Revision Summary |
|----------------|--|
| September 2012 | Revised Plan to include updated <i>Biosafety in Microbiological and Biomedical Laboratories</i> 2009 information |
| January 2013 | Revised Plan to included Machine shop information |
| April 2013 | Added information regarding LRSP policy |
| July 2013 | NIOSH Carcinogen table updated Added information on Global Harmonization System |
| October 2013 | Updated Ansi shower flow requirements |
| June 2014 | Added link to Fisher Scientific chemical storage guidance |

LABORATORY AND RESEARCH SAFETY PLAN

1.0 INTRODUCTION

Penn State University has established a policy for the management of laboratory and research hazards, SY43 Laboratory and Research Safety Plan policy, <http://guru.psu.edu/policies/SY43.html>

The Laboratory and Research Safety Plan is made up of four sections, the General Safety Plan, Waste Management Logbook, [Rules and Procedures for the Use of Radioactive Material at The Pennsylvania State University](#), and the Unit Specific section

The Laboratory and Research Safety Plan provides information and guidance to help you conduct your laboratory and research work safely and in compliance with environmental health and safety regulations and University policy. It is also a useful training resource for principal investigators and other supervisory personnel.

The General Safety Plan serves as a reference source for a broad range of general safety issues for laboratories and research areas. Your facility's Unit Specific Plan is the portion of the plan that addresses hazards specific to your laboratory or research area. Users of Radioactive material should include a copy of [Rules and Procedures for the Use of Radioactive Material](#) with these two sections and generators of hazardous waste should include their Waste Management Logbook. These four sections should provide comprehensive information to address hazards in your area. It is recommended that you also maintain emergency plans; medical surveillance and scheduling information; and fit test reports and training documents with your Laboratory and Research Safety Plan.

The Laboratory and Research Safety plan should be made available to all research and laboratory workers.

Although the information in this document is compiled from sources believed to be reliable, it is not all-encompassing and is intended only to serve as a starting point for good safety practices. The laboratory or research area manager or supervisor is responsible for adding specific information, for developing and maintaining a safe workplace, and for complying with federal, state, and local laws and University policy.

Whenever used, the word **shall** indicates required procedures. The word **should** indicates a recommendation for good practice.

The requirements for working with radioactive material can be found in [SY-14](#) and the [Rules and Procedures for the Use of Radioactive Material](#). This Safety Policy and the Rules and Procedures require all users of radioactive material to obtain prior authorization from the University Isotopes Committee before acquiring any radioactive material. Contact EHS for details on how to apply for this authorization.

The requirements for working with Lasers can be found in [SY-17](#). This Penn State Safety Policy has specific registration, general training, laser specific training, and self inspection requirements. In addition, the policy requires the issuance and required use of laser specific safety materials.

The requirements for working with radiation producing equipment (x-rays) can be found in [SY-15](#). This Penn State Safety Policy has specific registration, general training, and device specific training,

EMERGENCY NUMBERS

| | |
|-------------------------|--------------|
| EHS | 814-865-6391 |
| FIRE, POLICE, AMBULANCE | 911 |
| UNIVERSITY POLICE, UP | 814-863-1111 |

2.0 RESPONSIBILITIES

This section describes and assigns responsibilities associated with laboratory and research safety practices.

2.1 Penn State Leadership

The university president endorses the Penn State's Environmental Health and Safety Policy [SY01](#) requiring that the University leadership maintain a safe work environment within their jurisdiction, by monitoring and exercising control over their assigned areas.

2.2 Senior Vice President for Finance and Business

Penn State University Safety policy [SY01](#) includes the President's statement to the entire PSU leadership of his commitment to the University's Environmental Health and Safety Policy. He has delegated administrative responsibility for the laboratory and research safety programs to the Senior Vice President for Finance and Business

2.3 Associate Vice President of Office of Physical Plant

The Associate Vice President of the Office of Physical Plant reports to the Senior Vice President for Finance and Business and oversees the activities of EHS.

2.4 Environmental Health and Safety

The director of EHS reports to the Associate Vice President of Office of Physical Plant. EHS has overall responsibility for the administration of the University's environmental health and safety programs. Their mission is to work with the campus community to develop and implement efficient, comprehensive and proactive health and safety programs.

EHS responsibilities include:

- Developing safety programs that protect the health and safety of students, faculty, staff, visitors and the environment.
- Assisting the campus community in complying with federal, state, and local regulations.
- Providing oversight to help ensure conformance with these programs.

EHS representatives are authorized to enter University facilities within their jurisdiction at any time to observe working conditions, monitor equipment, and sample for contaminants. EHS is authorized to close a facility or stop a process or procedure that poses an imminent danger to life or property.

2.5 Budget Executives and Budget Administrators (Chancellors, Deans, Associate Deans, Division Heads, etc.):

These functions have the primary responsibility to maintain a safe work environment within their jurisdiction, by monitoring and exercising control over their assigned areas.

S/He must assign a representative from each academic and administrative unit to the University Safety Council. This representative must be selected to ensure compliance with University safety policies, rules, procedures and practices. This is often the individual designated to act on behalf of the budget executive or budget administrator.

S/He must communicate to all faculty, employees and students that health and safety of persons in the workplace and environment are of the highest priority at Penn State University.

S/He must ensure that health and safety responsibilities are carried out in the academic departments or administrative units for which they are responsible.

S/He must ensure that environmental health and safety obligations established by this program applicable to their areas of jurisdiction are carried out. This includes assuring compliance with applicable state and federal health and safety rules, regulations, standards and procedures. Included, for example, are regulations of the Pennsylvania Department of Environmental Protection (PADEP), and Nuclear Regulatory Commission (NRC), and policies and procedures established by the Office of Environmental Health and Safety.

S/He must monitor implementation of programs designed to protect the health and safety of faculty, staff, students and visitors:

- a. Consult with their University Safety Council representative and/or the Office of Environmental Health and Safety with respect to new, existing or planned facilities or equipment that may present a health or safety hazard to determine specific measures that may need to be implemented to control these hazards *before* exposure to these hazards may occur.
- b. Support measures such as training, use of protective devices, and resources to control and prevent hazards.

2.6 University Safety Council

The University Safety Council is comprised of members representing academic colleges and administrative units, as appointed by their respective budget executives. University Safety Council representatives are commonly referred to as "Safety Officers."

The duties of the University Safety Council are to develop and implement, under the guidance of the Office of Environmental Health and Safety, a comprehensive and practical occupational health and safety program, and to maintain an environment that is conducive to the safety, health and well-being of the University community.

Each member of the University Safety Council shall attend the regularly scheduled meetings and special meetings of the University Safety Council, and report Council activities to the appropriate budget executive.

S/He must establish and maintain, as chairperson, a Safety Committee within the member's area of responsibility. The size and structure of this Committee shall be dictated by the types of activities, the potential hazards inherent to those activities, and the number of persons who may be exposed.

S/He must accompany insurance company loss prevention representatives on inspections of areas under the Safety Officer's jurisdiction.

S/He must review all [Employer's Reports of Occupational Injury or Illness](#) for employee accidents, or the [Incident Report](#) for non-employees or employees not engaged in normal employment activities, whichever report is appropriate for the accident/illness, and any other associated accident/illness reports.

S/He must assist in the investigation of all serious accidents, and all other accidents when requested by the supervisor.

S/He must initiate proper follow-up measures and ensure corrective actions are implemented when unsafe conditions, practices or equipment are reported or observed.

2.7 The Institutional Biosafety Committee

The Institutional Biosafety Committee (IBC) oversees the research and instruction involving biohazards. Members are drawn from a variety of disciplines including chemistry, engineering, and biomedical sciences and the community.

The committee's responsibilities do not include research involving ionizing and non-ionizing radiation. Such activities are under the jurisdictions of the University Isotopes Committee. Research involving animals is under the jurisdiction of the Institutional Animal Care and Use Committee.

The IBC is responsible for reviewing and approving all research and instruction involving biohazards, as defined in University Policy [SY-24](#). Approval by the IBC must be granted prior to the use of any biohazardous material.

2.8 Department Heads, Center Directors, and Other Facility Directors

The term **department head** will be used in this text to include center directors and other facility directors.

The Senior Vice President for Finance and Business and the Vice President for Research have assigned direct responsibility for compliance with the University's safety and health programs to department heads. This means that the department head shall provide a safe workplace and shall implement the safety and health programs. This includes ensuring that personnel are adequately trained, and overseeing the preparation and submission of annual laboratory safety self-audits. Department heads shall appoint building safety officers and alternates.

The department head shall maintain discipline, enforce rules and regulations, and take prompt, effective corrective action when necessary. The department head shall also provide assistance to EHS staff when situations arise involving investigators and other personnel in the department.

The department head shall be familiar with and understand the federal, state, and local regulations and University policies applicable to the department's work and shall ensure compliance through principal investigators and other supervisory personnel. Regulatory and policy documents are available on the EHS website, www.ehs.psu.edu and from EHS.

The department head may delegate safety and health-related tasks to principal investigators or other supervisors, but ultimately compliance is the department head's responsibility

2.9 Principal Investigators and Supervisors

The PI or supervisor is responsible to the department head for the safe and legal conduct of research under his or her purview. This responsibility shall not be delegated. The supervisor shall be aware of the physical and health hazards associated with all materials present in his/her laboratory. In the event of an accident, the principal investigator shall initiate appropriate emergency procedures.

All supervisors (department chairs, faculty, and other employees with direct oversight of University activities and employees or students) have specific responsibilities to provide for the health and safety of those supervised. They are in a key position in the organizational structure to carry out the department's safety policies and to prevent injuries to their employees.

S/He must be thoroughly informed of appropriate University and Departmental safety policies, rules and procedures and how they specifically apply to his/her responsibilities and authority including the LRSP.

S/He must inform all new and current employees and students that safety and health, and concern for the environment, are priorities at Penn State and to inform them about safety and health policies, rules, regulations and procedures, as well as their specific responsibilities (the next Section, [below](#)).

S/He must ensure that required safety equipment, devices and personal protective equipment and apparel are provided and maintained, and are properly used by individuals working in their operations.

S/He must provide employees and students with instruction and assistance in the proper operation of equipment or materials involved in any operation which may be potentially hazardous.

S/He must take prompt corrective action when unsafe conditions, practices or equipment are reported or observed.

S/He must encourage prompt reporting of health and safety concerns.

S/He must promptly conduct a thorough investigation in all work-related injuries, illnesses and accidents, submit appropriate recommendations on all accident reports, including the [Employer's Reports of Occupational Injury or Illness](#) or the [Incident Report](#), as appropriate, and follow through to ensure corrective measures have been implemented.

S/He must coordinate or conduct inspections to maintain safe and healthful conditions, and address any deficiencies that are identified.

S/He must provide for health and safety training.

S/He must provide financial support for health and safety improvements, or request assistance from the next higher level of supervision regarding these requests.

The PI/supervisor shall prepare a Unit Specific Plan and shall make all laboratory personnel aware of the plan. See Section 3.0 for information about the Unit Specific Plan. S/He shall be familiar with and understand the rules, regulations, and University policies pertaining to the workplace. These encompass but are not limited to the following items: training, record keeping, labeling of chemicals, labeling and proper disposal of surplus and waste chemicals and biological materials, posting of warnings, medical surveillance, inventory reporting, engineering controls, safe work practices, provision of personal protective clothing and equipment, and access restrictions.

S/He ensures Standard Operating Procedures are developed for hazardous chemicals/operations not covered in the LRSP.

S/He either acts as or assigns an individual in his/her laboratory the responsibility for overseeing safety within the laboratory. This person serves as the Laboratory/Research Safety Officer.

S/He ensures employees, visitors, and students receive general Laboratory Safety training provided by EHS.

S/He ensure employees, visitors and students receive unit specific training on hazards not covered by general EHS safety training.

S/He ensures employees, visitors, and students read, comply and complete LRSP certification.

S/He notifies employees, visitors, or students of hazardous chemical monitoring results, if any.

S/He answers employee's questions and concerns and forwards unresolved questions and concerns to EHS for response...

S/He provides training and information on the LRSP including the [Unit Specific Plan](#) to all affected employees, visitors, and students.

S/He reviews and updates Unit Specific Plan annually, ensuring completion of certification by all affected lab/researchers.

S/He makes sure employees, visitors, or students who develop signs or symptoms associated with hazardous chemical exposure are given an opportunity to receive medical attention. Makes available to employees permissible exposure limits for hazardous chemicals, information on signs and symptoms associated with exposures to hazardous chemicals used, and Safety Data Sheets for hazardous chemicals used. EHS is available to provide guidance.

2.10 Laboratory/Research Safety Officer

Each laboratory/research Principle Investigator/Supervisor shall either act as, or assign, an individual in his/her laboratory/research area the responsibility for overseeing safety within his/her area. This person serves as the Laboratory/Research Safety Officer. In areas where chemicals are used, this person also serves as the Chemical Hygiene Officer.

S/He monitors procurement, use, and disposal of chemicals used in the lab.

S/He ensures that appropriate self-inspections are maintained.

S/He provides input to PI's/Supervisors on developing precautions and adequate facilities.

S/He knows the current legal requirements concerning regulated substances, as provided through EHS resources.

S/He seeks ways to improve the chemical hygiene program.

2.11 The Individual

Each individual working in a laboratory or other work-site where hazardous materials are used shall know and comply with the University's safety policies and rules and shall follow both oral and written instructions from the principal investigator or supervisor. The individual shall report to the principal investigator any unsafe conditions and any accident or exposure to chemicals or biological agents. If the individual receives no response or an unsatisfactory response, s/he shall contact the department head or EHS.

All University employees and students have specific responsibilities to comply with established health and safety policies, standards, rules, procedures and regulations. Compliance with these is essential to create and maintain a healthy and safe environment at all University locations.

S/He must comply with applicable environmental health and safety policies, standards, rules, regulations and procedures. These include safety-related signs, posters, warnings and written/oral directions when performing tasks.

S/He must not perform any function or operation which is considered hazardous, or is known to be hazardous without proper instructions and authorization.

S/He must only use equipment and materials approved or provided by the supervisor or instructor and for which instruction has been provided by this or other experience.

S/He must become thoroughly knowledgeable about potential hazards associated with the work area; knowing where information on these hazards is maintained and how to use this information when needed.

S/He must wear or use prescribed protective equipment.

S/He must report all unsafe conditions, practices, or equipment to the supervisor, instructor or safety officer whenever deficiencies are observed.

S/He must inform the supervisor or instructor immediately of all work-related injuries or accidents and obtain prompt medical attention when necessary.

S/He must provide information necessary for the supervisor or safety officer to adequately and thoroughly complete the [Employer's Report of Occupational Injury and Illness](#) and any other associated accident/illness reports.

2.12 Laws and Regulations

Numerous laws and regulations govern work with chemicals and biological materials and the responsibilities of employers and employees. A list of the major regulatory acts follows.

FEDERAL LAWS

- Occupational Safety and Health Act of 1970 (OSHA Act). Contains the general industry regulations.
- OSHA Hazard Communication Standard. Governs the use of hazardous chemicals in nonlaboratory locations.
- OSHA Occupational Exposure to Hazardous Chemicals in Laboratories Standard. Governs the use of chemicals in laboratories. In general, the Laboratory Standard adopts the guidelines found in [Prudent Practices for Handling Hazardous Chemicals in Laboratories](#) (published by the National Research Council) and incorporates some elements of the Hazard Communication Standard.
- OSHA Occupational Exposure to Bloodborne Pathogens Standard. Governs workplace exposure to human blood, blood products, and other potentially infectious material in any occupational setting.
- National Institutes of Health Guidelines for Research Involving Recombinant DNA Molecules.
- EPA Superfund Amendments and Reauthorization Act (SARA), Title III: Emergency Preparedness and Community Right-to-Know Act. Establishes responsibilities for chemical reporting to the community.
- EPA Worker Protection Standard (WPS). Protects farm workers from pesticide exposure.
- EPA Clean Water Act. Provides for surface water protection and results in many environmental regulations.
- EPA Spill Prevention, Control, and Countermeasures Rule. Provides requirements for oil storage and spill plans
- Resource Conservation and Recovery Act of 1976. Governs hazardous waste disposal.
- Other regulations of the U.S. Environmental Protection Agency.
- Regulations of the U.S. Department of Transportation.
- Regulations of the U.S. Department of Agriculture.

STATE LAW

- OSHA Regulation Hazard Communication 1910.1200. Governs chemical safety in the workplace.
- Pennsylvania Pesticide Control Act of 1973. Governs the licensing of applicators and the application of pesticides

2.13 Students

Although the Pennsylvania laws apply only to employees (including student employees), it is the policy of the Pennsylvania State University to ensure that all students who might be exposed to hazardous materials in the course of their activities at the University are also adequately protected and trained. Students shall receive instruction in the appropriate safety precautions for their specific teaching lab and will be expected to follow the given rules.

3.0 THE LABORATORY AND RESEARCH SAFETY PLAN

3.1 Laboratory and Research Safety Plan

The Laboratory and Research Safety Plan is intended to be a central safety resource for the laboratory or research area. The complete Safety Plan includes:

1. General Safety Plan
2. Waste Management Logbook
3. Rules and Procedures for the Use of Radioactive Material at The Pennsylvania State University
4. Unit Specific Plan
5. Recommended documents included with Plan:
 - Emergency Plans
 - Annual Reviews
 - Respirator Records: Medical Examinations and Fit Test Reports
 - Training Documentation

The Plan should be located in the laboratory or research area preferably in a holder on the back of the room's entrance door or to either side of the door inside the lab.

The department-level safety records, including accumulation area locations, self audits, training records and a list of overseers, shall be maintained by the head of each department (or designee) where hazardous materials are used.

3.2 Unit Specific Plan

The Unit Specific Plan is the laboratory-specific section of the Laboratory and Research Safety Plan for research labs, teaching labs, research areas and common facilities (those shared by more than one researcher). See Unit Specific Plan Form in Appendix C. In the case of shared facilities, the director, coordinator, or designated facility supervisor for the center shall compile the Unit Specific Plan.

3.2.1 Initial Preparation

If chemical, biological or radioactive materials or reactive processes are used, the principal investigator/supervisor shall prepare a Unit Specific Plan available for review by EHS. The Unit Specific Plan contains the following sections; only sections that are appropriate need be completed.

- I. Research Overview**
- II. Chemical Safety**
- III. Biological Safety**
- IV. Radiation Safety**
- V. Animal Related Hazards**
- VI. Physical Hazards**
- VII. Safety Precautions in Place**
- VIII. Certification Agreement**
- IX. Appendix**

3.2.2 Change of Facility

A new Unit Specific Plan shall be prepared when new facilities are opened. The original Unit Specific Plan will not be considered valid for the new space.

3.2.3 Addition of or Change to a Specific Project

A Unit Specific Plan shall be prepared or modified for new projects not covered by the original Unit Specific Plan.

3.3 Inspections

The University has an inspection program for all laboratories and research areas. Self audits are conducted annually by lab personnel. Laboratory inspections are also regularly conducted by the EHS staff.

Investigators may be asked to update the Unit Specific Plan and other information. The inspector may examine general laboratory/research conditions, engineering controls, work practices, chemical storage, use of personal protective clothing and equipment, signs and postings, and records. Workers may be interviewed. Inspection findings are provided to the principal investigator/supervisor, department head and safety officer.

GENERAL SAFETY PLAN

4.0 UNIVERSITY EMERGENCY INFORMATION

4.1 Where to Find Specific Information

This section provides general information about the University's emergency response programs.

- For detailed emergency notification procedures and other general emergency information, including fire safety, see the EHS website, www.ehs.psu.edu.
- For emergency information relating to chemical spills and exposures, see Section 6.0.
- For emergency information relating to biological spills and exposures, including exposure to bloodborne pathogens, see Section 7.0.

Call for assistance when needed. **Always** call the University Police 911 if there is an explosion, fire, injury, or spill-related evacuation. If there is a chemical or biological spill, call EHS, 814-865-6391 during business hours and 863-1111 at University Park at other times.

4.2 University Emergency Response Plan

Police Services maintains the University's Emergency Response Plan and an Operation Plan for emergencies. The Emergency Response Plan formalizes responses to all classes of emergencies, from small events to catastrophes. In emergency situations, the role of University Police (UP) is to investigate the situation, provide site security, implement the emergency plan, and establish communications. EHS will advise and assist with hazardous-material spill control and cleanup. When the ability to respond adequately to an emergency is beyond the capability of University personnel, UP will call the local fire department or local hazardous materials response team.

4.3 Building Emergency and Evacuation Plans

In the event of a fire, hazardous material release, or other hazardous situation requiring emergency response the first responder will:

- Activate the fire alarm, if needed
- Call 911
- Evacuate the zone
- Assist emergency personnel by providing information regarding location of the incident, origin, and persons involved

4.4 Power Failure

In the event of a power failure when there is adequate emergency lighting, cap any open chemical containers and close gas cylinders, perform an orderly shutdown of equipment and processes, and close the fume hood sash. Leave immediately when the area has been secured and can be left unattended. Contact EHS or UP if there is a possibility of an uncontrolled reaction in a process that cannot be shut down.

4.5 Incident (Accident) Reporting

All laboratory research incidents shall be reported to EHS, including spills, fires, or injuries. Laboratory incidents shall be investigated. The supervisor shall be responsible for providing a written report of investigation findings and corrective actions to EHS and ensuring that corrective actions to prevent repeat incidents are undertaken.

EHS may also prepare an investigation report, as follow-up for the incident. Investigations are made and reports written to learn the cause of the problem and what changes in procedures, equipment, or training should be made to avoid other accidents.

4.6 EHS Assistance

EHS will respond to chemical spills. However, if the spilled material is not volatile and there is no immediate fire or toxic hazard, cleanup may be done by area employees (under direction of the principal investigator/supervisor or EHS). In situations involving a fire or toxic hazard, EHS will advise on evacuation or other precautions to protect persons or property in the immediate area.

4.7 Personal Injury

4.7.1 Burn

If your clothing catches fire, decide very quickly how to put out the fire and minimize burns. The following methods are in order of preference:

1. Get under a safety shower or other water source if one is **immediately** at hand.
2. If a safety shower is not immediately available, stop, drop, and roll to extinguish the fire, holding your hands over your face to shield your face and eyes.

Assess the condition of the skin's burn area. If skin is not broken, run water over the burn area to remove heat. If skin is broken, apply a dry, sterile dressing over the wound. Seek medical attention as soon as possible.

4.7.2 Inhalation

Call 911 to solicit trained emergency medical personnel in the event of an emergency. A person exposed to smoke or fumes shall be removed to uncontaminated air. Any victim overcome by smoke or fumes shall be treated for shock. Give cardiopulmonary resuscitation (CPR) if necessary

and if trained personnel are available. If a person needs to be rescued from a contaminated area, evaluate the possibility of harm to the rescuer before anyone enters or remains in the contaminated area without proper protective equipment.

The SDS should accompany the victim to the medical treatment facility.

4.7.3 Ingestion

If a person ingests a toxic chemical, determine, if possible, what was ingested and notify the emergency medical personnel by calling 911.

The SDS should accompany the victim to the medical treatment facility.

4.7.4 Puncture or Cut

When treating a victim with a puncture wound or cut, wear personal protective equipment (e.g., gloves) to minimize exposure to human blood, body fluids, or other chemical or biological contamination. Apply a pressure pad or clean cloth firmly to the wound. Raise the wounded area above the level of the heart to slow the bleeding. For severe bleeding or spurting, very firmly press the pressure pad directly on the wound and apply pressure at the applicable body pressure point above the wound to stop the flow of blood. In a severe injury, keep the victim warm, calm, and oriented to prevent shock. Seek medical attention as soon as possible.

4.7.5 Needlestick

Needlesticks or other accidents involving skin punctures by a chemical or biological agent shall be reported to the supervisor immediately and EHS as soon as possible. Appropriate medical testing, treatment, and follow-up may be indicated and shall be provided as appropriate. When a needlestick occurs, do **not** wait to report the incident and obtain medical attention. See Section 7.0 for more information on needlestick exposures to human blood and other potentially infectious human materials.

FIG. 4.1 MEDICAL EMERGENCY PROCEDURES

In the event you are injured or exposed to a hazardous substance, follow these procedures to obtain medical care and establish any Workers' Compensation benefits to which you may be entitled. All work-related injuries and illnesses must be reported to your supervisor.

Medical services are provided to Penn State University employees at Occupational Medicine, (814) 863-8492, and Mount Nittany Medical Center, (814) 234-6110.

PROCEDURES

- I. Ambulatory victims (able to walk)
 - A. Inform your supervisor or designated departmental employee of your injury or illness.
 - B. Proceed to Occupational Medicine or Mount Nittany Medical Center to secure treatment.

- II. Nonambulatory victims (unconscious or unable to walk)
 - A. Call 911.
 - B. Report the injury, victim's name, and location (building, floor).
 - C. Ask for an ambulance.

FIG. 4.2 MEDICAL EMERGENCY PROCEDURES, STUDENTS

Students in need of emergency medical assistance should call 911.

For other, less severe medical emergencies, call University Health Services, 863-0774 or local health care panel provider.

Extreme caution should be taken when determining whether to transport an injured employee to medical care in your personal vehicle. It is better to call for an ambulance if there is any chance complications could arise during transport.

5.0 GENERAL SAFETY

Working safely requires having the proper containment equipment and engineering controls, wearing appropriate personal protective equipment, using proper work practices, knowing safety information for the materials and equipment used, and following safety instructions and protocols.

The general safety information in this section is provided to assist investigators and supervisors in planning work and guiding those carrying out procedures.

Because each laboratory or research area is unique, judgment is required in interpreting general concepts for individual settings. The Unit Specific Plan provides specific information for individual areas. If you have questions or concerns about implementing general safety concepts or specific safety procedures, consult your supervisor or EHS.

Some areas contain more than one type or category of hazardous material. For example, biochemistry laboratories may work with chemicals, biological agents, and radioactive materials. In such cases, the protective equipment and work practices to be used are those that provide protection against all the hazardous agents.

The [Laboratory Safety Self Inspection form](#) provides a useful tool for evaluating your laboratory. This form must be completed in January and a copy placed in your [Waste Management Logbook](#). This same form can be used for peer inspections of laboratories.

5.1 Personal Hygiene

Personal hygiene is extremely important to persons working in a laboratory. Contamination of food, beverages, or smoking materials is a potential route of exposure to toxic chemicals or biological agents through ingestion.

Laboratory personnel shall not prepare, store, or consume food or beverages; pipette by mouth; smoke; apply lip balm or cosmetics; or handle contact lenses in the work area. This familiar elementary safety rule shall be followed by everyone working in or visiting a laboratory.

Handwashing is a primary safeguard against inadvertent exposure to toxic chemicals or biological agents. Always wash your hands before leaving the laboratory, even though you use gloves. Wash your hands after removing soiled protective clothing, before leaving the laboratory, and before eating, drinking, smoking, or using a rest room.

Wash your hands periodically during the day at intervals dictated by the nature of your work. Wash with soap and running water, with hands held downward to flush the contamination off the hands. Turn the tap off with a clean paper towel to prevent recontamination, and dry your hands with clean towels.

Confine long hair and loose clothing when in the laboratory to keep them from catching fire, dipping into chemicals, or becoming entangled in moving machinery. Avoid wearing finger rings and wrist-watches which may become contaminated, react with chemicals, or be caught in the moving parts of equipment.

Remove laboratory coats and gloves before you leave the laboratory to prevent spreading contamination to other areas. Never wear contaminated or potentially contaminated gloves outside the laboratory. Change gloves often and whenever contaminated.

5.2 Personal Protective Clothing and Equipment

Personal protective clothing and equipment protects you from injury due to absorbing, inhaling, or coming into physical contact with hazardous materials. Some protection is afforded by ordinary clothing and eyeglasses. You have a responsibility to dress sensibly for laboratory work. Laboratory clothing protects workers' own clothing. You are responsible for using special protective clothing and equipment when they are required for safety. Protective wear may include laboratory coats, wraparound gowns, cloth masks, coveralls, aprons, gloves, shoe covers, and respirators. Select garments and fabric based on the nature of the hazardous agent.

Personal protective clothing and equipment shall be used and maintained in a sanitary and reliable condition and shall be cleaned regularly to avoid spreading contamination.

Laboratory coats shall never be washed at home. Regular clothing that is suspected of being contaminated shall be evaluated by EHS for a proper decontamination or disposal method. It shall not be washed with or come into contact with other personal laundry.

There are special precautions to be taken for clothing used during pesticide applications. Please see the Penn State University Pesticide Management Program Manual for further instructions.

5.2.1 Clothing

Cover unprotected skin whenever possible. Suitable clothing shall be worn in the laboratory; shorts are not appropriate. Clothing may absorb liquid spills that would otherwise come in contact with your skin. Long sleeves protect arms and shall fit snugly, especially when you are working around machinery. Wool affords more protection from flash burns or corrosive chemicals than cotton or synthetic fabrics. Synthetic fabrics may increase the severity of injury in case of fire. Cotton is less prone to static electricity buildup than nylon or other synthetics.

Wear substantial shoes in the laboratory or research area to protect against chemical splashes or broken glass. Do not wear sandals, cloth sport shoes, perforated shoes, or open-toe shoes. If you clean up a spill from the floor, you may need the added protection of rubber boots or plastic shoe covers. Steel-toe shoes are required for handling heavy items, such as gas cylinders or heavy equipment components.

Aprons, laboratory coats, gloves, and other protective clothing, preferably made of chemically inert material shall be readily available and used. Laboratory coats are essential to protect

street clothing from biological agent aerosols or chemical splashes and spills, vapors, or dusts. For work involving carcinogens, disposable coats may be preferred. For work with mineral acids, acid resistant protective wear is desirable. See Table 5.1 for properties of protective clothing materials.

TABLE 5.1 PROPERTIES OF PROTECTIVE CLOTHING MATERIALS *

| PROPERTIES | | | | | | |
|---------------|---|--|---|---|---|----------------------------------|
| MATERIAL | STRENGTH | CHEMICAL RESISTANCE | FLAMMABILITY | STATIC PROPERTIES | COMFORT | USES |
| Cotton | Fair durability | Degraded by acids; binds | Special treatment for flame | No static problems | Comfortable, lightweight | Lab coats |
| Modacrylic | Resistant to rips and tears but less so than polyamide fibers; abrasion-resistant but less so than nylon or polyester | Resistant to most chemicals | In direct flame, fabric shrinks to resist flame penetration; will not melt or drip; self-extinguishing; rapidly dissipates when source of ignition is removed | Has antistatic properties | Comfortable, soft, and resilient; easy to clean; has soil release properties | Lab coats |
| Nylon | Exceptionally strong and abrasion resistant | Not water absorbent | Melts when heated; requires flame retardant | Static buildup possible; requires antistatic agent. | Lightweight | Lab coats |
| Plastic | Usually reinforced at points of strain; will not stick together, peel, crack, or stiffen | Resistant to corrosive chemicals | Can be ignited by flammable solvents and others in event of static discharge | Accumulates considerable charge of static electricity | Lightweight | Aprons, sleeve protectors, boots |
| Polyolefin | Resistant to rips and tears | Excellent chemical resistance; low binding for chemicals | High melting point; flame-resistant | Good static dissociation | Lightweight; good permeability; limited moisture absorbency; wearer perspiration may cause discomfort | Bouffant caps |
| Polypropylene | Strong | Resistant to most chemicals; oxygen and light-sensitive | Low melting point; requires flame retardant | Static buildup requires antistatic agent | Lightweight | Aprons |
| Rayon | Fairly durable | Degraded by acids; binds some chemicals. | | | | Lab coats |

*Based on manufacturer's claims

From Chemical Safety Manual for Small Businesses, American Chemical Society, second edition, 1992.

5.2.2 Eye Protection

Eye protection that meets ANSIZ87.1 requirements is mandatory in laboratories where there is risk of flying objects, splashing chemicals, and corrosive vapors. Eyes are very vascular and can quickly absorb many chemicals. Eye protection is not interchangeable among employees and shall be provided for each individual unless disinfected after use.

Safety glasses with clear side shields are adequate protection for general laboratory use. **Goggles** shall be worn when there is danger of splashing chemicals or flying particles, such as when chemicals are poured or glassware is used under elevated or reduced pressure. A **face shield** (or face shield with goggles) offers maximum protection (for example, with vacuum systems that may implode). Face shields are designed to be used in conjunction with either safety glasses or goggles.

Corrective lenses in spectacles do not in themselves provide sufficient protection. Persons whose vision requires corrective lenses, and who are required to wear eye protection, shall wear goggles over their eyeglasses, prescription safety glasses, or goggles with prescription lenses.

5.2.3 Gloves

Gloves are worn to prevent contact with toxic or biological agents, burns from hot or extremely cold surfaces or corrosives, or cuts from sharp objects. Skin contact is a source of exposure to infectious agents and toxic chemicals, including carcinogens. Many gloves are made for specific uses. For adequate protection, select the correct glove for the hazard in question.

A leather glove provides good protection for picking up broken glass, handling objects with sharp edges, and inserting glass tubing into stoppers. However, because they absorb liquid, leather gloves do not provide protection from chemicals, nor are they adequate for handling extremely hot surfaces. Gloves designed to insulate against hot surfaces and dry ice are not suitable for handling chemicals.

The chemical resistance of rubber or plastic gloves varies greatly according to the glove material and the chemical handled. ([Glove Selection Chart](#))

Chemicals can eventually permeate all glove materials. Select glove materials resistant to the chemical being used, and change gloves periodically to minimize penetration. The chemical resistance of common glove materials varies according to the glove manufacturer, as manufacturers may vary the thicknesses and formulations of materials. Call the manufacturer to verify that a particular glove material is suitable for the chemical in use.

Inspect gloves for punctures or tears before putting them on. To prevent contamination of your hands or work surfaces, wash rubber or plastic gloves thoroughly with water before removing them. Pull off disposable gloves inside out and dispose of them according to the contamination hazard. Always remove contaminated gloves **before** leaving the laboratory. Always wash your hands after handling chemicals or biological agents, before leaving the work area, and before eating, drinking, smoking, or applying cosmetics.

5.2.4 Respirators

When feasible, engineering controls shall be provided to minimize airborne hazards. If accepted engineering control measures are not available to prevent or protect against airborne contaminants, employers are required to provide respirators at no cost to employees and employees are required to wear them. EHS must evaluate area to determine hazard and appropriate controls. Respirators are considered a last resort of protection against exposure to inhalation hazards after all practicable engineering options have been exhausted.

Many kinds of respirators are available. The supervisor or principal investigator, after consultation with EHS, is responsible for selecting an appropriate respirator for protection against a given contaminant and for evaluating it in terms of the range of contaminants to which an employee is exposed during a particular procedure.

An employee or student must meet certain qualifications before being allowed to wear a respirator. The individual shall be examined by a licensed physician to determine whether he or she is in sufficiently good health to wear the respirator. A medical history of respiratory or heart disease could preclude the use of a respirator.

Annual fit testing is necessary to establish that the chosen respirator seals to the face properly to prevent inward leakage of contaminants. Respirator wearers shall receive interactive training in respirator use, limitations and care. The respirator shall be cleaned and disinfected on a regular basis and inspected before and after each use.

Respirators shall not be worn when conditions prevent a good facepiece-to-face seal, as with beard growth, sideburns, or dentures. With full-face respirators, temple bars on eyeglasses interfere with the sealing edge of the facepiece.

Persons desiring to use a respirator shall inform EHS and obtain information on the requirements. The formal written respiratory protection program for the University is available on the EHS website, www.ehs.psu.edu and respirator wearers must read this document in its entirety.

5.3 General Laboratory Protocol

All laboratory protocols shall include basic safety precautions. These include personal hygiene, work practices, and the appropriate personal protective clothing and equipment needed to protect you from exposure to chemicals or biological agents. Each situation is unique, and safety aspects shall be assessed individually as described in your laboratory's Unit Specific Plan. Some of the fundamental principles of laboratory operation are described below.

5.3.1 Housekeeping

In the laboratory and elsewhere, keeping things clean and organized helps provide a safer environment. Keep drawers and cabinet doors closed and electrical cords off the floor to avoid tripping hazards. Keep aisles clear of obstacles such as boxes, chemical containers, and other storage items that might be put there even temporarily. Avoid slipping hazards by cleaning up spilled liquids promptly and keeping the floor free of stirring rods, glass beads, stoppers, and other

such hazards. Never block or even partially block the path to an exit or to safety equipment, such as a fire extinguisher or safety shower.

Make sure that supplies and equipment on shelves provide sufficient clearance so that fire sprinkler heads operate correctly. Sprinkler heads require at least 18 inches of vertical clearance.

Broken glass and other sharp items shall be disposed of in rigid, puncture-resistant containers to protect persons collecting the waste materials; maroon barrels for broken glass disposal are located in most locations. Needles and syringes that are not contaminated may be sealed in a rigid, puncture-resistant container and placed in infectious waste barrels for disposal. When discarding empty boxes or other containers bearing hazardous materials labels, the labels shall be defaced or removed before disposal. Contaminated boxes or containers shall not be disposed of in the regular trash.

Chemical wastes and unwanted chemicals shall be disposed of promptly and not left to clutter a laboratory. The procedure is described in Section 6.0. Infectious waste management is described in Section 7.0. Additional information on disposal of human body fluids or other potentially infectious materials appears in Section 7.0.

5.3.2 Cleaning Glassware

When cleaning laboratory glassware, wear appropriate gloves that have been checked for tears or holes. Avoid accumulating too many articles in the cleanup area around the sink; space is usually limited, and piling up glassware leads to breakage. Do not clean food containers in a sink that is used for cleaning contaminated glassware.

Many fingers have been badly cut by broken glass from glassware that was intact when put into the water. Handle glassware carefully, and watch out for broken glass at the bottom of the sink. A rubber or plastic mat in the sink will help minimize breakage.

Avoid using strong cleaning agents such as nitric acid, chromic acid, sulfuric acid, strong oxidizers, or any chemical with "per" in its name (perchloric acid, ammonium persulfate, etc.). The prefix "per" signifies a state of completeness or extremity. In a chemical name, it denotes 1) a compound containing an element in its highest state of oxidation, such as perchloric acid; 2) the presence of the peroxy group (-O-O-), as in peracetic acid; or 3) exhaustive substitution or addition, as in perchloroethylene.

If you must use these substances for cleaning, you should be thoroughly familiar with their hazardous characteristics and use appropriate protective equipment. Flammable solvents such as acetone should be used in minimum quantities for cleaning and with appropriate precautions taken during their use. Acids and solvents, except those covered by the Drain Disposal Guideline, shall not be rinsed down the drain during cleaning but shall be collected for proper treatment and disposal.

5.3.3 Laboratory Animals

Federal regulations require that the Animal Care and Use Committee review and approve the use of animals in research.

Laboratory animals may be potential sources of hazardous chemical exposure from metabolic products, wastes, cage litter, and contaminated cages. The preparation of food and water containing toxic substances under investigation shall be done with all precautions ordinarily taken to protect the health and safety of personnel. Precautions in administration of toxic substances, aerosol suppression, personal protection, and waste disposal shall be taken.

5.3.4 Relocating or Closing a Laboratory

Guidelines are available from EHS website, www.ehs.psu.edu, to assist you in safely relocating laboratory chemicals or biological agents within the University.

All chemicals that will not be relocated shall be listed on a chemical pick-up request form available on the EHS website, www.ehs.psu.edu. The form shall be completed before the principal investigator relinquishes possession of the vacated laboratory. Disposition of all unwanted chemicals is the responsibility of the principal investigator. The department of record is responsible for the safe and lawful cleanup and disposition of all chemicals and biological materials that are abandoned. All biological materials shall be autoclaved or chemically disinfected and disposed of before the laboratory is vacated.

Surfaces and equipment potentially contaminated with hazardous chemicals or biological agents shall be decontaminated before the laboratory is vacated. The principal investigator/supervisor is responsible for ensuring that the equipment is properly decontaminated. Accessible surfaces (chemical fume hoods, sinks, benchtops) should be cleaned, when practical, by the principal investigator and staff. If this is not possible, an outside contractor specializing in the industrial testing and cleaning of contaminated laboratory equipment should be contacted. The principal investigator shall provide the contractor with thorough and accurate information pertaining to the past uses of the equipment.

5.3.5 Transportation of Hazardous Materials

The U.S. Department of Transportation (DOT) requires that a licensed hazardous materials transporter be employed if hazardous materials are transported on a public highway or by air or water. DOT also requires that all individuals offering a hazardous material for transport receive training. The material to be shipped shall be properly packaged in accordance with all applicable regulations, and appropriate shipping papers shall be provided, see [Hazardous Material Shipping Guidelines](#).

A personal vehicle shall not be used to transport hazardous chemicals. Biological materials shall be shipped in compliance with DOT and Centers for Disease Control and Prevention regulations. Transport of regulated plant or animal pathogens shall comply with U.S. Department of Agriculture regulations.

5.3.6 Laboratory Doors

Fire and life safety codes as well as University policy require that laboratory doors be kept closed at all times. Keeping doors closed also helps ensure that ventilation systems work properly. This is especially important in newer buildings with energy conservation systems.

5.3.7 Children in Laboratories

Laboratory areas contain many physical, chemical, biological or other potential health and safety hazards. Children are likely to have a limited understanding of these hazards, and should be kept away from areas where known hazardous conditions exist. Penn State University prohibits children under the age of 16 from entering areas where known or suspected laboratory hazards exist.

High school students that wish to work in Penn State laboratories must provide parental consent and insurance documentation to the University on the paperwork available [here](#).

5.4 General Laboratory Techniques

5.4.1 Laboratory Ventilation

Laboratories shall be provided with general ventilation adequate for employee comfort and sufficient to supply air for hoods and other local ventilation devices. Because the general air supply is not adequate for manipulating hazardous materials in the open, volatile or toxic chemicals shall be handled in a chemical fume hood or other appropriate containment device.

Laboratory ventilation shall change the air at least six times per hour, depending on the nature of the laboratory work. Except in special circumstances approved by EHS, air in laboratories shall be at a negative pressure with respect to the rest of the building. Air diffusers or grilles shall be so designed and located as to direct the air over the laboratory personnel and sweep the contaminated air away from their breathing zone. To promote uniform distribution and mixing of air in large laboratories, the supply registers shall deliver the air in all directions, at a typical velocity of 20 linear feet per minute.

Problems with general ventilation shall be reported promptly to the Office of Physical Plant (OPP). Adjustments or alterations to the general ventilation equipment of a laboratory shall be performed only under the supervision of OPP.

On occasion, OPP will issue notices of intent to perform maintenance work on the ventilation system. These notices shall be heeded and chemical fume hoods shall not be used when OPP is involved in repairing or adjusting the ventilation system. In the event that a hood in a particular laboratory is being repaired, the supervisor of the laboratory is responsible for ensuring that the OPP crew is informed of the hazards in the area. The hood shall be cleared of toxic materials and properly decontaminated before the work begins. A [Laboratory/Equipment Safety Clearance Form](#) must be completed and submitted to EHS.

5.4.2 Chemical Fume Hoods

A chemical fume hood is an important engineering control for preventing exposure to hazardous materials. In conjunction with sound laboratory techniques, a chemical fume hood serves as an effective means for capturing toxic, carcinogenic, offensive, or flammable vapors or other airborne contaminants that would otherwise enter the general laboratory atmosphere. With the sash lowered, the fume hood also forms a physical barrier to protect workers from hazards such as chemical splashes or sprays, fires, and minor explosions. Fume hoods may also provide effective containment for accidental spills of chemicals, although this is not their primary purpose. Additions, such as shelving; tampering with or changing damper settings; or any other alterations to the chemical fume hood structure may reduce their performance and is prohibited.

Hoods are not meant for storage of chemicals. Volatile and odorous chemicals and highly toxic gases shall be stored in ventilated cabinets. Storing chemical containers and equipment in a hood impairs the performance of the hood. Hoods are backup safety devices to protect against toxic vapors or dusts if an accident occurs or if the design of an experiment fails. The deliberate release and venting of chemicals (i.e., evaporation) in hoods shall **never** be used as a means of disposal.

Apparatus in hoods shall be fitted with traps, condensers, or scrubbers to remove toxic fumes, gases, vapors, or dusts before venting to the atmosphere. Hood performance is dependent on the room's air flow pattern, including air flow generated by drafts and persons walking by. Equipment in the hood should be stationed at least six inches away from the sash. This practice can reduce vapor concentrations at the hood face by about 90 percent. Sashes should be pulled down as far as workable when in use.

Hoods used for hazardous chemicals shall have an average face velocity of 80 - 100 feet per minute.

Compounds such as perchloric acid or aqua regia are likely to cause hood corrosion and only hoods designed for perchloric acid use may be used. Please refer to Section 6.0 for further information.

Hoods shall be evaluated for performance regularly by EHS. The fans and duct systems are maintained and inspected by OPP. Any problems with hood ventilation or airflow should be reported to EHS or OPP for inspection and evaluation.

5.4.3 Safety Showers

Safety showers shall be installed in all areas where employees may be exposed to splashes or spills of materials that may be injurious to the eyes and body. As a general rule, new shower installations shall adhere to the recommendations for shower location and minimum performance requirements established in American National Standard Z-358.1. Showers shall be placed as close to the hazard as possible, but in no case more than 10 seconds travel time from the hazard. Department heads shall ensure that safety showers are installed in the department where needed.

Every laboratory employee shall be instructed in the location(s) and use of a safety shower. Ideally, a person should be able to find the shower with his or her eyes closed, if the shower is within reasonable distance. Safety showers shall provide a minimum of 20 gallons of water per minute and deliver the volume at low velocity; a high-velocity shower could further damage injured tissue.

Ideally, the water temperature of the shower should be between 60° and 95° F to prevent pain or shock to a person standing under it for 10 to 15 minutes. Safety showers shall have quick-opening valves requiring manual closing so that a person does not have to hold the valve open while trying to undress or wash off. The pull handle shall be a delta bar or large ring within easy reach but not so low as to be in the way.

Access to the shower or the activating handle shall not be impeded. The floor shall be clear in a 36-inch-diameter area under the shower.

Showers shall be evaluated for performance regularly by EHS. The plumbing is maintained and inspected by OPP. Any problems with water flow or shower operation should be reported to EHS or OPP for inspection and evaluation.

5.4.4 Eyewash

New eyewash installations shall adhere to the recommendations for minimum performance requirements established in American National Standard Z-358.1. Eyewash fountains shall supply 0.4 gallons of water per minute. The two basic kinds of eyewash fountains are the fixed-base shower, much like a drinking fountain, with arm or foot-pedal operation, and the handheld-hose type, with an aerating nozzle and lever-operated valve.

The fixed-base type has the advantage of multistream, cross-flow washing that can flush the face and eyes at the same time. Faucet-mounted cross-flow eyewash fountains are also available. The hose type has the advantage of also serving as a minishower for splashes on the arms, hands, and other limited areas of the body. Contact EHS for information on the types of eyewashes available. In older laboratories where eyewashes were not originally provided, faucet-mounted models may be appropriate.

Gravity-feed eyewash devices (wall-mounted or on mobile carts) are not recommended unless they provide adequate water supply for 15 minutes of eye washing and the stored water is treated so that it does not become microbially contaminated. For such units, a documented monthly maintenance program shall be established to ensure that the water supply remains in satisfactory and usable condition. Bottle-type portable eyewashes are not acceptable, as they do not have the capacity to deliver 0.4 gallons of water per minute.

Principal investigators are responsible for ensuring that eyewash fountains are tested weekly to ensure that the valves operate properly, the required volume and aerated stream are available, and the pipes or hose are cleared of sediment that might collect. A [form](#) for recording testing information is available on the EHS website, www.ehs.psu.edu

Eyewash fountains shall be evaluated for performance regularly by EHS. The plumbing is maintained and inspected by OPP. Any problems with water flow or operation should be reported to EHS or OPP for inspection and evaluation

5.4.5 Pesticide Decontamination Supplies

Decontamination supplies are required to be located at all pesticide mixing and loading sites, at areas within ¼ mile of areas where pesticides are being applied, and at areas where applicators remove their PPE.

At the required locations, there must be sufficient water to wash the entire body in the case of an emergency, which shall be at a minimum, three gallons for each pesticide applicator that may be mixing or loading at any one time. A clean hose with running water meets this requirement. In addition, soap and single-use towels must be supplied in sufficient quantities to meet the needs of all of these applicators. There must also be clean clothes, such as one size fits all coveralls in case the pesticide applicator needs to change.

Eyeflush is also required at all pesticide mixing and loading sites and at areas within ¼ mile of areas where pesticides are being applied. However, if a pesticide label requires eye protection, the eyeflush must be immediately available. This has been defined to mean within 10 seconds reach. In order to meet this requirement for outdoor applications, a sealed pint bottle of water or saline solution is allowed. This type of eyeflush should be discarded if partially used, out of date, or if the seal has been broken. At other locations such as greenhouses and laboratories an emergency eyewash station or running water meets this requirement.

5.4.6 Laboratory Sinks and Drain Traps

Every laboratory using chemical or biological agents shall have at least one sink, preferably located near the room exit, available for handwashing. The sink shall be cleaned regularly to eliminate contamination, and soap shall be supplied for handwashing.

Drain traps in sinks, floors, and other places will dry out if they are not used regularly, allowing odors and contamination to back up into the room. Drain traps shall be kept filled with water to prevent backup. Also fill cup sinks on benches and in hoods.

5.4.7 Electrical Equipment

Electrical currents of very low amperage and voltage may result in fatal shock under certain circumstances. Voltages as low as 24 volts AC can be dangerous and present a lethal threat. Low-voltage DC circuits do not normally present a hazard to human life, although severe burns are possible. The duration of contact with a live circuit affects the degree of damage, especially with regard to burns.

All electrical switches shall be labeled, including circuit breakers in the service panels, and all laboratory personnel shall know where these controls are and how to shut off circuits or equipment in case of fire or other accident. Any electrical equipment that is not operating properly or seems to be overheating shall be turned off immediately and inspected by a qualified technician.

Electrical equipment should be inspected periodically to confirm that the cords and plugs are in safe condition. Circuit diagrams, operating instructions, descriptions of hazards, and safety devices are usually provided by the manufacturer and should be kept on file for reference.

Only three-wire grounded, double insulated, or isolated wiring and equipment shall be used in 110V-115V AC applications. All wiring and equipment shall comply with the National Electrical Code.

Electrical extension cords should be avoided where practical by installing additional electrical outlets. When they are used, the wire gauge shall be equal to or larger than the size of the cord being plugged into them. Electrical cords on equipment shall be discarded or repaired if frayed or damaged. Cords should be kept as short as practical to avoid tripping hazards and tangles.

Place electrical equipment so as to minimize the possibility that water or chemicals could spill on it or that water could condense and enter the motor or controls. In particular, place such equipment away from safety showers. In cold rooms, minimize condensation by mounting electrical equipment on walls or vertical panels.

Electrical equipment shall be de-energized and tagged or locked out according to PSU Electrical Safety Program requirements before repairs are made. If adjustments or other contact are to be made with energized electrical equipment, a second person shall be present. Be sure you are not on a damp surface or touching a potential grounding surface. Use insulated tools, wear appropriate flash resistant clothing, keep your hands dry, and wear safety glasses to prevent injury from sparks.

If a worker receives an electrical shock and is in contact with the energized device, use non-conducting gloves or a non-conducting device to pull or push the victim free from the current source. Help victims only if you are certain that you will not endanger your own safety. Turn off the current if possible. Call 911. If a trained person is available, start CPR if necessary. Get medical assistance at once.

5.4.8 Static Electricity

Static electricity may be generated whenever two surfaces are in contact with one another. Examples are processes such as evaporation, agitation, pumping, pouring of liquids, or grinding of solids or powders. Equipment used in these operations shall be bonded and grounded to prevent static charges from accumulating on the containers. Blanketing with inert gas may also prevent sparks in equipment where flammable vapors are present. Static electricity is increased by low absolute humidity, as is likely in cold weather. Some common potential sources of electrostatic discharges are ungrounded metal tanks and containers; metal-based clamps, nipples, or wire used with non-conducting hoses; high-pressure gas cylinders upon discharge; and clothing or containers made of plastic or synthetic materials.

5.4.9 Centrifuges

If a tabletop centrifuge is used, make certain that it is securely anchored in a location where its vibration will not cause bottles or equipment to fall. Centrifuge rotors shall be balanced each time they are used. Securely anchor and shield each unit against flying rotors. Regularly clean rotors and buckets with non-corrosive cleaning solutions.

Always close the centrifuge lid during operation, and do not leave the centrifuge until full operating speed is attained and the machine appears to be running safely without vibration. Stop the

centrifuge immediately and check the load balances if vibration occurs. Check swing-out buckets for clearance and support.

5.4.10 Vacuum Pumps

If vacuum pumps are used with volatile substances, the input line to the pump shall be fitted with a cold trap to minimize the amount of volatiles that enter the pump and dissolve in the pump oil. The exhaust from evacuation of volatile, toxic, or corrosive materials shall be vented to an air exhaust system. A scrubber or trap may also be required.

If pump oil becomes contaminated with toxic chemicals, it will exhaust the chemicals into the room air during future use. Pump oil shall be changed if it becomes contaminated. Dispose of used pump oil with EHS.

Before using the vacuum pump, ensure that the moving parts have been properly guarded and that there are no exposed points of operation (i.e., exposed belt) that could nip a finger or catch hair or clothing. Wear eye protection when working with a vacuum pump or setting up the cold trap assembly.

5.4.11 Drying Ovens and Furnaces

Volatile organics shall not be dried in ovens that vent to the room air. Glassware rinsed with organics should not be oven dried unless it is first re-rinsed with water. Non-mercury thermometers rather than mercury thermometers shall be used for measuring oven temperatures. Nothing should be stored on top of ovens. Careful attention should be used when using ovens to dry plastic pipette tips to ensure the temperature is properly maintained.

Wear heat-resistant gloves and appropriate eye protection when working at ovens or furnaces. ANSI-approved eyewear (i.e., heat-absorbing, reflective goggles) offers protection against projectiles and infrared radiation.

5.4.12 Syringes and Scalpel Blades

Syringes used with hazardous agents shall have needle-locking or equivalent tips to assure that the needles cannot separate during use. Disposal of needles and syringes contaminated with infectious agents is described in Section 7.0. **Do not recap needles after use.** Recapping of needles potentially contaminated with human blood, blood products, or other potentially infectious materials is prohibited.

Syringes, needles, or scalpels shall be disposed of immediately after use in sealable, puncture-resistant, disposable containers that are leakproof on the sides and bottom. The containers shall be appropriately labeled as to the chemical or biological hazard. These sharps containers shall be easily accessible to personnel in the immediate area of use.

5.4.13 Facility Cleaning and Maintenance

OPP janitors wet-mop floors (including laboratory space) on a weekly basis. However, building services and custodial staff are prohibited from cleaning up chemical and biological materials (including spills), and custodians shall not be expected to mop any floors that have not been properly decontaminated after a spill.

In preparation for the cleaning service, the laboratory staff shall remove hazards that the housekeeping workers might encounter during their activities. Chemical containers on the floor and all containers of biohazardous waste shall be moved by laboratory occupants to a safe and secure location before custodians enter the lab. In the event that a supervisor does not wish a particular laboratory to be disturbed, custodial floor cleaning can be suspended on request of the area occupants. To have the mopping discontinued, contact Area Services and post a sign on the lab.

Likewise, if maintenance is required on any component of the laboratory, such as a sink or piece of equipment, the same principles of preparation apply. The supervisor shall again ensure that the immediate area is decontaminated and any infectious agents or chemicals removed to another secure area prior to initiation of work. Further, the laboratory supervisor shall inform maintenance personnel of the presence of any hazardous materials to which they might become exposed. A Laboratory/Equipment Safety Clearance Form, available on the EHS website, www.ehs.psu.edu, must be completed, taped to the area and a copy sent to EHS.

Cleaning duties that are the specific responsibility of laboratory personnel shall be conducted on a regular basis to prevent accidental contact with hazards and to reduce clutter in the lab space. Laboratory equipment, including refrigerators, freezers, and work surfaces, shall be cleaned by laboratory staff. In laboratories using large amounts of powdered carcinogens, reproductive toxins, or acutely toxic materials, lab workers should avoid dry mopping or sweeping with a broom if this could cause the materials to become airborne.

Facility maintenance and custodial staff shall not handle or remove hazardous waste bags or other hazardous containers.

5.4.14 Glassware

Borosilicate glassware, such as Pyrex 7740, is the type preferred for laboratory experimentation, except in special experiments involving ultraviolet or other light sources or hydrofluoric acid, for which polypropylene containers are most appropriate. Measuring glassware, stirring rods, tubing, and reagent bottles may be ordinary soft glass. Vacuum or suction flasks shall be designed with heavy walls. Dewar flasks and large vacuum vessels shall be taped or otherwise screened or contained in metal to prevent glass from flying if they should implode. An ordinary thin-walled thermos bottle is not an acceptable replacement for a Dewar flask.

Because it can be damaged in shipping, handling, or storage, inspect glassware carefully before using it to be sure it does not have hairline cracks or chips. Even the smallest flaw renders glassware unacceptable and possibly dangerous. Flawed glassware shall be discarded in a rigid, puncture-resistant broken-glass maroon container. Where the integrity of glassware is especially important, it can be examined in polarized light for strains.

5.4.15 Assembling Apparatus

Operations that may generate airborne contaminants or that use flammable liquids or toxic, reactive, or odoriferous materials shall be conducted in a chemical fume hood or other appropriate containment enclosure. Whenever hazardous gases or fumes are likely to evolve, an appropriate trap, condenser, or scrubber shall be used to minimize release of material to the environment.

Apparatus should be set up well back from the edge of the work area, be it a bench or a hood. When assembled in a hood, apparatus should not obstruct the area. To avoid overflow, choose apparatus with at least 20 percent more capacity than would normally accommodate the volume of chemical planned for the operation. All parts of the apparatus shall be firmly balanced and supported. Tubing shall be fastened with wire or appropriate clamps.

Stirrer motors and vessels shall be positioned and secured to ensure proper alignment. Magnetic stirring is preferable, and non-sparking motors or air motors shall be used in any laboratory that might contain flammable vapors.

Funnels and other apparatus with stopcocks shall be firmly supported and oriented so that gravity will not loosen the stopcock plug. Use a retainer on the stopcock plug, and lubricate glass stopcocks. Do not lubricate Teflon stopcocks.

Include a vent in apparatus for chemicals that are to be heated, and place boiling stones in unstirred vessels. If a burner is to be used, distribute the heat with a ceramic-centered wire gauze. Insert a thermometer in heated liquids if dangerous exothermic decomposition is possible. This will provide a warning and may allow time to remove the heat and apply external cooling.

A pan under a reaction vessel or container will confine spilled liquids in the event of glass breakage.

If a hot plate is used, be sure that its temperature is less than the autoignition temperature of the chemicals likely to be released and that the temperature control device does not spark. Whenever possible, use controlled electrical heaters or steam in place of gas or alcohol burners.

5.4.16 Fire Extinguisher Policy

Fire extinguishers are provided by the University in corridors, public areas, and other locations as required by building and life safety codes. It is the responsibility of the principal investigator or the department head to ensure that appropriate fire extinguishers are purchased and installed in laboratories. Contact the Fire Safety Engineer (EHS) for assistance in selecting fire extinguishers. Fire extinguishers may be purchased through OPP. OPP will inspect and maintain all fire extinguishers, both inside and outside laboratories. When fire extinguishers are installed or moved to a new location, OPP must be contacted.

Basic fire prevention and fire safety training; and fire extinguisher [training](#) is provided by EHS.

5.4.17 Special Precautions against Ultraviolet Light

Germicidal lamps using ultraviolet light are common fixtures in biological safety cabinets, where they serve to destroy bacteria and molds. These lamps are considered a high-level source of UV

radiation; exposure to the lamps without adequate personal protection could result in skin or eye injury.

Acute skin effects due to direct UV exposure vary with dose. Dermal effects include three types: erythema (sunburn), increase in pigmentation (sun tanning), and hyperplasia (increase in epidermal cell growth, resulting in enlargement of tissue). UV radiation may also increase the cutaneous effects of certain solvents and photosensitizing chemicals.

Eye injuries attributable to UV exposure are most prevalent among welders. Laboratory applications are unlikely to achieve doses comparable to those in industrial settings, but a small amount of UV light may produce temporary eye injury, such as corneal inflammation and "sand-in-the-eye" sensation.

A great concern with UV eye exposure is that the victim is often unaware that damage is occurring. Usually, no pain develops from the eye injury until four to six hours after the exposure. The only way to prevent injury is to minimize eye exposure to UV light.

Appropriate protection against UV exposure includes long sleeves and laboratory gloves. For individuals particularly sensitive to UV light, suntan lotion on the exposed skin of the face is recommended. ANSI-approved shaded eye protection with side enclosures shall be worn in the vicinity of a UV light fixture not shielded by a physical barrier.

5.5 Signs and Labels for Laboratories

Various signs and labels are required by government regulations and University policy. The principal investigator shall obtain and post the signs and labels required for the laboratory. Most required signs and labels may be obtained from EHS. The following signs and labels are required for **all** laboratories in University facilities:

- A "Laboratory Information" sign shall be posted outside all laboratories on the outside of the door. Electronic copies are available on the EHS website, www.ehs.psu.edu ; hard copies on sticker backing are available by request through EHS. This sign includes blank areas to be filled out by laboratory personnel on information on specific hazards in the laboratory, telephone numbers of responsible faculty and staff and emergency contacts. The information provided on these signs shall be updated as necessary.
- An "Emergency and laboratory Safety phone numbers" sign shall be posted in a prominent location inside the laboratory, near the door or telephone. Electronic copies are available on the EHS website, www.ehs.psu.edu. This sign lists who to call and their telephone numbers in the event of an emergency.
- A label bearing the University Police emergency number shall be placed on each telephone in the laboratory.

5.6 Training

Training is required under the Hazard Communication Standard, for Chemical and chemical Waste handling, Bloodborne Pathogens, and various general industry standards such as the Respiratory Protection Program. University policy prohibits persons without appropriate training from working in laboratories and other areas where hazardous chemicals are used. **Federal law mandates training at the time of initial assignment to a laboratory or work area where hazardous chemicals are present or exposure to bloodborne pathogens is possible.** Additional training is required whenever a new chemical exposure hazard is introduced. Refresher training shall be conducted **annually** for persons working in areas of potential exposure to bloodborne pathogens and for persons with potential exposure to chemical hazards.

Principal investigators shall ensure that laboratory personnel are properly trained and shall certify training on the Unit Specific Plan. Bloodborne-pathogens training information may be found in Section 7.0.

A [training](http://www.ehs.psu.edu/training/training_matrix%5Cindex.html) table listing required and recommended training is available on the EHS website at http://www.ehs.psu.edu/training/training_matrix%5Cindex.html. In addition, EHS can provide general safety seminars for laboratory or department groups. EHS training is general in nature; principal investigators are required to provide specific safety training in the particular hazards of their laboratories.

5.7 Machine Shop Equipment

PSU has a machine shop safety program that is intended to prevent injuries which may occur in a shop environment. The program is oriented towards work in student and employee shops, but many of the requirements also apply to work performed using shop equipment in labs that fall under the scope of the PSU Laboratory & Research Safety Plan.

Shop equipment includes, but is not limited to, items such as belt sanders, miter saws, band saws, drill presses, lathes, milling machines, radial arm saws, table saws and routers. Labs with this type of equipment must incorporate the necessary requirements contained in the PSU Machine Shop Safety Program. The specific requirements that must be implemented and complied with include General Shop Safety Training, Equipment Specific Training, Monitoring, Room/Tool Access Control and Machine Guarding.

Refer to section 9.0 of the PSU Shop Safety Program for more information. The program can be found here: <http://www.ehs.psu.edu/occhealth/safety.cfm>

6.0 CHEMICAL HAZARDS

"What is it that is not poison? All things are poison, and nothing is without poison. It is the dose only that makes a thing not a poison."









-- Paracelsus (1493 - 1541)

6.1 Hazard Communication

The United States has adopted the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS). The GHS is a comprehensive approach to defining a chemical's hazards and communicating those hazards and protective measures to workers.

Pictograms identify health, physical and environmental hazards associated with a chemical.

GHS Pictograms and their Corresponding Chemical Hazards

| Name | Hazard | Name | Hazard |
|---|---|---|---|
|  Explosion Bomb | Explosive (Unstable, Divisions 1.1, 1.2, 1.3 and 1.4), Self Reactive (Type A and B), Organic Peroxide (Type A and B) |  Corrosive | Corrosive (Skin Corrosion Categories 1A, 1B and 1C, Eye Corrosion Category 1), Corrosive to metals. |
|  Flame | Flammable (Solids Categories 1 and 2, Liquids Categories 1, 2 and 3, Gases Category 1, Flammable Aerosols Categories 1 and 2), Self Reactive (Type B, C, D, E and F), Pyrophoric, Self-heating, Emits Flammable Gas, Organic Peroxide (Type B, C, D, and F) |  Skull | Acute toxicity (Categories 1, 2, and 3) |
|  Flame over Circle | Oxidizer |  Exclamation Mark | Irritant (Skin Irritation Category 2 and Eye Irritation Category 2A), Dermal Sensitizer (Category 1), Acute Toxicity (Category 4, harmful), Target Organ Toxicity/STOT Category 3 = narcotic effects, respiratory irritation |
|  Gas Cylinder | Gas under pressure |  Chronic Health Hazard | Carcinogen (Categories 1A, 1B, and 2), Respiratory Sensitizer (Category 1), Reproductive Toxicity (Categories 1A, 1B, and 2), Target Organ Toxicity/STOT (Categories 1 and 2), Mutagenicity (Categories 1A, 1B and 2), Aspiration Toxicity (Categories 1 and 2) |

6.1.1 Safety Data Sheets (SDSs)

SDSs are the most basic source of chemical hazard information. The SDS summarizes the chemical's properties, the health and physical hazards, including the type of toxicity information discussed in the sections below, and related safety information required by emergency responders.

PIs or supervisors shall provide staff with easy access to SDSs for each of the chemicals in use or storage in their labs. Contact EHS for help in obtaining access to SDSs.

6.1.2 Chemical Labels

Hazardous chemicals must have labels which include:

- Product identifier: name or number used for a hazardous chemical on the label or SDS.
- Signal word: a word used to indicate the relative severity of the hazard and alert the reader to a potential hazard on the label. "Danger" is used for the more severe hazards, while "warning" is used for the less severe hazards.
- Pictogram: a graphic symbol intended to convey specific information about the hazards of a chemical.
- Hazard statement: describes the nature of the hazard(s) of a chemical, including, where appropriate, the degree of hazard. Includes hazard class, which describes the nature of the physical or health hazard (e.g., flammable solid, carcinogen)

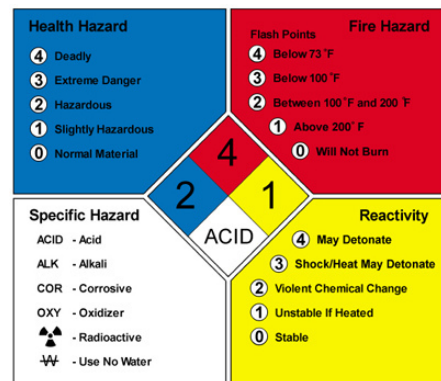
All containers of chemicals in the laboratory or research area **shall** be labeled. See Figure 6.1 for an example of a standard hazard warning labels used by manufacturers and others throughout the country.

When labeling workplace chemical bottles such as squirt bottles or working solutions, it is acceptable to use standard labels such HMIS or NFPA (see examples below). Copying the manufacturer's label and applying it to the container is also an option. However, the employees must be fully aware of the hazards of the chemicals used." *OSHA brief on Hazard*

Communication: Labels and Pictograms,

<https://www.osha.gov/Publications/OSHA3636.pdf>

| HAZARDOUS MATERIALS IDENTIFICATION SYSTEM | |
|---|---|
| HAZARD INDEX | PERSONAL PROTECTION INDEX |
| 4 = SEVERE HAZARD | A |
| 3 = SERIOUS HAZARD | B |
| 2 = MODERATE HAZARD | C |
| 1 = SLIGHT HAZARD | D |
| 0 = MINIMAL HAZARD | E |
| | F |
| | G |
| | H |
| | I |
| | J |
| | K |
| | X |
| | Consult your supervisor or S.O.P. for "SPECIAL" handling directions |
| | A B C D E F G H I J K L M N O P Q R S T U V W X Y Z |
| | Acid Alkali Corrosive Oxidizer Radioactive Use No Water |



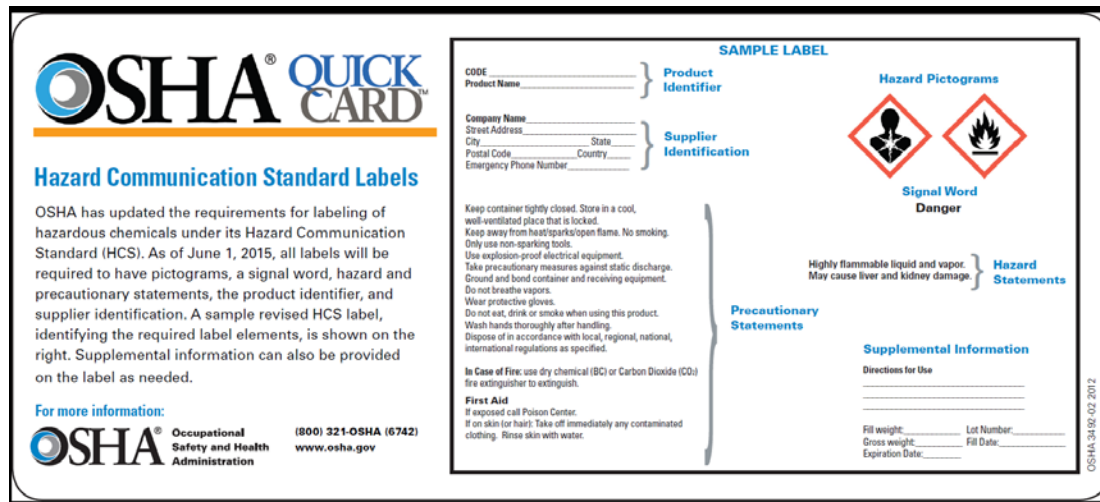
The standard recognizes the use of alternative in-plant labeling systems such as the HMIS (Hazardous Material Information System), NFPA (National Fire Protection Association), and others which may be used in industry. These systems rely on numerical and/or alphabetic codes to convey hazards and are generally non-specific. OSHA has permitted these types of in-plant labeling systems to be used when an employer's overall HCS program is proven to be effective despite the potential absence of target organ information on container labels. Under these circumstances, the employer should assure – through more intensified training – that its employees are fully aware of the hazards of the chemicals used. Additionally, employers must ensure that their training program instructs employees on how to use and understand the alternative labeling systems so that employees are aware of the effects (including target organ effects) of the hazardous chemicals to which they are potentially exposed. CSHOs should determine whether workers can recognize what hazards correspond to what code ratings/symbols. This can be achieved through employee interviews.

Employers using alternative labeling systems must ensure that their employees are aware of all information required to be conveyed under the HCS. OSHA will make a plant-specific determination of the effectiveness of the complete program when an inspection is conducted. Any employer who relies on one of these types of alternative labeling systems, instead of using labels containing complete health effects information will – in any enforcement action alleging the inadequacy of the labeling system – bear the burden of establishing that it has achieved a level of employee awareness which equals or exceeds that which would have been achieved if the employer had used labels containing complete health effects information (59 F.R. 6156).

The key to evaluating the effectiveness of any alternative labeling method is to determine whether employees can correlate the visual warning on the in-plant container with the applicable chemical and its appropriate hazard warnings. The alternative labeling system must also be readily accessible to all employees in their work area throughout each work shift. For purposes of this provision, the term “other such written materials” does not include material safety data sheets used in lieu of labels.

- See more at: <http://www.msds-online.com/blog/2013/05/nfpa-hmis-and-osha%E2%80%99s-ghs-aligned-hazard-communication-standard/#sthash.rn6xuvng.dpuf>

FIG. 6.1



6.2 Exposure to Chemicals

A thorough discussion of toxicity is beyond the scope of any single publication. Individuals who handle chemicals should supplement the information in this manual with specific details applicable to their laboratories. Safety Data Sheets and other reference materials are available electronically on the EHS website, www.ehs.psu.edu and in hard copy by request from the EHS office.

The complex relationship between a material and its biological effect in humans involves considerations of dose, duration and frequency of the exposure, route of exposure, and many other factors, including gender, allergic factors, age, previous sensitization, and lifestyle.

6.2.1 Exposure Routes

Chemicals enter the body through the following routes:

- Inhalation -- absorption through the respiratory tract by inhalation. This is probably the easiest way for chemicals to enter the body.
- Ingestion -- absorption through the digestive tract by eating or smoking with contaminated hands or in contaminated work areas. Depending on particle or droplet size, aerosols may also be ingested.
- Skin or eye contact -- absorption through the skin or eyes. Skin contact is the most common cause of the widespread occupational disease dermatitis. The eyes are very porous and can easily absorb toxic vapors that cause permanent eye damage.

- Injection -- percutaneous injection through the skin. This can occur through misuse of sharp items, especially hypodermic needles. Toxic effects can be immediate or delayed, reversible or irreversible, local or systemic.

6.2.2 Acute and Chronic Toxicity

Toxicity is the measure of a poisonous material's adverse effect on the human body or its ability to damage or interfere with the metabolism of living tissue. Generally, toxicity is divided into two types, acute and chronic. Many chemicals may cause both types of toxicity, depending on the pattern of use.

Acute toxicity is an adverse effect with symptoms of high severity coming quickly to a crisis. Acute effects are normally the result of short-term exposures and are of short duration. Examples of acutely toxic chemicals are hydrogen cyanide and ammonia.

Chronic toxicity is an adverse effect with symptoms that develop slowly over a long period of time as a result of frequent exposure. The dose during each exposure period may frequently be small enough that no effects are noticed at the time of exposure. Chronic effects are the result of long-term exposure and are of long duration. Carcinogens as well as many metals and their derivatives exhibit chronic toxicity.

Cumulative poisons are chemicals that tend to build up in the body as a result of numerous chronic exposures, leading to chronic toxicity. The effects are not seen until a critical body burden is reached. Examples of cumulative poisons are lead and mercury.

With substances in combination, such as exposure to two or more hazardous materials at the same time, the resulting effect can be greater than the combined effect of the individual substances. This is called a synergistic or potentiating effect. One example is concurrent exposure to alcohol and chlorinated solvents.

The published toxicity information for a given substance is general--human data may not be available--and the actual effects can vary greatly from one person to another. Do not underestimate the risk of toxicity. All substances of unknown toxicity should be handled as if they are toxic, with the understanding that any mixture may be more toxic than its most toxic component.

6.2.3 Carcinogenicity

A carcinogen is a chemical that causes malignant (cancerous) tumors. A list of substances NIOSH considers to be potential occupational carcinogens are listed in Table 6.1 along with recognized and suspected carcinogens identified by other agencies.

6.2.4 Reproductive Toxins

Chemicals can affect both adult male and female reproductive systems. Chemicals may also affect a developing fertilized ovum, embryo, or fetus through exposure to the mother (teratogenic effects). Reproductive hazards affect people in a number of ways, including mental disorders, loss of sexual

drive, impotence, infertility, sterility, mutagenic effects on cells, teratogenic effects on the fetus, and transplacental carcinogenesis. Consult the SDS for information on possible reproductive hazards. Table 6.2 provides a list of developmental and reproductive toxins.

6.2.5 Designated Area

Work involving selected carcinogens, reproductive toxins, and substances of high acute toxicity shall be conducted in a "designated area." This area shall be so posted, and all employees working within the area shall be informed of the hazardous substances used there. The designated area may be a chemical fume hood, a part of a laboratory, or the entire laboratory.

TABLE 6.1 [NIOSH CARCINOGEN LIST](#)

The following is a list of substances NIOSH considers to be potential occupational carcinogens.

A number of the carcinogen classifications deal with groups of substances: aniline and homologs, chromates, dinitrotoluenes, arsenic and inorganic arsenic compounds, beryllium and beryllium compounds, cadmium compounds, nickel compounds, and crystalline forms of silica. There are also substances of variable or unclear chemical makeup that are considered carcinogens, coal tar pitch volatiles, coke oven emissions, diesel exhaust and environmental tobacco smoke.

Some of the potential carcinogens listed in this index may be re-evaluated by NIOSH as new data become available and the NIOSH recommendations on these carcinogens either as to their status as a potential occupational carcinogen or as to the appropriate recommended exposure limit may change.

| |
|--|
| Acetaldehyde |
| 2-Acetylaminofluorene |
| Acrylamide |
| Acrylonitrile |
| Aldrin |
| 4-Aminodiphenyl |
| Amitrole |
| Aniline and homologs |
| o-Anisidine |
| p-Anisidine |
| Arsenic and inorganic arsenic compounds |
| Arsine |
| Asbestos |
| Asphalt fumes |
| Benzene |
| Benzidine |
| Benzidine-based dyes |
| Beryllium |
| Butadiene |
| tert-Butyl chromate; class, chromium hexavalent |
| Cadmium dust and fume |
| Captan |
| Captan |
| Carbon black (exceeding 0.1% PAHs) |
| Carbon tetrachloride |
| Chlordane |
| Chlorinated camphene |
| Chlorodiphenyl (42% chlorine); class polychlorinated biphenyls |

| |
|--|
| Chlorodiphenyl (54% chlorine); class polychlorinated biphenyls |
| Chloroform |
| Chloromethyl methyl ether |
| bis(Chloromethyl) ether |
| B-Chloroprene |
| Chromium, hexavalent [Cr(VI)] |
| Chromyl chloride; class, chromium hexavalent |
| Chrysene |
| Coal tar pitch volatiles; class, coal tar products |
| Coke oven emissions |
| DDT (dichlorodiphenyltrichloroethane) |
| Di-2-ethylhexyl phthalate (DEHP) |
| 2,4-Diaminoanisole |
| o-Dianisidine-based dyes |
| 1,2-Dibromo-3-chloropropane (DBCP) |
| Dichloroacetylene |
| p-Dichlorobenzene |
| 3,3'-Dichlorobenzidine |
| Dichloroethyl ether |
| 1,3-Dichloropropene |
| Dieldrin |
| Diesel exhaust |
| Diglycidyl ether (DGE); class, glycidyl ethers |
| 4-Dimethylaminoazobenzene |
| Dimethyl carbomoyl chloride |
| 1,1-Dimethylhydrazine; class, hydrazines |
| Dimethyl sulfate |
| Dinitrotoluene |

| |
|--|
| Dioxane |
| Environmental tobacco smoke |
| Epichlorohydrin |
| Ethyl acrylate |
| Ethylene dibromide |
| Ethylene dichloride |
| Ethylene oxide |
| Ethyleneimine |
| Ethylene thiourea |
| Formaldehyde |
| Gallium arsenide |
| Gasoline |
| Heptachlor |
| Hexachlorobutadiene |
| Hexachloroethane |
| Hexamethyl phosphoric triamide (HMPA) |
| Hydrazine |
| Kepone |
| Malonaldehyde |
| Methoxychlor |
| Methyl bromide; class, monohalomethanes |
| Methyl chloride |
| Methyl iodide; class, monohalomethanes |
| Methyl hydrazine; class, hydrazines |
| 4,4'-Methylenebis(2-chloroaniline) (MBOCA) |
| Methylene chloride |
| 4,4-Methylenedianiline (MDA) |
| a-Naphylamine |
| B-Naphylamine |
| Nickel, metal, soluble, insoluble, and inorganic; class, nickel, inorganic |
| Nickel carbonyl |
| Nickel sulfide roasting |
| 4-Nitrobiphenyl |
| p-Nitrochlorobenzene |
| 2-Nitronaphthalene |
| 2-Nitropropane |
| N-Nitrosodimethylamine |
| Pentachloroethane; class, chloroethanes |
| N-Phenyl-b-naphthylamine; class, b-naphthalene |
| Phenyl glycidyl ether; class, glycidyl ethers |
| Phenylhydrazine; class, hydrazines |

| |
|--|
| Propane Sultone |
| B-Propiolactone |
| Propylene dichloride |
| Propylene imine |
| Propylene oxide |
| Radon |
| Rosin core solder, pyrolysis products (containing formaldehyde) |
| Silica, crystalline cristobalite |
| Silica, crystalline quartz |
| Silica, crystalline tripoli |
| Silica, crystalline tridymite |
| silica, fused |
| Soapstone, total dust silicates |
| Tremolite silicates |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) (dioxin) |
| 1,1,2,2-Tetrachloroethane |
| Tetrachloroethylene |
| Titanium dioxide |
| o-Tolidine-based dyes |
| o-Tolidine |
| Toluene diisocyanate (TDI) |
| Toluene diamine (TDA) |
| o-Toluidine |
| p-Toluidine |
| 1,1,2-Trichloroethane; class, chloroethanes |
| Trichloroethylene |
| 1,2,3-Trichloropropane |
| Uranium, insoluble compounds |
| Uranium, soluble compounds |
| Vinyl bromide; class, vinyl halides |
| Vinyl chloride |
| Vinyl cyclohexene dioxide |
| Vinylidene chloride (1,1-dichloroethylene); class, vinyl halides |
| Welding fumes, total particulates |
| Wood dust |
| Zinc chromate; class, chromium hexavalent |

TABLE 6.2 Reproductive Toxins

This list was produced from the State of California Safe Drinking Water and Toxic Enforcement Act ([Proposition 65](#)) list of chemicals known to the State to cause reproductive toxicity. **Developmental toxins:**

| Chemical | CAS Number |
|--|------------|
| acetoxyhydroxamic acid | 546883 |
| all-trans retinoic acid | 302794 |
| alprazolam | 28981977 |
| amikacin sulfate | 39831555 |
| aminoglutethimide | 125848 |
| aminopterin | 54626 |
| benomyl | 17804352 |
| benzphetamine hydrochloride | 5411223 |
| bis(2-chloroethyl) nitrosourea (BNCU) (Carmustine) | 154938 |
| bromoxynil | 1689845 |
| 1,4-butanediol dimethylsulfonate (Busulfan) | 55981 |
| carbon disulfide | 75150 |
| carboplatin | 41575944 |

| | |
|---|----------|
| chenodiol | 474259 |
| chlorcyclizine hydrochloride | 1602219 |
| chlorambucil | 305033 |
| chlordecone (Kepone) | 143500 |
| 1-(2-chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU) | 13010474 |
| clomiphene citrate | 50419 |
| conjugated estrogens | |
| cyanazine | 21725462 |
| cycloheximine | 66819 |
| cyclophosphamide (anhydrous) | 50180 |
| cyclophosphamide (hydrated) | 6055192 |
| cyhexatin | 13121705 |
| cytarabine | 147944 |
| danazol | 17230885 |
| daunorubicin hydrochloride | 23541506 |
| diethylstilbestrol (DES) | 56531 |
| dinocap | 39300453 |
| dinoseb | 88857 |

| | |
|----------------------------------|----------|
| diphenylhydantoin (phenytoin) | 54410 |
| doxycycline | 564250 |
| ergotamine tartrate | 379793 |
| ethylene glycol monoethyl ether | 110805 |
| ethylene glycol monomethyl ether | 109864 |
| etoposide | 33419420 |
| etretinate | 54350480 |
| fluorouracil | 51218 |
| fluoxyesterone | 76437 |
| flutamide | 13311847 |
| halazepam | 23092173 |
| hexachlorobenzene | 118741 |
| ifosfamide | 3778732 |
| iodine-131 | 24267569 |
| isotretinoin | 4759482 |
| lead | 7439921 |
| lithium carbonate | 554132 |
| lithium citrate | 919164 |

| | |
|--------------------------------------|----------|
| medroxyprogesterone acetate | 71589 |
| megestrol acetate | 595335 |
| melphalan | 148823 |
| menotropins | 9002680 |
| mercaptopurine | 6112761 |
| mercury and mercury compounds | 7439976 |
| methacycline hydrochloride | 3963959 |
| methimazole | 60560 |
| methotrexate | 59052 |
| methotrexate sodium | 15475566 |
| methyl mercury | 593748 |
| methyltestosterone | 58184 |
| midazolam hydrochloride | 59467968 |
| misoprostol | 62015398 |
| mitroxantrone hydrochloride | 70476823 |
| nafarelin acetate | 86220420 |
| netilmicin sulfate | 56391572 |
| nitrogen mustard (merchloroethamine) | 51752 |

| | |
|--|-------------|
| nitrogen mustard hydrochloride (mechlorethamine hydrochloride) | 55867 |
| norethisterone (norethindrone) | 68224 |
| norethisterone (norethindrone)/ethinyl estradiol | 68224/57636 |
| norethisterone (norethindrone)/mestranol | 68224/72333 |
| norgestrel | 6533002 |
| oxytetracycline | 79572 |
| paramethadione | 115673 |
| penicillamine | 52675 |
| pentobarbital sodium | 57330 |
| phenacemide | 63989 |
| pipobroman | 54911 |
| plicamycin | 18378897 |
| polychlorinated biphenyls | |
| procarbazine hydrochloride | 366701 |
| propylthiouracil | 51525 |
| streptomycin sulfate | 3810740 |
| tamoxifen citrate | 54965241 |
| temazepam | 846504 |

| | |
|---|----------|
| testosterone enanthate | 315377 |
| 2,3,7,8-tetrachlorodibenzo-para-dioxin (TCDD) | 1746016 |
| tetracycline hydrochloride | 64755 |
| thalidomide | 50351 |
| thioguanine | 154427 |
| tobramycin sulfate | 49842071 |
| toluene | 108883 |
| triazolam | 28911015 |
| trilostane | 13647353 |
| trimethainone | 127480 |
| urofollitropin | 26995915 |
| valproate | 99661 |
| vinblastine sulfate | 143679 |
| vinvristine sulfate | 2068782 |
| warfarin | 81812 |

2. Female reproductive toxins:

| <i>Chemical</i> | <i>CAS Number</i> |
|------------------------------|-------------------|
| aminopterin | 54626 |
| anabolic steroids | |
| carbon disulfide | 75150 |
| cyclophosphamide (anhydrous) | 50180 |
| cyclophosphamide (hydrated) | 6055192 |
| ethylene oxide | 75218 |
| lead | 7439921 |

3. Male reproductive toxins:

| <i>Chemical</i> | <i>CAS Number</i> |
|------------------------------|-------------------|
| anabolic steroids | |
| benomyl | 178043252 |
| carbon disulfide | 75150 |
| cyclophosphamide (anhydrous) | 50180 |
| cyclophosphamide (hydrated) | 6055192 |
| 1,2-dibromo-3-chloropropane | 96128 |
| m-dinitrobenzene | 99650 |

| | |
|----------------------------------|---------|
| o-dinitrobenzene | 528290 |
| p-dinitrobenzene | 100254 |
| dinoseb | 88857 |
| ethylene glycol monoethyl ether | 110805 |
| ethylene glycol monomethyl ether | 109864 |
| lead | 7439921 |

6.2.6 Monitoring Airborne Concentrations of Contaminants

OSHA has established permissible exposure limits (PELs) for airborne concentrations of selected materials. The PEL is defined as a time-weighted average (TWA) concentration of a particular substance for a normal 8-hour workday and a 40-hour workweek, a concentration to which nearly all workers (except those with particular sensitivities) may be exposed, day after day, without adverse effect.

Corollaries to the 8-hour PEL are the short-term exposure limit (STEL) and the ceiling exposure limit. The STEL is the time-weighted average concentration of a compound to which a worker may be exposed over a period of 15 minutes without expecting symptoms of irritation, chronic or irreversible tissue damage, or narcosis. The ceiling is the concentration of a substance that should not be exceeded during any part of the working exposure. In conventional industrial hygiene practice, the ceiling limit is also assessed over 15 minutes.

As the PELs were designed to protect workers in industrial settings, it is unlikely that these limits will be exceeded during the performance of laboratory procedures. Laboratory workers do not generally handle the same quantities of hazardous materials as do manufacturing and production employees.

Nonetheless, exposure to airborne chemicals in laboratories shall not exceed PELs. If there is reason to believe that airborne concentrations may exceed PELs, contact EHS for consultation on the need for air monitoring. PELs are listed on Safety Data Sheets or are available from EHS. Please note that PELs have not been developed for all the compounds to which laboratory workers may be exposed. In all circumstances, caution shall be used in handling hazardous chemicals.

In addition to PELs, OSHA has set action levels for specific compounds, such as formaldehyde, cadmium, and lead, for which individual standards have been promulgated. OSHA has classified these compounds as potential carcinogens. Action levels are concentrations of a chemical in air at which OSHA regulations to protect workers take effect.

If monitoring of airborne concentrations reveals that levels are above the OSHA action level, then levels shall either be immediately reduced by a procedural change or equipment modification or the department head and principal investigator shall comply with the requirements of the OSHA standard for the chemical. OSHA regulations govern periodic monitoring and termination of monitoring, as well as employee notification. Medical surveillance may be a requirement.

For chemicals without regulated action levels, the general rule is that half the PEL may be considered a de facto action level. Engineering controls shall be instituted to reduce exposure to the hazardous substance in question.

6.3 Guidelines for Handling Chemicals

The chemical handling guidelines described in this document are founded on several basic principles:

- Minimize chemical exposures
- Avoid underestimating risk
- Provide adequate ventilation

Since most chemicals are hazardous to some degree, it is prudent to minimize exposure to chemicals as a general rule, rather than implementing safety protocols only for specific compounds. Avoid skin contact with chemicals as much as possible. Assume that mixtures are more toxic than their components and that **all** substances of unknown toxicity are toxic. Do not work with a volatile or aerosolizing material without adequate ventilation from chemical fume hoods or other protective devices. Remember: Prepare yourself, then protect yourself.

6.3.1 General Guidelines

The guidelines in Figure 6.1 are applicable to nearly all uses of chemicals in laboratories. They apply to most hazardous chemicals, such as acids, bases, and flammable liquids. They are also applicable to chemicals that display low carcinogenic potency in animals and are not considered carcinogens.

The general guidelines are not, by themselves, adequate for chemicals with high acute toxicity or high chronic toxicity such as heavy metals, chemical carcinogens, or reproductive toxins.

FIG. 6.2 GENERAL GUIDELINES FOR CHEMICAL HANDLING

- Wear gloves selected on the basis of the hazard. Inspect them before use. Wash reusable gloves before removal. Turn disposable gloves inside out carefully to avoid contaminating hands.
- Always wash hands, and possibly arms and face, before leaving the laboratory, eating, smoking, drinking, chewing gum, applying lip balm or cosmetics, or handling contact lenses.
- Do not store or prepare food, eat, drink, chew gum, apply lip balm or cosmetics, or handle contact lenses in areas where hazardous chemicals are present.
- Wear eye protection at all times where chemicals are used or stored.
- Never pipette or start a siphon by mouth.
- Never smell or taste chemicals.
- Vent into local exhaust devices any apparatus that may discharge toxic vapors, fumes, mists, dusts, or gases. Never release toxic chemicals into cold rooms or warm rooms that have recirculating atmospheres.
- Use chemical fume hoods or other engineering controls to minimize exposure to airborne contaminants. Use a respirator **only** if engineering controls are not adequate.
- Keep work areas clean and uncluttered.
- Label all chemical containers.
- Obtain an SDS for each chemical, and consult the SDS before you use a chemical.
- Confine long hair and loose clothing.
- Wear sturdy shoes that cover feet completely.
- Wear a laboratory coat or other protective clothing. Remove protective clothing immediately if it becomes significantly contaminated.
- Know the emergency procedures for the building, the department, and the chemicals being used.
- Keep personal belongings away from chemicals

6.3.2 Guidelines for Working with Chemicals of Acute Toxicity

Chemicals of acute toxicity are defined by OSHA as those that cause rapid effects as a result of a short-term exposure--generally sudden and severe, as in the case of a leak from equipment. Acute toxic effects include irritation, corrosion, sensitization, and narcosis.

To illustrate, hydrofluoric acid is a chemical of high acute toxicity because of its destructive effect on skin and bone tissue. Arsine and other hydrides may be lethal at low concentrations because of red blood cell hemolysis. Inhalation of high concentrations of carbon monoxide can cause immediate poisoning and death, as the gas directly interferes with oxygen transport in the body by preferentially binding with hemoglobin. Hydrogen cyanide inhalation inhibits enzyme systems vital to cellular uptake of oxygen.

When working with significant quantities of such chemicals, the aim is to minimize exposure to the material in use and to minimize the effects of exposure. Special care should be taken in the selection of protective clothing to ensure it is appropriate for the hazard. Personal hygiene and work practices should also be carefully evaluated to minimize exposure. The following guidelines should be practiced **in addition** to the general guidelines for handling chemicals.

FIG. 6.3 GUIDELINES FOR HANDLING ACUTELY TOXIC CHEMICALS

- Wear lab coat, gloves, and appropriate eyewear.
- When performing procedures that may result in the release of airborne contaminants, use a chemical fume hood with adequate draw or other protective ventilation devices, such as snorkels or hard-piped cabinet or equipment-exhaust ventilation.
- Trap or treat effluents to remove gases, fumes, vapors, and particulates before discharging them to facility exhaust.
- Restrict access to the laboratory or work area.
- Establish and label a "designated area" for work with acutely toxic chemicals. Keep materials within the designated area.
- Use plastic-backed paper or trays under work areas. Replace the paper when contaminated.
- Develop and know special emergency procedures. Keep emergency supplies at hand for immediate use.
- Store and dispose of chemical wastes safely.

6.3.3 Guidelines for Working with Pesticides

In addition to the general guidelines for working with chemicals, the following are specific to pesticide use.

FIG. 6.4 Guidelines for Working with Pesticides

- Pesticide applications must be made at licensed facilities by certified applicators. For the rare exceptions to this requirement, please contact EHS.
- Properly store pesticides. Liquid pesticides are required to have secondary containment. The storage of pesticides should be kept to a minimum. Pesticide storage area must be posted with this warning sign:



- Provide a spill kit, fire extinguisher, and first aid kit near all pesticide storage facilities.
- Provide all label required PPE for all of the pesticides within the storage area. Keep this PPE separate from the pesticides.
- Provide decontamination supplies (See Section 5.4.5)
- The label is the law!
- Ensure notification of hypersensitive persons within 500 feet of the application site.
- Use Integrated Pest Management (IPM).
- Transport of pesticides requires that the vehicle be posted with the business license number.
- Ensure that Worker Protection Standards are followed for applications used in the production of agricultural plants on farms, forests, nurseries, and greenhouses. Agricultural plants include those grown or maintained for commercial or research purposes.
 - Training of workers/handlers every 5 years
 - Central posting location (worker safety poster, application records, emergency information)
 - Restricted entry intervals (REIs) followed
 - Post pesticide applications



6.3.4 Guidelines for Chemicals with High Chronic Toxicity, Carcinogens, and Reproductive Toxins

In addition to the general guidelines for handling chemicals, use the following guidelines for handling chemicals with high chronic toxicity, which include most heavy metals, chemicals displaying moderate to high carcinogenic potency in animals, and reproductive toxins.

FIG. 6.5 **GUIDELINES FOR HANDLING CHEMICALS WITH HIGH CHRONIC TOXICITY, CARCINOGENS, AND REPRODUCTIVE TOXINS**

- * Wear laboratory coats and have them cleaned frequently. Laboratory coats shall be removed before leaving the laboratory; they shall not be worn outside the laboratory in hallways, offices, conference rooms, or eating areas. The principal investigator shall decide whether impermeable aprons or disposable laboratory coats are required.
- * Select protective glove material on the basis of the chemical being handled. Remove gloves before leaving the work area. Turn disposable gloves inside out when removing them. Wash reusable gloves before removing them.
- * Wash hands and arms immediately after working with toxic materials or carcinogens, even though you wore gloves.
- * Cover laboratory surfaces, including hood surfaces, with plastic-backed paper or protective trays. Inspect work surfaces following procedures, and remove the paper if contamination is present.
- * Perform transfers of toxic or carcinogenic substances in a controlled area, such as a hood. Weigh materials on a balance only in closed containers. Procedures generating either solid or liquid airborne contaminants or involving volatile chemicals are always to be performed in a hood.
- * Transport highly toxic or carcinogenic materials through public areas, such as hallways, in closed containers within unbreakable outer containers. Sealed plastic bags may be used as secondary containment in many cases.
- * Eating, drinking, smoking, gum or tobacco chewing, application of lip balm or cosmetics, handling of contact lenses, and food storage in laboratories shall be prohibited.
- * Cupboards, cabinets, hoods, and refrigerators used to store or handle carcinogens shall be labeled "Chemical Carcinogen." If they are used for chemicals with high chronic toxicity or reproductive toxins, they shall be labeled "Toxic Chemical" or "Toxic Substance."

Continued on next page.

FIG. 6.5 **GUIDELINES FOR HANDLING CHEMICALS WITH HIGH CHRONIC
(CONTD.)** **TOXICITY, CARCINOGENS, AND REPRODUCTIVE TOXINS**

- * Access to areas where carcinogens or chemicals with high chronic toxicity are used shall be restricted, and entry doors shall be kept closed. Doors shall be labeled "Cancer-Suspect Agent: Authorized Personnel Only" or "Toxic Chemical (or Toxic Substance): Authorized Personnel Only."
- * Establish a designated area within the laboratory for use of the materials. Label the area. Materials shall be kept within the designated area to the extent possible.
- * To avoid potential inhalation hazards, handle powdered carcinogens and toxins in a hood, even during weighing procedures. Inside the hood, measure the powder with a spatula into a preweighed vessel. Then seal or cover the vessel, remove it from the hood, and take it to the balance to be weighed. If more or less material is needed, return the container to the hood for addition or subtraction of material. Close the container again and reweigh it. Repeat these steps until the desired amount is obtained. This procedure eliminates contamination of the air, the work bench, and the scale.
- * In the event that a worker is exposed to a known chemical, the worker shall follow general or chemical-specific first aid procedures for chemical spills. Wash the affected area or take a shower as soon as possible and notify EHS. See the emergency information in this section.
- * Vacuum pumps shall be protected against contamination (e.g., traps and filters in lines) and vented into direct exhaust ventilation. Pumps and other equipment and glassware shall be decontaminated before they are removed from the designated area. The designated area shall be decontaminated before other normal work is conducted. Vacuum pump oil shall be collected as a contaminated waste and disposed of through EHS.
- * Water vacuum lines shall be equipped with traps to prevent vapors from entering the wastewater stream.
- * Floors shall be wet-mopped or cleaned with a high-efficiency particulate air filter (HEPA) vacuum cleaner if powdered materials are used.
- * Wastes, potentially contaminated gloves and other protective equipment, glassware, and equipment used with material of high chronic toxicity shall be kept within the designated area to the extent possible. Decontaminate materials and equipment to the extent possible before moving them out of the designated area.

6.4 Chemical Emergency Procedures

FIG. 6.6 PROCEDURE FOR SPILLS OF VOLATILE, TOXIC, OR FLAMMABLE MATERIALS

- * Warn all persons nearby.
- * Turn off any ignition sources such as burners, motors, and other spark-producing equipment.
- * Leave the room and close the door if possible.
- * Call EHS and UP and go to a safe location to wait for help.

Small spills can be absorbed with paper towels or other absorbents. However, these materials can increase the surface area and evaporation rate, increasing the potential fire hazard if the material is flammable and airborne concentration reaches the flammability level.

FIG. 6.7 PROCEDURE FOR CHEMICAL SPILL ON A PERSON

- * Be prepared. Keep appropriate spill-containment material on hand for emergencies. Consult with EHS to determine which materials are suitable in a particular lab.
- * Know where the nearest eyewash and safety shower are located.
- * For small spills on the skin, flush immediately under running water for at least 15 minutes, removing any jewelry that might contain residue. If there is no sign of a burn, wash the area with soap under warm running water.

If pain returns after the 15-minute flooding, resume flooding the area. When providing assistance to a victim of chemical contamination, use appropriate personal protective equipment.

- * For a chemical splash in the eyes, immediately flush the eyes under running potable water for 15 minutes, holding the eyes open and rotating the eyeballs. This is preferably done at an eyewash fountain with tepid water and properly controlled flow. Hold the eyelids open and move the eye up, down, and sideways to ensure complete coverage. If no eyewash fountain is available, put the victim on his or her back and gently pour water into the eyes for 15 minutes or until medical personnel arrive.
- * For spills on clothing, immediately remove contaminated clothing, including shoes and jewelry, while standing under running water or the safety shower. When removing shirts or pullover sweaters, be careful not to contaminate the eyes. Cutting off such clothing will help prevent spreading the contamination. To prepare for emergencies, shears (rounded-tip scissors) should be available in the first aid kit to allow safe cutting of contaminated clothing.
- * Consult the SDS to see if any delayed effects should be expected, and keep the SDS with the victim. Have the victim taken to the emergency room for medical attention. Be sure to inform emergency personnel of the decontamination procedures used prior to their arrival (for example, washing for 15 minutes with water). Be certain that emergency room personnel are told exactly what the victim was contaminated with so they can treat the victim accordingly.

FIG. 6.8 PROCEDURE FOR CRYOGENIC LIQUID SPILL ON A PERSON

Contact with cryogenic liquids may cause crystals to form in tissues under the spill area, either superficially or more deeply in the fluids and underlying soft tissues. The first aid procedure for contact with cryogenic liquids is identical to that for frostbite. Rewarm the affected area as quickly as possible by immersing it in warm, but not hot, water (between 102° and 105° F). Do not rub the affected tissues. Do not apply heat lamps or hot water and do not break blisters. Cover the affected area with a sterile covering and seek assistance as you would for burns.

FIG. 6.9 PROCEDURE FOR SMALL, LOW-TOXICITY CHEMICAL SPILLS*

- * Alert persons in the area that a spill has occurred.
 - * Evaluate the toxicity, flammability, and other hazardous properties of the chemical as well as the size and location of the spill (for example, chemical fume hood or elevator) to determine whether evacuation or additional assistance is necessary. For large or toxic spills beyond your ability to control, call 911.
 - * Contain any volatile material within a room by keeping doors closed. Increase exhaust efficiency by minimizing sash height of chemical fume hood.
 - * Consult your SDS or procedures in this document, or call EHS for correct cleaning procedures.
 - * Wear protective equipment such as goggles, apron, laboratory coat, or gloves. Base the selection of the equipment on the hazard.
 - * Absorb liquid spills using paper towels, spill pillows, vermiculite, or sand. Place the spill pillow over the spill and draw the free liquid into the pillow. Sprinkle vermiculite or sand over the surface of the free liquid.
 - * Place the used pillows or absorbent materials in plastic bags for disposal along with contaminated disposable gear, such as gloves.
 - * Neutralize spills of corrosives and absorb, if appropriate. Sweep up waste and place in plastic bags for disposal.
 - * Complete a Chemical Request Form on the EHS website, www.ehs.psu.edu. EHS will pick up the wastes.
 - * Complete an incident investigation to determine cause and preventive measures for reoccurrence.
- * Information for specific chemicals may be found in Table 6.3, "Quick Reference for Spill Cleanups," and Fig. 6.8, "Mercury Spill Procedure." Consult the SDS and your laboratory's Unit Specific Plan, which has specific information on spill procedures for your workplace.

TABLE 6.3 QUICK REFERENCE FOR SPILL CLEANUPS

| <u>CHEMICAL SPILLED</u> | <u>CLEANUP</u> |
|--|---|
| Acids, organic | Apply sodium bicarbonate. Absorb with spill pillow or vermiculite. |
| Acids, inorganic | Apply sodium bicarbonate/calcium oxide or sodium carbonate/calcium oxide. Absorb with spill pillow or vermiculite. Note: Hydrofluoric acid is an exception to this general practice; see below. |
| Acid chlorides | Do not use water. Absorb with sand or sodium bicarbonate. |
| Aldehydes | Absorb with spill pillow or vermiculite. |
| Aliphatic amines | Apply sodium bisulfite. Absorb with spill pillow or vermiculite. |
| Aromatic amines | Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation. |
| Aromatic halogenated amines | Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation. |
| Azides (potential explosives) | Absorb with spill pillow or vermiculite. Decontaminate with 10% ceric ammonium nitrate solution. |
| Bases (caustic alkalis) | Neutralize with acid or commercial chemical neutralizers and absorb with spill pillow or vermiculite. |
| Carbon disulfide (flammable and toxic) | Absorb with spill pillow or vermiculite. |
| Chlorohydrins | Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation. |
| Cyanides | Wet or mist solids before sweeping, or use a HEPA filter vacuum to collect the solids. Absorb liquids with spill pillow or vermiculite. |
| Halides, organic or inorganic | Apply sodium bicarbonate. |
| Halogenated hydrocarbons | Absorb with spill pillow or vermiculite. |
| Hydrazine | Absorb with spill pillow or vermiculite. Avoid organic matter. |

| | |
|--|--|
| Hydrofluoric acid | Absorb with calcium carbonate (or calcium oxide) rather than sodium bicarbonate. The use of sodium bicarbonate will lead to the formation of sodium fluoride, which is considerably more toxic than calcium fluoride. Be careful in the choice of spill pillows used to absorb the acid. Certain pillows contain silicates that are incompatible with hydrofluoric acid. |
| Inorganic salt solutions | Apply soda ash. |
| Mercaptans/organic sulfides | Neutralize with calcium hypochlorite solution. Absorb with spill pillow or vermiculite. |
| Nitriles | Sweep up solids. Absorb liquids with spill pillow or vermiculite. |
| Nitro compounds, organic nitros | Absorb with spill pillow or vermiculite. Avoid skin contact or inhalation. |
| Oxidizing agents | Apply sodium bisulfite. |
| Peroxides (react violently with water) | Absorb with spill pillow or vermiculite. |
| Phosphates, organic and related | Absorb with spill pillow or vermiculite. |
| Reducing substance | Apply soda ash or sodium bicarbonate. |

Reference: Reagent Chemicals, MCB Manufacturing Chemists, Inc., 1981, pp. 359-402.

FIG. 6.10: MERCURY SPILL PROCEDURE

Mercury is a high-density, low-viscosity liquid at room temperature. During a spill, it can form tiny droplets that adhere to surfaces and enter cracks and crevices. EHS has a mercury-vacuum and mercury-vapor analyzer to clean up mercury spills. In the event of a spill, contact EHS immediately.

To minimize the spill hazard, place a splash plate beneath all mercury-containing equipment.

6.5 Medical Surveillance

6.5.1 When is Medical Surveillance Required?

Signs and Symptoms. Whenever an employee or student develops signs or symptoms associated with a hazardous chemical exposure, that person shall be provided an opportunity to receive an appropriate medical examination.

Exposure Monitoring. If exposure monitoring reveals that the airborne concentration of a chemical is above the action level or the permissible exposure limit (if no action level is set) for a chemical regulated by OSHA, medical surveillance shall be implemented for affected persons as prescribed in the OSHA standard for the material.

Spills, Leaks, and Other Releases. If a spill, leak, explosion, or other occurrence results in the likelihood of a hazardous chemical exposure, affected employees shall be provided an opportunity for a medical consultation. The consultation will determine whether there is a need for a medical examination.

6.5.2 Medical Consultation and Evaluation

Medical consultation and evaluation shall be performed under the direct supervision of a licensed physician without cost to the employee or student, without loss of pay, and at a reasonable time and place. For employees, medical examinations or surveillance shall be provided through the Workers' Compensation Program. For students, the medical program shall be administered through the University's Health Service facilities.

The department head shall ensure that the following information is provided to the physician: the identity of the chemical involved in the exposure, a description of conditions relating to the exposure, any quantitative data available regarding the exposure, and a description of signs and symptoms experienced by the affected person.

The employee shall ensure that the following information is obtained from the physician in writing:

- * Recommendation for medical follow-up
- * Results of the medical examination and associated tests
- * Any medical condition revealed in the course of the examination that may place the affected person at increased risk as a result of the exposure
- * A statement that the physician has informed the affected person of the results of the consultation or examination and any medical condition that may require further treatment

The physician shall not reveal specific findings or diagnoses unrelated to the chemical exposure. All medical records shall be kept as part of an employee's or student's permanent file.

6.5.3 Medical Surveillance for Chemicals of High Chronic Toxicity

Routine medical surveillance may be warranted for individuals working with chemicals of high chronic toxicity, including carcinogens.

Although no restriction of hiring can be made, candidates for work with carcinogens shall be informed of the possibility of increased risk associated with these conditions:

- * Strong family history of cancer, comprising at least two first-generation relatives from maternal and paternal ancestry or a specific pattern of cancer incidence that can be recognized as a genetic trait
- * A precancerous condition or past history of cancer
- * A history of treatment with cytotoxic drugs
- * A history of impaired immunity or current use of therapeutic doses of steroids or other immunosuppressive drugs
- * Concurrent pregnancy or likelihood of pregnancy during employment

Job tasks for certain workers using chemicals of high chronic toxicity should be evaluated to determine whether these workers should be temporarily excluded from work or reassigned to less hazardous activities. This is particularly appropriate for pregnant women or persons receiving immunosuppressive drugs or therapy.

6.6 Chemical Storage

6.6.1 Chemical Dating

Chemicals shall be dated on receipt in the laboratory and on opening. This information provides a history of the chemicals in each container and guides future researchers as to potential quality of the chemicals stored in the laboratory. Providing container-opening dates is especially important for peroxide-forming chemicals such as ethers, dioxane, and tetrahydrofuran that could pose an explosion hazard. Solutions shall be labeled and dated when prepared. Chemicals shall be disposed of through EHS if they are past their expiration date.

6.6.2 Chemical Compatibility

Fisher Scientific provides excellent and easy-to-implement guidance on chemical storage, http://www.fishersci.com/ecom/servlet/cmstatic?storeId=10652&href=Scientific/researchAnalytical/ProductsServices/Chemicals/Stockroom/storage_guidelines.jsp&store=Scientific

Chemicals shall be stored only with other compatible chemicals. Do not store them alphabetically, except within a grouping of compatible chemicals. Chemical groupings are listed below, and their storage arrangement is shown in a schematic diagram of a laboratory in Figure 6.10.

- * Highly toxic (poisons) and habit-forming organic chemicals
- * Flammable organic chemicals and organic acids
- * Organic bases and other organic compounds
- * Inorganic (mineral) acids and inorganic oxidizers (some additional separation may be required because of the reactivity of these materials)
- * Inorganic bases, reducers, and salts

Take into account specific chemical incompatibilities in all storage of chemicals. For example, nitric and chromic acids are incompatible and shall not be stored together. Nitric acid and organic compounds together present a dangerous fire risk. Carcinogenic chemicals are to be stored with others of a similar grouping based on their properties.

TABLE 6.4 INCOMPATIBLE MATERIALS: GENERAL CATEGORIES

In general, chemicals or wastes in Column A are incompatible with those in Column B.

| Column A | Column B |
|--|--|
| Acids Oxidizing agents: Chlorates Chromates Chromium trioxide Dichromates Halogens Halogenating agents Hydrogen peroxide Nitrates Nitric acid Perchlorates Permanganates Peroxides Persulfates | Bases Metals Reducing agents: Ammonia, anhydrous and aqueous Carbon Metal hydrides Metals Nitrites Organic compounds***** Phosphorus Silicon Sulfur |
| <p>The examples of oxidizing and reducing agents are illustrative of common laboratory chemicals and are not intended to be exhaustive.</p> <p>***** The mixing of organic compounds with oxidizers or strong acids is to be avoided. Extremely hazardous reactions may occur.</p> | |



From Prudent Practices for Disposal of Chemicals from Laboratories, Committee on Hazardous Substances in the Laboratory, et al., National Academy Press, Washington, D.C., 1983.

TABLE 6.5 INCOMPATIBLE MATERIALS CHART

| Chemical | Is Incompatible With | Chemical | Is Incompatible With |
|---|--|---|---|
| Acetic Acid | Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates | Fluorine | Isolate from everything |
| Acetic anhydride | Hydroxyl-containing compounds such as ethylene glycol, perchloric acid | Hydrides | Water |
| Acetone | Concentrated nitric and sulfuric acid mixtures, hydrogen peroxide | Hydrocarbons (benzene, butane, propane, gasoline, turpentine, etc.) | Fluorine, chlorine, bromine, chromic acid, peroxides |
| Acetylene | Chlorine, bromine, copper, fluorine, silver, mercury | Hydrocyanic acid | Nitric acid, alkalis |
| Alkali and alkaline earth metals, such as sodium, potassium, lithium, magnesium, calcium, powdered aluminum | Carbon dioxide, carbon tetrachloride, other chlorinated hydrocarbons (also prohibit the use of water, foam, and dry chemical extinguishers on fires) | Hydrofluoric acid (anhydrous) Hydrogen fluoride | Ammonia (aqueous or anhydrous) |
| Ammonia (anhydrous) | Mercury (in manometers, for example), chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride | Hydrogen peroxide | Copper, chromium, iron, most metals or their salts, any flammable liquid, combustible materials, aniline, nitromethane |
| Ammonium nitrate | Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organics, combustibles | Hydrogen sulfide | Fuming nitric acid, oxidizing gases |
| Aniline | Nitric acid, hydrogen peroxide | Hypochlorites | Acids, activated carbon |
| Arsenates and arsenites | Any reducing agents | Iodine | Acetylene, ammonia (aqueous or anhydrous) |
| Azides | Acids, heavy metals and their salts, oxidizing agents | Mercury | Acetylene, fulminic acid (produced in nitric acid-ethanol mixtures), ammonia |
| Bromine | Ammonia, acetylene, butadiene, butane, other petroleum gases, sodium carbide, turpentine, benzene, finely divided metals | Nitrates | Acids, reducing agents |
| Calcium oxide | Water | Nitric acid (concentrated) | Acetic acid, acetone, alcohol, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, nitratable substances |
| Carbon (activated) | Calcium hypochlorite, other oxidants | Nitrites | Acids, oxidizing agents |
| Carbon tetrachloride | Sodium | Nitroparaffins | Inorganic bases, amines |
| Chlorates | Ammonium salts, acids, metal powders, sulfur, finely divided organics, combustibles | Oxalic acid | Silver, mercury, and their salts |
| Chlorine | Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine | Oxygen | Oils, grease, hydrogen, flammable materials (liquids, solids, or gases) |
| Chlorine dioxide | Ammonia, methane, phosphine, hydrogen sulfide | Perchloric acid | Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils (all organics) |
| Chromic acid and chromium trioxide | Acetic acid, naphthalene, camphor, glycerol, turpentine, alcohol, other flammable liquids | Peroxides, organic | Acids (organic or mineral); avoid friction, store cold |
| Copper | Acetylene, hydrogen peroxide | Phosphorus (white) | Air, oxygen, alkalis, reducing agents |
| Cumene hydroperoxide | Acids (organic or inorganic) | Phosphorus pentoxide | Alcohol, strong bases, water |
| Cyanides | Acids | Potassium | Carbon tetrachloride, carbon dioxide, water |
| Flammable liquids | Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens | Potassium chlorate (see also chlorates) | Acids |

**TABLE 6.5 INCOMPATIBLE MATERIALS CHART
(CONTD.)**

| Chemical | Is Incompatible With | Chemical | Is Incompatible With |
|---|---|-----------------|--|
| Potassium perchlorate (see also perchloric acid) | Acids | Sodium nitrite | Ammonium nitrate and other ammonium salts |
| Potassium permanganate | Glycerol, ethylene glycol, benzaldehyde, sulfuric acid | Sodium peroxide | Any oxidizable substance, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural |
| Selenides | Reducing agents | Sulfides | Acids |
| Silver and silver salts | Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid (produced in nitric acid-ethanol mixtures) | Sulfuric acid | Chlorates, perchlorates, permanganates |
| Sodium (see also alkali metals) | Carbon tetrachloride, carbon dioxide, water | Tellurides | Reducing agents |

From Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Research Council, 1981.

6.6.3 Storage Facilities

Highly toxic chemicals (such as cyanide), shock-sensitive chemicals, and habit-forming chemicals shall be stored in locked cabinets to prevent theft.

Peroxide-forming chemicals and those that may become **shock-sensitive** with long-term storage shall be stored separately and shall be labeled and dated. Peroxide-forming chemicals shall be stored in a cool, dark, dry place.

Flammable liquids shall be stored in flammable-liquid cabinets if the laboratory contains a total of 10 gallons or more, including flammable liquid wastes.

Volatile or highly odorous chemicals shall be stored in a well-ventilated area; a ventilated cabinet is preferable. Chemical fume hoods are a poor choice for storage, as containers block proper air flow in the hood and take up work space.

Storage areas for **carcinogens** shall be labeled "Chemical Carcinogen." This requirement for cancer-warning labels applies even to chemicals that exhibit more than one hazard (e.g., carcinogenic and flammable).

FIG. 6.11 EXAMPLES OF CHEMICALS STORED BY HAZARD

I. Poisons and Habit-Formers

POISONS

Arsenic trioxide (carcinogen)
Sodium azide (solid may be shock-sensitive)
Sodium cacodylate (solid)
Strychnine

HABIT-FORMERS

Sodium pentobarbital

II. Flammable Organics and Organic Acids

FLAMMABLE ORGANICS

Acetone
Benzene (carcinogen)
Diethyl ether (peroxide-former)
Ethanol
Pyridine
Tetrahydrofuran (peroxide-former)
Xylene(s)

ORGANIC ACIDS

Acetic acid
Formic acid

III. Inorganic Acids and Oxidizers

INORGANIC ACIDS

Chromic acid (separate from nitric)
Hydrochloric acid
Hydrofluoric acid
Nitric acid (separate from chromic)
Perchloric acid
Sulfuric acid

INORGANIC OXIDIZERS

Ammonium persulfate (separate from sodium nitrite)
Chromium trioxide
Hydrogen peroxide
Silver nitrate
Sodium nitrate

IV. Inorganic Bases, Reducers, and Salts

INORGANIC BASES

Ammonium hydroxide
Potassium hydroxide
Sodium hydroxide

INORGANIC REDUCERS

Sodium sulfite

INORGANIC SALTS

Calcium chloride
Lithium carbonate
Sodium silicate

V. Organic Bases and Compounds

ORGANIC BASES

Diaminopentane
Diethylamine
Hexamethyleneimine

ORGANIC COMPOUNDS

Dextrose
Ethylenediaminetetraacetic acid (EDTA)
Formaldehyde (carcinogen)
Formamide
Isoleucine
Naphthol

VI. Carcinogens

(for which specific labeling is required)

Aflatoxins
Benzene
Benzidine
Carbon tetrachloride
3,3'-Diaminobenzidine
Ethidium bromide (mutagen)
Hydrazine
Nitrosodiethylamine

6.6.4 Inspection of Stored Chemicals

Storage Area. Chemical storage areas shall be inspected annually, and any unwanted or expired chemicals shall be removed. During this inspection, the list of chemicals present in the laboratory shall be updated or verified and the date and name of the inspector recorded.

Inspections. Although the deterioration in storage of a specific compound cannot be predicted in detail, generalization can often be made about the reaction characteristics of groups of compounds. Some general conclusions about the stability of classes of chemicals can be reached, and corresponding storage time spans can be identified. Visual inspection of stored chemicals is important in the disposal decision.

Chemicals showing any of the indications listed below shall be turned over to EHS for safe disposal:

- * Slightly cloudy liquids
- * Darkening or change in color
- * Spotting on solids
- * Caking of anhydrous materials
- * Existence of solids in liquids or liquids in solids
- * Pressure buildup in containers
- * Evidence of reaction with water
- * Corrosion or damage to the container

6.6.5 Refrigerator Storage (PSU Safety Policy [SY11](#) Refrigerators – Explosion Proof)

Flammable liquids shall not be stored in ordinary domestic refrigerators. Refrigerator temperatures are almost universally higher than the flash points of the flammable liquids most often stored in the units, and ignition sources are readily available inside the storage compartment. Furthermore, the compressor and its circuits are typically located at the bottom of the units, where vapors from flammable liquid spills or leaks may easily accumulate.

If refrigerators are used in a laboratory for purposes other than flammables storage, they shall be labeled "No Flammables Allowed." Flammable liquids shall not be stored in cold rooms that do not have explosion-proof wiring and fixtures. Such storage facilities pose explosion hazards because the various control switches and defroster heaters can spark and ignite flammable vapors.

Chemicals stored in refrigerators or cold rooms shall be sealed and labeled with the name of the material and the person who stored the material. Old chemicals shall be disposed of after a specified storage period.

Food shall not be stored in a refrigerator used for chemical storage. The refrigerator shall be labeled "No Food Allowed" or equivalent. Refrigerators used for food shall be marked "Food Only" or equivalent and shall not be near the work area.

Section 6.6.6 Tanks and Drums

All planned chemical and oil storage tanks and containers that hold 55 gallons or more must be identified to EHS in order to assess the potential for spills and releases, and to incorporate these containers and tanks into the various safety and training requirements of Preparedness, Prevention and Contingency (PPC) Plans, Spill Prevention, Control, and Countermeasure (SPCC) Plans, and the Storage Tank Management Program.

Chemicals and oils that are stored improperly may be released into the environment. Good practices, such as training, storage, and inspections can be used to help reduce the risk of spills and releases, and to mitigate the environmental impacts of spills and releases. In addition, there are regulatory requirements that must be satisfied.

Facilities that have storage tanks or drums (55-gallon) will need to meet storage requirements. Secondary containment must be provided if a spill or release from the tank or drum could enter the environment (surface water, soil, drainage ways) or flow down a drain. A double-walled tank meets the secondary containment requirement. Facilities that store materials in drum and tank quantities are also required to have a spill kit, first aid kit, and a fire extinguisher.

Annual training is required at locations that are part of the University's SPCC or PPC Plans. In addition, these plans require inspections of tanks and drums on a monthly basis to ensure that they are in good condition and are not causing a release.

6.7 Safety for Specific Chemical Operations

6.7.1 Unattended/Overnight Operations

The "Laboratory Information" posting on the outside of the laboratory shall have current emergency contact information.

Reactions that are left unattended for long periods of time or overnight are prime sources of fires, floods, and explosions. Do not run equipment such as power stirrers, hot plates, heating mantles, and water condensers overnight without fail-safe provisions such as flow monitors that will shut down equipment in case of water supply failure, temperature monitors interlocked into the system, or fail-safe hose connectors.

Remember that at night, emergency personnel are entirely dependent on accurate instructions and information available at the laboratory.

6.7.2 Procedures for Working Alone

No one should work alone in a laboratory. More specifically, this means that someone else should be in close proximity (down the hall) and check in periodically on the individual. When it is not possible to have someone close by, the individual should make arrangements to call someone every half hour to provide updates on their status.

Everyone needs to have a supervisor, or someone acting in that capacity, at all times in order to ensure that the supervisory responsibilities listed on p. 14 and in SY1 (<http://guru.psu.edu/policies/SY01.html>) are followed. If a faculty member or supervisor is out of town, someone else must be clearly assigned to take on those responsibilities and be familiar with the activities the individual is doing, including the potential hazards of the work.

6.7.3 Extractions and Distillations

Extractions. Extractions can present a hazard because of the potential buildup of pressure from a volatile solvent and an immiscible aqueous phase. Glass separatory funnels used in laboratory operations are particularly susceptible to problems because their stoppers or stopcocks can be forced out, resulting in a spill of the contained liquid. It is even possible for pressure to burst the vessel.

To use a separatory funnel correctly, do not attempt to extract a solution until it is cooler than the boiling point of the extractant. When a volatile solvent is used, the unstoppered separatory funnel should first be swirled to allow some solvent to vaporize and expel some air. Close the funnel and invert it with the stopper held in place and immediately open the stopcock to release more air plus vapor. Do this with the hand extended around the barrel to keep the stopcock plug securely seated.

Point the barrel of the separatory funnel away from yourself and others and vent it to the hood. Do not vent the funnel near a flame or other ignition source. Close the stopcock, shake with a swirl, and immediately open the stopcock with the funnel in the inverted position to vent the vapors again. If it is necessary to use a separatory funnel larger than one liter for an extraction with a volatile solvent, the force on the stopper may be too great, causing the stopper to be expelled. Consider performing the extraction in several smaller batches.

Distillations. Where possible, distillation should be replaced by column purification. During distillation, potential dangers arise from pressure buildup, commonly used flammable materials, and the use of heat to vaporize the chemicals involved. Careful design and construction of the distillation system is required to accomplish effective separation and avoid leaks that can lead to fires or contamination of the work area.

It is necessary to ensure smooth boiling during the separation process and avoid bumping, which can blow apart the distillation apparatus. Stirring the distillation mixture is the best method to

avoid bumping. Boiling stones are only effective for distillations at atmospheric pressure. Use fresh boiling stones when a liquid is boiled without stirring. Do not add boiling stones or any other solid material to a liquid that is near its boiling point, because this may cause it to boil over spontaneously.

An electric mantle heater, a ceramic cavity heater, steam coils, or a nonflammable liquid bath are best to provide even heating. Silicone oil or another suitable high-boiling-temperature oil can be used on a hot plate. Hot water or steam may also be used in some cases. An extra thermometer inserted at the center bottom of the distilling flask will warn of dangerously high temperatures that could indicate exothermic decomposition. Do not distill or evaporate organic compounds to dryness unless they are known to be free of peroxides.

Because superheating and bumping occur frequently during distillation using reduced pressure, it is important that the distillation assembly is secure and the heat distributed more evenly than is possible with a flame. Evacuate the assembly gradually to minimize the possibility of bumping. Stirring, or using an air or nitrogen bleed tube, provides good vaporization without overheating and decomposition.

Put a standing shield in place for protection in the event of an implosion. After finishing a reduced-pressure distillation, cool the system, and then slowly bleed in air so as not to induce an explosion in a hot system. Pure nitrogen is preferred to air and can be used even before cooling the system.

In a steam distillation, minimize the accumulation of condensate in the distillation flask. The heat of steam condensation is very high, and overfilling the flask is less likely if condensation from the entering steam line is trapped and the flask heated or insulated to prevent excessive condensation.

6.7.4 Temperature Control

Since the rates of most reactions accelerate as the temperature increases, highly exothermic reactions can become violent without adequate cooling. Viscous liquids transfer heat poorly and require special precautions. Apparatus shall be assembled so that either heating or cooling can be applied or withdrawn readily.

6.7.4.1 Oil and Sand Baths

Improper use of a hot oil or a sand bath may create serious hazards such as an overturned bath, spatter from water falling into the bath, smoke caused by decomposition of the oil or organic materials in the oil, and fire from overheating the oil. Baths shall not be left unattended without a high-temperature shutoff. The oil shall be properly labeled, including information on its safe working temperature.

6.7.4.2 Cooling Baths

Ice with salt may be used when ice water is not cool enough for use as a bath. Dry ice may be used with an organic liquid. A cooling liquid ideal for use with dry ice should have nontoxic vapors, low viscosity, no flammability, and low volatility. Although no substance is likely to meet all these criteria, some of the better liquids are:

- * Ethylene glycol or propylene glycol in a 3:2 ratio with water and thinned with isopropyl alcohol
- * Isopropyl alcohol (less flammable than other common solvents such as acetone or butanone)
- * Some glycol ethers

Either add the dry ice to the liquid or the liquid to the dry ice in small increments. Wait for the foaming to stop before proceeding with the addition. The rate of addition can be increased gradually as the liquid cools. Do not handle dry ice with bare hands; if skin is even slightly moist, severe burns can result. Use dry leather gloves or suitable cryo-gloves. Wear goggles when chipping ice.

Cryogenic coolants shall be handled in properly vented containers. Very-low-temperature coolants may condense oxygen and cause an explosion with combustible materials. Use gloves and a face shield; immerse the cooling object slowly to avoid too-vigorous boiling and overflowing the coolant. Dewar flasks should be made of borosilicate glass and wrapped with cloth-backed friction or duct tape or put in a metal enclosure to contain flying pieces in the event of implosion.

Dewar flasks should be equipped with safety necks. The flasks should be inspected periodically (at least once a day) to ensure that no air or ice plugs have collected in the neck opening.

Avoid pouring cold liquid onto the edge of a glass Dewar flask when filling because the flask may break and implode. For the same reason, do not pour liquid nitrogen out of a glass Dewar flask. Instead, use mild air pressure or a siphon. Metal or plastic Dewar-type flasks are preferable and eliminate this problem. Never use a household Thermos bottle in place of a Dewar flask.

6.7.5 Reduced Pressure Operations

Protect vacuum desiccators by covering them with cloth-backed friction or duct tape or shielding them for protection in case of implosion. Vacuum lines shall be trapped and shielding used whenever apparatus is under reduced pressure. Only chemicals being dehydrated should be stored in a desiccator. Before opening a desiccator that is under reduced pressure, make sure that atmospheric pressure has been restored.

Water aspirators for reduced pressure are used mainly for filtration purposes, and only equipment that is approved for this purpose should be used. Never apply reduced pressure to a

flat-bottomed flask unless it is a heavy-walled filter flask designed for that purpose. Place a trap and a check valve between the aspirator and the apparatus so that water cannot be sucked back into the system if the water pressure falls unexpectedly during filtering. This also applies to rotary evaporation equipment that use water aspirators for reduced pressure.

If vacuum pumps are used, place a cold trap between the apparatus and the vacuum pump so that volatiles from a reaction or distillation do not get into the pump oil or out into the atmosphere. **Exhausts from pumps shall be vented to a hood or ventilation system.** Pumps with belt drives must be equipped with belt guards to prevent hands or loose clothing from being caught in the belt pulley.

6.7.6 Cold Traps

Cold traps used in reduced-pressure systems should be placed in vermiculite-filled metal cans. If this option is not possible, the cold traps should be wrapped with cloth-backed friction or duct tape. In the event of an implosion, the tape will reduce the amount of flying glass.

Users of cold traps should be aware of the boiling points of the components and the possible products of materials in the reduced-pressure system. For instance, argon, a common inert gas, may condense into traps cooled with liquid nitrogen. When the cooling bath is removed, the argon rapidly vaporizes, and the rate of pressure buildup may be too great for the gas to be vented or pumped down. A serious explosion could occur.

6.7.7 Transporting Chemicals

The precautions that should be followed to protect laboratory and non-laboratory personnel and facilities when you transport chemicals in University buildings are listed below.

Use secondary containers. The container-within-a-container concept will protect the primary containers from shock during any sudden change of movement. Secondary containment is especially important when chemicals are moved in public areas, such as hallways or elevators, where the effects of a spill would be more severe.

Always use a sturdy cart, and make sure the cart has a low center of gravity. Carts with large wheels are best for negotiating irregularities in floors and at elevator doors.

Do not transport incompatible chemicals together on the same cart unless separated by secondary containment.

All chemical containers being transported shall have labels identifying the contents.

Transport large containers of corrosives in a chemically resistant bucket or other container designed for this purpose.

Anticipate sudden backing up or changes in direction from others. If you stumble or fall while carrying glassware or chemicals, try to project them away from yourself and others.

The transportation of pesticides between facilities or from agriculture suppliers must be done by a licensed pesticide applicator. In addition, the facility's business license number assigned by the PA Dept. of Agriculture must be displayed on the vehicle.

6.8 Hazards of Chemical Groups

6.8.1 Corrosives: Acids and Bases

Corrosive acids and bases attack the skin and can cause permanent damage to the eyes. See Table 6.4 for inorganic acid neutralization procedures for spills.

All the **hydrogen halide acids** are serious respiratory irritants. Hydrogen fluoride poses a special danger; both its gas and solutions are toxic, and it is rapidly absorbed through the skin, penetrating deeply into the body tissues. Contact with dilute solutions of hydrogen fluoride may cause no pain for several hours but result in serious burns. In all cases, immediate and thorough flushing with water and attention by a physician are necessary.

Oxyacids such as sulfuric and nitric acid have widely differing properties. Sulfuric acid is a very strong dehydrating agent. When preparing solutions, always add acid to water and remember that the heat of solution may produce a large increase in temperature. Nitric acid is a strong oxidizing agent that acts rapidly and turns exposed skin yellow to brown as a denaturing reaction occurs. Paper that has been used to wipe up nitric acid spills can ignite spontaneously when dry and should not be thrown into a wastebasket until first rinsed with water and neutralized.

Chromic acid is generally prepared as a cleaning solution; EHS recommends the use of replacement cleaners without chromium, which is carcinogenic. All chromic acid waste is collected and disposed of through EHS. For information regarding chromic acid substitutes, contact EHS.

Perchloric acid is a powerful oxidizing agent that may react explosively with organic compounds and other reducing agents. It shall be used only in a perchloric-acid, water-wash-down fume hood of noncombustible construction. Perchloric acid should be handled with extreme care and kept from organic matter to prevent a serious explosion. Beakers of fuming perchloric acid shall be handled with tongs rather than rubber gloves. Perchloric acid hoods shall be washed down after every perchloric acid digestion.

Perchloric acid containers shall be stored in glass outer containers and shall not be stored on wood shelving, as drips or leaks may render the wood shock-sensitive. Keep perchloric acid bottles on glass or ceramic trays that are large enough to hold all the acid if the bottle breaks. Storage of perchloric acid containers should not exceed one year. Digest organic matter with nitric acid before addition of perchloric acid. Never heat perchloric acid with sulfuric acid because dehydration may produce anhydrous perchloric acid, which is explosive.

Perchlorate esters have the same shattering effect as nitroglycerine. Transition metal perchlorates are capable of exploding. Perchlorates shall not be used without prior consultation with EHS.

The most common **bases** found in laboratories include the alkali metal hydroxides and aqueous solutions of ammonia. Sodium and potassium hydroxides are extremely destructive to both skin and eye tissues. When concentrated solutions are prepared, the heat of solution can raise the temperature to dangerous levels. Because ammonia solution vapors are such strong irritants, they should be used only in a chemical fume hood.

**TABLE 6.6 PROCEDURE FOR INORGANIC ACID NEUTRALIZATION
(DOES NOT APPLY TO CHROMIC ACID)**

APPLICABLE ACIDS: Hydrochloric, sulfuric,

EQUIPMENT: Chemical fume hood, sash pulled down as far as possible
Goggles
Gloves
Lab coat, either acid resistant or with impermeable apron
pH paper, wide range

CAUTION: Wear protective clothing and work in a hood
Beware of heat and fumes generated by neutralizing acid
Add acid to water
Keep containers cool while neutralizing, using ice in the water or
in baths
Dilute concentrated acids before neutralization

1. Prepare a large amount of an ice-water-and-base solution of one of the following:
Sodium carbonate (soda ash)
Calcium hydroxide (slaked lime)
Sodium hydroxide, 5 to 10% one-molar solution is about 4% (4 grams per 100 ml)
2. Slowly stir acid (which has been diluted to about 5%) into the base solution until the pH reaches about 5 to 10.
3. Slowly pour the neutralized solution down the drain with large amounts of water.

NOTE: The pH of solutions poured down the drain shall be between 5 and 10 to avoid violating local, state, or federal regulations.

Reference: Prudent Practices for Disposal of Chemicals from Laboratories, Committee on Hazardous Substances in the Laboratory, et al., National Academy Press, 1983.

6.8.2 Flammable and Combustible Liquids (PSU Safety Policy [SY08 Storage, Dispensing, and Use of Flammable Liquids on PSU Property](#))

Definitions. According to most fire codes and regulations, including those for laboratories, a flammable liquid is a liquid with a flash point below 100^o F and a vapor pressure not exceeding 40 psi (absolute) at 100^o F; it is called a Class I liquid. A liquid with a flash point of 100^o F or greater is classified as a combustible liquid and may be referred to as a Class II or Class III liquid (see Table 6.5).

The U.S. Department of Transportation (DOT) and the U.S. Environmental Protection Agency (EPA) use a different definition. These agencies define flammable liquids as those with a flash point of 140^o F or lower and combustible liquids as those with a flash point greater than 140^o F but less than 200^o F. DOT and EPA definitions apply primarily to chemicals in transit.

Flash point is the minimum temperature at which the liquid gives off vapors in sufficient concentration to form an ignitable mixture with air. The classes of liquids are further divided into subclasses, depending on the flash points and boiling points of the liquids. The classifications are important because regulations governing storage and use of a liquid are largely based on the liquid's flash point.

Flammable liquids shall be handled only in areas with no ignition sources and shall not be heated with open flames. If flammable liquids in metal containers or equipment are transferred, the equipment and containers shall be bonded to avoid static-generated sparks.

Storage. Flammable liquids shall not be stored in ordinary refrigerators or cold rooms. If it is necessary to refrigerate flammable materials, explosion-proof or flammable-storage refrigerators shall be used. Combustible liquids are less of a fire hazard, although a rise in temperature increases their evaporation rate and the potential for ignition. If the quantity of flammable liquids in storage exceeds 10 gallons (including liquid waste), flammable-liquid storage cabinets must be used.

Allowable Quantities. The maximum allowable size of containers and portable tanks for flammable and combustible liquids is shown in Table 6.8. Although the table indicates that the maximum allowable size of glass containers for Class IA and Class IB are one pint and one quart respectively, the liquids may be stored in glass containers of not more than one-gallon capacity if the required liquid purity (such as ACS analytical reagent grade or higher) would be affected by storage in metal containers or if the liquid would cause excessive corrosion of the metal container.

Bonding and Grounding. When a flammable liquid is poured into or withdrawn from a metal drum, the drum and the secondary container shall be electrically bonded to each other and to the ground to avoid the possible buildup of a static charge. Only small quantities should be transferred to a glass container. If the liquid is transferred from a metal container to glass, the

metal container should be grounded. Drums of flammable liquids are not permitted in laboratories unless the quantity is necessary for daily use and is approved by EHS.

TABLE 6.7 FLAMMABLE LIQUID CLASSIFICATION

| CLASS | FLASH POINT (°F) | BOILING POINT (°F) |
|-------|----------------------------|--------------------|
| IA | Below 73 | Below 100 |
| IB | Below 73 | At or above 100 |
| IC | At or above 73, below 100 | NA |
| II | At or above 100, below 140 | NA |
| IIIA | At or above 140, below 200 | NA |
| IIIB | At or above 200 | NA |

TABLE 6.8 MAXIMUM ALLOWABLE SIZE OF FLAMMABLE AND COMBUSTIBLE LIQUID CONTAINERS IN LABORATORIES

| CONTAINER | FLAMMABLE LIQUIDS | | | COMBUSTIBLE LIQUIDS | |
|--|---------------------|------------------------|------------------------|-------------------------|------------|
| | CLASS IA | CLASS IB | CLASS IC | CLASS II | CLASS III |
| Glass | 1 pint ^a | 1 quart ^a | 1 gallon | 1 gallon | 5 gallons |
| Metal (other than DOT drums) or approved plastic | 1 gallon | 5 gallons ^b | 5 gallons ^b | 5 gallons ^b | 5 gallons |
| Safety cans | 2 gallons | 5 gallons ^b | 5 gallons ^b | 5 gallons ^b | 5 gallons |
| Metal drum (DOT Spec.) | Not allowed | 5 gallons ^b | 5 gallons ^b | 60 gallons ^b | 60 gallons |
| ^a Glass containers of not more than one-gallon capacity are acceptable if the required purity would be affected by storage in metal or if excessive corrosion would result from storage in metal. ^b In instructional laboratory work areas, no container for Class I or II liquids shall exceed a capacity of one-gallon, other than safety cans which may be of two-gallon capacity. | | | | | |

Reference: NFPA 45, Fire Protection for Laboratories Using Chemicals, National Fire Protection Association, 1991.

6.8.3 Compressed Gases (PSU Safety Policy [SY25](#) Compressed Gas Cylinders)

Securing Cylinders. An added hazard of toxic, oxidizing, and other hazardous gases as well as inert gases in cylinders is the potential for accidental pressure release; a cylinder with the valve broken off can turn into a rocket. It is important to keep cylinders secured to the bench or wall and to keep the caps on when they are not in use. See Table 6.9 for maximum size and quantity limitations for compressed-gas or liquified-gas cylinders in laboratories.

Storage. When a cylinder is not in use, close the main cylinder valve tightly. Promptly remove the regulator from an empty cylinder, replace the protective cap, and label the cylinder by using an "empty" tag or writing on the side of the cylinder with chalk. Never bleed cylinders completely empty; leave a slight pressure to keep contaminants out.

Transport. When transporting a cylinder, use a wheeled cylinder cart with the capped cylinder strapped to the cart.

Connections. Threads on cylinder-valve outlet connections have been standardized by the Compressed Gas Association and are not the same on all cylinders. This prevents accidental mixing of incompatible gases from an interchange of connections. Never lubricate, modify, force, or tamper with cylinder valves. Especially do not put oil or grease on the high-pressure side of a cylinder containing oxygen, chlorine, or another oxidizing agent. An autoignition or explosion could result.

Environmental. Do not expose cylinders to temperatures higher than 50° C. Some rupture devices on cylinders release at about 65° C.

Toxic Gases. For the purposes of this section, the definitions of toxic gas and highly toxic gas in the Compressed Gas Association Standard CGA P-1.1991, "Safe Handling of Compressed Gases in Containers," can be applied. A toxic gas is one with a median lethal concentration (LC50) of more than 200 and less than 2,000 parts per million by volume of gas or vapor when administered by inhalation for an hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each. A highly toxic gas is characterized by a median LC50 of 200 ppm or less under the same conditions.

Toxic gases shall be treated by absorption, wet or dry scrubbing, combustion, or condensation via refrigeration, before being vented to hoods or other local exhaust arrangements. Pressure-relief devices on cylinders shall be vented to a safe place. Flow-restricting orifices are required on cylinders of toxic gases. Toxic-gas cylinders shall be stored in continuously mechanically ventilated enclosures, with no more than three cylinders per enclosure. Any new laboratory construction shall require gas cabinets for

storage of highly toxic gases. Some toxic gases may be supplied in mixtures. Purchase of diluted toxic gas, if feasible, will serve to reduce risk.

If these alternatives are not possible, alarm systems shall be employed to monitor the toxic gas in use. Respirators or self-contained breathing apparatus may be available in the event of a leak. Consult the emergency plan for the given lab area to determine the action expected during a leak situation. EHS shall be contacted for information on selection, fit testing, and training if respirators or SCBA have been provided. No one may use respirators on the job without prior medical approval.

6.8.3.1 Acetylene

The following special rules apply to work with cylinders of acetylene in the laboratory:

- Acetylene cylinders are partially filled with acetone and should always be kept upright. If a cylinder has been handled in a nonupright position, do not use it until it has sat upright for at least 30 minutes.
- When connecting an acetylene cylinder, be sure to use a flash arrester at the outlet of the cylinder and the correct kind of tubing to transfer the gas. Some tubing materials, such as copper and lead solder, form explosive acetylides.
- Never exceed the pressure limit indicated by the warning red line of an acetylene pressure gauge.

6.8.3.2 Lecture Bottles

In addition to standard precautions, the following special rules apply to work with lecture bottles in the laboratory:

- Lecture bottles shall be stored where the temperature does not exceed 50° C, because unlike larger cylinders, they do not have pressure-relief devices to prevent rupturing. Also unlike larger cylinders, lecture bottles all have identical valve threads, irrespective of the gas contained within.
- If labels and valve tags do not agree or if there is any question as to the contents of a lecture bottle, return the unused bottle to the supplier or contact EHS. Whenever possible, purchase lecture bottles from suppliers who will accept the return of empty or partially empty bottles.
- When transporting lecture bottles, use a cart and block the bottles to prevent rolling and falling.

6.8.4 Cryogenic Liquids and Liquefied Gases

The hazards of cryogenic liquids include fire or explosion, pressure buildup, embrittlement of structural materials, asphyxiation, and destruction of living tissue on contact. Liquid helium and liquid nitrogen may displace air and create an atmosphere without sufficient oxygen. Fire or explosion may occur when the liquid form of flammable gases, such as hydrogen, is used without proper management of the gaseous phase. Liquid oxygen may produce an enriched oxygen atmosphere, which increases the flammability of ordinary combustible materials. Enriched oxygen levels may also cause some nonflammable materials, such as carbon steel, to burn readily.

Contact with cryogenic liquids generally causes tissue freezing and frostbite. Even brief contacts may be intense and painful. Prolonged contact may result in blood clots. Appropriate protective clothing, gloves, and eye protection--preferably a face shield--shall be worn when cryogenic liquids are handled. Do not use cloth gloves, as the cryogenic liquids can saturate them and cause more extensive cold damage to the skin.

TABLE 6.9 MAXIMUM SIZE AND QUANTITY LIMITATIONS FOR COMPRESSED OR LIQUIFIED GAS CYLINDERS IN LABORATORIES

| | Flammable Gases and Oxygen | Liquefied Flammable Gases | Gases with High Health Hazard Rating |
|--|-----------------------------------|----------------------------------|---|
| Maximum cylinder size (approximate dimensions in inches) | 10 x 50 | 9 x 30 | 4 x 15 |
| Maximum number of cylinders per 500 square feet or less of floor space in nonsprinklered areas | 3 | 2 | 3** |
| In sprinklered areas | 6* | 3 | 3** |
| <p>* In instructional laboratory work areas, the total number of cylinders shall be reduced to 3 maximum-sized cylinders. Ten approximately 2" x 12" cylinders (lecture bottles) are allowed. In other than instructional laboratories, 25 lecture bottles are permitted.</p> <p>**Cylinders of all toxic gases shall be kept in a continuously mechanically ventilated hood or other continuously mechanically vented enclosure, with no more than 3 cylinders per enclosure.</p> | | | |

Reference: NFPA 45, Protection for Laboratories Using Chemicals, National Fire Protection Association, 1991.

6.8.5 Highly Reactive Chemicals

6.8.5.1 Organic Peroxides

Organic peroxides are among the most hazardous chemicals normally handled in laboratories. As a group, they are flammable, low-power explosives and oxidizers that are sensitive to shock, heat, sparks, friction, impact, and light. Many of them are much more shock-sensitive than typical explosives such as TNT.

Purchase and use of peroxides shall be kept to a minimum. Unused peroxides shall not be returned to the container. Glass containers with screw caps or glass stoppers shall not be used. Polyethylene bottles with screw caps are acceptable. Liquid peroxides or solutions shall be stored so that the peroxide will not freeze or precipitate, because these forms are extremely sensitive to heat or shock. Consistent with this precaution, they shall be kept as cold as practical to avoid decomposition.

The sensitivity of organic peroxides to heat and shock may be reduced by diluting the peroxides with inert solvents (such as aliphatic hydrocarbons or mineral oil). However, not all solvents are appropriate to mix with peroxides. Toluene, in particular, is known to induce the decomposition of diacyl peroxides. Do not use acetone or other oxidizable materials for dilution of organic peroxides.

Ceramic, Teflon, or wood spatulas shall be used. Metal spatulas will contaminate the peroxide, which can lead to explosive decomposition. Friction, grinding, and other forms of impact shall be avoided.

6.8.5.2 Peroxide-Forming Chemicals

As a general rule, peroxide forming chemicals should not be stored longer than a year. Certain chemicals are known to form peroxides on exposure to air or light. Peroxide concentrations may accumulate over long periods of time. The distillation of solvents contaminated with peroxides may lead to violent explosions as the peroxides become concentrated during the process. A peroxide present as a contaminating reagent in a solvent can change the course of a planned reaction.

Keep all stored chemicals, especially flammable liquids, away from heat and direct sunlight. Peroxide-forming chemicals call for special consideration at all times and particularly in storage. They should be stored in dark bottles; ultraviolet light and elevated temperature accelerate peroxide formation.

Peroxide-forming solvents shall be dated when opened and checked for the presence of peroxides with either wet chemicals or test strips. The checks should be conducted prior to heating the solvent and after each month of storage. Peroxides may be removed by

passing the solvent through an alumina column. The alumina shall not be allowed to dry out and shall be given to EHS promptly for disposal.

Some peroxide-forming chemicals are listed in Table 6.10. Most typical are ethyl ether, dioxane, and tetrahydrofuran. They shall not be stored more than six months and shall not be put into storage without special posting indicating their presence and removal date.

Several acceptable colorimetric tests for peroxides in ethers are available. Contact EHS for information. If sufficient peroxide is present to form a precipitate, the container and its contents shall be handled with extreme care. Call EHS to have it removed. Generally, if you think you should test for the presence of peroxides, then you probably have kept the material too long and should dispose of it immediately.

A test for peroxides should only be attempted if it is clear that no danger will result from moving or opening the container. Solids in the liquid or around the cap can indicate dangerous peroxide buildup.

If old containers of peroxide-forming chemicals are found, do not move them without consulting EHS. This is especially true if they contain precipitate. If they are to be moved, handle them only by the bottom of the container and never by the cap or lid, as friction may cause a violent explosion.

In general, do not attempt to dilute the concentration of peroxides in peroxide-forming solvents by adding additional solvent. Increasing the total volume may dilute the peroxide concentration but creates a larger quantity of waste for disposal. The higher volume of waste may require stabilization because of the presence of the peroxides.

TABLE 6.10 LIST OF PEROXIDIZABLE COMPOUNDS

| | | |
|-----------------------------|----------------------------------|----------------------------|
| Acetal | Diethylene glycol dimethyl ether | Limonene |
| Acetaldehyde | Diethylketene | 1,5-p-Menthadiene |
| Acrylamide | Digylme | Methoxy-1,3,5,7-cyclo |
| Acrylic Acid | 2,3-Dihydrofuran | octatetraene |
| Acrylonitrile | 2,3-Dihydropyran | 2-Methoxyethanol |
| Allyl ethyl ether | Diisopropyl ether * | 2-Methoxyethyl vinyl ether |
| Allyl phenyl ether | 1,1-Dimethoxyethane | Methyl acetylene |
| Allyl vinyl ether | 1,2-Dimethoxyethane | Methyl methacrylate |
| 1-Allyloxy-2,3-epoxypropane | 1,1-Dimethoxypropane | 4-Methyl-1,3-dioxane |
| Benzyl-1-naphthyl ether | 2,2-Dimethoxypropane | 2-(1-Methylheptyl)-4,6 |
| Benzyl butyl ether | 3,3-Dimethoxypropene | dinitrophenyl |
| Benzyl ethyl ether | 2,2-Dimethyl-1,3-dioxolane | crotonate |
| Bis(2-ethoxyethyl) ether | 2,6-Dimethyl-1,4-dioxane | 2,3-Methyl-2-methylene |
| Bis(2-methoxyethyl) ether | 1,3-Dioxane | butanal |
| 1,3-Butadiene | 1,4-Dioxane | 4-Methyl-2-pentanone |
| 1,3-Butadiene | 1,3-Dioxep-5-ene | 2-Methyltetrahydrofuran |
| 2-Butanol | 1,3-Dioxol-4-en-2-one | Methyl vinyl ether |
| Buten-3-yne | Dipropoxymethane | 2-Penten-4-yn-3-ol |
| Butyl ethyl ether | Dipropyl ether | a-Pentylcinnamaldehyde |
| Butyl formate | Divinyl acetylene * | Potassium * (forms yellow |
| Butyl vinyl ether | Divinyl ether | potassium peroxide on the |
| 2-Chloro-1,3-butadiene | 1,2-Epoxy-3-isopropoxy | surface) |
| 1-Chloro-2,2-diethoxyethane | propane | Potassium amide |
| 2-Chloroacrylonitrile | 1-Ethoxy-2-propyne | 2-Propanol |
| 2-Chloroethyl vinyl ether | 2-Ethoxyethanol | Propionaldehyde |
| Chloroethylene | 2-Ethyl butanal | 2-Propyne-1-thiol |
| Chloroprene | Ethyl isopropyl ether | Sodium 5,8,11,14,- |
| Chlorotrifluoroethylene | Ethyl propenyl ether | eicosatetraenoate |
| Cinnamaldehyde | Ethyl vinyl ether | Sodium amide * |
| Crotonaldehyde | 2-Ethylacrylaldehyde oxime | Sodium ethoxyacetylde |
| Cyclohexene | Ethylene glycol dimethyl ether | Styrene |
| Cyclooctene | 2-Ethylhexanal | 1,1,2,3-Tetrachloro-1,3,- |
| Cyclopropyl methyl ether | 2-Ethylhexyl vinyl ether | butadiene |
| Decahydronaphthalene | 2-Furaldehyde | Tetrafluoroethylene |
| Decalin | Furan | Tetrahydrofuran |
| Di(2-propynyl)ether | Glyme compounds | Tetrahydronaphthalene |
| Diacetylene | 4,5-Hexadien-2-yn-1-ol | Tetrahydropyran |
| Diallyl ether | 2,4-Hexadienal | Tetralin |
| Dibenzyl ether | 2,5-Hexadiyn-1-ol | Tridecanal |
| p-Dibenzyloxybenzene | 2-Hexenal | 1,3,3-Trimethoxypropene |
| 1,2-Dibenzyoxyethane | Indole-2-carboxyaldehyde | 3,3,5-Trimethyl-2-cyclo- |
| Dibutyl ether | Isobutyl vinyl ether | hexene-1-one |
| 1,1-Dichloroethylene | Isobutyraldehyde | (isophorone) |
| Dicyclopentadiene | Isopropoxypropionitrile | Vinyl acetate |
| 1,1-Diethoxyethane | Isopropyl ether * | Vinyl acetylene |
| 1,2-Diethoxyethane | Isopropyl propyl ether | Vinyl chloride |
| Diethoxymethane | Isopropyl vinyl ether | Vinyl ethers |
| 3,3-Diethoxypropene | 2-Isopropylacrylaldehyde | Vinyl pyridine |
| Diethyl ether | oxime | 4-Vinylcyclohexene |
| Diethyl fumarate | Isovaleraldehyde | Vinylidene chloride |

*Forms peroxides rapidly upon storage.

NOTE: Compounds with synonyms are listed under all known names.

From Handbook of Reactive Chemicals, L. Bretherick, 1990, and J. Chem Education, Jackson et al., vol. 47, No. 3 (1970).

6.8.5.3 Polynitro Compounds

Many polynitroaromatic compounds are shock-sensitive, as are some aliphatic compounds containing more than one nitro group. Many of these compounds are sold and stored with 10 to 20 percent water, which desensitizes their reaction to shock, although they are still flammable solids.

Storage. Polynitro compounds shall be stored separately from most chemicals and labeled so they will be easily identified as reactive. They shall not be placed in long-term storage without special posting indicating their presence and removal date. Long-term storage without checking for proper water content may allow the compounds to dehydrate sufficiently to make them highly reactive.

Surplus and waste polynitro compounds shall be given to EHS promptly for proper disposal or recycling and not left on a shelf to be forgotten.

If old containers of polynitro compounds are found, including picric acid or dinitrophenyl hydrazine, do not move them without consulting EHS. If they are moved, handle them only by the bottom of the container and never by the cap or lid, as friction may cause a violent explosion.

Picric Acid. Dry picric acid is highly explosive and should be brought into the laboratory only when specifically required. Users should have a thorough understanding of its hazards. Although not explosive when wetted, picric acid solutions may evaporate to leave the hazardous solid. Picric acid should be stored away from combustible materials and should not be kept for extended periods. Old containers of picric acid shall be handled only by EHS.

Methyl nitronitrosoguanidine. Methyl nitronitrosoguanidine is a carcinogenic agent that is also shock-sensitive. It is stored in a separate area, preferably locked. Waste paper, plastic, and glass contaminated with this material shall be given to EHS for proper disposal.

6.8.5.4 Catalysts

Catalysts such as raney nickel or palladium on carbon shall be filtered from catalytic hydrogenation reaction mixtures with care. The catalyst has usually become saturated with hydrogen and will produce flames spontaneously on exposure to air.

6.8.5.5 Calorimeters (Commonly Known as Parr Bombs)

Calorimeters/Parr bombs are pressure reactors designed for handling chemical reactions and tests at elevated temperatures and pressures. They are intended for the development

of new formulations, the study of reaction parameters, or the production of fine chemicals in small quantities.

Parr bombs shall be handled behind reaction shields. The operator shall wear goggles or preferably a face shield. The reactor shall never be filled to more than three-fourths of its available free space. Reactors shall be selected based on the prescribed ratings for maximum temperature and pressure. The user may not attempt to increase the working limits by altering the reactor or substituting components not recommended by the manufacturer. Also, the rating of the burst disc must not exceed the range of the pressure gage.

The bombs shall be constructed of metals or alloys that provide appropriate corrosion resistance properties. If necessary, the reactor's stirrer motor and heater assembly may need to be explosion-proof.

6.8.5.6 Sodium Azide

Sodium azide is a toxic, highly reactive, heat-sensitive, and potentially shock-sensitive material. Because it reacts with metals, Teflon or other nonmetal spatulas should be used with the material. It shall be used with appropriate personal protective gear.

Sodium azide should only be purchased in small quantities, ideally the minimum amount needed in the laboratory. Storage of solid sodium azide is strongly discouraged. Prepare stock solutions as soon as the material is delivered to the laboratory.

6.8.5.7 Organometallics

Organometallics are organic compounds comprised of a metal or nonmetal attached directly to carbon (RM). Examples are Grignard compounds and metallic alkyls such as triethylaluminum and trimethylindium. Many organometallics are highly toxic or flammable. Many are also water-reactive and spontaneously combustible in air. Trialkyltins are the most toxic as a group. Most are highly reactive chemically. Special firefighting equipment (e.g., dry chemical powder fire extinguisher) may be needed where organometallics are handled.

6.8.5.8 Hydrides

Hydrides are inorganic compounds composed of hydrogen and another element, often a metal. Examples include arsine (AsH_3), phosphine (PH_3), diborane (B_2H_6), germane (GeH_4), stibine (SbH_3), and silane (SiH_4). The listed hydrides are highly toxic and flammable. They react violently with water and oxidizing agents and pose a dangerous fire risk. Phosphine, diborane, and silane are spontaneously flammable in air.

Certain hydride gases, notably arsine and phosphine, are commonly used as dopants in semiconductor research applications. Arsine is one of the most toxic gases known. It is

a potent hemolytic agent (symptoms: red discoloration of the urine and sclera). Phosphine is extremely toxic to organs of high oxygen flow and demand. Thorough emergency planning for accidental releases shall be in place when such gases are to be used in the laboratory. Provision for continuous system monitoring for releases may be called for.

Exhaust streams of hydride gases shall be treated (e.g., scrubbing or thermal decomposition) before release. Inform EHS of the treatment procedures to be applied.

6.9 Chemical Waste Management (PSU Safety Policy [SY20](#) Hazardous Waste Disposal)

The University is required by regulation 25 PA Code Ch. 260 a - 262 a and by *Environmental Protection Agency regulation 40 CFR 260-262* to ensure the proper disposition of these wastes.

Proper handling of reaction byproducts, surplus and waste chemicals, and contaminated materials is an important part of safety procedures. Each worker is responsible for ensuring that wastes are handled in a manner that minimizes personal exposure and the potential for environmental contamination.

The first steps in managing chemical wastes are selecting the least hazardous chemicals for the task and ordering chemicals only in quantities really needed. Chemicals should not be kept in laboratories if they will not be needed, especially if they are peroxide-forming chemicals such as ethyl ether or dioxane, polynitro compounds such as picric acid or dinitrophenyl hydrazine, or chemicals that are air- or water-reactive.

PSU Safety Policy SY20:

A waste may be designated as a hazardous waste if it meets **one** of the following criteria:

Acute hazardous waste is a waste which has been found to be **fatal in humans** in low doses or, in the absence of data on humans, has been found to have, in laboratory animals:

(A) an oral LD50 of less than 50 mg/kg,

(B) an inhalation LC50 of less than 2 mg/l, or

(C) a dermal LD50 of less than 200 mg/kg.

- A waste is hazardous if it contains any of the toxic constituents listed in the regulations.
- A waste is hazardous if it exhibits any of the following characteristics:

(A) Ignitability

(C) Reactivity

B) Corrosivity

D) Toxicity

POLICY:

The Senior Vice President for Finance and Business establishes and approves the policy and procedure for hazardous waste disposal within the environment of The Pennsylvania State University. The basis for such policy and procedure shall be recommendations of the University Hazardous Waste Advisory Board. This Board shall review and recommend revisions to these procedures as appropriate.

Environmental Health and Safety shall be the University agency responsible for implementing and enforcing the established policy and procedure. This agency shall also be responsible for the coordination of all hazardous waste disposal efforts.

The Directors of Business Services, in conjunction with the individual hazardous waste generators at non-University Park locations, and the individual hazardous waste generators at University Park, shall be responsible for coordinating the collection of hazardous waste with Environmental Health and Safety.

The custody and disposition of all chemicals/materials obtained or produced by, for and/or resulting from experiments, research or purchase is the responsibility of the University employee and/of their organizational unit so pre-occupied. The organization's budget under which such chemicals/materials are obtained or produced may also be required to fund the analysis of such items which cannot be identified by their proper or generic name or are improperly labeled. All containers of chemicals/materials must be clearly identified and labeled as to their contents.

UNKNOWN OR IMPROPERLY LABELED CHEMICALS/MATERIALS WILL NOT BE ACCEPTED FOR DISPOSAL.

Normal hazardous waste disposal costs will be funded through Environmental Health and Safety.

Generators of hazardous waste are responsible to ensure the appropriate storage, labeling, inspection, auditing, documentation, and segregation of chemicals, and to provide and document training of all personnel involved in the handling of this waste.

The indiscriminate drain-disposal of chemicals/materials is not permitted. Drain disposal of chemical waste materials shall be permitted only with specific written approval by Environmental Health and Safety.

Departments that generate hazardous chemical wastes shall ensure that a waste reduction program is in effect and that it is being adhered to.

REDUCING HAZARDOUS MATERIALS:

To effect a reduction in the volume of hazardous waste generated at the University, as mandated by the Pennsylvania Department of Environmental Protection (PA DEP), and the Environmental Protection Agency (EPA), generators of hazardous waste shall minimize the volume or toxicity of their waste.

- Substitutions can be made to eliminate or reduce the amount of hazardous ingredients.
- Management practices can greatly reduce unnecessary waste generation. This includes the purchase of only the quantity of material anticipated to be used and establishing usage parameters for each chemical.
- Hazardous materials may be redistributed or returned. Often, surplus chemicals can be redistributed within the University or returned to the manufacturer. Lists of redistributable chemicals should be circulated among faculty and staff within work units or departments. Such a list should contain the following information:
 - chemical name,
 - amount,
 - manufacturer,
 - Purity, as stated on label, and
 - whether the container is unopened.

EHS maintains a listing of chemicals that are available for redistribution.

- Bulking of compatible chemicals. Environmental Health and Safety shall provide guidance in the consolidation of compatible chemicals. A significant reduction in disposal costs can be achieved in the bulking of these chemicals.
- Waste segregation. Mixing wastes **can be** hazardous; incompatible wastes can react - and explode. Wastes transported to the Chemical Waste Storage facility must be segregated to avoid these reactions. A further reduction in the costs for waste disposal can be achieved by reducing packaging time as compatible chemicals can be packed more efficiently. Chemicals should be segregated into the following categories: flammables, corrosives, poisons, and oxidizers.
- Integrate micro-scale techniques into organic and inorganic chemistry laboratory courses and research projects. These techniques can reduce chemical purchase costs and significantly reduce the quantities of waste chemicals for disposal. Use of micro-scale also reduces student and faculty exposure to toxic chemicals, carcinogens, flammables and explosives.

RESPONSIBILITIES:

Individuals responsible for laboratories and other areas which handle and store hazardous waste are required to:

1. Each room generating chemical waste must designate a location within the room for waste accumulation. This area is referred to as the "Accumulation Area."
2. Designate an individual who is responsible to oversee the proper storage, labeling and inspection of this Accumulation Area and who conducts weekly inspections of this area, documenting and maintaining the results of the inspection.
3. Ensure all laboratory personnel involved in chemical waste management are trained and documentation of training records is maintained.
4. Establish, implement and document an annual review of all hazardous materials to ensure those exceeding safe and practical usage are properly disposed of.
5. Incorporate waste disposal management practices into all procedures, including laboratory manuals used for instruction.
6. Conduct audits of waste management procedures as established in this policy to ensure compliance and implement the necessary changes.

Department heads/heads of administrative units are responsible to:

1. Prepare a written program description for compliance with this policy and designate an individual responsible for department-wide compliance.
2. Maintain a listing of accumulation areas and individuals responsible for oversight.
3. Maintain copies of training documents.
4. Conduct audits of waste management procedures within facilities under their jurisdiction as established in this policy to ensure compliance and implement the necessary changes.

Deans of Academic Colleges/Heads of Administrative Units are responsible to:

1. Designate a College/Unit-wide individual to oversee program.
2. Conduct audits of waste management procedures established in this policy to ensure compliance and implement the necessary changes.

PROCEDURES:

Collection and transportation of hazardous waste at University Park:

A laboratory or facility that has hazardous waste for disposal shall fill out a chemical pick up request available at www.ehs.psu.edu.

Environmental Health and Safety personnel will collect and transport the hazardous waste to the Chemical Accumulation Facility. Procedures for the collection of specially-arranged disposal activities will be established by EHS.

The spill or discharge of any hazardous material must be reported to Environmental Health and Safety at 865-6391 during regular working hours (8:00 a.m. to 5:00 p.m.). At other times and on weekends, the incident must be reported to University Police. Callers from 862, 863, and 865 telephones, dial 911; from other numbers, dial 863-1111. Environmental Health and Safety personnel will report to the site of the incident and provide guidance and direction in proper cleanup procedures, as deemed appropriate. They will provide or recommend appropriate equipment for the cleanup, and arrange for the proper disposal of the hazardous waste.

Disposal of hazardous waste at non-University Park locations (except Hershey Medical Center):

Other locations that have hazardous waste for disposal will forward a properly completed Chemical Waste Manifest Form to Environmental Health and Safety.

Environmental Health and Safety will arrange to have the hazardous waste picked up by a commercial vendor.

Penn State complies with U.S. and Pennsylvania Environmental Protection Agency regulations for disposal of hazardous chemical wastes and with U.S. and Pennsylvania Department of Transportation regulations for shipment to disposal sites. It is a federal and state offense to

dispose of chemicals improperly. EHS is responsible for disposal of chemicals and should be contacted to arrange the removal of chemical wastes.

6.9.1 Pickups

Chemical wastes are removed by EHS or a contracted vendor at non-University Park locations. To request a pickup, you must complete a Chemical Waste Pick-up Request on the EHS website, www.ehs.psu.edu. Chemicals shall not be brought directly to EHS. Chemical waste containers shall always be labeled with a red tag supplied by EHS with the complete chemical name. Abbreviations, trade names, or chemical formulas shall not be permitted. When materials have been added, the amount and concentration of constituents must be listed on the container tag.

Unused pesticides may be disposed of through the PDA program “CHEMSWEEP” or through EHS.

6.9.2 Sanitary Sewer Disposal (PSU Safety Policy - [Disposal of Pollutants in University Sanitary Systems \(SY40\)](#))

It is a violation of both safety and environmental regulations to pour chemicals down the drain unless they are treated or neutralized and local regulation allows them in the sanitary sewer system.

The management of hazardous waste is regulated at the federal level by the United States Environmental Protection Agency (EPA) under the authority of the Resource Conservation and Recovery Act (RCRA). At the state level, the Pennsylvania Department of Environmental Resources (PADEP) also regulates the disposal of hazardous waste. These regulations are contained in 25 PA Code Chapter 262a.

In accordance with these regulations, “the indiscriminate drain-disposal of chemicals/materials” is prohibited, see PSU policy SY40 Disposal of Pollutants in University Sanitary Systems.

Inappropriate disposal of certain chemicals into the sanitary sewer system may create a variety of hazards including the following:

- Fire and/or explosion hazards within the drain system.
- Inadvertent mixing, within the drain system, of incompatible chemicals from different laboratories.
- Corrosion of drainpipes.
- Chemical exposure hazards to plumbers.
- Escape of volatile, toxic and/or malodorous substances.
- Biocidal action on microorganisms that are necessary for the normal and effective operation of our waste water treatment plant.

- Addition of unacceptable amounts of toxic substances (e.g., certain heavy metals) to our sewage sludge and effluent.

6.9.3 Treatment

To reduce chemical hazard, the last step of an experiment may involve chemical treatment. All methods of treatment require advance approval by EHS. Generally, only neutralization of inorganic acids and bases is acceptable. Federal regulations and University policy require investigators to make every effort to minimize the amount and toxicity of waste removed from University facilities.

6.9.4 Storage

Storage of waste chemicals shall include separation of incompatible materials, as in "Chemical Storage," Section 6.0. Separate organic and inorganic chemicals.

Waste containers shall be capped at all times and uncapped only for addition of more waste.

When the amount of flammable liquid present in a laboratory is calculated, flammable waste volumes shall be included. All stored waste containers must be properly labeled.

6.9.5 Containers

Chemically contaminated laboratory waste is stored in plastic tubs supplied by EHS to prevent its being inadvertently placed in the trash and to provide secondary containment. All containers shall be sealed and properly labeled prior to pickup. The container must be compatible with the chemical waste.

6.9.6 Collection of Sharps

Chemically contaminated sharps such as broken glass, syringes, pipettes, and razors shall be collected in sturdy, rigid, puncture-resistant containers for proper disposal. Plastic bags are not suitable for the collection of sharps as they provide those handling the bags with no protection from needlesticks or cuts.

Keep in mind that the sharps containers will be handled by a number of individuals before final disposal. It is the responsibility of the sharps users to ensure that the packaging of the waste does not pose a hazard for providers of disposal service. For information concerning suppliers of suitable sharps containers, consult EHS.

6.9.7 Mixed Waste

Mixed waste is any waste that contains radioactive material and also one or more hazardous chemical or biological components. Generators shall contact EHS **prior** to generating a mixed waste. Special requirements govern the disposal of such waste. Disposal of some mixed waste is prohibited by law. Generation of mixed waste in a university laboratory could jeopardize the University's compliance with federal regulations. Potential mixed-waste generation must be addressed in the **planning** stage of any experiment that will create mixed waste.

6.9.8 Waste Minimization

The Environmental Protection Agency's regulations and PSU Safety Policy [SY20](#) for hazardous waste management place the highest priority on waste minimization. Under current environmental laws, the University must certify that it has a waste minimization program in place. In addition, the University must annually report to the government on efforts it has made to reduce hazardous wastes.

Waste minimization as defined by the EPA means a reduction in both the volume and physical hazard or toxicity of the material. The benefits of waste minimization include reduced disposal costs, decreased liability, improved working conditions, and less impact on the environment at the time of disposal.

The waste minimization policy at the University requires investigators to make every effort to minimize the volume or the toxicity of their waste. Substitutions can be made to eliminate or reduce the amount of hazardous components. Wastes can be minimized by treatment in the lab to yield less toxic or hazardous materials. Experimental procedures can also be altered to reduce wastes. Finally, improved laboratory management can result in waste minimization.

It is the responsibility of every investigator who generates waste to incorporate the principles of waste minimization into experimental design. EHS can help evaluate procedures for potential waste minimization benefits.

6.10 Nanomaterials*

Exposure standards have not been established for engineered nanoparticles in the United States or internationally [Safe Nanotechnology 2008.] Until more definitive findings are made regarding the potential health risks of handling nanomaterials, researchers planning to work with nanomaterials must implement a combination of engineering controls, work practices, and personal protective equipment to minimize potential exposures to themselves and others. For a quick guide to the exposure risks and prudent control measures to be used for common laboratory operations involving nanomaterials, refer to the table below. It is important to consider if the nanoparticles are in an agglomerated or aggregated form, functionalized, suspended in liquid, or bound, as these conditions may affect the exposure potential.

6.10.1 Engineering Controls:

Use glove bags, glove boxes, fume hoods, or other containment or exhausted enclosures when there is a potential for aerosolization, such as: handling powders; creating nanoparticles in gas phase; pouring or mixing liquid media which involves a high degree of agitation. (DO NOT use horizontal laminar flow hoods (clean benches), as these devices direct the air flow towards the worker.) *Consult with EH&S if engineering controls are not feasible.*

Use fume hoods or other local exhaust devices to exhaust tube furnaces and or chemical reaction vessels.

Perform any maintenance activities, such as repair to equipment used to create nanomaterials or cleaning/replacement of dust collection systems, in fume hoods or under appropriate local exhaust.

6.10.2 Work Practices:

Selection of Nanomaterials:

Whenever possible, handle nanomaterials in solutions or attached to substrates to minimize airborne release.

Consult the Safety Data Sheet (SDS), if available, or other appropriate references prior to using a chemical or nanomaterial with which you are unfamiliar. Note: Information contained in some SDSs may not be fully accurate and/or may be more relevant to the properties of the bulk material rather than the nano-size particles.

Safety Equipment:

Know the location and proper use of emergency equipment, such as safety showers, fire extinguishers, and fire alarms.

Hygiene:

Do not consume or store food and beverages, or apply cosmetics where chemicals or nanomaterials are used or stored since this practice increases the likelihood of exposure by ingestion.

Do not use mouth suction for pipetting or siphoning.

Wash hands frequently to minimize potential chemical or nanoparticle exposure through ingestion and dermal contact.

Remove gloves when leaving the laboratory, so as not to contaminate doorknobs, or when handling common use objects such as phones, multiuser computers, etc.

Labeling and Signage:

Store in a well-sealed container, preferably one that can be opened with minimal agitation of the contents.

Label all chemical containers with the identity of the contents (avoid abbreviations/ acronyms); include term "nano" in descriptor (e.g., "nano-zinc oxide particles" rather than just "zinc oxide." Hazard warning and chemical concentration information should also be included, if known.

Use cautious judgment when leaving operations unattended: i) Post signs to communicate appropriate warnings and precautions, ii) Anticipate potential equipment and facility failures, and iii) Provide appropriate containment for accidental release of hazardous chemicals.

Cleaning:

Wet wipe and or HEPA-vacuum work surfaces regularly.

Transporting:

Use sealed, double-contained container when transporting nanomaterials inside or outside of the building.

Buddy System:

Communicate with others in the building when working alone in the laboratory; let them know when you arrive and leave. Avoid working alone in the laboratory when performing high-risk operations.

6.10.3 Personal Protective Equipment:

Wear gloves, lab coats, safety goggles, long pants, closed-toe shoes, and face shields, as appropriate dependent on the nature of the materials and procedure.

If work cannot be conducted inside a fume hood or other ventilated enclosure, consult with EHS 814/865-6391 regarding the need for respiratory protection or other alternative controls.

6.10.4 Training:

Ensure that researchers have both general safety training and lab-specific training relevant to the nanomaterials and associated hazardous chemicals used in the process/experiment.

Lab-specific training can include a review of this safety fact sheet, the relevant Safety Data Sheets (if available), and the lab's Standard Operating Procedure for the experiment.

6.10.5 Standard Operating Procedures:

Prepare a Standard Operating Procedure (SOP) for operations involving nanomaterials. A general use Standard Operating Procedure for working with nanomaterials is available in below. The SOP should be tailored to be specific to the proposed experimental procedure.

Consider the hazards of the precursor materials in evaluating the process.

Special consideration should be given to the high reactivity of some nanopowders with regard to potential fire and explosion. [Pritchard 2004].

6.10.6 Consultation:

Consult with your Principal Investigator prior to procuring or working with nanomaterials. For additional assistance, contact EHS 814/865-6391.

TABLE 6.11 QUICK GUIDE: EXPOSURE RISKS AND CONTROL MEASURES FOR COMMON LABORATORY OPERATIONS INVOLVING NANOMATERIALS

| Activity types, by Risk of Exposure | Primary Control Measures |
|---|---|
| <p>Low Probability:</p> <ul style="list-style-type: none"> • Non-destructive handling of solid nanoparticle composites or nanoparticles permanently bonded | <ul style="list-style-type: none"> • Disposable nitrile or PVC gloves. Do not reuse gloves. • Wet cleaning procedures and/or HEPA vacuum for surfaces/equipment. |
| <p>Medium / High Probability:</p> <ul style="list-style-type: none"> • Working w/ nanomaterials in liquid media during pouring or mixing, or where a high degree of agitation is involved (e.g., sonication) • Handling nanostructured powders* • High speed abrading/grinding nano-composite materials • Maintenance on equipment used to produce nanomaterials • Cleaning of dust collection systems used to capture nanoparticles | <ul style="list-style-type: none"> • Conduct task within a fully enclosed system (e.g., glovebox), or fume hood • Disposable gloves appropriate for the solvent in which the particles are suspended. Do not reuse gloves. • Safety eyewear (+ face shield if splash potential exists) • Wet cleaning procedures for surfaces/equipment |
| <p>High Probability:</p> <ul style="list-style-type: none"> • Generating nanoparticles in the gas phase or in aerosol (spill or liquid) • Manipulation of nanoparticles in gas stream | <ul style="list-style-type: none"> • Work in enclosed systems only (e.g., glovebox, glovebag, or sealed chamber). |

* EH&S recognizes that low-density nanomaterials (e.g., carbon-based) become aerosolized by even the slightest air movement and may not be practical when weighed or handled in laboratory fume hoods. Consult with EH&S on alternative sets of controls.

Standard Operating Procedure Template for the Laboratory Use of Nanomaterials

| | |
|---|---|
| #1 | Contact Information: |
| Procedure Title | |
| Procedure Author | |
| Date of Creation/Revision | |
| Name of Responsible Person (<i>The PI, Lab Supervisor, or Autonomous Researcher</i>) Work phone: e-mail: | |
| Location of Work (building/lab #) | |
| #2 | Process or Experiment Overview: <i>Description of the process or experiment that the SOP covers. This process may be described in general terms, such as cleaning and purification of single walled carbon nanotubes.</i> |
| | |
| Frequency: | <input type="checkbox"/> one time <input type="checkbox"/> daily <input type="checkbox"/> weekly <input type="checkbox"/> monthly <input type="checkbox"/> other: _____ |
| Duration per Expt: | _____ minutes; or _____ hours |
| #3 | Risk Assessment: <i>Identify potential chemical and safety hazards. Special consideration should be given to the high reactivity of some nanopowders with regard to potential fire and explosion. Consider the hazards of the precursor materials in evaluating the process.</i> |

#4

Controls: *(Check those that apply to the risks and procedures for the work that will be done)*

#4a Engineering/Ventilation Controls:

| Engineering Controls | Activity type |
|---|---|
| <input type="checkbox"/> General laboratory ventilation | <ul style="list-style-type: none">• Non-destructive handling of solid nanoparticle composites or nanoparticles permanently bonded to a substrate |
| <input type="checkbox"/> Laboratory fume hood; or <input type="checkbox"/> Exhausted enclosure | <ul style="list-style-type: none">• Working w/ nanomaterials in liquid media during pouring or mixing, or where a high degree of agitation is involved (e.g., sonication)• Handling nanostructured powders*• Maintenance on equipment used to produce nanomaterials• Cleaning of dust collection systems used to capture nanoparticles |
| <input type="checkbox"/> Glove box; or <input type="checkbox"/> Other sealed enclosure | <ul style="list-style-type: none">• Generating nanoparticles in the gas phase or in aerosol• Manipulation of nanoparticles in gas stream |

**If work cannot be conducted with appropriate engineering controls, consult with EHS 814/865-6391.*

#4b Personnel Protective Equipment:

- gloves; indicate type: _____
- safety goggles face shield lab coats other: _____
- appropriate street clothing

Respiratory protection is generally not required for lab research, provided the appropriate engineering controls are employed. For additional guidance on respiratory protection, consult with EHS, 814/865-6391.

#4c Location of Nearest Emergency Safety Equipment:

| Item: | Location: |
|--------------------------------|-----------|
| Eyewash/Safety Shower | |
| First Aid Kit | |
| Chemical Spill Kit | |
| Fire Extinguisher | |
| Telephone | |
| Fire Alarm Manual Pull Station | |

#5 **Step-By-Step Operating Procedure:** *Provide a sequential description of work, including details such as chemical concentrations and when special safety equipment is to be utilized. Clearly label areas where nanomaterials are used.*

| | |
|--|---------------------------------------|
| | |
| #6 | Decontamination: |
| <ul style="list-style-type: none">• Upon leaving the nanomaterial work area, remove any personal protective equipment worn and wash hands, forearms, face, and neck.• After each use (or day), wipe down and or HEPA vacuum the immediate work area and equipment to prevent accumulation of nanoparticles. | |
| #7 | Spill and Accident Procedures: |

Health Threatening Emergencies (ex. Fire Explosion, Serious Injury, or other Immediate Danger)

1. CALL 911
2. Alert people in the vicinity, activate local alarm systems.
3. Evacuate the area.
4. REMAIN NEARBY TO ADVISE EMERGENCY RESPONDERS.
5. Once personal safety is established, call EHS at **814/865-6391**

If Personnel Exposed:

1. Remove exposed/contaminated individual(s) from area, unless unsafe to do so because of (a) medical condition of victim(s), or (b) potential hazard to rescuer(s).
2. If immediate medical attention is required, notify 911
3. Notify EHS to report the potential exposure by calling **814/865-6391**.
4. Administer First Aid as appropriate.
5. Flush contamination from eyes/skin using the nearest emergency eyewash /shower for a minimum of 15 minutes. Remove any contaminated clothing.
6. Take copy of SDS(s) of chemical(s) to hospital with victim.
7. Contact EHS 814/865-639 for follow-up.

Non-Health Threatening Emergencies (ex. spills requiring cleanup assistance)

In the event of a spill or release, which may or has impacted the environment (storm drain, soil, air outside the building), or spill or release that cannot be cleaned up by local personnel:

1. Notify EHS **814/865-639, during nights and weekends contact 863-1111 and EHS staff will be contacted.**
2. **Provide local notifications to your supervisor.**

Small Spills/Local Cleanup:

In the event of a minor spill or release that can be cleaned up by local personnel using readily available equipment (absorbent):

1. Notify personnel in the area and restrict access. Eliminate all sources of ignition.
2. Review the SDS for the spilled material, or use your knowledge of the hazards of the material to determine the appropriate level of protection.
3. Wearing appropriate Personal Protective Equipment, clean up spill involving nanomaterials using wet methods and/or HEPA vacuum. **DO NOT SWEEP SPILLED OR DRIED NANOMATERIALS.** Collect spill cleanup materials in a tightly closed container. Manage spill cleanup debris as Hazardous Waste.
4. **Submit on-line waste pickup request to EHS.**

#8 Waste Disposal:

- Manage nanoparticle wastes, including contaminated lab debris, as a part of your normal laboratory Hazardous Waste stream.
- Collect and store waste materials in a tightly closed container. Include information describing the base nanoparticle materials on the waste tag.

#9 Training Requirements:

General Training

- Chemical and Hazardous Waste handling
- Other: _____

| | |
|---|--|
| Location Where Records Maintained: | |
| Laboratory-specific training (<i>check all that apply</i>): | |
| <input type="checkbox"/> Review of SDS for Nanomaterial (if available) | |
| <input type="checkbox"/> Review of SDS for other chemicals involved in process/experiment | |
| <input type="checkbox"/> Review of this SOP | |
| <input type="checkbox"/> Other: _____ | |
| Location Where Records Maintained: | |

*Nanomaterial information is courtesy of Stanford University and Larry Gibbs

6.11 CONTROLLED SUBSTANCES IN RESEARCH

6.11.1 Introduction

The University must ensure that research activities that involve controlled substances (also referred to as drugs or pharmaceuticals) are done in compliance with federal and state laws. These materials must be stored in a manner that prevents theft or diversion. This information does not apply to licensed physicians, pharmacists, or veterinarians who are licensed differently by the DEA.

6.11.2 Licensing

All faculty and staff who wish to work with controlled substances must be licensed by the Drug Enforcement Administration (DEA, a division of the Department of Justice) to do so. The University does not have a blanket license to cover purchases of such materials. Information on applying for a license (DEA Form 225) is available at:

http://www.dea.gov/divisions/office-of-regulatory-affairs/225/225_instruct.htm#6

Information on various drug schedules is available at:

http://www.dea.gov/divisions/office-of-regulatory-affairs/225/225_instruct.htm#3d

In addition to the application form, faculty and staff will need to provide the DEA with the following:

- The applicant's social security number.
- The applicant's curriculum vitae.

- A copy of the research protocol summarizing the procedures to be performed using controlled substances, including specific information on monitoring drug usage, inventory control, destruction, security, storage and access to the material.
- Names of all persons who will have access to the controlled substances or records.

Note that the State of Pennsylvania does not issue licenses for the use of controlled substances (a question often asked on the application or by the DEA).

6.11.3 Renewal of License

License holders will be notified by U.S. Mail prior to the expiration of their DEA license. If continued work with controlled substances is anticipated, licensees are strongly encouraged not to let their license expire.

6.11.4 Storage

Controlled substances must be stored in a manner that prevents theft or diversion of the material. Schedule I materials (those with a high potential for diversion AND a high potential for abuse) must be stored in a locked safe; Schedule 2-5 materials must be stored in a substantially constructed cabinet that is locked at all times and cannot be easily removed from the lab/office. The location of the safe or cabinet should have limited access during normal working hours and be secured after hours. The licensee should maintain a list of all persons who are authorized to have access to controlled substances.

6.11.5 Ordering

Ordering controlled substances requires a DEA license. DEA form 222 is the paper-based form used to order these materials. It is available at:

<https://www.deadiversion.usdoj.gov/webforms/orderFormsRequest.jsp>

This form is required to order Schedule I or II controlled substances. Schedule III-V drugs do not require the use of DEA form 222, but still require a DEA license number.

6.11.6 Recordkeeping

Licensees must maintain detailed inventory records as specified in [21CFR1304.03](#). All records must be maintained for at least two years, and five years is advisable. Records should include purchasing records, which can be an invoice, shipping papers, or a packing slip, and must contain: the name, address and DEA number of the company where the controlled substance was purchased, the name of the controlled substance purchased, the size and strength of the controlled substance purchased, the amount purchased, and the date of receipt (which may be hand-written). Usage records must include the date that the material is used, the initials of the person dispensing on behalf of the licensee, the name of the controlled substance, the strength and size of the

controlled substance, and the amount dispensed. Records for Schedule I and II drugs must be kept separately from records for Schedule III – V material.

Complete inventory requirements can be found at [21CFR1304.11](#). In addition to these specific requirements, additional general requirements include:

A separate sheet must be used for each compound. The sheet must list the date, amount of receipt, source of the material, and fate of the material (i.e., destroyed in chemical reaction, neutralized, disposed of through EHS, etc.). Each licensee must be able to account for all of any given compound that they are licensed to work with (i.e., licensees must know the amount they have on hand at any given date). The inventory must be updated at least annually, and whenever materials are removed from their original container.

6.11.7 Disposal

Unwanted or outdated controlled substances should be disposed of through Environmental Health and Safety (EHS). The material will be disposed of through a hazardous waste vendor who is licensed to provide disposal services. EHS will provide the licensee with written documentation of the destruction of the material for their records.

6.11.8 Contacting the DEA

PITTSBURGH DISTRICT OFFICE

1781 McKees Rocks Road
Pittsburgh, PA 15136

Diversion and Registration Number: (412) 777-1870

Diversion and Registration Fax: (412) 777-1880

Jurisdiction: Western Pennsylvania (zip codes 150 to 168)

PHILADELPHIA DIVISION
William J. Green Federal Building
600 Arch Street, Room 10224
Philadelphia, PA 19106

Diversion Number: (215) 238-5160

Diversion Fax: (215) 238-5170

Diversion Program Manager - Donetta Spears

Jurisdiction: Delaware and Eastern Pennsylvania

7.0 BIOLOGICAL AGENTS

7.1 General

Many laboratory practices and requirements are common to laboratories using chemicals and handling biological agents. The use of Biological Agents, especially Biohazards, is regulated by University Policy SY-24. The laboratory procedures described in Section 5.0, "General Safety," and Section 6.0, "Chemical Hazards," also apply to laboratories using biological agents, and that information will not be repeated in this part. Most of the information in this section is taken from the book Biosafety in Microbiological and Biomedical Laboratories (National Research Council, 2009). A copy of the book is available for reference in EHS.

Biological agent hazards in the laboratory are relatively well defined, especially in the case of conventional disease-producing agents. Major exceptions to this general observation are oncogenic agents and "slow virus" infections.

Broadly speaking, two major risk situations can be identified. In the first, known agents are used and are integral to scientific research or teaching; in the second, potentially harmful biological agents are endogenous to humans or laboratory animals or to animal tissues or fluids. Examples of these are zoonotic infections in animal handlers, viral contaminants in human tissues and cell cultures, and lymphocytic or choriomeningitis-infected animal tumor lines.

Other issues that do not relate specifically to personal safety but should be considered include work with agents that infect lower animals and plants, especially if an accident could seriously jeopardize the agricultural sector of the economy. The possibility of cross-contamination by infectious agents in laboratory animals and media preparation areas can also be a significant problem, especially in common resource facilities.

7.2 Responsibilities

7.2.1 General

The responsibilities of the department head, principal investigator, and others working with biological hazards include all those described in Section 2.0 of this document. Additional responsibilities specific to the handling of biological agents include selecting safety practices based on awareness of the particular hazard and training all personnel accordingly.

7.2.2 Institutional Biosafety Committee Application

A principal investigator wishing to use a biological agent in research shall complete an Institutional Biosafety Committee Application form, which may be obtained from the Office for Research Protections ([ORP](#)). ORP determines the biosafety level of the agent, notifies the principal investigator of the biosafety level, and then the laboratory space is inspected for compliance.

7.3 Containment Methods

The term **containment** is used to describe safe methods for managing infectious agents in the laboratory environment. The purpose of containment is to reduce exposure of laboratory workers and others to potentially hazardous agents and to prevent their escape into the outside environment. The three elements of containment are laboratory practice and technique, safety equipment, and facility design.

7.3.1 Laboratory Practice

The most important element of containment is strict adherence to standard microbiological practices and techniques. Persons working with infectious agents or infected materials shall be aware of potential hazards and shall be trained and proficient in the practices and techniques required for safely handling such material. When standard laboratory practices are not sufficient to control the hazard associated with a particular agent or laboratory procedure, additional measures may be needed involving safety equipment and facility design.

7.3.2 Safety Equipment (Primary Barriers)

Safety equipment includes biological safety cabinets, enclosed containers, and other engineering controls designed to prevent or minimize exposures to hazardous biological materials. The use of vaccines may in some cases provide an increased level of personal protection.

7.3.2.1 Biological Safety Cabinets

The biological safety cabinet is the principal device used to provide containment of infectious splashes or aerosols. There are three types of biological safety cabinets: Class I, Class II, and Class III.

Class I is an open-fronted, negative-pressure, vented cabinet with HEPA-filtered exhaust. It may be equipped with a front closure and gloves for use as a glove box. The inward face velocity is 75 feet per minute. Suitable for work with low- or moderate-risk biological agents, it provides protection for personnel and the environment but not for the product.

Class II cabinets are open-fronted laminar-flow cabinets with an inward face velocity of 75 linear feet per minute. Class II design resembles that of a fume hood but with HEPA-filtered, recirculated mass airflow within the workspace. Exhaust air is also filtered. Class II cabinets provide protection for personnel, product, and the environment. They are designed for work with low- or moderate-risk biological agents.

Class III cabinets provide the highest level of protection. Class III is a totally enclosed glove-box cabinet of gas-tight construction. The cabinet is maintained under negative air pressure of at least 0.5 inches of water gauge. Supply air is drawn into the cabinet through HEPA filters, and the exhaust air is filtered by two

HEPA filters in series before it is discharged to the outside. Generally, the ventilation system is separate from the facility's ventilation system. Class III cabinets are suitable for high-risk biological agents.

Biological safety cabinets used to protect workers from hazardous biological agents shall be tested and certified after installation and before use, any time they are moved, and at least annually. The department head shall provide annual certification and maintain certification records for the department. Testing shall meet the criteria in National Sanitation Foundation Standard Number 49. Call EHS for information on the standard and a list of companies qualified to certify biological safety cabinets.

7.3.2.2 Other Safety Equipment

Other safety equipment includes enclosed containers. An example of an enclosed container is the safety centrifuge cap, designed to prevent release of aerosols during centrifugation.

Safety equipment also includes personal protective clothing and equipment such as gloves, coats, gowns, shoe covers, boots, respirators, face masks or shields, and safety glasses or goggles. This clothing and equipment is generally used in combination with biological safety cabinets and other devices that contain the agents, animals, or materials being worked with.

In some situations in which it is impractical to work in biological safety cabinets, personal protective devices may form the primary barrier between personnel and the infectious materials. Examples of such situations include certain animal studies, animal necropsy, and activities relating to maintenance, service, or support of the laboratory facility. Consult with EHS to develop specific safety procedures.

7.3.3 Secondary Barriers

Secondary barriers protect the environment within the facility and outside the laboratory from exposure to infectious materials. The design of the facility provides the secondary barrier. The three facility designs are the basic laboratory, the containment laboratory, and the maximum containment laboratory.

The Basic Laboratory provides general space where work is done with viable agents that are not associated with disease in healthy adults; it includes Biosafety Levels 1 and 2 facilities. This laboratory is also appropriate for work with infectious agents or potentially infectious materials when the hazard levels are low and laboratory personnel can be adequately protected by standard laboratory practice. While work is commonly conducted on the open bench, certain operations are confined to biological safety cabinets. Conventional laboratory designs are adequate.

The Containment Laboratory has special engineering features that enable laboratory workers to handle hazardous materials without endangering themselves, the community, or the environment. The containment laboratory is described as a Biohazard Level 3 facility. The features that distinguish this laboratory from the basic laboratory are the provisions for access control and a

specialized ventilation system. In all cases, a controlled access zone separates the laboratory from areas open to the public.

The Maximum Containment Laboratory has special engineering and containment features that allow laboratory workers to safely conduct activities involving infectious agents that are extremely hazardous to humans or capable of causing serious epidemic disease. The maximum containment laboratory is described as a Biosafety Level 4 facility; it is not applicable to activities at the University.

7.4 Biosafety Levels

The following guidelines are recommended by the Centers for Disease Control and Prevention and the National Institutes of Health and have been adopted as required procedure at the University. They are drawn from the book Biosafety in Microbiological and Biomedical Laboratories (Government Printing Office ISBN # 978-0-085042-4, Centers for Disease Control and Prevention, and National Institutes of Health, 2009).

7.4.1 Biosafety Level 1

Biosafety Level 1 is suitable for work involving well-characterized agents not known to consistently cause disease in immunocompetent adult humans, and present minimal potential hazard to laboratory personnel and the environment. BSL-1 laboratories are not necessarily separated from the general traffic patterns in the building. Work is typically conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is not required, but may be used as determined by appropriate risk assessment. Laboratory personnel must have specific training in the procedures conducted in the laboratory and must be supervised by a scientist with training in microbiology or a related science.

The following standard practices, safety equipment, and facility requirements apply to BSL-1.

7.4.1.1 Standard Microbiological Practices

1. The laboratory supervisor must enforce the institutional policies that control access to the laboratory.
2. Persons must wash their hands after working with potentially hazardous materials and before leaving the laboratory.
3. Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human consumption must not be permitted in laboratory areas. Food must be stored outside the laboratory area in cabinets or refrigerators designated and used for this purpose.
4. Mouth pipetting is prohibited; mechanical pipetting devices must be used.

5. Policies for the safe handling of sharps, such as needles, scalpels, pipettes, and broken glassware must be developed and implemented. Whenever practical, laboratory supervisors should adopt improved engineering and work practice controls that reduce risk of sharps injuries. Precautions, including those listed below, must always be taken with sharp items.
These include:
 - a. Careful management of needles and other sharps are of primary importance. Needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal.
 - b. Used disposable needles and syringes must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal.
 - c. Non-disposable sharps must be placed in a hard walled container for transport to a processing area for decontamination, preferably by autoclaving.
 - d. Broken glassware must not be handled directly. Instead, it must be removed using a brush and dustpan, tongs, or forceps. Plastic ware should be substituted for glassware whenever possible.
6. Perform all procedures to minimize the creation of splashes and/or aerosols.
7. Decontaminate work surfaces after completion of work and after any spill or splash of potentially infectious material with appropriate disinfectant.
8. Decontaminate all cultures, stocks, and other potentially infectious materials before disposal using an effective method. Depending on where the decontamination will be performed, the following methods should be used prior to transport.
 - a. Materials to be decontaminated outside of the immediate laboratory must be placed in a durable, leak proof container and secured for transport.
 - b. Materials to be removed from the facility for decontamination must be packed in accordance with applicable local, state, and federal regulations.
9. A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents are present. The sign may include the name of the agent(s) in use, and the name and phone number of the laboratory supervisor or other responsible personnel. Agent information should be posted in accordance with the institutional policy.
10. An effective integrated pest management program is required. (See Appendix G.)
11. The laboratory supervisor must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures.

Personnel must receive annual updates or additional training when procedural or policy changes occur. Personal health status may impact an individual's susceptibility to infection, ability to receive immunizations or prophylactic interventions. Therefore, all laboratory personnel and particularly women of childbearing age should be provided with information regarding immune competence and conditions that may predispose them to infection. Individuals having these conditions should be encouraged to self-identify to the institution's healthcare provider for appropriate counseling and guidance.

7.4.1.2 Special Practices

None required.

7.4.1.3 Safety Equipment (Primary Barriers and Personal Protective Equipment)

1. Special containment devices or equipment, such as BSCs, are not generally required.
2. Protective laboratory coats, gowns, or uniforms are recommended to prevent contamination of personal clothing.
3. Wear protective eyewear when conducting procedures that have the potential to create splashes of microorganisms or other hazardous materials. Persons who wear contact lenses in laboratories should also wear eye protection.
4. Gloves must be worn to protect hands from exposure to hazardous materials. Glove selection should be based on an appropriate risk assessment. Alternatives to latex gloves should be available. Wash hands prior to leaving the laboratory. In addition, BSL-1 workers should:
 - a. Change gloves when contaminated, glove integrity is compromised, or when otherwise necessary.
 - b. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory.
 - c. Do not wash or reuse disposable gloves. Dispose of used gloves with other contaminated laboratory waste. Hand washing protocols must be rigorously followed.

7.4.1.4 Laboratory Facilities (Secondary Barriers)

1. Laboratories should have doors for access control.
2. Laboratories must have a sink for hand washing.
3. The laboratory should be designed so that it can be easily cleaned. Carpets and rugs in laboratories are not appropriate.

4. Laboratory furniture must be capable of supporting anticipated loads and uses. Spaces between benches, cabinets, and equipment should be accessible for cleaning.
 - a. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals.
 - b. Chairs used in laboratory work must be covered with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.
5. Laboratories windows that open to the exterior should be fitted with screens.

7.4.2 Biosafety Level 2

Biosafety Level 2 builds upon BSL-1. BSL-2 is suitable for work involving agents that pose moderate hazards to personnel and the environment. It differs from BSL-1 in that: 1) laboratory personnel have specific training in handling pathogenic agents and are supervised by scientists competent in handling infectious agents and associated procedures; 2) access to the laboratory is restricted when work is being conducted; and 3) all procedures in which infectious aerosols or splashes may be created are conducted in BSCs or other physical containment equipment.

The following standard and special practices, safety equipment, and facility requirements apply to BSL-2.

7.4.2.1 Standard Microbiological Practices

1. The laboratory supervisor must enforce the institutional policies that control access to the laboratory.
2. Persons must wash their hands after working with potentially hazardous materials and before leaving the laboratory.
3. Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human consumption must not be permitted in laboratory areas. Food must be stored outside the laboratory area in cabinets or refrigerators designated and used for this purpose.
4. Mouth pipetting is prohibited; mechanical pipetting devices must be used.
5. Policies for the safe handling of sharps, such as needles, scalpels, pipettes, and broken glassware must be developed and implemented. Whenever practical, laboratory supervisors should adopt improved engineering and work practice controls that reduce risk of sharps injuries. Precautions, including those listed below, must always be taken with sharp items. These include:
 - a. Careful management of needles and other sharps are of primary importance. Needles must not be

bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal.

- b. Used disposable needles and syringes must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal.
 - c. Non-disposable sharps must be placed in a hard walled container for transport to a processing area for decontamination, preferably by autoclaving.
 - d. Broken glassware must not be handled directly. Instead, it must be removed using a brush and dustpan, tongs, or forceps. Plastic ware should be substituted for glassware whenever possible.
6. Perform all procedures to minimize the creation of splashes and/or aerosols.
 7. Decontaminate work surfaces after completion of work and after any spill or splash of potentially infectious material with appropriate disinfectant.
 8. Decontaminate all cultures, stocks, and other potentially infectious materials before disposal using an effective method. Depending on where the decontamination will be performed, the following methods should be used prior to transport:
 - a. Materials to be decontaminated outside of the immediate laboratory must be placed in a durable, leak proof container and secured for transport.
 - b. Materials to be removed from the facility for decontamination must be packed in accordance with applicable local, state, and federal regulations.
 9. A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents are present. Posted information must include: the laboratory's biosafety level, the supervisor's name (or other responsible personnel), telephone number, and required procedures for entering and exiting the laboratory. Agent information should be posted in accordance with the institutional policy.
 10. An effective integrated pest management program is required. (See Appendix G.)
 11. The laboratory supervisor must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures. Personnel must receive annual updates or additional training when procedural or policy changes occur. Personal health status may impact an individual's susceptibility to infection, ability to receive immunizations or prophylactic interventions. Therefore, all laboratory personnel and particularly women of childbearing age should be provided with information regarding immune competence and conditions that may predispose them to infection. Individuals having these conditions should be encouraged to self-identify to the institution's healthcare provider for appropriate counseling and guidance.

7.4.2.2 Special Practices

1. All persons entering the laboratory must be advised of the potential hazards and meet specific entry/exit requirements.
2. Laboratory personnel must be provided medical surveillance, as appropriate, and offered available immunizations for agents handled or potentially present in the laboratory.
3. Each institution should consider the need for collection and storage of serum samples from at-risk personnel.
4. A laboratory-specific biosafety manual must be prepared and adopted as policy. The biosafety manual must be available and accessible.
5. The laboratory supervisor must ensure that laboratory personnel demonstrate proficiency in standard and special microbiological practices before working with BSL-2 agents.
6. Potentially infectious materials must be placed in a durable, leak proof container during collection, handling, processing, storage, or transport within a facility.
7. Laboratory equipment should be routinely decontaminated, as well as, after spills, splashes, or other potential contamination.
 - a. Spills involving infectious materials must be contained, decontaminated, and cleaned up by staff properly trained and equipped to work with infectious material.
 - b. Equipment must be decontaminated before repair, maintenance, or removal from the laboratory.
8. Incidents that may result in exposure to infectious materials must be immediately evaluated and treated according to procedures described in the laboratory biosafety manual. All such incidents must be reported to the laboratory supervisor. Medical evaluation, surveillance, and treatment should be provided and appropriate records maintained.
9. Animal and plants not associated with the work being performed must not be permitted in the laboratory.
10. All procedures involving the manipulation of infectious materials that may generate an aerosol should be conducted within a BSC or other physical containment devices.

7.4.2.3 Safety Equipment (Primary Barriers and Personal Protective Equipment)

1. Properly maintained BSCs, other appropriate personal protective equipment, or other physical containment devices must be used whenever:

- a. Procedures with a potential for creating infectious aerosols or splashes are conducted. These may include pipetting, centrifuging, grinding, blending, shaking, mixing, sonicating, opening containers of infectious materials, inoculating animals intranasally, and harvesting infected tissues from animals or eggs.
 - b. High concentrations or large volumes of infectious agents are used. Such materials may be centrifuged in the open laboratory using sealed rotor heads or centrifuge safety cups.
2. Protective laboratory coats, gowns, smocks, or uniforms designated for laboratory use must be worn while working with hazardous materials. Remove protective clothing before leaving for non-laboratory areas, e.g., cafeteria, library, and administrative offices). Dispose of protective clothing appropriately, or deposit it for laundering by the institution. It is recommended that laboratory clothing not be taken home.
 3. Eye and face protection (goggles, mask, face shield or other splatter guard) is used for anticipated splashes or sprays of infectious or other hazardous materials when the microorganisms must be handled outside the BSC or containment device. Eye and face protection must be disposed of with other contaminated laboratory waste or decontaminated before reuse. Persons who wear contact lenses in laboratories should also wear eye protection.
 4. Gloves must be worn to protect hands from exposure to hazardous materials. Glove selection should be based on an appropriate risk assessment. Alternatives to latex gloves should be available. Gloves must not be worn outside the laboratory. In addition, BSL-2 laboratory workers should:
 - a. Change gloves when contaminated, glove integrity is compromised, or when otherwise necessary.
 - b. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory.
 - c. Do not wash or reuse disposable gloves. Dispose of used gloves with other contaminated laboratory waste. Hand washing protocols must be rigorously followed.
 5. Eye, face and respiratory protection should be used in rooms containing infected animals as determined by the risk assessment.

7.4.2.4 Laboratory Facilities (Secondary Barriers)

1. Laboratory doors should be self-closing and have locks in accordance with the institutional policies.
2. Laboratories must have a sink for hand washing. The sink may be manually, hands-free, or automatically operated. It should be located near the exit door.
3. The laboratory should be designed so that it can be easily cleaned and decontaminated. Carpets and rugs in laboratories are not permitted.

4. Laboratory furniture must be capable of supporting anticipated loads and uses. Spaces between benches, cabinets, and equipment should be accessible for cleaning.
 - a. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals.
 - b. Chairs used in laboratory work must be covered with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.
5. Laboratory windows that open to the exterior are not recommended. However, if a laboratory does have windows that open to the exterior, they must be fitted with screens.
6. BSCs must be installed so that fluctuations of the room air supply and exhaust do not interfere with proper operations. BSCs should be located away from doors, windows that can be opened, heavily traveled laboratory areas, and other possible airflow disruptions.
7. Vacuum lines should be protected with liquid disinfectant traps.
8. An eyewash station must be readily available.
9. There are no specific requirements for ventilation systems. However, planning of new facilities should consider mechanical ventilation systems that provide an inward flow of air without recirculation to spaces outside of the laboratory.
10. HEPA filtered exhaust air from a Class II BSC can be safely recirculation back into the laboratory environment if the cabinet is tested and certified at least annually and operated according to manufacturer's recommendations. BSCs can also be connected to the laboratory exhaust system by either a thimble (canopy) connection or directly exhausted to the outside through a hard connection. Provisions to assure proper safety cabinet performance and air system operation must be verified.
11. A method for decontaminating all laboratory wastes should be available in the facility (e.g., autoclave, chemical disinfection, incineration, or other validated decontamination method).

7.4.3 Biosafety Level 3

BL3 work must be conducted in accordance with the facility safeguards, standard microbiological practices, special practices, and safety equipment described in Biosafety in Microbiological and Biomedical Laboratories. See Tables 7.5 and 7.6 for lists of biohazardous agents that must be handled at BL3.

Biosafety Level 3 is applicable to clinical, diagnostic, teaching, research, or production facilities in which work is done with indigenous or exotic agents that may cause serious or potentially lethal disease as a result of exposure by inhalation. Laboratory personnel have specific training in

handling pathogenic and potentially lethal agents and are supervised by scientists experienced in working with these agents.

All procedures involving the manipulation of infectious materials are conducted within biological safety cabinets or other physical containment devices, or by personnel wearing appropriate personal protective clothing and equipment. The laboratory has special engineering and design features such as access zones, sealed penetrations, and directional airflow.

Many laboratories may not have all the facility safeguards recommended for Biosafety Level 3. In these circumstances, acceptable safety may be achieved for routine or repetitive operations (e.g., diagnostic procedures involving the propagation of an agent for identification, typing, and susceptibility testing) in Biosafety Level 2 facilities. However, the recommended standard microbiological practices, special practices, and safety equipment for Biosafety Level 3 must be rigorously followed.

7.4.4 Biosafety Level 4

University use of biological agents requiring Biosafety Level 4 containment practices is not anticipated. Should an investigator wish to conduct research with these agents, a description of the research shall be submitted to the Institutional Biosafety Committee for review and approval prior to the initiation of research. Approval is also required by the vice president for research and graduate studies prior to the initiation of research.

7.5 Biological Spills

A biological spill shall be followed by prompt action to contain and clean up the spill. When a spill occurs, warn everyone in the area and call for assistance as needed. The degree of risk involved in the spill depends on the volume of material spilled, the potential concentration of organisms in the material spilled, the hazard of the organisms involved, the route of infection of the organisms, and the diseases caused by the organisms.

Spills of biological agents can contaminate areas and lead to infection of laboratory workers. Prevention of exposure is the primary goal in spill containment and cleanup, exactly as in chemical spills. In evaluating the risks of spill response, generation of aerosols or droplets is a major consideration.

If an accident generates droplets or aerosols in the laboratory room atmosphere, especially if the agent involved requires containment at Biosafety Level 2 or higher, **the room shall be evacuated immediately**.

Doors shall be closed and clothing decontaminated. Call EHS, 814-865-6391, to supervise the cleanup. In general, a 30-minute wait is sufficient for the droplets to settle and aerosols to be reduced by air changes. Longer waiting periods may be imposed depending on the situation. Laboratory personnel and/or EHS must exercise judgment as to the need for outside emergency help in evacuation.

If a spill of a biological agent requiring containment at Biosafety Level 2 or higher occurs in a public area, evacuation of the area shall be immediate. The principal investigator shall be responsible for designating the extent of evacuation until EHS or emergency personnel arrive. Prevention of exposure to hazardous aerosols is of primary importance.

Anyone cleaning a spill shall wear personal protective equipment (for example, laboratory coat, shoe covers, gloves, and possible respiratory protection) to prevent exposure to organisms. An air-purifying negative-pressure respirator with HEPA filter cartridges is generally adequate protection against inhalation of most biological agents. However, there may be exceptions (e.g., work with tubercle bacilli). Contact EHS for advice in choosing the correct respiratory protection and for information regarding the requirements that must be met to wear a respirator.

7.5.1 Sterilization, Disinfection, and Decontamination

An appropriate chemical disinfectant should be chosen that is effective against the organisms involved in the spill (see Table 7.1). The Environmental Protection Agency recognizes the following categories of chemical germicides (a germicide is an agent that kills pathogenic organisms). The information in this section is drawn from Protection of Laboratory Workers from Infectious Disease Transmitted by Blood, Body Fluids, and Tissue, Tentative Guideline, NCCLS Document M29-T, Vol. 9, No.1 (National Committee for Clinical Laboratory Standards, November, 1988).

- o **Sterilizer or Sterilant:** An agent intended to destroy **all** microorganisms and their spores on inanimate surfaces.
- o **Disinfectant:** An agent intended to destroy or irreversibly inactivate specific viruses, bacteria, or pathogenic fungi, but not necessarily their spores, on inanimate surfaces. Most disinfectants are not effective sterilizers.
- o **Hospital Disinfectant:** An agent shown to be effective against specific organisms such as *Staphylococcus aureus*, *Salmonella choleraesuis*, and *Pseudomonas aeruginosa*. It may also be effective against other organisms and some viruses. The labels of all commercially available hospital disinfectants contain a claim (which must be documented) of effectiveness for specific agents.
- o **Antiseptic:** A chemical germicide formulated for use on skin or tissue. Antiseptics should not be used as disinfectants.

Decontamination means a procedure that eliminates or reduces microbial contamination to a safe level with respect to the transmission of infection. Sterilization and disinfection procedures are often used for decontamination.

The OSHA Bloodborne Pathogens Standard requires that all equipment and environmental and working surfaces shall be cleaned and decontaminated after contact with blood or other potentially infectious materials. The standard also requires decontamination of contaminated work surfaces

after completion of procedures, immediately or as soon as feasible after any overt contamination of surfaces or any spill of potentially infectious material, and at the end of the work shift if the work surface has become contaminated. All reusable equipment shall be decontaminated immediately or as soon as feasible upon visible contamination.

It should be emphasized that, for any infectious material, adequate pre-cleaning of surfaces is important for any disinfection or sterilization procedure. Ten minutes of exposure to a disinfectant may not be adequate to disinfect objects that have narrow channels or other areas that can harbor microorganisms. **Alcohols**, for example, are effective for killing HBV but are not recommended for this purpose because of their rapid evaporation and the consequent difficulty of maintaining proper contact times.

Formaldehyde is an OSHA-regulated chemical that is a suspect carcinogen, so its use as a disinfectant is not recommended.

Iodophors that are registered with the EPA may be effective hard-surface decontaminants when used per manufacturer's instructions, but iodophors formulated as antiseptics are not suitable for use as disinfectants.

Chlorine compounds are probably the most widely used disinfectants in the laboratory. An inexpensive, broad-spectrum disinfectant for use on table tops and similar surfaces can be prepared by diluting common household bleach (which is a 5.25% sodium hypochlorite solution) to obtain at least 500 ppm of free available chlorine. A 1:100 dilution of commercial bleach produces a solution containing 500 ppm free chlorine (approximately 1% bleach solution). Subject to the judgment of the lab worker, large spills of cultured or concentrated infectious agents should first be flooded or mixed with a more concentrated disinfectant. In this case, use a 1:10 dilution of commercial bleach, which produces a solution containing 5000 ppm of free chlorine.

Make the solution fresh each day. Be aware that chlorine compounds may corrode metals, especially aluminum. While a 10% household bleach solution is a commonly used decontaminant concentration, it is probably stronger than necessary for ordinary uses. Therefore, the use of higher concentrations of bleach in chemical fume hoods, and the autoclaving of materials that have been treated with bleach, should be reserved for significant contamination.

Quaternary ammonium compounds are low-level disinfectants and are not recommended for spills of human blood, blood products, or other potentially infectious materials.

7.5.2 Decontamination of Spills

The following procedure is recommended for decontaminating spills of agents used at BL2 and for human blood, body fluids, and other potentially infectious material.

1. **Wear gloves and a laboratory coat or gown.** Heavyweight, puncture-resistant utility gloves, such as those used for housecleaning and dishwashing, are recommended.

2. **Do not handle sharps with the hands.** Clean up broken glass or other sharp objects with sheets of cardboard or other rigid, disposable material. If a broom and dustpan are used, they must be decontaminated later.
3. **Avoid generating aerosols by sweeping.**
4. **Absorb the spill.** Most disinfectants are less effective in the presence of high concentrations of protein, so absorb the bulk of the liquid before applying disinfectants. Use disposable absorbent material such as paper towels. After absorption of the liquid, dispose of all contaminated materials as waste.
5. **Clean the spill site** of all visible spilled material using an aqueous detergent solution (e.g., any household detergent). Absorb the bulk of the liquid to prevent dilution of the disinfectant.
6. **Disinfect the spill site** using an appropriate disinfectant, such as a household bleach solution. Flood the spill site or wipe it down with disposable towels soaked in the disinfectant.
7. **Absorb the disinfectant or allow it to dry.**
8. **Rinse the spill site** with water.
9. **Dispose of all contaminated materials properly.** Place them in a biohazard bag or other leakproof, labeled biohazard container for sterilization.

7.5.3 Biological Spill in the Open Laboratory

For a spill in the open laboratory outside a biological safety cabinet, the spill response depends on the size of the spill and hazard of the material. A minimally hazardous material spilled without generating appreciable aerosols can be cleaned with a paper towel soaked in a chemical disinfectant.

A spill of a larger volume of hazardous material with aerosol generation requires evacuating the room, waiting for aerosol reduction, donning personal protective gear (including appropriate respiratory protection), selecting a disinfectant effective against the organisms involved, and cleaning as described above. Following cleanup, response personnel shall wash or shower with a disinfectant soap.

7.5.4 Biological Spill within a Biological Safety Cabinet

A spill that is confined within a biological safety cabinet generally presents little or no hazard to personnel in the area. However, chemical disinfection procedures are to be initiated at once while the cabinet continues to operate. The disinfectant shall be one that is active against the organisms of potential hazard. Flammable liquids, such as ethanol or isopropanol, shall not be used, even if

effective, because of the fire hazard of generating dangerous vapor concentrations within the cabinet that could be ignited by an electrical spark or other source.

Spray or wipe the walls, work surfaces, and equipment with the chosen disinfectant. Allow the disinfectant to remain on the surface for the appropriate contact time (refer to Table 7.1 B for recommended contact times). Minimize the generation of aerosols and use sufficient disinfectant to ensure that drain pans and catch basins below the work surface contain disinfectant. The front exhaust shall also be wiped and the disinfectant drained into a container.

7.5.5 Biological Spill in a Centrifuge or Other Equipment

A biological spill in a centrifuge has the potential for producing large volumes of aerosols. On becoming aware that a spill may have occurred within a centrifuge or other piece of equipment, turn off the equipment, warn others in the area, notify the principal investigator, allow aerosols to settle, and decontaminate following the principles described above.

7.5.6 Biological Spill on a Person

If a biological material is spilled on a person, emergency response is based on the hazard of the biological agent spilled, the amount of material spilled, and whether significant aerosols were generated. If aerosol formation is believed to have been associated with the spill, a contaminated person shall leave the contaminated area immediately. If possible, he or she should go to another laboratory area so that hallways and other public areas do not become contaminated.

Contaminated clothing is removed and placed in red or orange biohazard bags for disinfecting. Contaminated skin shall be flushed with water and thoroughly washed with a disinfectant soap. Showering may be appropriate, depending on the extent of the spill.

7.6 Human Blood, Blood Products, and Other Potentially Infectious Materials

Penn State University has chosen to comply with the OSHA Occupational Exposure to Bloodborne Pathogens Standard found in Title 29, Code of Federal Regulations, and Part 1910.1030. The information in this section summarizes the requirements of the standard. Additional information on the [Bloodborne Pathogen Program](#) is available from EHS.

The standard applies to employees who have occupational exposure to

- Blood (human blood, human blood components, and products made from human blood)
- The following human body fluids:

- semen
 - vaginal secretions
 - cerebrospinal fluid
 - synovial fluid
 - pleural fluid
 - pericardial fluid
 - peritoneal fluid
 - amniotic fluid
 - saliva (in dental procedures)
 - any body fluid that is visibly contaminated with blood
 - all body fluids in situations where it is difficult or impossible to differentiate between body fluids
- Any unfixed tissue or organ (other than intact skin) from a human, living or dead.
 - HIV-containing cell, tissue, or organ cultures; HIV- or HBV-containing culture medium or other solutions; and blood, organs, or other tissues from experimental animals infected with HIV or HBV.

Occupational exposure means reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of an employee's duties.

7.6.1 Exposure Control Plan

The standard requires a written **Exposure Control Plan**, the University's plan to identify and control exposures to blood and other potentially infectious materials. The Exposure Control Plan defines the scope of the program, provides definitions, explains the exposure determination process, lists methods of compliance with the standard, and provides information on post-exposure evaluation and training.

The OSHA standard requires review and updating of the Exposure Control Plan at least annually as well as whenever necessary to reflect new or modified tasks and procedures that affect occupational exposure and new or revised employee positions with occupational exposure.

7.6.2 Unit Specific Plan

Principal investigators and supervisors in departments with laboratories are required to complete Unit Specific Plans if they use human blood, blood products, and other potentially infectious materials. The Unit Specific Plan augments, but is not a substitute for, an Exposure Control Plan. Both plans are required for laboratory facilities, although the Exposure Control Plan does not require approval by the Institutional Biosafety Committee.

7.6.3 HIV and HBV Research Laboratories and Production Facilities

In the OSHA standard, a research laboratory is defined as a laboratory using research-laboratory-scale amounts of HIV or HBV. Research laboratories may use high concentrations of HIV/HBV but not in the volume found in production facilities. A laboratory working with human blood or other potentially infectious materials containing **clinical** levels of HIV or HBV is **not** considered an HIV/HBV research laboratory. Although compliance with most of the standard is required, most laboratories will not be subject to the additional requirements for HIV/HBV research laboratories.

A production facility is defined as a facility engaged in industrial-scale, large-volume or high-concentration production of HIV or HBV.

HIV and HBV research laboratories and production facilities are subject to more stringent regulations. Consult the OSHA standard or contact OHS if you are unsure whether your laboratories qualify and for information about additional requirements for these facilities.

7.6.4 Universal Precautions

The practice of **universal precautions** is an approach to infection control in which all human blood and other potentially infectious materials are treated as if known to be infectious for HIV, HBV, and other bloodborne pathogens.

Universal precautions shall be observed to prevent contact with blood or other potentially infectious materials. When it is difficult or impossible to differentiate between fluid types, universal precautions shall be observed.

7.6.5 Engineering and Work Practice Controls

Engineering controls are controls that isolate or remove the bloodborne pathogens hazard from the workplace. Examples are sharps containers and self-sheathing needles. **Work practice controls** are controls that reduce the likelihood of exposure by altering the manner in which a task is performed. If a likelihood of occupational exposure remains even when engineering and work practice controls are in place, then personal protective clothing shall also be used. Human blood, blood products, and other potentially infectious materials shall be used with Biosafety Level 2 work practices, containment, and facilities.

- a. **Handwashing.** The department shall provide readily accessible handwashing facilities or, if this is not feasible, an appropriate antiseptic hand cleanser and clean cloth or paper towels. In any case, employees shall wash hands with soap and running water as soon as feasible after possible exposure.

The department head shall ensure that employees wash hands immediately or as soon as feasible after removing gloves or other personal protective equipment and that employees wash hands and any other skin with soap and water, or flush mucous membranes with water, immediately or as soon as feasible following contact of such body areas with potentially infectious materials.

- b. **Needles and Sharps.** Contaminated needles and other contaminated sharps shall not be bent, recapped, or removed except as noted below. Shearing or breaking contaminated needles is prohibited.

Contaminated needles and sharps shall be recapped or removed **only** when no alternative is feasible or when required by a specific medical procedure. Any recapping or removal must be accomplished using a mechanical device or a one-handed technique. The recapping or removal of contaminated sharps is actively discouraged under any circumstances because of the high potential risk of injection.

Immediately after use, contaminated reusable sharps shall be placed in sharps containers that are puncture-resistant, labeled or color coded, and leakproof.

- c. **Eating, Drinking, Smoking, etc.** Eating, drinking, smoking, applying cosmetics or lip balm, and handling contact lenses are prohibited in work areas with a reasonable likelihood of occupational exposure. Food and drink shall not be kept in refrigerators, freezers, shelves, or cabinets or on countertops or benchtops where blood or other potentially infectious materials are present.
- d. **Splashing, Spraying, Spattering.** All procedures involving blood or other potentially infectious materials shall be performed so as to minimize splashing, spraying, spattering, and generation of droplets.
- e. **Mouth Pipetting.** Mouth pipetting of blood or other potentially infectious materials is prohibited.
- f. **Specimen Containers.** The standard includes detailed requirements for specimen containers. In general, specimens of blood or other potentially infectious materials shall be placed in a container that prevents leakage during collection, handling, processing, storage, transport, or shipping. Secondary containers are used when the outside of the primary container may be contaminated and when puncture of the primary container is possible. Storage, transport, or shipping containers are closed and labeled; the label should include the biohazard symbol. Color-coded containers should be red or orange.
- g. **Potentially Contaminated Equipment.** Any equipment to be serviced or shipped that may be contaminated shall be examined prior to servicing or shipping and decontaminated as necessary. If decontamination is not feasible, then the equipment shall be clearly labeled as to which portions remain contaminated. The department is obligated to communicate this information clearly to employees, service personnel, and manufacturers as appropriate.
- h. **Other Engineering Controls.** Other engineering controls include biological safety cabinets (e.g., tissue culture hoods) and chemical fume hoods. Engineering controls shall be examined and maintained on a regular schedule.

Chemical fume hoods used for containment of potentially infectious material are inspected by EHS according to a regular schedule. The Office of Physical Plant (OPP) inspects and maintains chemical fume hood fan and duct systems.

Biological safety cabinets should be certified on installation, whenever they are moved, and annually, especially if they are used with pathogens. Certification shall be in accordance with National Sanitation Foundation Standard Number 49 or manufacturers specifications.

7.6.6 Personal Protective Equipment

- a. **Responsibility.** The department head shall provide or ensure provision of appropriate personal protective equipment to each employee who is subject to occupational exposure to human blood or potentially infectious material. The equipment is provided at no cost to the employee. Appropriate equipment does not permit blood or other potentially infectious materials to pass through to or reach the street clothes. Examples of such equipment include gloves, gowns, laboratory coats, head and foot coverings, face shields, masks, eye protection, resuscitation bags, pocket masks, and other ventilation devices.

The department head shall either directly or by delegation ensure that each employee uses personal protective equipment when warranted.

- b. **Availability.** Protective equipment in appropriate sizes shall be available in the work area or issued to employees. Hypoallergenic gloves or similar alternatives shall be readily available to those allergic to the gloves normally provided.
- c. **Maintenance.** The department head shall ensure that personal protective equipment be cleaned, laundered, or disposed of at no cost to the employee. Personal protective equipment shall be repaired or replaced as needed to maintain its effectiveness.
- d. **Gloves.** Gloves shall be worn when it is reasonably anticipated that employees may have hand contact with blood, other potentially infectious materials, mucous membranes, or nonintact skin as well as when employees perform vascular access procedures and handle or touch contaminated items or surfaces.

Disposable gloves shall be replaced as soon as practical when contaminated or when torn, punctured, or otherwise compromised in their ability to function as a barrier.

Utility gloves (nondisposable gloves) may be decontaminated for reuse provided the integrity of the glove is not compromised. They must be discarded if they are cracked, peeling, torn, or punctured or exhibit other signs of deterioration.

Gloves shall be removed prior to leaving the work area.

For specific regulations related to phlebotomy, see the OSHA standard or contact EHS.

- e. **Masks, Eye Protection, and Face Shields.** Masks in combination with eye protection devices (such as goggles or glasses with solid side shields) or chin-length face shields shall be worn whenever splashes, spray, spatter, or droplets of blood or other potentially infectious material may be generated and eye, nose, or mouth contamination can be reasonably anticipated.
- f. **Gowns, Aprons, and Other Protective Body Clothing.** Appropriate protective body clothing shall be worn in occupational exposure situations. When gross contamination can be anticipated, surgical caps or hoods and shoe covers should be worn. Contaminated clothing shall not be worn outside the work area.
- g. **Implementation for Personal Protective Clothing and Equipment.** Appropriate personal protective equipment shall be worn by workers occupationally exposed to blood or other potentially infectious materials unless, under rare and extraordinary circumstances, the use of such equipment would prevent the delivery of health care or public safety services or would pose an increased hazard to the safety of the worker or a coworker. Should such a situation occur, the circumstances shall be investigated and documented to prevent future occurrences.

7.6.7 Housekeeping

- a. **Responsibility.** The department head is responsible for ensuring that the work area shall be maintained in a clean and sanitary condition. A written schedule for cleaning and method of decontamination is required.
- b. **Cleaning.** All equipment and environmental and working surfaces shall be cleaned and decontaminated with an appropriate disinfectant after contact with blood or other potentially infectious material. Contaminated work surfaces shall be decontaminated after completion of procedures, immediately or as soon as feasible after any contamination of surfaces or any spill of blood or other potentially infectious materials, and at the end of the work shift if the surface may have become contaminated since the last cleaning.

Protective coverings such as plastic-backed absorbent paper shall be removed and replaced as soon as feasible when they become overtly contaminated or at the end of the work shift if they may have become contaminated during the shift.

All bins, pails, cans, and similar receptacles intended for reuse that have a reasonable likelihood of becoming contaminated shall be inspected and decontaminated on a regularly scheduled basis. They shall be cleaned or decontaminated immediately or as soon as feasible if there is visible contamination.

Chemical disinfectants are listed in Tables 7.1 (A) and (B) with their usage parameters, applications, and the organisms for which they are effective. Any of the disinfectants listed are effective for bloodborne pathogens. Purchased disinfectants are recommended if their parameters meet those described. If other disinfectant materials are used, they are to be listed in the department-specific information.

- c. **Broken Glassware.** Broken glassware shall not be picked up directly with the hands. It shall be cleaned up using mechanical means, such as a brush or dustpan, vacuum cleaner, tongs, or forceps.

7.6.8 Waste Disposal

- a. **Contaminated Sharps.** Contaminated sharps shall be discarded immediately or as soon as feasible in containers that are closable, puncture-resistant, leakproof, and labeled or color-coded. Sharps containers shall be easily accessible to employees and located close to the immediate area where sharps will be used. They shall be maintained upright throughout use, be replaced routinely, and not be allowed to overfill.

Before sharps containers are removed from the work area, they shall be closed securely. If leakage is possible, a closable, sturdy, leakproof, and labeled or color-coded secondary container shall be used.

- b. **Other Biohazardous Wastes.** Waste containers that contain blood or other potentially infectious material shall be sealable, large enough to contain all intended contents, leakproof, labeled and/or color-coded, and closed securely prior to removal. If the primary waste container is contaminated on the outside, a closable, sturdy, leakproof, and labeled or color-coded secondary container shall be used and shall also be closed prior to removal.

All wastes shall be appropriately decontaminated before disposal (e.g., wastes should be autoclaved). Once decontaminated, the waste shall be overbagged.

7.6.9 Laundry

- a. **Instructions.** Contaminated laundry shall be handled as little as possible and with a minimum of agitation. It shall be placed in bags or containers at the point of use. It shall not be sorted or rinsed at the location of use. The bags or containers shall be labeled with the biohazard symbol or color-coded (red or orange). The bag or container shall be constructed to prevent soak-through or leakage.

The department head shall ensure that employees who handle contaminated laundry shall wear protective gloves and other appropriate personal protective equipment.

Whenever possible, contaminated laundry is disinfected or sterilized prior to submission to the laundry service for cleaning. Contaminated sharps shall never be included with

laundry. Contaminated laundry is never washed with an individual's personal belongings or sent to a laundry service without notice of the hazards.

7.6.10 Hepatitis B Vaccination and Postexposure Evaluation and Follow-up

- a. **Responsibility.** EHS is responsible for making the hepatitis B vaccine and vaccination series available to all employees who have occupational exposure and for making post-exposure evaluation and follow-up available to all employees who have sustained an exposure incident. All laboratory tests shall be conducted by an accredited laboratory at no cost to the employee.
- b. **Hepatitis B Vaccination.** Hepatitis B vaccination shall be made available **after** the employee has received the training required in this document section and within 10 working days of initial assignment to all employees who have occupational exposure, **unless** the employees have previously received the complete hepatitis B vaccination series, antibody testing has revealed that the employee is immune, or the vaccine is contraindicated for medical reasons. Participation by the employee in a prescreening program shall not be a prerequisite for receiving hepatitis B vaccination.

Vaccinations are provided through the Occupational Medicine Division of University Health Services.

HBV vaccination programs have been established on each campus. Contact EHS for specific instructions.

- c. **Postexposure Evaluation and Follow-up.** Following a report of an exposure incident, the department head shall ensure that a confidential medical evaluation and follow-up are made available to the exposed employee.
- d. **Medical Records.** Occupational Medicine shall ensure that an accurate record is maintained for each employee with occupational exposure. Employee medical records shall be kept confidential and shall not be disclosed or reported to any person without the employee's express written consent except as required by the OSHA standard and by law. Employee medical records shall be maintained for at least the duration of employment plus 30 years.

7.6.11 Communication of Hazard to Employees: Labels

Warning labels are required on containers of biohazardous waste (unless the waste is placed in red or orange bags), refrigerators and freezers containing blood or other potentially infectious material,

and other containers used to store, transport, or ship blood or other potentially infectious materials. The labels shall include the biohazard symbol and the word "biohazard."

7.6.12 Communication of Hazard to Employees: Information and Training

- a. **Responsibility.** The principal investigator is responsible for ensuring that all employees with occupational exposure participate in a training program, which must be provided during working hours at no cost to the employee.
- b. **Schedule.** Training shall be provided at the time of initial assignment to tasks where occupational exposure may take place and at least annually thereafter. The annual training shall be provided within one year of previous training.
- c. **Additional Training.** The principal investigator shall ensure that employees receive additional training when changes, such as modifications of tasks and procedures or institution of new tasks or procedures, affect the employee's occupational exposure.
- d. **Language, Literacy, and Educational Level.** Training shall consist of material which, insofar as possible, shall be appropriate in content and vocabulary to the educational level, literacy, and language of employees.
- e. **Content.** Training may be provided through a combination of videotapes, handouts, pre- and posttests, and personal presentations. Each training session shall include an opportunity for employees to ask questions. Minimum training program requirements have been provided to department heads.
- f. **Records.** EHS shall maintain training records which shall be kept in the department for three years from the date on which the training occurred. Training records shall be provided to employees and to employee representatives on request for examination and copying.

7.7 Recombinant DNA Activities

Recombinant DNA research shall comply with the National Institutes of Health's "Guidelines for Research Involving Recombinant DNA Molecules" and by University Policy SY-24. The Institutional Biosafety Committee is responsible for implementing the guidelines and overseeing recombinant DNA research.

Principal investigators intending to use recombinant DNA molecules shall notify the University Biosafety Committee by contacting the Office for Research Protections (ORP) for information and appropriate registration forms. The principal investigator shall prepare registration documents according to the nature of the research. Principal investigators working with or planning to work with recombinant DNA molecules shall contact ORP for further information.

In general, the containment practices to be used for recombinant DNA research shall follow those described for Biosafety Levels 1, 2, and 3 in the CDC-NIH Biosafety in Microbiological and Biomedical Laboratories. However, the NIH Recombinant DNA guidelines take precedence.

7.8 Animal Studies

Animal studies involving the use of hazardous biological agents represent special problems in containment. Policies and operational practices governing the use of animal containment facilities are under the direction of the Institutional Animal Care and Use Committee (IACUC) and the Animal Resource Program (ARP). In general, practices for Animal Biosafety Levels 1, 2, and 3 presented in the CDC-NIH manual, Biosafety in Microbiological and Biomedical Laboratories, are followed.

Experiments involving the use of infectious biological agents in animals are generally conducted in containment facilities. Research in laboratory facilities shall be reviewed and approved, prior to the initiation of work, by the Institutional Biosafety Committee in conjunction with the Animal Care and Use Committee.

7.9 Infectious Waste Management (PSU Safety Policy SY29 Infectious Waste Disposal)

Infectious waste materials shall be treated properly to eliminate the potential hazard that these wastes pose to human health and the environment. Management of Infectious Waste is governed by [University Policy SY-29](#).

7.9.1 Separation and Packaging of Infectious Waste

Infectious wastes shall be separated from general, noninfectious waste materials and from wastes containing radioactive, carcinogenic, or toxic materials. Some wastes may contain multiple hazards. These shall be handled such that priority is given to the greatest hazard present. Contact EHS (814-865-6391) for information on handling mixed biological/radioactive waste. In general, it is easier to inactivate the biohazard and then deal with the material as radioactive or hazardous waste.

Disposable infectious materials shall be placed in red or orange plastic bags. The bags shall be seamless, tear-resistant, and autoclavable. Single bags shall have a minimum thickness of 3.0 mils and double bags, 1.5 to 2.0 mils. Bags shall be closed by folding or tying when full, at the end of the day, or before transporting.

To minimize formation of aerosols, infectious wastes shall not be compacted prior to decontamination.

7.9.2 Storage and Transport of Infectious Waste

Infectious wastes that are removed from a laboratory or stored temporarily shall be closed and double-bagged or placed inside a covered, unbreakable outer container.

7.9.3 Infectious Waste Treatment

Infectious wastes are generally rendered noninfectious by autoclaving. The janitorial/custodial staff has been instructed not to touch or remove red or orange bags. Liquid wastes may also be rendered noninfectious by adding a sufficient amount of household bleach (5.25% Sodium Hypochlorite) to account for 10% of the final volume. (i.e., 100 ml of bleach to 1000 ml of liquid waste and incubate for at least 1 hour). Sterilized liquid wastes may be discarded to the sewer.

Infectious waste that is also radioactive must be autoclaved and then placed in radioactive waste containers for disposal through EHS.

Sharps that are radioactive must be placed into sharps containers and then placed in radioactive waste containers for disposal through EHS.

As described under procedures for Biosafety Levels 2 and 3 and procedures for human blood and related materials, syringes and needles shall be handled with extreme caution to avoid autoinoculation and the generation of aerosols. Needles shall not be bent, sheared, replaced in the sheath or guard, or removed from the syringe following use. The needle and syringe shall be promptly placed in a puncture-resistant container and decontaminated, preferably by autoclaving. Needles may be rendered unusable following sterilization. Grinding, compaction, or clipping in a destruction device are acceptable techniques for destroying sterile needles.

All human blood, blood products, nonfixed human tissues, and other potentially infectious materials are considered infectious and shall be disinfected by steam sterilization.

Infectious wastes, including cultures and stocks of etiologic agents, shall be made noninfectious by steam sterilization or chemical inactivation.

Animal carcasses, bedding, and wastes are handled by the [Animal Resource Program](#) (ARP).

7.9.3.1 Steam Sterilization

Most infectious wastes are sterilized, based on the type of waste, load volume, packaging material, and load configuration. It is recommended that the efficacy of the autoclave be monitored using *Bacillus stearothermophilis*. The frequency of monitoring depends on the hazard of the organism being used and the frequency of waste sterilization.

Infectious wastes that also contain volatile chemicals should be autoclaved only if a chemical (hydrophobic) filter is on line. EHS shall be contacted before steam sterilizing wastes containing carcinogens or radionuclides.

7.9.3.2 Chemical Disinfection

Chemical treatment is usually a disinfection rather than sterilization. Thus it is usually intended as a temporary measure to control infectious wastes until sterilization can treat the hazard. Disinfection may be used as final treatment on a case-by-case basis following a petition by the principal investigator and approval by EHS.

Section 7.5.1 and Tables 7.1 (A) and (B) summarize information on practical disinfectants. Commercially available chlorine bleach is 5.25 percent chlorine (52,500 ppm).

Note that bleach will react with water to form hypochlorous acid (HOCl), which will decompose to chlorine (Cl₂) and hydrogen chloride (HCl). Special care should be taken when autoclaving hypochlorite solutions because the procedure can generate chlorine gas, which will corrode steel. To avoid evolution of chlorine, the hypochlorite solution should be neutralized with sodium thiosulfate prior to autoclaving.

7.9.3.3 Mixed Waste

Infectious waste that is mixed with radioactive waste or chemical waste requires special handling. Liquid infectious waste that contains radioactive material must be rendered biologically inactive before the Radiation Protection Office will accept it. This can be done by autoclaving or adding sufficient household bleach (5.25% sodium hypochlorite) to make up 10% of the total volume (i.e., 100 ml of bleach for each liter of liquid waste). Solid infectious waste containing radioactive material must be autoclaved prior to disposal.

TABLE 7.1 (A) SUMMARY OF PRACTICAL DISINFECTANTS

| CATEGORY | DILUTION | CONTACT TIME IN MINUTES | | IRRITANT TYPE | | |
|-------------------------------|------------------------|-------------------------|----------------|---------------|-----|---------|
| | | LIPOVIRUS | BROAD SPECTRUM | SKIN | EYE | RESPIR. |
| Quaternary ammonium cpds. (l) | 0.1-2.0% | 10 | Not effective | Yes | Yes | No |
| Phenolic cpds. (l) | 1.0-5.0% | 10 | Not effective | Yes | Yes | No |
| Chlorine cpds. (l) | **500 ppm | 10 | 30 | Yes | Yes | Yes |
| Iodophor cpds. (l) | 25-1,600 ppm | 10 | 30 | Yes | Yes | No |
| Ethyl alcohol (l) | 70-85% | 10 | Not effective | No | Yes | No |
| Isopropyl alcohol (l) | 70-85% | 10 | Not effective | No | Yes | No |
| Formaldehyde (l) | 0.2-8.0% | 10 | 30 | Yes | Yes | No |
| Glutaraldehyde (l) | 2% | 10 | 30 | Yes | Yes | No |
| Ethylene oxide (g) | 8-23 g/ft ³ | 60 | 60 | Yes | Yes | Yes |
| Paraformaldehyde (g) | 0.3 g/ft ³ | 60 | 60 | Yes | Yes | Yes |

l = liquid; g = gas

**Commercially available chlorine bleach is 5.25% chlorine (52,500 ppm). A dilution of 1 to 100 will yield a 525 ppm solution, which is suitable for disinfecting purposes.

Source: Laboratory Safety Monograph, U.S. Department of Health, Education, and Welfare, Public Health Service, and National Institutes of Health, 1979.

TABLE 7.1 (B) SUMMARY OF PRACTICAL DISINFECTANTS

| DISINFECTANTS | USE PARAMETERS | | | |
|-------------------------------|------------------------------------|----------------|---------------------|------------------------|
| | Concentration of active ingredient | Temperature °C | Relative Humidity % | Contact time (minutes) |
| Ethylene oxide | 400-800 mg/l | 35-60 | 30-60 | 105-240 |
| Paraformaldehyde (gas) | 0.3 g/ft ³ | >23 | >60 | 60-180 |
| Quaternary ammonium compounds | 0.2-1% | | | 10-30 |
| Phenolic compounds | 0.2-3% | | | 10-30 |
| Chlorine compounds | 0.01-5% | | | 10-30 |
| Iodophor compounds | 0.47% | | | 10-30 |
| Alcohol (ethyl or isopropyl) | 70-85% | | | 10-30 |
| Formaldehyde (liquid) | 4-8% | | | 10-30 |
| Glutaraldehyde | 2% | | | 10-600 |

| DISINFECTANTS | EFFECTIVE AGAINST: | | | | | | |
|-------------------------------|---------------------|------------------|--------------|---------------------|------------------|-----|-----|
| | Vegetative bacteria | Bacterial Spores | Lipo viruses | Hydrophilic viruses | Tubercle bacilli | HIV | HBV |
| Ethylene oxide | + | + | + | + | + | + | + |
| Paraformaldehyde (gas) | + | + | + | + | + | + | + |
| Quaternary ammonium compounds | + | | + | | | + | |
| Phenolic compounds | + | | + | ± | + | + | ± |
| Chlorine compounds | + | ± | + | + | + | + | + |
| Iodophor compounds | + | | + | ± | + | + | ± |
| Alcohol (ethyl or isopropyl) | + | | + | ± | | + | ± |
| Formaldehyde (liquid) | + | ± | + | + | + | + | + |
| Glutaraldehyde | + | + | + | + | + | + | + |

+ denotes very positive response; ± denotes less positive response; a blank denotes a negative response or not applicable.

Adapted from Biosafety in the Laboratory: Prudent Practices for the Handling and Disposal of Infectious Materials, National Research Council, 1989.

TABLE 7.2: AGENT SUMMARY STATEMENTS AVAILABLE

The following agent summary statements are available from EHS. Source: Biosafety in Microbiological and Biomedical Laboratories, HHS Publication No. (CDC) 93-8395, CDC/NIH, 4th edition, May 1999.

Nematode Parasites of Humans

Protozoal Parasites of Humans

Trematode Parasites of Humans

Cestode Parasites of Humans

Fungal Agents

Blastomyces dermatitidis

Coccidioides immitis

Cryptococcus neoformans

Histoplasma capsulatum

Sporothrix schenckii

Pathogenic Members of the Genera Epidermophyton, Microsporum and Trichophyton

Miscellaneous Molds

Bacterial Agents

Bacillus anthracis

Bordetella pertussis

Brucella (B. abortus, B. canis, B. melitensis, B. suis)

Campylobacter (C. jejuni/C. coli, C. fetus subsp. fetus)

Chlamydia psittaci, C. pneumoniae, C. trachomatis

Clostridium botulinum

Clostridium tetani

Corynebacterium diphtheria

Francisella tularensis

Leptospira interrogans - all serovars

Legionella pneumophila; other Legionella-like agents

Mycobacterium leprae

Mycobacterium spp. other than M. tuberculosis, M. bovis or M. leprae

Mycobacterium tuberculosis, M. bovis

Neisseria gonorrhoeae

Neisseria meningitidis

Pseudomonas pseudomallei

Salmonella - all serotypes except typhi

Salmonella typhi

Shigella spp.

Treponema pallidum

Vibrionic enteritis (Vibrio cholerae, V. parahaemolyticus)

Yersinia pestis

Rickettsial Agents

Coxiella burnetii

Rickettsia prowazekii, Rickettsia typhi (R. mooseri), Rickettsia tsutsugamushi, Rickettsia canada, and Spotted Fever Group agents of human disease; Rickettsia rickettsii, Rickettsia conorii, Rickettsia akari, Rickettsia australis, Rickettsia siberica

Viral Agents (other than arboviruses)

Hepatitis A Virus, Hepatitis E Virus
 Hepatitis B Virus, Hepatitis C Virus (formerly known as nonA nonB Virus), Hepatitis D Virus
 Herpesvirus simiae (B-virus)
 Human Herpesviruses
 Influenza
 Lymphocytic Choriomeningitis Virus
 Poliovirus
 Poxviruses
 Rabies Virus
 Retroviruses, including Human and Simian Immunodeficiency Viruses (HIV and SIV)
 Transmissible Spongiform Encephalopathies (Creutzfeldt-Jakob, kuru, and related agents)
 Vesicular Stomatitis Virus

Arboviruses and Arenaviruses - see the following tables:

- Table 7.3 Arboviruses and Arenaviruses Assigned to Biosafety Level 2
- Table 7.4 Vaccine Strains of BSL 3/4 Viruses Which May be Handled at BSL2
- Table 7.5 Arboviruses and Certain Other Viruses Assigned to Biosafety Level 3 (on the basis of insufficient experience)
- Table 7.6 Arboviruses and Certain Other Viruses Assigned to Biosafety Level 3

TABLE 7.3 ARBOVIRUSES AND ARENAVIRUSES ASSIGNED TO BIOSAFETY LEVEL 2

| | | | |
|-------------|---------------|------------|--------------|
| Acado | Arumowot | Batama | Burg E Arab |
| Acara | Aura | Bauline | Bushbush |
| Aguacate | Avalon | Bebaru | Bussuquara |
| Alfuy | Abras | Belmont | Buttonwillow |
| Almpiwar | Abu Hammad | Benevides | Bwamba |
| Amapari | Aabahoyo | Benfica | Cacao |
| Ananindeua | Bagaza | Bertioga | Cache Valley |
| Anhanga | Bahig | Bimiti | Caimito |
| Anhembi | Bakau | Birao | California |
| Anopheles A | Baku | Bluetongue | encephalitis |
| Anopheles B | Bandia | Boraceia | Calovo |
| Apeu | Bangoran | Botambi | Candiru |
| Apoi | Bangui | Boteke | Cape Wrath |
| Aride | Banzi | Bouboui | Capim |
| Arkonam | Barmah Forest | Bujaru | Caraparu |
| Aroa | Barur | Bunyamwera | Carey Island |
| Aruac | Batai | Bunyip | Catu |

| | | | |
|------------------------------|------------------|-------------|--------------------|
| Chaco | Hart Park | Kokobera | Mirim |
| Chagres | Hazara | Kolongo | Mitchell River |
| Chandipura | Highlands J | Koongol | Modoc |
| Changuinola | Huacho | Kotonkan | Moju |
| Charleville | Hughes | Kowanyama | Mono Lake |
| Chenuda | Icoaraci | Kunjin | Mont. myotis leuk. |
| Chilibre | Ieri | Kununurra | Moriche |
| Chobar gorge | Ilesha | Kwatta | Mosqueiro |
| Clo Mor | Ilheus | La Crosse | Mossuril |
| Colorado tick fever | Ingwavuma | La Joya | Mount Elgon Bat |
| Corriparta | Inkoo | Lagos Bat | Murutucu |
| Cotia | Ippy | Landjia | Mykines |
| Cowbone Ridge | Irituia | Langat | Navarro |
| Csiro Village | Isfahan | Lanjan | Nepuyo |
| Cuiaba- | Itaporanga | Las Maloyas | Ngainingan |
| D'aguilar | Itaqui | Latino | Nique |
| Dakar Bat | Jamestown Canyon | Le Dantec | Nkolbisson |
| Dengue-1 | Japanaut | Lebombo | Nola |
| Dengue-2 | Jerry Slough | Lednice | Ntaya |
| Dengue-3 | Johnston Atoll | Lipovnik | Nugget |
| Dengue-4 | Joinjakaka | Lokern | Nyamanini |
| Dera Ghazi Khan | Juan Diaz | Lone Star | Nyando |
| East equine encephalitis* | Jugra | Lukuni | O'nyong-nyong |
| Edge Hill | Jurona | M'poko | Okhotskiy |
| Entebbe Bat | Jutiapa | Madrid | Okola |
| Ep. Hem. Disease | Kadam | Maguari | Olifantsvlei |
| Erve | Kaeng Khoi | Mahogany | Oriboca |
| Eubenangee | Kaikalur | Hammock | Ossa |
| Eyach | Kaisodi | Main Drain | Pacora |
| Flanders | Kamese | Malakal | Pacui |
| Fort Morgan | Kammavan pettai | Manawa | Pahayokee |
| Frijoles | Kannaman galam | Manzanilla | Palyam |
| Gamboa | Kao Shuan | Mapputta | Parana |
| Gan Gan | Karimabad | Maprik | Pata |
| Gomoka | Karshi | Marco | Pathum Thani |
| Gossas | Kasba | Marituba | Patois |
| Grand Arbaud | Kemerovo | Marrakai | Phnom-Penh Bat |
| Great Island | Kern Canyon | Matariya | Pichinde |
| Guajara | Ketapang | Matruh | Pixuna |
| Guama | Keterah | Matucare | Pongola |
| Guaratuba | Keuraliba | Melao | Ponteves |
| Guaroa | Keystone | Mermet | Precarious |
| Gumbo Limbo | Kismayo | Minatitlan | Point |
| | Klamath | Minnal | Pretoria |

| | | | |
|-----------------------|---------------|---------------|-----------------|
| Prospect Hill | Tahyna | Tibrogargan | Wonga |
| Puchong | Tamiami | Timbo | Wongorr |
| Punta Salinas | Tanga | Timboteua | Wyeomyia |
| Punta Toro | Tanjong Rabok | Tindholmur | Yaquina Head |
| Qalyub | Tataguine | Toscana | Yata |
| Quaranfil | Tehran | Toure | Yogue |
| Restan | Tembe | Tribec | Zaliv Terpeniya |
| Rio Bravo | Tembusu | Triniti | Zegla |
| Rio Grande | Tensaw | Trivittatus | Zika |
| Ross River | Tete | Trubanaman | Zingilamo |
| Royal Farm | Tettngang | Tsuruse | Zirqa |
| Sabo | Thimiri | Turlock | |
| Saboya | Thottapalayam | Tyuleny | |
| Saint Floris | | Uganda S | |
| Sakhalin | | Umatilla | |
| Salehabad | | Umbre | |
| San angelo | | Una | |
| Sandfly f. (Naples) | | Upolu | |
| Sandfly f. (Sicilian) | | Urucuri | |
| Sandjimba | | Usutu | |
| Sango | | Uukuniemi | |
| Sathuperi | | Vellore | |
| Sawgrass | | Venkatapuram | |
| Sebokele | | Vinces | |
| Seletar | | Virgin River | |
| Sembalam | | VS-Indiana | |
| Serra do Navio | | VS-New Jersey | |
| Shamonda | | Wad Medani | |
| Shark River | | Wallal | |
| Shuni | | Wanowrie | |
| Silverwater | | Warrego | |
| Simbu | | Westequine | |
| Simian hem. fever | | encephalitis* | |
| Sindbis | | Whataroa | |
| Sixgun City | | Witwatersrand | |
| Snowshoe Hare | | | |
| Sokuluk | | | |
| Soldado | | | |
| Sororoca | | | |
| Stratford | | | |
| Sunday Canyon | | | |
| Tacaiuma | | | |
| Tacaribe | | | |
| Taggert | | | |

* A vaccine is available and is recommended for all persons working with this agent.

TABLE 7.4 VACCINE STRAINS OF BSL 3/4 VIRUSES WHICH MAY BE HANDLED AT BLS2

| Virus | Vaccine Strain |
|-------------------------------------|-----------------------|
| Chikungunya | 131/25 |
| Junin | Candid #1 |
| Rift Valley Fever | MP-12 |
| Venezuelan equine encephalomyelitis | TC-83 |
| Yellow fever | 17-D |

TABLE 7.5 ARBOVIRUSES AND CERTAIN OTHER VIRUSES ASSIGNED TO BIOSAFETY LEVEL 3 (ON THE BASIS OF INSUFFICIENT EXPERIENCE)

| | | |
|----------------|----------------|---------------|
| Adelaide River | Bobaya | Estero Real |
| Agua Preta | Bobia | Fomede |
| Alenquer | Bozo | Forecariah |
| Almeirim | Buenaventura | Fort Sherman |
| Altamira | Cabassue | Gabek Forest |
| Andasibe | Cacipacore | Gadgets Gully |
| Antequera | Calchaqui | Garba |
| Araguari | Cananeia | Gordil |
| Aransas Bay | Caninde | Gray Lodge |
| Arbia | Chim | Gurupi |
| Arboledas | Coastal Plains | Iaco |
| Babanki | Connecticut | Ibaraki |
| Batken | Corfou | Ife |
| Belem | Dabakala | Ingangapi |
| Berrimah | Douglas | Inini |
| Bimbo | Enseada | Issyk-Kul |

Itaituba
Itimirim
Itupiranga
Jacareacanga
Jamanxi
Jari
Kedougou
Khasan
Kindia
Kyzylgach
Lake Clarendon
Llano Seco
Macaua
Mapuera
Mboke
Meaban
Mojui Dos Compos
Monte Dourado
Munguba
Naranjal
Nariva
Nasoule
Ndelle
New Minto
Ngari
Ngoupe
Nodamura
Northway
Odrenisrou
Omo
Oriximina
Ouango
Oubangui
Oubi
Ourem
Palestina
Para
Paramushir
Paroo River
Perinet
Petevo
Picola
Playas
Pueblo Viejo

Purus
Radi
Razdan
Resistencia
Rochambeau
Salanga
San Juan
Santa Rosa
Santarem
Saraca
Saumarez Reef
Sedlec
Sena Madureira
Sepik
Shokwe
Slovakia
Somone
Spipur
Tai
Tamdy
Telok Forest
Termeil
Thiafora
Tilligerry
Tinaroo
Tlacotalpan
Tonate
Ttinga
Xiburema
Yacaaba
Yaounde
Yoka
Yug Bogkanovac

TABLE 7.6 ARBOVIRUSES AND CERTAIN OTHER VIRUSES ASSIGNED TO BIOSAFETY LEVEL 3

| | | |
|-----------------------|-----------------------------|---|
| Aino | Louping III (a,c) | Sal Vieja |
| Akabane | Mayaro | San Perlita |
| Bhanja | Middelburg | Semliki Forest |
| Chikungunya (c,d) | Mobala | Seoul |
| Cocal | Mopeia (e) | Spondweni |
| Dhori | Mucambo (c,d) | St. Louis enc. |
| Dugbe | Murray Valley enc. | Thogoto |
| Everglades (c,d) | Nairobi sheep disease (a) | Tocio (c) |
| Flexal | Ndumu | Turuna |
| Germiston (c) | Negishi | Venezuelan equine encephalitis (c,d) |
| Getah | Oropouche (c) | Vesicular Stomatitis (alagoas) |
| Hantaan | Orungo | Wesselsbron (a,c) |
| Israel Turkey mening. | Peaton | West Nile |
| Japanese enc. | Piry | Yellow fever (c,d) |
| Junin (c,d) | Powassan | Zinga (b) |
| Kairi | Puumala | |
| Kimberley | Rift Valley fever (a,b,c,d) | |
| Koutango | Sagiyama | |

- a. The importation, possession, or use of this agent is restricted by USDA regulation or administrative policy.
- b. Zinga virus is now recognized as being identical to Rift Valley Fever virus.
- c. SALS recommends that work with this agent should be conducted only in Biosafety Level 3 facilities that provide for HEPA filtration of all exhaust air prior to discharge from the laboratory.
- d. A vaccine is available and is recommended for all persons working with this agent.
- e. This virus is presently being registered in the Catalogue of Arboviruses.

8.0 Research Involving Animals

Research involving live animals introduces additional new hazards into the workplace. These hazards are in addition to the chemical, biological, radiological and physical hazards previously discussed.

8.1 Physical Hazards

- Bites
- Scratches
- Kicks
- Crushing or pinning injuries (large animals)
- Protocol-associated hazards

8.2 Allergens – Allergic reactions to animals are among the most common conditions that adversely affect the health of workers involved in the care and use of animals in research. The estimated prevalence of allergic symptoms in the general population of regularly exposed animal-care workers ranges from 10% to 44%. An estimated 10% of workers eventually develop occupation-related asthma, in some cases requiring them to find a new vocation. Persons with pre-existing allergies such as allergic rhinitis (hay fever) are up to 73% more likely to develop allergy to animals. These allergies are usually manifested as nasal symptoms, itchy eyes, and rashes, but can be more severe in some cases

8.3 Zoonoses – Zoonoses refer to any infectious disease that can be transmitted from animals (wild or domestic) to humans, or from humans to animals. They may be bacterial, rickettsial, bacterial, protozoal, fungal, or caused by parasites. Symptoms and physiological effects may range from non-existent to life-threatening. Knowing the zoonoses associated with any given animal species, the route of exposure and symptoms is quite beneficial in identifying and controlling worker exposure to these agents.

Source: Occupational Health and Safety in the Care and Use of Research Animals, National Research Council, 1997.

APPENDIX A

FACT SHEETS

EMERGENCY RESPONSE TRAINING FACT SHEET

Based on Title 29 of the Code of Federal Regulations (29 CFR) 1910.120, Hazardous waste operations and emergency response.

CHEMICAL SPILLS YOU CAN HANDLE YOURSELF

Principal investigators, employees, and students working in research labs should be aware that required safety training for lab workers includes emergency response training

Emergency training applies to building evacuation procedures during fires and explosions, recognition of system alarms, and appropriate action in the event of spills of hazardous materials in the lab. Lab workers must receive training to distinguish between the types of spills they can handle on their own and those spills that are classified as “MAJOR.” Major spills dictate the need for outside help.

Lab workers are qualified to clean-up spills that are “minor.” A minor spill is defined as a spill that does not pose a significant safety or health hazard to employees in the immediate vicinity nor does it have the potential to become an emergency within a short time frame. Lab workers can handle minor spills because they are expected to be familiar with the hazards of the chemicals they routinely handle during an “average” workday. If the spill exceeds the scope of the lab workers’ experience, training or willingness to respond, the workers must be able to determine when outside help is necessary.

Emergency assistance is provided by EHS and the University Hazardous Materials Team. Spills requiring the involvement of individuals outside the lab are those exceeding the exposure one would expect during the normal course of work. Spills in this category are those which have truly become emergency situations in that lab workers are overwhelmed beyond their level of training. Their response capability is compromised by the magnitude of the incident. Emergencies such as this involve:

- the need to evacuate employees in the area
- the need for response from outside the immediate release area
- the release poses, or has potential to pose, conditions that are immediately dangerous to life and health
- the release poses a serious threat of fire and explosion
- the release requires immediate attention due to imminent danger
- the release may cause high levels of exposure to toxic substances
- there is uncertainty that the worker can handle the severity of the hazard with the personal protective equipment (PPE) and equipment that has been provided and the exposure limit could be exceeded easily
- the situation is unclear or data is lacking regarding important factors.

Depending on the circumstances, what begins as a minor spill could at some point escalate into a major emergency. Responding lab workers must monitor changing conditions. Again, lab-specific training must cover how to tell the difference!

EHS employees have received in-depth training qualifying them for emergency response beyond the level of minor spills. They are prepared to answer calls which exceed the training scope of lab workers. Lab workers are encouraged to play it safe and contact EHS for clean-up assistance when in doubt about the status of a spill. EHS assistance is available 24 hours a day, seven days a week.

EHS: 814-865-6391

ALL SPILLS THAT REQUIRE OUTSIDE INTERVENTION

A. Emergency Response Procedures. Call 911 to report fires, explosions, medical emergencies, and hazardous material spills. Dispatch will contact EHS and appropriate emergency response personnel at anytime to respond to hazardous material spills.

An *Incident Report* form must be completed for each emergency incident involving laboratories.

Following a “MAJOR” incident, EHS responders may determine, based on the circumstances of the spill or release, that clean-up of the site can be handled by lab workers or other University employees (under the direction of the lab supervisor or EHS

In the event that EHS is called to a “minor” spill (i.e., lab workers have been conservative in assessing hazard and assumed worst case), EHS representatives will participate in or oversee the clean-up to support the lab workers. In both of these cases where clean-up becomes a lab responsibility, EHS can provide clean-up supplies and equipment, personal protective equipment (to the level of training of the workers), and safety instructions.

GENERAL UNIVERSITY EMERGENCY INFORMATION

A. Building Emergency and Evacuation.

In the event of a fire, hazardous material release, or other hazardous situation requiring emergency response, the person who discovers the emergency will:

- evacuate the zone
- activate the fire alarm, if needed
- call Police Services and report the incident
- assist emergency personnel by providing information regarding location of the incident, origin, and persons involved.

The person who discovers the emergency shall not be placed in imminent danger.

C. Incident (Accident) Reporting. All laboratory incidents shall be reported to EHS, including minor spills, fires, or injuries. Laboratory incidents shall be investigated. The supervisor shall be responsible for implementing corrective action to prevent repeat incidents.

In the event of worker injury, the immediate supervisor of the injured employee must fill out the [First Report of Injury](#)

D. Signs. The following signs and labels are required for **all** laboratories in University facilities:

- A “[Laboratory Information](#)” sign shall be posted outside all laboratories, either on the outside of the door or on the wall beside the door. This sign provides information on specific hazards in the lab and telephone numbers of responsible faculty and staff. The information shall be updated as necessary.
- An “Emergency and Laboratory Safety Phone numbers” sign shall be posted in a prominent location inside the lab, near the door or telephone. This sign provides emergency numbers in case of an emergency, available from EHS.
- A label bearing the University Police emergency number shall be placed on each telephone in the lab, available from EHS.

CHEMICAL SAFETY FACT SHEET

University Safety Policies [Storage, Dispensing and Use of Flammable Liquids Policy \(SY08\)](#)
[Hazardous Waste Disposal \(SY20\)](#)

Based on 29 CFR 1910.1450, *Occupational exposure to hazardous chemicals in laboratories.*

EXPOSURE

This section describes remedies for personal exposure to chemicals by inhalation, ingestion, inoculation, or dermal or eye contact. Additional first aid information for specific chemicals is available from EHS. General procedures are as follows.

POISON CONTROL Phone (800) 942-5969

Inhalation: Get to a source of fresh air. Seek immediate medical assistance.

Ingestion: Seek immediate medical assistance. Never give an unconscious person anything to drink. Do not neutralize acids or bases. Do not induce vomiting of acid or bases or other solvents unless advised by Poison Control.

Injection: Obtain medical treatment immediately.

Dermal Contact: Obtain immediate medical treatment. Remove the victim from the source of the contamination. Remove contaminated clothing, cutting it away if necessary. The first aid kit should contain scissors with blunted shear tips for this purpose. Immediately wash affected areas with water for at least 15 minutes, except in the event of hydrofluoric (HF) acid exposure. For HF spills, flush for a maximum of 5 minutes. Use the calcium gluconate as soon as possible.

Eye Contact: Obtain immediate medical treatment. Wash eye(s) with water until medical help arrives. Keep the affected eye lower than the unaffected eye to prevent the spread of contamination. Sterile eyewash cups or irrigator loops are commercially available to assist in opening the eyelids without prying or traumatizing the injured eye and causing excess pain. These devices can augment washing of the central portion of the cornea and the superior cul-de-sac where particulate materials may become lodged (thus forming a solid mass).

SPILLS

This section describes the procedures for decontamination in the event of a minor chemical spill onto surfaces, materials, instruments, or equipment. Please address handling of spills of solids **and** liquids if both are stored in your lab.

Lab workers are responsible for the clean-up of releases that are clearly minor, i.e., do not pose a significant safety or health hazard to workers in the immediate vicinity or to the worker cleaning the release. Lab workers should not handle spills that have the potential to become an emergency within a short time. EHS should be contacted for all spills of elemental mercury.

Minor spills are of limited quantity, exposure potential, or toxicity. 911 should be called in the event of an emergency. **Lab workers shall be properly trained to recognize emergency conditions and to notify appropriate responders for situations that are beyond their own capacity.**

When a spill occurs, first cordon off the spill area to prevent inadvertently spreading the contamination over a much larger area.

Pick up small spills of solids with paper towels wetted with water or an appropriate solvent. Solids may be swept up, if harmful aerosols will not be generated. Place wastes in compatible, sealable containers and dispose of through EHS. Clean instruments or large areas contaminated with solids with an HEPA filter vacuum cleaner to prevent aerosolization of the contaminant. EHS is available to provide information and equipment or supervise clean-up.

Wipe up small spills of liquids with paper towels. Use loose absorbent or spill pillows to absorb spills.

Select and wear the appropriate protective gear during clean-up. Basic gear includes lab coat, gloves, and eye protection. Thicker gloves or double layers may be necessary in some cases. EHS may provide spill equipment if none is present in the lab.

PROPER WORK AND HANDLING PRACTICES

The following practices are considered standard for use or storage of hazardous chemicals, including carcinogens and reproductive toxins.

A. Personnel Practices.

1. Eye protection is worn.
2. Gloves are worn for handling hazardous chemicals, including carcinogens, or reproductive toxins.
3. Gloves used are appropriate for the chemicals handled, see [glove selection chart](#).
4. Lab workers wash their hands immediately after removing gloves, after handling chemical agents, and before leaving the lab.
5. Lab coats are worn, fully fastened.
6. Lab coats and gloves are worn only in the lab. They are not taken outside the lab to lunch rooms or offices nor are they worn outdoors.
7. Following a significant chemical exposure to skin or clothing, lab workers are instructed to use the safety shower immediately.
8. Eating, drinking, smoking, gum chewing, or applying of cosmetics are prohibited in the work area.
9. Food storage is prohibited in the work area.
10. Food is stored in cabinets or refrigerators designated for such use only.
11. Mechanical pipetting devices are used; mouth pipetting is prohibited.

B. Operational Practices.

1. Hazardous chemicals are used in a chemical fume hood to provide further protection to researchers.
2. All containers of hazardous chemicals are labeled with name of chemical. Abbreviations or formula are not sufficient.
3. Chemical storage is by hazard class. Chemicals are not stored merely by alphabetical order.
4. Chemicals are dated on receipt and opening.
5. Chemicals are removed when the expiration date is exceeded, especially in the case of peroxide-formers.
6. Incompatible materials are physically separated.
7. Flammable materials in amounts exceeding 10 gallons are stored in a flammables storage cabinet.
8. Acids and bases are stored on low shelves or in an acid/base cabinet. Plastic-coated bottles and plastic trays are used to minimize the effects of leaks.
9. Shock-sensitive, detonable compounds (such as sodium azide, dry picric acid) or extremely poisonous materials (such as cyanides, osmium tetroxide, cacodylic acid, tetrodotoxin, picrotoxin, ricin) are stored in locked cabinets. DEA-regulated substances (e.g., pentobarbital, phenobarbital) are also locked in cabinets with keys accessible only to authorized lab workers.
10. Designated work areas are established for handling materials with a high degree of acute toxicity (such as chemicals with corrosive effects, e.g., nitric, sulfuric and hydrochloric acids, hydrofluoric acid, sodium hydroxide; or chemical asphyxiants such as carbon monoxide and hydrogen sulfide).

C. Waste Management.

1. A Waste Management Logbook (Appendix B) containing weekly checks, training records, self audits, chemical inventories and any other waste records and documentation is maintained in all areas where waste is accumulated.
2. All employees and students working with or supervising those working with chemicals or chemical waste must receive training annually and within 90 days of hire.
3. A waste accumulation area must be designated near the point of waste generation and posted with the sign available in the Waste Management Manual.
4. An individual working in the area must be assigned the responsibility for oversight of the accumulation area.
5. Weekly, the area must be checked for the following
 - Chemicals are not leaking
 - Chemicals are labeled with red labels provided by EHS. Information on the label includes generator name; chemical name, amount and concentration; and room and building where generated.
 - Chemicals are in secondary containment
 - Chemicals are segregated so that incompatible chemicals are not next to each other.
 - The total volume of chemicals in the accumulation area does not exceed 55 gal.
6. Wastes are collected in compatible containers which are sealed. Food containers are not appropriate.
7. Sharps (razors, needles, thin pipettes) are collected in puncture-resistant, leakproof containers.

8. Waste pump oil is collected for disposal as hazardous waste.
9. Empty solvent bottles are rinsed 3 times with water and then vented in a chemical fume hood for at least 24 hours. After this procedure, the bottles may be recycled or thrown in regular trash. All labels must be defaced prior to disposal of the bottle. Five gal. containers are collected by EHS.

D. Specific Practices for Use with Carcinogens and Reproductive Toxins.

1. Lab surfaces are covered with plastic-backed paper or its equivalent.
2. Procedures involving volatile, powdered, or aerosolized carcinogens are performed in a chemical fume hood that is exhausted to the outside.
3. Designated work and storage areas are established for carcinogens and reproductive toxins.
4. These areas, including chemical fume hoods and refrigerators, are labeled "Chemical Carcinogen."
5. Unbreakable outer (secondary) containers are used for transportation of carcinogens.
6. Access procedures are used if work involves moderate or greater amounts of carcinogens or moderate to lengthy procedures. These procedures may include:
 - closed doors
 - restricted access—only authorized personnel permitted
 - written access procedures posted on the outer door.
7. Dry sweeping and mopping are prohibited if powdered carcinogens or mutagens (e.g., acrylamide and ethidium bromide) are used.
8. Waste containers for carcinogens are labeled as follows: "Cancer Hazard," compound name, concentration, and amount.
9. Solid wastes (e.g., pipette tips, gloves, lab paper) are collected in plastic bags, which are sealed and enclosed in a second bag. The bags are labeled as follows: "Cancer Hazard," compound name, concentration, and amount.

E. OSHA-Specified Cancer-Causing Agents. Reference in section **B** found in the [Unit Specific Plan Form](#).

alpha-Naphthylamine
 Methyl chloromethyl ether
 3,3'-Dichlorobenzidine (and its salts)
 bis-Chloromethyl ether
 beta-Naphthylamine
 Benzidine
 4-Aminodiphenyl
 Ethyleneimine
 beta-Propiolactone
 2-Acetylaminofluorene
 4-Dimethylaminoazobenzene
 N-Nitrosodimethylamine
 Vinyl chloride
 Inorganic arsenic
 Lead
 Cadmium
 Benzene
 1,2-dibromo-3-chloropropane
 Acrylonitrile
 Ethylene oxide
 Formaldehyde
 Methylenedianiline
 1,3-Butadiene
 Methylene chloride
 Asbestos

F. Explanation of Medical Surveillance Provisions. If exposure to an OSHA-specified carcinogen is measured to be above the action level or the short-term exposure limit (STEL), certain specific regulatory requirements come into play, one of which is a medical surveillance program. Medical surveillance is intended to determine whether employees are experiencing adverse health effects from exposure to contaminants. It is to be provided without cost to employees and at a reasonable time and place. The parameters of the medical examination are contaminant-specific and primarily determined by or under the supervision of a licensed physician. For example, following a worker's potential exposure to lead, the occupational physician will order biological monitoring for blood lead level, as required in the OSHA Lead Standard, but the other exam elements are left to the physician's

discretion. The OSHA Formaldehyde Standard requires medical questionnaires to be completed by workers with possible formaldehyde exposure. The physician discerns who needs a physical from reviewing the questionnaires.

COMPRESSED GAS CYLINDERS FACT SHEET

Based on 29 CFR 1910.1450, Occupational exposure to hazardous chemicals in laboratories, by reference to Prudent Practices in the Laboratory, National Research Council.

[University Safety Policy SY-25 Compressed Gas Cylinders](#)

PROPERTIES AND HAZARDS

Handling compressed gases may be more hazardous than handling solid and liquid materials because of the unique properties of gases. These properties and their associated hazards are:

- pressure hazards causing equipment failure and leakage
- rapid diffusion, causing dangerous toxic or anesthetic effects, asphyxiation, and rapid formation of explosive concentrations
- low boiling-point materials, cryogenic materials, or liquefied gases causing frostbite
- the same hazards as those associated with solid or liquid chemicals, including corrosion, irritation, flammability, and high reactivity.

PROPER WORK AND HANDLING PRACTICES

A. Storage Practices.

1. The regulator is removed and the valve protection cap is in place when cylinders are stored.
2. Cylinders are situated away from heat and ignition sources.
3. Flammable gases (e.g., hydrogen, carbon monoxide) are stored away from other gases, especially oxidizers (e.g., oxygen and nitrous oxide).
4. Cylinders are situated away from major traffic flow.
5. Cylinders are maintained in an environment at near-room temperatures. They are not subjected to a temperature greater than 125° F or lower than -21° F.
6. Flames never come into contact with any part of a compressed gas cylinder.
7. A valve protection cap is left on each cylinder until it has been properly secured in the lab and when it is not in use (after having been secured).
8. Cylinders are secured in accordance with local fire codes. Cylinders must be secured against a wall or bench with cylinder clamps, chains, or straps, or are placed in a cylinder stand.

B. Transportation.

1. Large cylinders are transported only on a wheeled cylinder cart. Cylinders are not slid or rolled, since even practiced handlers can lose control of them.
2. Small cylinders are transported in a manner that protects them from potential damage from falling or striking objects.

C. Use of Cylinders.

1. Lab workers wear eye protection when changing regulators or manipulating tubing or equipment potentially under pressure.
2. Cylinders are situated away from heat and ignition sources.
3. Cylinders are situated away from major traffic flow.
4. Cylinders are maintained in an environment at near-room temperatures. They are not subjected to a temperature greater than 125° F or lower than -21° F.
5. Flames never come into contact with any part of a compressed gas cylinder.
6. Cylinders are used only with a regulator. Cylinders contain pressures greater than most lab equipment can withstand. Cylinder users are aware that inadvertent closing of a valve or stop cock or plugging of a line could result in a violent failure of the apparatus.
7. A regulator and gauge shall be installed at the point of use to show the outlet pressure when the source cylinder is outside of the lab.
8. Cylinder valves are closed when not in use, if feasible. They are never tampered with, forced, lubricated, or modified.
9. Cylinder leaks are attended to immediately. If a leak persists and/or cannot be controlled by simple adjustment, the supplier and EHS are contacted immediately. The cylinder is removed to a chemical fume hood or location where the leakage can be exhausted or diluted and left there until the contents can be disposed of according to manufacturer's directions.
10. When discharging a gas into a liquid, a trap or suitable check valve is used to prevent liquid from backflowing into the cylinder or regulator.
11. Cylinders are used only with fittings, valves, regulators, and tubing designated by the manufacturer for the gas being used.
12. Connections are not forced or used with homemade adapters.
13. Incompatible gases linked by a direct potential pathway are protected by check valves or other safety devices appropriate for the gases being used.
14. Ventilation in the use location is adequate to exhaust potential asphyxiant (e.g., carbon dioxide, helium, nitrogen) releases.

D. Empty Cylinders.

Note: Cylinders are never truly "empty." Empty cylinders shall be handled in the same manner as full and partially full cylinders.

1. Full and empty cylinders are not manifolded together.
2. Empty cylinders are promptly removed from manifolded systems. (Hazardous suckback can occur when an empty cylinder is mistakenly attached to a pressurized system.)
3. Empty cylinders are labeled "Empty" or "MT."
4. Valves are closed on empty cylinders, leaving a positive pressure. (This prevents the interior from becoming contaminated.)
5. Valve outlets and protective caps received with the cylinder are replaced on empty cylinders.
6. Whenever possible, empty cylinders should be returned to the manufacturer.
7. Where return is not feasible, a chemical pick up request should be completed to have EHS pick up the empty cylinder.
8. Small empty propane or mapp gas cylinders for handheld torches may be disposed of in the regular trash.

E. Specific Procedures for Corrosive Gases.

1. Corrosive gases are stored only for short periods before use, preferably less than three months. Using small cylinders ensures a reasonable turnover.
2. Corrosive gases are removed from areas containing instruments or other devices sensitive to corrosion.
3. Storage areas for corrosive gases are as dry as possible.
4. A supply of water is available in case of emergency leaks in corrosive gas cylinders. (Most corrosive gases can be absorbed in water.)
5. Cylinder valve stems on corrosive gases are manipulated frequently to prevent "freezing."
6. Regulators and valves are closed when corrosive gas cylinders are not in use.
7. Regulators and valves are detached from the cylinder except when it is in frequent use (weekly or daily).
8. When corrosive gases are in use, an eyewash is immediately adjacent to the work area.
9. When corrosive gases are in use, a shower is available in close proximity to the work area. The shower must be within 10 seconds travel time of the gas cylinder.
10. Appropriate gloves are worn by lab workers handling corrosive gases.

F. Specific Procedures for Using Acetylene Gas.

1. Acetylene cylinders are stored upright (because they are partially filled with acetone).
2. Acetylene cylinders that have not stood upright are used only after they have been upright for at least 30 minutes.
3. The outlet line of acetylene cylinders contains a flash arrestor.
4. Pressures are always maintained below the limit indicated by the red warning line on an acetylene pressure gauge.
5. Appropriate tubing is used with acetylene gas. (Copper tubing forms explosive acetylides and shall not be used.)

G. Specific Procedures for Use with Oxygen.

1. When oxygen is used, the cylinder valve is opened momentarily and then closed to blow dirt from the outlet. The valve outlet of an oxygen cylinder valve is never wiped or touched; this avoids leaving organic residues that might be ignited by exposure to high oxygen pressure.
2. Oil or grease is never used on the high-pressure side of oxygen and chlorine cylinders or other cylinders containing oxidizing material. (Otherwise a fire or explosion could result.)

H. Specific Procedures for Use with Toxic, Flammable, and Pyrophoric Gases.

1. Toxic gases are purchased and stored in the smallest sizes possible.
2. During use and storage, highly toxic gases are located in continuously ventilated gas cabinets or mechanical spaces.
3. A continuous gas monitoring system is available for signaling releases of highly toxic gases.
4. Lecture bottles of highly toxic gases are used in a chemical fume hood.
5. Flash arrestors are present on the cylinder lines leading from flammable gases. When flammable gases are used in conjunction with oxygen, the flammable gas lines are equipped with backflow protection to prevent mixing of oxygen with the fuel.
6. Fires of pyrophoric or highly combustible gases are not considered extinguished until the source of gas is closed off; otherwise, it can reignite and cause an explosion.

HIGHLY REACTIVE MATERIALS, HIGH-PRESSURE REACTIONS, OR VACUUM SYSTEMS FACT SHEET

Based on 29 CFR 1910.1450, Occupational exposure to hazardous chemicals in laboratories, by reference to Prudent Practices in the Laboratory, National Research Council.

GENERAL OPERATIONAL PRACTICES FOR REACTIVE/EXPLOSIVE HAZARDS/SYSTEMS

Note: There may be overlap between these categories. Compounds may be reactive, may cause system over-pressurization, and may be used with vacuums. All three areas (highly reactive materials, high-pressure systems, vacuum systems) may apply to one reaction.

1. When working with pyrophoric and other highly reactive materials, a flame resistant, fully buttoned lab coat with sleeves fully extended to the wrists must be worn at all times.
2. Heat guns are not used for heating if flammable vapors are present. Instead, heating tapes, mantles, or water, steam, or oil baths are used.
3. If an explosion were to occur, provisions have been made to contain the entire reaction mixture.
4. Dry ice solvent baths are not used for reactive gases.
5. Hot liquids are not brought into sudden contact with lower-boiling liquids.
6. Boiling chips are not added once the heated liquid has exceeded its boiling point.
7. The areas where highly reactive chemicals, high-pressure, or vacuum equipment are used are posted with signs to warn colleagues of potential danger.
8. When a reaction becomes uncontrollable, heat is removed, the addition of reagents is suspended, nearby lab workers are notified, and the chemical fume hood sash is closed until the temperature has dropped.
9. Emergency equipment is on hand for reactions that could runaway violently.
10. When appropriate, tongs are used to manipulate highly reactive chemicals to prevent exposure of any part of the body to possible injury (e.g., when immersing sodium metal in solvents, handling heated crucibles, or removing weighing dishes from ovens).

HIGHLY REACTIVE MATERIALS

A. Definition. Highly reactive materials are those agents that undergo rapid chemical change causing exothermic or other self-accelerating reactions when subjected to heat, impact, friction, light, catalysts, or other initiation. These agents are materials that will detonate or deflagrate. Highly reactive materials encompass (but are not limited to):

- Air-reactive chemicals (e.g., palladium or platinum on carbon, platinum oxide, Raney nickel)
- Metal hydrides (e.g., lithium aluminum hydride, sodium borohydride)
- Cryogenic materials/liquefied gas, supercritical fluids (e.g., oxygen, nitrogen, helium)
- Highly water-reactive chemicals (e.g., aluminum bromide, metal hydrides, phosphorus pentachloride, tin tetrachloride, titanium tetrachloride)
- Explosive dusts (e.g., magnesium powder, zinc dust, carbon powder, flowers of sulfur)
- Explosives, other (e.g., diazomethane, hydrogen peroxide, hydrogen, chlorine, polymerizing acrolein, trinitrotoluene)
- Organic peroxides (e.g., acetyl peroxide, benzoyl peroxide)
- Organometallic chemicals and active metals (e.g., trimethyl gallium; sodium, magnesium, lithium, potassium)
- Oxidizing agents (e.g., halogens, oxyhalogens, peroxyhalogens, permanganates, nitrates, chromates, persulfates, peroxides)
- Perchloric acid and perchlorates (e.g., sodium perchlorate)
- Peroxide-forming chemicals (e.g., acrylonitrile, dioxane, ether, isopropanol, tetrahydrofuran)
- Polymerization reactions (e.g., acrylate monomers)
- Polynitro organic chemicals (e.g., picric acid, dinitrophenylhydrazine, methyl nitronitrosoguanidine)
- Pyrophoric chemicals (e.g., boranes, white phosphorus, alkyl metals such as n-butyllithium and dibutyl magnesium)
- Shock-sensitive and other unstable chemicals (e.g., acetylides, azides, nitro compounds, organic nitrates, perchlorates).

Note: Many of the above classes of materials overlap with other classes (e.g., organometallics may be pyrophoric). The list is intended merely to provide guidance for determining whether this section applies to the research in your lab. Exact classification is not necessary.

B. Operational Practices for Specific Classes of Reactives. The categories listed below are not exhaustive and do not necessarily cover all possible circumstances that must be controlled.

Cryogenic materials

1. Cryogenic materials are not warmed in closed containers.

2. Relief devices have been engineered into the containers or closed systems.
3. Dewars are inspected for ice plug formation.
4. Dry leather or other impervious thermal gloves are worn to prevent burns. Potholders may be used to handle cryogenic containers.
5. Cryogenic materials are not used in a confined space with inadequate ventilation due to the potential for asphyxiation.
6. Transfers of materials are conducted very slowly to minimize boiling and splashing.

Explosive dusts

1. Suspensions of oxidizable particles are handled wet.
2. The airborne particulates are not exposed to ignition sources.
3. Adequate ventilation has been provided to control the concentration of airborne dusts.

Organometallics and pyrophoric chemicals

1. Where organometallics are used, Class D fire extinguishers or pails of dry powder extinguishing agent or sand are provided.
2. All pyrophorics are used and stored in an inert atmosphere (e.g., under nitrogen or argon).
3. Regulators are set correctly to prevent glassware from being over pressurized with nitrogen or argon.
4. To avoid spills resulting in fires, breakable glass bottles are stored inside a rubber or plastic bottle carrier.

Organic peroxides and peroxide-forming solvents

1. Organic peroxides and peroxide-forming solvents are protected from and stored away from light.
2. Ceramic, plastic, or wooden spatulas are used with organic peroxides. Metal spatulas are never used.
3. Glass containers with screw caps or glass stoppers are not used with organic peroxides.
4. Friction, grinding, or other forms of impact are not permitted near peroxides.
5. Organic peroxides are diluted with inert solvents such as mineral oil to reduce their sensitivity to heat and shock.
6. Liquid organic peroxides are never allowed to freeze, as phase changes increase the sensitivity of these compounds to shock and heat.
7. Peroxide-forming solvents are checked for the presence of peroxides prior to heating of the solvent and after each month of storage. Testing may be conducted with instantaneous peroxide indicator strips.
8. Peroxide-forming solvents are disposed of through EHS within six months after opening.
9. Peroxide-forming compounds are stored in a cool, dark, well-ventilated area.

Ether used as an anesthetic

1. Like other peroxide-formers, ether must be stored in a cool, dry, well-ventilated place, out of direct sunlight. It must be purchased in small containers, no more than is absolutely necessary. It shall be stored as far back on a shelf as possible to minimize the potential for falling. It should be easy-to-reach to prevent knocking against the container.
2. Ether is checked for peroxides monthly or discarded six months after opening. Peroxide test strips are available from Lab Safety Supply and other reputable safety supply distributors (e.g., Fisher, Baxter). In compliance with University safety policy, a chart of test results accompanies the container of ether. It may be posted on the storage area or kept on a clipboard. A lab safety designate has been assigned responsibility for regular peroxide testing.
3. Both unused ether supplies (older than 6 months) and ether known to contain peroxides must be disposed of through EHS. Evaporation of ether in a chemical fume hood is forbidden by law, except for residual amounts in an empty can. Disposal down the drain is also unlawful.
4. Animal carcasses containing ether are stored in explosion-safe refrigerators or freezers where ether vapors cannot ignite.

Oxidizing agents

1. Oxidizing agents are separated from reducing materials, metals, and ordinary combustibles.
2. Oil baths are not used when oxidizing agents are present.

Perchloric acid and perchlorates

1. Organic materials are digested with nitric acid before the addition of perchloric acid.
2. Perchloric acid is heated (i.e., during acid-based digestion) only in a water-washdown laboratory chemical fume hood of noncombustible construction.
3. Chemical fume hoods in which perchloric acid is heated are inspected frequently for the accumulation of perchlorates. Deposits are saturated with water and removed.
4. Perchloric acid is never used near, nor stored on, wooden shelves.
5. Perchloric acid is stored in glass bottles on noncombustible (e.g., ceramic or plastic) trays large enough to contain the entire contents of the bottle.
6. Perchloric acid and perchlorates are never stored with organic materials.

7. Perchloric acid is never heated with sulfuric acid.

Polynitro organic chemicals and shock-sensitive or unstable compounds

1. The stock of polynitro compounds is stored separately from other lab chemicals.
2. Stock is regularly inspected for degradation or dehydration, as these compounds may become more shock-sensitive with age.
3. Polynitro compounds are disposed of through EHS when no longer needed. They are not placed in storage for future use, as they may become more hazardous over time.
4. When polynitro and shock-sensitive compounds are moved, they are handled by the container bottom and never by the cap or lid.
5. Picric acid is hydrated or kept in solution to reduce sensitivity. It is never allowed to dry out completely.
6. Solid sodium azide, in quantities above 25 g, is dissolved when it arrives in the lab. Solutions of sodium azide do not pose the danger of shock-sensitivity associated with the solid form; however, the hydrazoic acid generated when the azide is dissolved is extremely toxic. Therefore, the solution is always prepared inside a chemical fume hood. If not dissolved, solid azide must be stored in a locked cabinet.
7. Teflon or other nonmetal spatulas are used with solid sodium azide due to its reactivity with metals.

HIGH-PRESSURE SYSTEMS

A. Definition. High-pressure reactions are those experiments that are carried out at pressures above one atmosphere. This includes most hydrogenation reactions since explosive oxygen-hydrogen mixtures can be formed as a result of these reactions.

B. Operational Practices.

1. A label on each pressure vessel indicates the maximum allowable working pressure and temperature.
2. Service lines are not connected to any closed apparatus incapable of withstanding the maximum pressure of the service line (air, water, etc.).
3. All pressure systems are protected with appropriate pressure-relief devices.
4. The pressure-relief device is installed so that the discharge is directed away from the area where a person could be affected.
5. Pressure-relief devices are inspected periodically. Orifices on both sides of the pressure-relief device are checked for obstruction.
6. The lab workers use pressure gauges with pressure ranges about twice the working pressure of the system.
7. Containers, fittings, and other equipment to be used when working with pressure vessels are able to withstand the stresses imposed by the given pressures and temperatures.
8. Vessels containing solution are not filled above capacity; preferably, the vessel is only half full.
9. The pressure levels of high-pressure devices are monitored periodically as heating proceeds.

VACUUM SYSTEMS

A. Definition. Vacuum systems include those activities involving mechanical vacuum pumps, building vacuum systems, water aspirators, or steam aspirators.

Work with vacuum systems poses a substantial danger of injury to the operator from flying glass shrapnel released during an implosion. Other hazards may include:

- the toxicity of the chemicals in the vacuum system
- fire following breakage of a flask containing flammable solvents
- toxicity from the mercury in manometers and gauges
- over- or under-pressurization arising with thermal conductivity gauges
- electric shock with hot cathode ionization systems.

B. Operational Practices.

Vacuum apparatus

1. Vessels used in vacuum operations are protected with suitable relief valves (vacuum breaker).
2. A protective shield is placed around evacuated systems.
3. Lab workers wear safety glasses and face shields when working with evacuated systems or setting up such systems.
4. The vacuum system has been arranged to allow the equipment to be moved without transmitting strain to the neck of the flask; flasks are supported from below as well as by their necks.

5. The vacuum apparatus is well out of the way of traffic to avoid being struck inadvertently.
6. Belt-driven mechanical pumps have been equipped with protective guards to enclose the moving belts.

Capture of contaminants

1. Each vacuum system used for solvent distillation operations is protected by a suitable trapping device (cold trap, filter, liquid trap) with a backflow check valve.
2. Water, solvents, and corrosive gases are not allowed to be drawn into the building vacuum (house) system.
3. When mechanical vacuum pumps are used with volatile substances, the input line to the pump is fitted with a cold trap to minimize the amount of volatile materials entering the pump and dissolving in the oil.
4. If particulates could contaminate a vacuum line (e.g., from an inert atmosphere dry box or glovebox), a HEPA filter will be installed.
5. If pump oil becomes contaminated, it is drained and changed to prevent the exhaust of chemicals into room air.
6. Used pump oil is disposed of through EHS.
7. Records of use are maintained for general-purpose lab pumps in order to forestall cross-contamination or reactive chemical incompatibility problems.
8. The exhaust from evacuation of volatile, toxic, or corrosive materials is vented to an air exhaust system such as a chemical fume hood or local exhaust duct.

Vessels

1. Glass vessels used in conjunction with the vacuum system should be checked with polarized light for cracks, scratches, or etching each time the vessel is used. At minimum, a visual inspection will be conducted.
2. Dewar flasks are wrapped with tape or enclosed in wooden or metal containers.
3. Reduced pressure is never applied to flat-bottomed flasks unless they have been designed for this purpose.
4. Vacuum desiccators are made of borosilicate/Pyrex glass or plastic.
5. Evacuated desiccators are never carried or moved.
6. Lab workers wait to open desiccators until atmospheric pressure has been restored.
7. If rotary evaporators are used, increases in rotation speed and application of vacuum to the flask are gradual.

BIOLOGICAL SAFETY FACT SHEET

University Safety Policy [Use of Biohazardous Materials in Research and Instruction \(SY24\)](#)

BIOSAFETY LEVEL 2 CONTAINMENT

A. Principles of Biosafety Containment. “Containment” refers to a reliable plan for managing infectious agents in the lab environment where they are being handled or maintained. The purpose of containment is to reduce or eliminate exposure of lab workers, other persons, and the outside environment to potentially hazardous agents.

Biosafety Level 2 (BL2) practices, equipment, and facilities are applicable to clinical, diagnostic, teaching and other facilities in which work is performed with the broad spectrum of indigenous moderate-risk agents present in the community and associated with human disease of varying severity. With good microbiological techniques, such agents can be used safely in activities conducted on the open bench, provided the potential for producing splashes or aerosols is low. Hepatitis B virus, the salmonellae, and *Toxoplasma* spp. are representative of microorganisms assigned to this containment level.

B. Applicability of Biosafety Level 2. The BL2 requirements apply to research work:

- studying known infectious agents classified as requiring BL2 precautions by the CDC/NIH in [Biosafety in Microbiological and Biomedical Laboratories \(BMBL\)](#), and
- involving the handling of vertebrate animals experimentally or naturally infected with agents classified as requiring BL2 controls by BMBL.

The biological hazard exists in the potential for autoinoculation, ingestion, or mucous membrane exposure by a worker handling the agents or infected animals.

In addition, BL2 requirements are prescribed for the handling of human blood, blood products, and other potentially infectious human-derived materials. The following materials are considered potentially infectious:

- Human blood, blood components, and blood products
- Semen
- Vaginal secretions
- Cerebrospinal fluid
- Synovial fluid
- Pleural fluid
- Peritoneal fluid
- Amniotic fluid
- Saliva in dental procedures
- Any body fluid visibly contaminated with blood
- All body fluids in situations where it is difficult or impossible to differentiate between body fluids
- Any unfixed tissue or organs from a human (living or dead)
- HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions
- Blood, organs, or other tissues from experimental animals infected with HIV or HBV
- Human albumin
- Human tissue culture cell lines (even those that are established).

Note: Human albumin and established human cell lines are exempt from the requirements of the Bloodborne Pathogens Standard if they can be characterized as free of contamination from human hepatitis viruses, human immunodeficiency viruses, and other recognized bloodborne pathogens. The standard states that the final determination that human or other animal cell lines in culture are free of bloodborne pathogens must be made by a biological safety professional or other qualified scientist with background and experience to review such potential contamination and risk. The professional would be expected to comment, in writing, on the test methods and molecular technology applied to a cell line sample to identify or screen for latent viruses capable of infecting humans.

Documentation that given cell lines in use in a lab are not classified as “other potentially infectious materials” should be available in the labs in the Lab Safety Plan. Documentation may be provided by the cell line distributor or vendor (e.g., ATCC) at the point of origin but these records do not generally account for potential contamination during shipping. To meet the requirements of the law, the principal investigator would need to document that the package was protected from environmental contamination during transport and arrived at the lab undamaged.

SPILLS

A biological spill shall be followed by prompt action to contain and clean-up the spill. When a spill occurs, warn everyone in the area and call for assistance as needed. Assess the degree of risk involved in the spill based on:

- the volume of material spilled
- the potential concentration of organisms in the material spilled
- the hazard of the organisms involved
- the route of infection of the organisms
- the diseases caused by the organisms.

Spills of biological agents can contaminate areas and lead to infection of lab workers. Thus, prevention of exposure is the primary goal in spill containment and clean-up, exactly as in chemical spills. In evaluating the risks of spill response, consider the potential for generation of aerosols or droplets.

If an accident is expected to generate droplets or aerosols in the laboratory room atmosphere, **the room shall be evacuated immediately**. Doors shall be closed and clothing decontaminated. Call EHS to supervise the clean-up. In general, a 30-minute wait is sufficient for the droplets to settle and aerosols to be reduced by air changes. Longer waiting periods may be imposed depending on the situation and the ventilation system in this area. Lab workers and/or EHS will exercise judgment as to the need for outside emergency help in evacuation.

If a spill of a biological agent occurs in a public area, evacuation of the area shall be immediate. The principal investigator will be responsible for designating the extent of evacuation until EHS or emergency personnel arrive. Remember that prevention of exposure to hazardous aerosols is of primary importance.

Anyone cleaning a spill wears personal protective equipment (for example, lab coat, shoe covers, gloves, safety glasses, and, possibly, respiratory protection) to prevent exposure to organisms. An air-purifying negative-pressure respirator with HEPA filter cartridges is generally adequate protection against inhalation of most biological agents. Only personnel trained and cleared through EHS are permitted to wear respirators.

PROPER WORK AND HANDLING PRACTICES

A. Standard Practices.

1. Access to the lab is limited or restricted by the supervisor when work with infectious agents is in progress.
2. Work surfaces are decontaminated once a day and after any spill of infectious material.
3. All infectious wastes are chemically decontaminated or autoclaved before disposal.
4. Lab workers wash their hands immediately after removing gloves, after handling agents, and before leaving the lab.
5. All procedures are performed carefully to minimize the creation of aerosols.
6. Eating, drinking, smoking, gum chewing, or applying of cosmetics are prohibited in the work area.
7. Food storage is prohibited in the work area.
8. Food is stored in cabinets or refrigerators designated for such use only.
9. Mechanical pipetting devices are used; mouth pipetting is prohibited.
10. An insect and rodent control program is in effect.

B. Special Practices.

1. Lab doors are kept closed when experiments are in progress.
2. Contaminated materials that are to be transported in public areas (hallways, etc.) are placed in leak-proof, closed, and labeled or color-coded containers before removal.
3. Access to the lab is restricted. Persons who are at increased risk of acquiring infection or for whom infection may be unusually hazardous are not permitted. The supervisor has final responsibility regarding entry and work in the lab. Only persons who are advised of the potential hazard and who meet entry requirements, such as immunization, may enter the lab.
4. If the infectious agents used require special entry provisions, such as immunization, a hazard warning sign is posted on access doors to the lab. This includes the universal biohazards symbol, infectious agent, principal investigator's name and phone number, and special entry requirements.
5. Animals unrelated to research are prohibited in the lab.

6. Hypodermic needles and syringes are used only for injection and aspiration of fluids. Needle-locking syringes or disposable units are used.
7. Used needles and syringes are immediately placed in a puncture-resistant container and chemically decontaminated or autoclaved before discard or reuse.
8. Extreme caution is used when handling needles and syringes to avoid autoinoculation and generation of aerosols during use.
9. Spills and accidents resulting in overt exposures are reported to the supervisor, and EHS.

C. Primary Barriers.

1. Lab workers wear clothing that protects street clothing. This includes at least one of the following options: lab coats, solid-front gown, smocks, or uniforms.
2. Lab clothing is worn only inside the lab.
3. Lab clothing that is contaminated is either autoclaved or disinfected with 10% bleach solution prior to laundering.
4. Lab workers wear gloves when handling infectious materials.
5. Gloves are carefully removed and changed when visibly contaminated.
6. Persons coming into indirect contact with potentially infectious materials wear gloves if they have lesions or dermatitis on their hands.
7. Eye protection is worn when splashes, spray, spatter, or droplets of potentially infectious materials may occur.
8. Face shields, or surgical masks and eye protection, are worn when splashes, spray, spatter, or droplets of potentially infectious materials may occur.

D. Containment Equipment. The following procedure is conducted only in a physical containment device such as a biological safety cabinet or a chemical fume hood:

- Centrifuging, grinding, blending, vigorous shaking or mixing, sonic disruption, opening infectious-material containers for which internal pressures may differ from ambient pressures, inoculating animals intranasally, and harvesting infected tissue from animals or eggs.
- Exception:** Materials may be centrifuged in the open lab if sealed heads or centrifuge safety cups are used and if the centrifuge tubes are opened only in a physical containment device.

The following procedure is conducted only in a biological safety cabinet:

- Use of high concentrations or large volumes of infectious agents.

Lab workers are to be trained in the proper use of biological safety cabinets, with an emphasis on activities that may disrupt the inward flow of air through the work opening. Staff are aware that the activities that can cause escape of aerosols include:

- repeated insertion and withdrawal of worker's arms
- opening and closing lab doors or isolation cubicle
- improper placement or operation of equipment or materials in the cabinet
- brisk walking past the cabinet during use.

ADDITIONAL PRACTICES SPECIFIC TO THE USE OF HUMAN BLOOD, BLOOD PRODUCTS OR OTHER POTENTIALLY INFECTIOUS MATERIALS

Based on 29 CFR 1910.1030, Bloodborne pathogens.

University Safety Policy SY-24 Use of Biohazardous Materials in Research and Instruction

A. Standard Practices. The requirements of the Bloodborne Pathogens Standard are discussed in the University's Exposure Control Plan, entitled *Bloodborne Pathogens Program (BPP)*. A copy of the formal plan should be available in your laboratory Safety and Research Plan. The plan relates the general elements of the program and the expected protocols that shall apply in your lab.

Any lab worker who may be exposed to human blood or other human products shall:

- be included in the group's exposure determination
- practice universal precautions
- have the opportunity to receive Hepatitis B vaccination
- sign a waiver or consent form for vaccination
- be offered postexposure evaluation and follow-up (PEEFU)
- be trained to understand the hazards of bloodborne pathogens and how to protect against these hazards.

In order to comply with the requirement for universal precautions, the PI shall thoroughly evaluate current lab procedures and supplies for adequacy. Proper application of universal precautions entails:

- proper work practice controls for all work involving blood or other potentially infectious materials
- initial and annual training, as required by the BPP
- provision of engineering controls, as required by the BPP
- proper waste disposal with an adequate supply of appropriate sharps containers and biohazard bags present
- posting of warning labels and signs
- provision of appropriate personal protective clothing and equipment, as required by the BPP.

As further pertains to PPE, the PI shall:

- monitor that such supplies are consistently available
- ensure its use through periodic checks
- oversee its regular cleaning and/or proper disposal
- ensure any necessary repair or replacement.

B. Special Practices and Primary Barriers.

1. When working with human blood, blood products, and other potentially infectious materials, lab workers are prohibited from bending or shearing needles. Needles shall not be replaced in the guards or removed from the syringe.
2. Waste materials from operations involving human blood, blood products, and other potentially infectious materials are autoclaved or treated with 10% bleach solution before being discarded in regular trash.
3. Spilled material is treated with 10% bleach solution and wiped up with paper towels by lab workers wearing gloves.
4. All paper towels, gloves, and other supplies used in cleaning the spill are disinfected with bleach.
5. Bleached materials are not autoclaved due to corrosion of the steel equipment by potential generation of chlorine gas.
6. Spills on skin are immediately washed with soap and water.
7. Contaminated clothing is immediately autoclaved or treated with 10% bleach solution.
8. Contaminated clothing is not sent for laundering unless it has been autoclaved or treated with 10% bleach solution.
9. All materials disinfected with 10% bleach solution are in contact with the solution for 10 – 30 minutes.

RECOMBINANT DNA SAFETY PROGRAM

Research involving recombinant DNA shall comply with the National Institute of Health's *Guidelines for Research Involving Recombinant DNA Molecules* (NIH Guidelines) as published in the Federal Register. The recombinant DNA guidelines are applicable to all recombinant DNA research conducted at or sponsored by an institution that receives any support for recombinant DNA research from NIH. The purpose of the NIH Guidelines is to specify practices for constructing and handling recombinant DNA molecules, and organisms and viruses containing recombinant DNA molecules.

NIH defines Recombinant DNA molecules as:

- molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell
- molecules that result from the replication of those described above.

Synthetic DNA segments which are likely to yield a potentially harmful polynucleotide or polypeptide (e.g., a toxin or a pharmacologically active agent) are considered as equivalent to their natural DNA counterpart. If the synthetic DNA segment is not expressed in vivo as a biologically active polynucleotide or polypeptide product, it is exempt from the NIH guidelines. Genomic DNA of plants and bacteria that have acquired a transposable element, even if the latter was donated from a recombinant vector no longer present, are not subject to the NIH guidelines unless the transposon itself contains recombinant DNA.

APPENDIX B

WASTE MANAGEMENT LOGBOOK

WASTE MANAGEMENT LOGBOOK

GENERAL INSTRUCTIONS

A. Background

Proper handling of reaction byproducts, surplus and waste chemicals, and contaminated materials is an important part of laboratory safety procedures. Each laboratory worker is responsible for ensuring that wastes are handled in a manner that minimizes personal exposure and potential for environmental contamination.

Each laboratory that generates chemical waste must maintain a *Waste Management Logbook* where chemical waste is stored. Below is a listing of the required forms that are to be included in the Logbook; copies of those forms immediately follow this list.

B. The Waste Management Logbook

Contents:

1. Location, Supervisor and Person Responsible for Oversight
2. Acknowledgement of Worker's Instructions
3. Copy of signed refresher training sheet
4. Lists all people trained to handle hazardous waste
5. Weekly Chemical Waste Review Log
6. Print-out of CHIMS inventory
7. Annual Self Inspection
8. Satellite Accumulation Area Sign



Waste Management Log Book

Web address: www.ehs.psu.edu

Designated Accumulation Area:

Building & Room Number

Location in Room

Supervisor:

E-mail

**Individual designated to ensure
procedures are followed:**

(Lab Chemical Hygiene Officer)

E-mail

Laboratory Safety

Acknowledgement of Worker Instructions

I hereby acknowledge having received instructions on the safety procedures for chemical storage and waste management, including:

- log book documentation
- proper labeling
- proper segregation
- non-leaking chemicals
- chemical containers kept closed when not in use
- storage limits under 55 gal.
- chemical review and inventory
- safety
- self audit
- secondary containment
- waste disposal procedure policy (SY 20)
- spill/emergency response procedures
- use/selection of PPE (Personal Protective Equipment)

Specific training topics:

- Plan to designate specific location of waste accumulation
- Ensure documentation is maintained; check labeling, non-leaking chemicals, storage, and containment limits weekly
- How to fill out chemical disposal form and proper procedure for disposal of chemicals
- Segregation of chemicals into categories: flammable, bases, and acids in separate storage pans
- Chemicals are labeled and closed when not in use
- Storage limit (55 gallons) not exceeded
- Spill/ emergency response procedures
- Use/selection of PPE (Personal Protective Equipment)
- Maintain inventory in CHIMS, review chemicals annually: document date reviewed, whether chemical is retained or disposed of, and explanation
- Self-audit established by your research group.

Name (Last, First, Middle Initial)

Signature

Date of Training

Trainer

Print out and date a copy of CHIMS Inventory

All chemicals stored must be reviewed annually. Any retained chemicals must be non-leaking, labeled and confirmed to be in good condition with plans to be used in upcoming research.

I have reviewed all chemicals in my laboratories and confirm that they are in good condition and there are plans to use them in the future.

PI Signature

Date



PSU LABORATORY SAFETY INSPECTION FORM

(To be completed annually in January & submitted to your Dept. Office)

Date: _____ **Inspector(s):** _____
Building & rm #: _____ **Department:** _____

Yes No NA

| A. COMPRESSED GASES: | | | |
|--|--|--|--|
| (1) Are cylinders properly secured in an upright position? | | | |
| (2) Are stored cylinders tightly capped & kept to a minimum? | | | |
| (3) Are flammable materials stored a minimum of 20 ft from oxygen cylinders? | | | |
| (4) Are regulators, connections, and tubing in good condition? | | | |
| (5) Is flammable gas tubing secured and labeled? | | | |
| (7) If toxic gases are used, are appropriate leak sensors/alarms in place, regularly checked, and calibrated? | | | |
| (8) If toxic gases with poor warning qualities are used (i.e. odorless), are redundant systems and shutoffs in place? | | | |
| B. ELECTRICAL EQUIPMENT: | | | |
| <i>Refrigerators and Freezers:</i> | | | |
| (1) Are only "explosion proof" or "flammable storage" refrigerators/freezers used to store flammables? | | | |
| (2) Are refrigerators/freezers which are not "explosion proof" or "Flammable Storage" clearly labeled "NO FLAMMABLES ALLOWED"? | | | |
| (3) Are refrigerators labeled for "CHEMICAL USE ONLY" or "FOOD USE ONLY" and used accordingly? | | | |
| (4) Is the interior sound and free of chemical spills or contamination? | | | |
| (5) Are containers stored within stoppered or tightly closed? | | | |
| <i>General Equipment:</i> | | | |
| (1) Is electrical apparatus equipped with ground plugs or properly grounded? | | | |
| (2) Are extension cords in good condition and free of any splices? | | | |
| (3) Are extension cords for temporary use only, not overloaded, and no longer than six feet? | | | |
| (4) Are two-prong appliances not located directly above or within a five-foot radius of flammables or sinks? | | | |
| (5) Are electrical panels free from obstruction? | | | |
| (6) Are appliances properly grounded? | | | |
| C. EMERGENCY EQUIPMENT: | | | |
| <i>Fire Extinguishers:</i> | | | |
| (1) Are extinguishers in designated locations & are these locations labeled? | | | |
| (2) Are extinguishers accessible and free from obstructions? | | | |
| (3) Is the current year and date of last inspection indicated on the tag? | | | |
| <i>Safety Showers and Eyewashes:</i> | | | |
| (1) Are showers/eyewashes labeled, accessible, and free from obstructions? | | | |
| (2) Are eyewashes and drench hoses flushed weekly? | | | |
| (3) Are safety showers flushed annually? | | | |
| <i>First Aid:</i> | | | |
| (1) Are first aid kits stored in designated areas? | | | |
| (2) Is the kit properly stocked according to University Policy SY-21? | | | |

Yes No NA

| D. HAZARDOUS SUBSTANCES: | | | |
|---|--|--|--|
| Chemical Storage: | | | |
| (1) Has chemical inventory been updated annually? | | | |
| (2) Are chemicals dated upon receipt? | | | |
| (3) Are chemical containers labeled, capped, and in good condition? | | | |
| (4) Is the storage of chemicals on, above, or next to a desk avoided? | | | |
| (5) Are all corrosive chemicals stored below "eye level"? | | | |
| (6) Are chemicals segregated by hazard (organics away from oxidizers, flammables away from acids)? | | | |
| (7) Is chemical storage kept to a minimum? | | | |
| Solvent Storage: | | | |
| (1) Is excess solvent stored in approved safety cans or solvent storage cabinets and not placed high on shelving? | | | |
| (2) Are approved safety cans equipped with self-closing lids and are flame arrestors intact? | | | |
| (3) Are safety can lids closed? | | | |
| (4) Are safety cans/wash bottles properly labeled? | | | |
| Infectious/Chemical Waste: | | | |
| (1) Are waste containers labeled and chemical compositions identified? | | | |
| (2) Are waste areas inspected weekly and documentation maintained? | | | |
| (3) Is waste stored in secondary containment? | | | |
| (4) Have waste area overseer and Supervisor been designated? | | | |
| (5) Is total volume of all chemical waste < 55 gallons? | | | |
| (6) Has the self audit been conducted annually? | | | |
| (7) Are biohazard containers properly used where needed (i.e. autoclave bags, sharps containers)? | | | |
| Laboratory Hoods/Local Exhaust: | | | |
| (1) Are exhaust hoods working properly? (Confirm date of last inspection). | | | |
| (2) Do hood sashes open/close properly and is glass intact? | | | |
| (3) Is hood free of excess chemical storage/equipment? | | | |
| (4) Are hood sashes down (panels closed) when not accessing? | | | |
| E. PROTECTIVE EQUIPMENT: | | | |
| Personal Equipment: | | | |
| (1) Are safety glasses with side shields worn as required? | | | |
| (2) Are substantial shoes worn with no sandals or open toes? | | | |
| (3) Is protective clothing worn while working at benches? | | | |
| (4) Are gloves selected and worn according to hazard? | | | |
| (5) Are chemical splash goggles/face shields worn when appropriate? | | | |
| Other Equipment: | | | |
| (1) Is proper protective equipment in place (shields, guards, warning sigs, etc)? | | | |
| (2) Is secondary containment used for Hg use and storage? | | | |
| General Housekeeping: | | | |
| (1) Are aisles and exits free from obstructions? | | | |
| (2) Are benches/shelves not overloaded with unused equipment/chemicals? | | | |
| (3) Are no combustibles stored within three feet of the ceiling? | | | |
| (4) Is no damaged glassware in use (i.e. broken or chipped)? | | | |
| (5) Is lab apparatus properly assembled and used in a safe manner? | | | |
| (6) Are bicycles not stored in lab? | | | |
| F. SIGNS: | | | |
| (1) Are special hazard signs in place (i.e. lasers, cryogenic hazards, biohazards)? | | | |
| (2) Are lab doors labeled and information up-to-date? | | | |

Yes No NA

| G. TRAINING: | | | |
|---|--|--|--|
| (1) Have lab personnel been instructed in potential hazards and lab safety practices? | | | |
| (2) Has information been provided on the availability of "Right-to-Know" training? | | | |
| (3) Have all personnel in lab (including PI) received initial chemical/waste training? | | | |
| (4) Have all personnel in lab (including PI) completed the mandatory refresher training? | | | |
| H. VACUUM EQUIPMENT: | | | |
| (1) Are vacuum pump belt guards in place? | | | |
| (2) Are glass Dewars wrapped or shielded? | | | |
| (3) Are protective shatterproof shields in place when vacuum equip. is used? | | | |
| (4) Are glass desiccators under vacuum stored in metal guards or shielded? | | | |
| I. SECURITY (PSU POLICY SY-24): | | | |
| (1) Are radioactive, biohazardous material, and hazardous materials secured from unauthorized removal? | | | |
| (2) Is lab complying with Erickson/Schultz letter "Safety and Security Procedures for Hazardous Materials and Food Processing?" | | | |
| (3) Is lab familiar with PSU Policy SY-24 <i>Use of Biohazardous Materials in Research and Instruction</i> and conducting annual inventory of materials regulated by this policy? | | | |
| J. STANDARD OPERATING PROCEDURS: | | | |
| (1) Are standard operating procedures established & available for hazardous operations? | | | |
| (2) Have you completed your Unit Specific Plan? | | | |

Name of Principal Investigator (print)

Signature of Principal Investigator

Name of Department Head (print)

Signature of Department Head

SATELLITE ACCUMULATION AREA

Please Post

Do you know your responsibilities for proper handling of hazardous waste?

Please review the following requirements to ensure that you comply with environmental regulations and safe handling procedures.

TRAINING: Environmental regulations require training of people who generate or handle hazardous waste. Training must take place within 90 days of date-of-hire; and annually thereafter.

Training is offered on a regular schedule by Environmental Health and Safety (EHS). Check EHS Homepage www.ehs.psu.edu for available dates and times.

CONTAINER LABELING AND SECONDARY CONTAINMENT: All hazardous waste containers must have a red waste tag at the time waste is first placed into the container. The red Chemical Disposal Label must accurately identify the content of the container. All containers must also be stored in plastic bins to catch any leakage.

EHS supplies secondary containers and red tags. Call EHS if you need supplies or additional information.

CONTAINER CLOSURE: Hazardous waste containers must be closed at all times during storage, except when waste is being added or removed.

Keep containers closed. Regulations do not permit open funnels in waste Containers when not in use.

STORAGE: For safety and environmental reasons, hazardous waste must be stored in a designated "Satellite Accumulation Area". These areas must be inspected weekly for container leakage, labeling, chemical compatibility and to determine that total volume does not exceed 55 gallons.

If you have full waste containers, please fill out a Chemical pick up request available on our web page, www.ehs.psu.edu.

APPENDIX C

UNIT SPECIFIC PLAN

UNIT SPECIFIC PLAN

GENERAL INSTRUCTIONS

A. Background. At PSU, four documents comprise the PSU Laboratory and Research Safety Plan – the General Safety Plan, the Waste Management Logbook (WML), Rules and Procedures for the Use of Radioactive Material (RPU) and the Unit Specific Plan. The WML, GSP and the RPU are the companion pieces to the *Unit Specific Plan*, which is the lab-specific portion of the Laboratory and Research Safety Plan Together they cover the most salient information needed by workers to protect themselves from workplace hazards. Should you have difficulty preparing the *Unit Specific Plan*, Please refer to EHS for guidance.

Please complete the [Unit Specific Plan Form](#) available on the EHS website. The plan will be reviewed by EHS during routine safety inspections to evaluate whether the types of hazards in your area have been addressed in the plan.

EHS has developed a Web site to inform faculty, staff, and students of the safety and compliance programs and the policies and procedures with which they should become familiar while at PSU. This Web site is accessible at www.ehs.psu.edu. All other EHS documents and programs referred to in this *Unit Specific Plan* are available through the EHS Web site.

B. Specifics for Completion. The *Unit Specific Plan* Form consists of the follow sections:

- I. Research Overview
- II. Safety Infrastructure
- III. Chemical Safety
- IV. Biological Safety
- V. Animal Related Hazards
- VI. Radiation Safety
- VII. Safety Precautions in Place
- VIII. Certification of Agreement
- IX. Appendices

The *Research Overview* and *Certification of Agreement* sections are required from every principal investigator who supervises or has responsibility for a lab or group of labs. **Lab workers must read the *Unit Specific Plan* as an element of initial lab safety training.** Section VII. must be signed by everyone working in the lab. New lab workers who join the group after the *Unit Specific Plan* has been finalized must read and sign the form as an element of initial safety training.

The first segment of the *Unit Specific Plan* should consist of “Fact Sheets” (located in Appendix A) for the various safety topics of concern in labs. The Fact Sheets summarize standard University guidelines for prudent practice in research laboratories. **Faculty, staff, and students shall familiarize themselves with the guidelines contained on the following Fact Sheets:**

- Emergency Response Training Fact Sheet
- Chemical Safety Fact Sheet
- Compressed Gas Cylinders Fact Sheet
- Highly Reactive Materials, High-Pressure Reactions, or Vacuum Systems Fact Sheet
- Biological Safety Fact Sheet

Please answer all questions and do not leave any blanks. If a question has no connection to the work in your lab(s), please write “NA” or “not applicable” next to the answer. You are not confined to the boxes for your responses. If you wish to add additional information, attach separate sheets for elaboration.

The *Unit Specific Plan* shall be formally reviewed by the PI on an annual basis. Annually you must complete the *Annual Review* form. The *Unit Specific Plan* shall be kept current between *Annual Reviews*. Whether seen by EHS or not, the *Unit Specific Plan* shall reflect new or modified tasks and procedures which affect occupational exposure and new or revised employee positions with occupational exposure.

The *Unit Specific Plan* and its component Fact Sheets shall be made available to lab workers and must be readily available at all times.

Please call EHS with any questions or comments regarding the *Unit Specific Plan* process. Thank you for your time and effort in supporting this important safety tool. EHS will be glad to meet with you if you have difficulty with the plan.

C. Information for Contacting EHS.

6 Eisenhower Parking Deck
University Park, PA
814-865-6391
FAX 814-863-7427
www.ehs.psu.edu