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| **Title:** Laboratory and Research Safety Plan  **Document #:** EHS-0004 **Issued:** 1/17/2019  **Approved By:** Robert Segura **Version:** 8  **Page:** 1 of 145 |

**Laboratory and Research**

**Safety Plan**

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

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**The Pennsylvania State University**

**ehs.psu.edu**

**814-865-6391**

Emergency Phone Numbers

Fire, Police, Ambulance 911

Environmental Health and Safety 814-865-6391

University Police and Public Safety 814-863-1111

University Health Services 814-863-0774

Occupational Medicine 814-863-8492

Mount Nittany Medical Center Emergency Department 814-234-6110

Poison Control 800-222-1222

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# LABORATORY AND RESEARCH SAFETY PLAN

## Purpose

The Pennsylvania State University (Penn State) has established a policy for the management of laboratory and research hazards, [**SY43**](https://policy.psu.edu/policies/sy43)**,** Laboratory and Research Safety Plan (LRSP).

The LRSP provides information and guidance to help you conduct your laboratory and research work safely and in compliance with environmental health and safety regulations and Penn State policy. It is also a useful training resource for principal investigators (PI) and other supervisory personnel.

The LRSP is made up of four sections: the General Safety Plan (this document), the [**Laboratory Waste Management Plan**](https://ehs.psu.edu/chemical-and-hazardous-waste-management/requirementsguidelines), [**Rules and Procedures for the Use of Radioactive Material at The Pennsylvania State University**](https://ehs.psu.edu/radioactive-materials/radioactive-materials-requirements-guidelines), and the [**Unit Specific Plan**](https://ehs.psu.edu/laboratory-safety/overview). All four documents make up the entirety of the LRSP.

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**](https://ehs.psu.edu/laboratory-safety/overview) is the portion of the plan that addresses hazards specific to your laboratory or research area. Users of radioactive material shall follow the [**Rules and Procedures for the Use of Radioactive Material at The Pennsylvania State University**](https://ehs.psu.edu/radioactive-materials/radioactive-materials-requirements-guidelines). Generators of unwanted chemical material shall follow the [**Laboratory Waste Management Plan**](https://ehs.psu.edu/chemical-and-hazardous-waste-management/requirementsguidelines). These four sections should provide comprehensive information to address hazards in your area.

The LRSP shall be made available to all research and laboratory workers. Electronic access to the General Safety Plan (this document), [**Laboratory Waste Management Plan**](https://ehs.psu.edu/chemical-and-hazardous-waste-management/requirementsguidelines), and [**Rules and Procedures for the Use of Radioactive Material at The Pennsylvania State University**](https://ehs.psu.edu/radioactive-materials/radioactive-materials-requirements-guidelines) is sufficient. A completed [**Unit Specific Plan**](https://ehs.psu.edu/laboratory-safety/overview) shall be made available in paper copy in each laboratory or research area.

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 PI 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 Penn State policy.

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

The LRSP is the Chemical Hygiene Plan for Penn State, including all associated materials, such as the Unit Specific Plan, Standard Operating Procedures, Fact Sheets, CHIMS, etc. Further information about the requirements of the Chemical Hygiene Plan, as per the Occupational Safety and Health Administration (OSHA), can be found in [**29 CFR 1910.1450**](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10106&p_table=STANDARDS) and its appendices.

# Scope

As per [**SY43**](https://policy.psu.edu/policies/sy43), this program applies to all employees, students, visitors, and any other individuals at all locations of Penn State who work in research or laboratory settings (except for the Hershey Medical Center and College of Medicine). Penn State employees and students shall follow the guidelines and regulations of institutions they are visiting for research purposes, including other universities, laboratories, and field sites.

# RESPONSIBILITIES

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

## Penn State Leadership

The University president endorses Penn State’s Environmental Health and Safety (EHS) policy [**SY01**](https://policy.psu.edu/policies/sy01)requiring that the University leadership maintain a safe work environment within their jurisdiction, by monitoring and exercising control over their assigned areas.

## Finance and Business

The president has delegated administrative responsibility for activities of EHS to the senior vice president for Finance and Business.

## Office of Physical Plant

The associate vice president of the Office of Physical Plant (OPP) reports to the senior vice president for Finance and Business and oversees the activities of EHS.

## Environmental Health and Safety

The director of EHS reports to the associate vice president of OPP. EHS has overall responsibility for the administration of Penn State’s environmental health and safety programs. Their mission is to work with the university community to develop and implement efficient, comprehensive, and pro-active health and safety programs.

EHS responsibilities include:

* developing the LRSP, including appropriate chemical hygiene policies and practices,
* providing resources and assisting work units in implementing the LRSP,
* developing and providing related training materials,
* auditing compliance in laboratory and research areas,
* coordinating collection of hazardous waste produced in laboratories,
* responding to emergencies in the event of a spill, and
* periodically reviewing and updating the LRSP, as needed.

EHS representatives are authorized to enter Penn State 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.

### Assistant Director of Environmental Health and Safety

The assistant director of EHS serves as the Chemical Hygiene Officer for Penn State.

## Budget Executives and Budget Administrators

Individuals in roles such as chancellor, dean, associate dean, division head, institute directors, etc., have the primary responsibility to maintain a safe work environment within their jurisdiction, by monitoring and exercising control over their assigned areas.

* These positions have the primary responsibility to maintain a safe work environment within their jurisdiction, by monitoring and exercising control over their assigned areas.
* Assign a representative from each academic and administrative unit to the University Safety Council. This representative must be selected to ensure compliance with this policy and other appropriate University safety policies, rules, procedures and practices. This is often the individual designated to act on behalf of the budget executive or budget administrator.
* 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.
* Ensure that health and safety responsibilities are carried out in the academic departments or administrative units for which they are responsible.
* 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.
* Monitor implementation of programs designed to protect the health and safety of faculty, staff, students, and visitors:
  + Consult with their University Safety Council representative and/or EHS 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.
  + Support measures such as training, use of protective devices, and resources to control and prevent hazards.

### College Safety Officers

Each College Safety Officer shall:

* attend the regularly scheduled meetings and special meetings of the University Safety Council, and report Council activities to the appropriate budget executive.
* 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.
* accompany insurance company loss prevention representatives on inspections of areas under the Safety Officer's jurisdiction.
* review all [**Employer's Report of Occupational Injury or Disease**](https://policy.psu.edu/policies/sy04) for employee accidents, or the [**Incident Report**](https://policy.psu.edu/policies/sy05) 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. They shall also assist in the investigation of all serious accidents, and all other accidents when requested by the supervisor.
* initiate proper follow-up measures and ensure corrective actions are implemented when unsafe conditions, practices, or equipment are reported or observed.

### 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 "College Safety Officers."

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

## Vice President for Research

The vice president for research reports to the executive vice president and provost and oversees the activities of the Office of Research Protections (ORP), including appointing members to the Institutional Animal Care and Use Committee (IACUC), Institutional Biosafety Committee (IBC), Institutional Review Board (IRB), and University Isotope Committee (UIC).

### Office of Research Protections

The ORP partners with researchers working with human subjects, vertebrate animals, regulated biohazardous materials, and radioisotopes to maintain the integrity of Penn State research.

#### Institutional Animal Care and Use Committee

The IACUC is responsible for reviewing all proposed research, testing, or teaching activities involving vertebrate animals to be conducted at Penn State. Animal work involving the use of biohazardous agents or radioisotopes requires prior approval of the IBC or UIC, respectively. See Penn State Research Protection Policy [**RP04, Care and Use of Vertebrate Animals**](https://policy.psu.edu/policies/RP04) for further details.

#### Institutional Biosafety Committee

The IBC oversees research and instruction involving regulated biohazardous materials. Members are drawn from a variety of disciplines including chemistry, engineering, and biomedical sciences along with the community.

The IBC is responsible for reviewing and approving all research and instruction involving regulated biohazardous materials, including recombinant DNA, as defined in Penn State Research Protection Policy [**RP11, Use of Regulated and Biohazardous Materials in Research and Instruction**](https://policy.psu.edu/policies/rp11). Approval by the IBC must be granted *prior* to the use of any biohazardous material.

#### Institutional Review Board

The IRB has the authority to review all human subject research in which Penn State is engaged, regardless of funding or research site, including the categories exempted or waived by Office of Human Research Protections or Food and Drug Administration (FDA) regulations. See Penn State Research Protection Policy [**RP03, The Use of Human Participates in Research**](https://policy.psu.edu/policies/RP03) for further details.

#### University Isotopes Committee

The UIC is responsible for the administration of specific licenses issued to Penn State for the use of radioactive materials and insuring that such licensed use meets federal, state, and local regulations and University policy. In addition, the UIC evaluates procedures, and approves, denies, or rescinds, individual University isotope authorizations. The Committee meets on a quarterly basis to address the University's radioactive material status. See Penn State Safety Policy [**SY14, Use of Radioactive Materials**](https://policy.psu.edu/policies/sy14) for further details.

## 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 Penn State’s environmental health and safety programs to department heads. This means that the department head shall provide a safe workplace and shall implement the environmental health and safety programs. This includes ensuring that personnel are adequately trained, and overseeing the preparation and submission of annual laboratory and research safety self-inspections.

Department heads shall appoint departmental safety officers and alternates who are responsible for the oversight and coordination of safety issues within that specific department, and serve as the primary point of contact and liaison with the College Safety Officer.

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 Penn State policies applicable to the department's work and shall ensure compliance through PIs and other supervisory personnel. Regulatory and policy documents are available on the EHS website, [**ehs.psu.edu**](http://www.ehs.psu.edu) and from EHS.

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

### Departmental Safety Officers

Each Departmental Safety Officer shall:

* establish and maintain, as chairperson, a Safety Committee within their 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.
* work with Department administration to visibly demonstrate leadership commitment to workplace safety and health.
* implement processes to raise work unit awareness of the safety officer and safety committee.
* assist in the investigation of all serious accidents and incidents, and all other accidents and incidents when requested by the supervisor or EHS.
* initiate proper follow-up measures and ensure corrective actions are implemented when unsafe conditions, practices, or equipment are reported or observed.
* implement processes to ensure that students and employees in their area know what to do in an emergency.
* familiarize themselves, and members of their department’s safety committee, with the EHS website, identifying those programs that are applicable to their areas.
* proactively provide EHS information and serve as a resource for students and employees in their areas.
* ensure that required training is delivered and completed.
* coordinate centralized record keeping. This includes:
  1. copies of laboratory and research safety self inspections, including PI and Department Head signatures.
  2. list of hazardous waste storage areas, including PI and overseers for those areas.
  3. list of individuals who have had laboratory and research safety training, including initial and annual refresher.
* contact EHS to facilitate laboratory moves, both moving within or leaving the university.
* provide to EHS:
  1. Confirmation that all affected individuals have completed and submitted the laboratory and research safety self-inspection in January.
  2. a list of chemical waste areas.
* serve as the Chemical Inventory Management System (CHIMS) officer with the following responsibilities:
  1. Contact EHS with required building and personnel information.
  2. Be familiar with the use and features of the CHIMS.
  3. Ensure that all chemical users within their areas of jurisdiction update the CHIMS annually.
  4. Maintain ongoing communications with college safety officers in implementation of and compliance with this policy.
* help facilitate EHS laboratory inspections:
  1. Responsible for working with College Safety officer to schedule inspections.
  2. Accompany EHS on inspections.
  3. Distribute inspection forms to faculty following inspection.
  4. Collect all signed forms from faculty and ensure deficiencies have been corrected.
  5. Forward forms to EHS.

## Principal Investigators and/or Supervisors

Anybody who supervises or oversees laboratories or research is responsible for the safe and legal conduct of research under their purview. This is commonly the principal investigator (PI) for a laboratory, but also includes supervisors of laboratory and research areas, farms, facilities, etc. All supervisors, including department chairs, faculty, and other employees with direct oversight of Penn State 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 safety policies and to prevent injuries to their employees and students.

This responsibility shall not be delegated. The PI/supervisor shall be aware of all of the hazards associated with all materials present in their laboratory and research areas. In the event of an accident or incident, the PI/supervisor shall initiate appropriate emergency procedures.

The PI/supervisor shall:

* be thoroughly informed of appropriate Penn State and Departmental safety policies, rules, and procedures and how they specifically apply to their responsibilities and authority including the LRSP.
* inform all new and current employees and students that safety and health, and concern for the environment, are priorities at Penn State.
* inform all new and current employees about environmental health and safety policies, rules, regulations, and procedures, as well as their specific responsibilities.
* be familiar with and understand the rules, regulations, and Penn State 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 unwanted chemicals and biological materials, posting of warnings, medical surveillance, chemical inventory reporting, engineering controls, safe work practices, provision of PPE, and access restrictions.
* ensure that required safety equipment, devices, and personal protective equipment (PPE) are provided and maintained, and are properly used by individuals working in their operations.
* provide employees and students with instruction and assistance in the proper operation of equipment or materials involved in any operation that may be potentially hazardous.
* take prompt corrective action when unsafe conditions, practices, or equipment are reported or observed.
* require prompt reporting of health and safety concerns.
* promptly conduct a thorough investigation in all work-related injuries, illnesses, and accidents, submit appropriate recommendations on all reports, including the [**Employer's Report of Occupational Injury or Disease**](https://policy.psu.edu/policies/sy04) or the [**Incident Report**](https://policy.psu.edu/policies/sy05), as appropriate, and follow through to ensure corrective measures have been implemented.
* coordinate or conduct inspections to maintain safe and healthful conditions, and address any deficiencies that are identified.
* provide financial support for health and safety improvements, or request assistance from the next higher level of supervision regarding these requests.
* prepare a Unit Specific Plan and shall make all laboratory personnel aware of the plan.
* review and update the Unit Specific Plan annually, ensuring completion of certification of agreement by all affected lab/researchers.
* ensure Standard Operating Procedures (SOPs) are developed for hazardous chemicals and operations not covered in the LRSP.
* provide for health and safety training.
* ensure employees, visitors, and students receive Laboratory and Research Safety training (initial) provided by EHS, including completion of an annual refresher. PIs are also required to complete these trainings.
* provide training and information on the LRSP including the Unit Specific Plan to all affected employees, visitors, and students.
* notify employees, visitors, or students of hazardous chemical monitoring results, if any.
* answer employee’s questions and concerns, and forwards unresolved questions and concerns to EHS for response.
* make sure employees, visitors, or students who develop signs or symptoms associated with hazardous chemical exposure are given an opportunity to receive medical attention.
* make available to employees permissible exposure limits (PEL) for hazardous chemicals, information on signs and symptoms associated with exposures to hazardous chemicals used, and Safety Data Sheets (SDS) for hazardous chemicals used. EHS is available to provide guidance.
* either act as or assigns an individual in their laboratory the responsibility for overseeing safety within the laboratory. This person serves as the Laboratory/Research Safety Officer.
* serve as the Chemical Hygiene Officer (CHO) unless they have delegated this responsibility to an individual within their laboratory.

## Laboratory/Research Safety Officers

Each PI/supervisor shall either act as, or assign, an individual in their laboratory and research area the responsibility for overseeing safety within the area. This person serves as the Laboratory/Research Safety Officer. In areas where hazardous chemicals are used, this person also serves as the lab’s Chemical Hygiene Officer.

Laboratory/Research Safety officers:

* monitor the procurement and use of chemicals.
* oversee the Satellite Accumulation Area and ensure they are inspected weekly.
* ensure proper disposal of chemicals used in the laboratory and that they are submitted for pick up promptly.
* ensure that appropriate self-inspections are maintained.
* provide input to PIs/Supervisors on developing precautions and adequate facilities.
* know the current legal requirements concerning regulated substances, as provided through EHS resources.
* seek ways to improve the lab’s Unit Specific Plan.

## The Individual

Each individual working in a laboratory, any other work site where research is conducted, or where hazardous materials are used, shall know and comply with Penn State’s safety policies and rules, and shall follow both oral and written instructions from the PI or supervisor. The individual shall report to the PI any unsafe conditions and any accident or exposure to chemicals or biological agents. If the individual receives no response or an unsatisfactory response, they shall contact the department head or EHS.

All Penn State 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 Penn State locations.

Individuals working in research, laboratories, or with hazardous materials shall:

* comply with applicable environmental health and safety policies, standards, rules, regulations, and procedures. These include safety-related signs, posters, warnings, and written or oral directions when performing tasks.
* not perform any function or operation that is considered hazardous, or is known to be hazardous, without proper instructions and authorization.
* only use equipment and materials approved or provided by the supervisor or instructor and for which instruction has been provided by this or prior experience, training, and proven competence.
* 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.
* wear or use appropriate PPE.
* report all unsafe conditions, practices, or equipment to the PI, supervisor, instructor, or safety officer whenever deficiencies are observed.
* inform the PI, supervisor, or instructor immediately of all work-related injuries or accidents and obtain prompt medical attention when necessary.
* provide information necessary for the PI, supervisor, or safety officer to adequately and thoroughly complete the [**Employer's Report of Occupational Injury or Disease**](https://policy.psu.edu/policies/sy04) or the [**Incident Report**](https://policy.psu.edu/policies/sy05), as appropriate, and any other associated accident/illness reports.

### Students

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

# Abbreviations and definitions

## Abbreviations

The following are abbreviations commonly used throughout the LRSP and its associated attachments.

|  |  |
| --- | --- |
| ANSI | American National Standards Institute |
| ARP | Animal Resource Program |
| BMBL | Biosafety in Microbiological and Biomedical Laboratories |
| BSC | Biosafety Cabinet |
| BSL | Biosafety Level |
| CDC | Centers for Disease Control and Prevention |
| CHIMS | Chemical Inventory Management System |
| CPR | Cardiopulmonary resuscitation |
| DEA | Drug Enforcement Administration |
| DEP | Department of Environmental Protection |
| DOT | Department of Transportation |
| EHS | Environmental Health and Safety |
| EPA | Environmental Protection Agency |
| HBV | Hepatitis B virus |
| HEPA | High Efficiency Particulate Air |
| IACUC | Institutional Animal Care and Use Committee |
| IBC | Institutional Biosafety Committee |
| IPM | Integrated Pest Management |
| LRSP | Laboratory and Research Safety Plan |
| NFPA | National Fire Protection Association |
| NIH | National Institutes of Health |
| OPP | Office of Physical Plant |
| ORP | Office for Research Protections |
| OSHA | Occupational Safety and Health Administration |
| PDA | Pennsylvania Department of Agriculture |
| PEL | Permissible Exposure Limit |
| Penn State | The Pennsylvania State University |
| PI | Principal Investigator |
| PPE | Personal Protective Equipment |
| ppm | parts per million |
| SDS | Safety Data Sheet |
| SOP | Standard Operating Procedure |
| UV | Ultraviolet |

## Definitions

The following terms are defined to allow for a better understanding of this plan.

**Action Level** – a concentration designated in 29 CFR Part 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

**Administrative Controls** – Focus on the interaction between an employee and a hazard. These controls involve the introduction of work practices that reduce the risk of injury or illness. Common examples of administrative controls include job rotation, training, and the development of standard operating procedures (SOPs).

**Employee** – may work for the University in a faculty, staff, technical service, or wage payroll capacity.

**Engineering Controls** – Focus on controlling a hazard at its source. The basic concept behind engineering controls is that work environments, equipment, and job tasks should be designed to eliminate or reduce exposure to hazards. Common examples of engineering controls include machine guarding, ventilation, and enclosure of noisy equipment.

**Flash point** – Thetemperature at which a liquid gives off vapor sufficient to form an ignitable mixture with the air near the surface of the liquid or within the vessel used as determined by appropriate test procedure.

**Graduate Assistant or Teaching Assistant** – A “student” that works and is compensated by Penn State similar to an employee.

**Hazardous chemical** –any chemical which is classified as a health hazard or simple asphyxiant in accordance of the Hazard Communication Standard.

**Health hazard** – any chemical that is classified as posing one of the following hazardous effects: acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); aspiration hazard.

**Laboratory** – A laboratoryis a facility that provides controlled conditions in which scientific research, experiments, and measurement may be performed. Any physical space that is owned or operated by Penn State, for teaching or research purposes, that is equipped to conduct experiments, tests, investigations or other activities, which may expose humans, animals, or the environment to chemical, radioactive, biological or other physical hazards, such as laser, electrical or mechanical hazards. Physical spaces that may be considered to be laboratories include scientific laboratories, greenhouses, farm buildings, field research stations, fine art studios, and theater stage design workspaces, as well as those areas that support the foregoing through storage, shipping, or transportation of these hazards.

**Permissible Exposure Limit (PEL)** – regulatory limits based on the amount or concentration of a substance in the air. They may also contain a skin designation. OSHA PELs are based on an 8-hour time weighted average exposure.

**Personal Protective Equipment (PPE)** – Clothing which provides a physical barrier between a person and a known hazard.

**Physical hazard** – any chemical that is classified as posing one of the following hazardous effects: explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid, or gas); self reactive; pyrophoric (gas, liquid, or solid); self-heating; organic peroxide; corrosive to metal; gas under pressure; in contact with water emits flammable gas; or combustible dust.

**Supervisor –** A Penn State employee who oversees a laboratory and/or research. In academic areas, supervisors include faculty/principal investigators, laboratory directors, class instructors, or others having direct supervisory and/or oversight authority.

# THE LABORATORY AND RESEARCH SAFETY PLAN

## Laboratory and Research Safety Plan

The LRSP is intended to be a central safety resource for the laboratory and research areas. The complete Safety Plan includes:

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

## Laboratory and Research Safety Documentation

The following documentation is required to be kept, on paper, in every laboratory and research area at Penn State:

* Unit Specific Plan (reviewed annually, updated as needed)
* Certification of Agreement page (re-signed every year)
* Standard Operating Procedures (SOPs)
* EHS safety training records (including all initial and refresher training records)
* CHIMs printout (updated electronically at least annually, printed yearly)
* Laboratory and Research Safety self-inspection form
* Laboratory Waste Management Plan
  + specifically 3 years of satellite accumulation area weekly inspection sheets

These documents should preferably be kept in one binder entitled Laboratory and Research Safety binder, in a holder on the back of the room’s entrance door or to either side of the door inside the lab.

Research groups may also, at their discretion, maintain the following documents on paper in the lab, though they are not required:

* The entirety of the Laboratory and Research Safety Plan
* The entirety of the Laboratory Waste Management Plan
* Safety Data Sheets

Laboratory and research groups that occupy more than once space within the same building are not required to make duplicate binders. The binder may be kept in one location with signage posted in the other locations about where the binder may be found. This does NOT apply to research groups that occupy space in multiple buildings. These labs are required to have a binder for each building that covers the research specific to that building.

### Department level documentation

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

## Unit Specific Plan

The Unit Specific Plan is the laboratory-specific section of the LRSP for research labs, teaching labs, research areas, and common facilities (those shared by more than one researcher). In the case of shared facilities, the director, coordinator, or designated facility supervisor for the center shall compile the Unit Specific Plan. A blank template of the Unit Specific Plan can be found in the [**forms section**](https://ehs.psu.edu/laboratory-safety/forms) of the Laboratory and Research Safety webpage.

### Initial Preparation

If biological, chemical, or radiological materials, or reactive processes are used, the PI/supervisor shall prepare a Unit Specific Plan. It shall be made available for review by EHS. The Unit Specific Plan contains the following sections; only sections that are applicable need be completed.

1. Research Overview
2. Chemical Safety
3. Biological Safety
4. Radiation Safety
5. Animal Related Hazards
6. Physical Hazards
7. Safety Precautions in Place
8. Certification Agreement
9. Appendices

### Change of Facility

A new Unit Specific Plan shall be prepared when new facilities are opened or when labs move within Penn State. The original Unit Specific Plan will not be considered valid for the new space.

### 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.

## Inspections

Penn State has an inspection program for all laboratory and research areas. Laboratory and research safety self inspections are conducted annually by lab personnel.

Laboratory inspections are also regularly conducted by the EHS staff. PIs 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 PPE, signs and postings, and records. Researchers may also be interviewed. Inspection findings are provided to the PI/supervisor, department head, and safety officer.

# UNIVERSITY EMERGENCY INFORMATION

## 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 “[**In Case of Emergency**](https://ehs.psu.edu/case-emergency)” website.
* For emergency information relating to chemical spills and exposures, see Section 8.0.
* For emergency information relating to biological spills and exposures, including exposure to bloodborne pathogens, see Section 9.0.

Call for assistance when needed. **Always** call 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 normal business hours, 8 am – 5 pm. After normal business hours, call University Police, 814-863-1111.

## University Emergency Response Plan

University Police and Public Safety maintains Penn State’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 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, University Police will call the local fire department or local hazardous materials response team.

## Building Emergency and Evacuation Plans

In the event of a fire, hazardous material release, or other hazardous situation requiring emergency response, the first person at the scene 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.

## Power Failure

In the event of a power failure, if 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 University Police if there is a possibility of an uncontrolled reaction in a process that cannot be shut down.

## Incident and Accident Reporting

All laboratory research incidents and accidents shall be reported to EHS, including spills, fires, or injuries. Laboratory incidents and accidents shall be investigated by the PI or supervisor. The PI or supervisor shall be responsible for providing a written report of investigation findings and corrective actions to EHS, and ensure 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.

## EHS Assistance

EHS will respond to spills. Cleanup may be done by area employees under the direction of the PI, supervisor, or EHS if there is no immediate risk of fire, or health or physical hazards. In situations involving these hazards, EHS will advise on evacuation or other precautions to protect persons and property in the immediate area.

## Medical Emergency Procedures

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

### For employees

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

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

**PROCEDURES**

I. Ambulatory victims (able to walk):

1. Inform the PI or supervisor of the injury or illness.
2. Proceed to Occupational Medicine or Mount Nittany Medical Center to secure treatment.

II. Nonambulatory victims (unconscious or unable to walk)

* + 1. Call 911.
    2. Report the injury, victim's name, and location (building, floor).
    3. Ask for an ambulance.

### For students

Students in need of emergency medical assistance should call 911.

For other, less severe medical emergencies, call University Health Services, 814-863-0774, or a local health care provider.

## Personal Injury

### 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.

### 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 PPE.

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

### Ingestion

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

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

### Puncture or Cut

When treating a victim with a puncture wound or cut, wear PPE (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.

### Needlestick

Needlesticks or other accidents involving skin punctures by a chemical or biological agent shall be reported to the PI or 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 obtain medical attention and report the incident. Many sections in this Plan include information about engineering controls and work practices that can be used to minimize the risk of needlesticks. See Sections 9.4, 9.6.5, and 9.8.3.

### Eye Exposure

Remove contact lens(es), if applicable, and promptly flush eye(s) using an eyewash for at least 15 minutes and seek immediate medical attention.

### Skin Exposure

Promptly flush the affected area with water using a safety shower for at least 15 minutes. Remove any contaminated clothing to ensure the chemicals are washed away from the body. Seek immediate medical attention.

# GENERAL LABORATORY and research SAFETY

Working safely requires having the proper containment equipment and engineering controls, wearing appropriate PPE, 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 PIs and supervisors in planning work and guide 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 PI/supervisor or contact EHS.

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

The [**Laboratory and Research Safety Self Inspection form**](https://ehs.psu.edu/laboratory-safety/forms) provides a useful tool for evaluating your laboratory. The self inspection shall be performed annually. This form should be completed in January and a copy placed in your Laboratory and Research Safety binder. This same form can also be used for peer inspections of laboratories.

## Training

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

PIs shall ensure that laboratory personnel are properly trained and shall certify training in the Unit Specific Plan. Training records shall be part of the Laboratory and Research Safety binder. Bloodborne-pathogens training information may be found in Section 9.6.

EHS can provide general safety seminars for laboratory or department groups. EHS training is general in nature; PIs are required to provide specific safety training in the particular hazards of their laboratories.

## Exposure to Hazardous Substances

A thorough discussion of hazards and risks associated with exposure to hazardous substances is beyond the scope of this publication. Individuals who handle hazardous substances should supplement the information in this plan with specific details applicable to their laboratories.

The complex relationship between a material and its biological effect in humans involves considerations of dose, duration, frequency of the exposure, route of exposure, and many other factors, including gender, allergic factors, age, previous sensitization, and lifestyle. Toxic effects can be immediate or delayed, reversible or irreversible, local or systemic.

### Exposure Routes

Hazardous materials may enter the body through the following routes:

1. Inhalation – absorption through the respiratory tract by inhalation. This is probably the easiest way for hazardous materials to enter the body.
2. 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.
3. 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.
4. Injection – percutaneous injection through the skin. This can occur through misuse of sharp items, especially hypodermic needles.

#### Acute Exposure

Short term, which can result in an acute effect, including:

* allergic reaction
* coughing
* shortness of breath
* skin rash
* burning eyes

#### Chronic Exposure

Long term, low exposure which may result in a chronic effect, including:

* asbestosis (from asbestos exposure)
* central nervous system disorders (organic mercury, metallic mercury)
* various cancers, lung, kidney, bladder, liver

### Signs and Symptoms of Exposure

Signs and symptoms of exposure to hazardous materials vary widely. Depending on the material, length of exposure, and a number of other factors, signs and symptoms can include everything from dizziness, headache, irritated or watery eyes, sneezing, coughing, sore throat, shortness of breath, rash, itching, to nausea, vomiting, diarrhea, and loss of balance or coordination. Exposure to some chemicals may even lead to death. Many other health problems also present similar signs and symptoms.

See Section 4 of the SDS for information specific to individual chemicals. For particularly hazardous chemicals, include this information in lab specific training and SOPs.

### 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, discussed further in Sections 7.2.5 and 7.2.6, reveals that the airborne concentration of a chemical is above the action level or the PEL (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.

### 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 Penn State’s University Health Services.

The department head, PI, or designee from the lab 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.

### 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.

### Monitoring Airborne Concentrations of Contaminants

OSHA has established 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 TWA 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 exposure limit 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 exposure 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 SDS 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 cadmium, formaldehyde, 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 PI 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.

## Exposure Control Methods

There are three general methods for controlling exposure to hazardous substances: engineering controls, work practices or administrative controls, and PPE. All laboratory SOPs shall include the safety precautions needed to protect researchers 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 exposure control methods are described below.

### Engineering Controls

Engineering controls provide protection by removing hazardous conditions or by placing a barrier between the researcher and the hazard. Examples include chemical fume hoods, biosafety cabinets, glove boxes, or machine guards. These are considered the first line of defense in the laboratory for the reduction or elimination of the potential exposure to hazards. More information about biosafety cabinets can be found in Section 9.3.2.1.

#### 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, odiferous, 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.

A fume hood should be used when working with:

* chemicals with a National Fire Protection Association (NFPA) Health rating of 3 or 4
* toxic volatile materials (ex: chloroform, formaldehyde)
* flammable chemicals
* carcinogens or particularly hazardous substances
* a procedure that may create an aerosol of a toxic substance
* reactive or explosive materials or chemicals that may spatter
* toxic gases (NH3, CO, F2, Cl2, H2S, NO2, etc.)
* odorous materials, both hazardous and non-hazardous

When working in a chemical fume hood, work at least six inches inside, with the sash lowered as far as practical, or with a panel in front of you. Equipment in the hood should also be stationed at least six inches away from the sash. These practices can reduce vapor concentrations at the hood face by about 90%. When not in use, the sash should be closed to both minimize energy usage and also serve as a blast shield should a fire or explosion occur inside the hood. In cases where you are performing experiments that are suspected to present an explosion hazard, you should use a portable blast shield inside the hood in addition to a closed sash.

**Hoods are not meant for storage of chemicals.** Storing chemical containers and equipment in a hood impairs the performance of the hood. Volatile and odorous chemicals and highly toxic gases shall be stored in ventilated cabinets, not in a chemical fume hood. The deliberate release and venting of chemicals (i.e., evaporation) in hoods shall **never** be used as a means of disposal.

Equipment 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.

Compounds such as perchloric acid or aqua regia are likely to cause hood corrosion and only hoods designed for their use may be used. Please refer to Section 8.3.1 for further information.

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

### Administrative Controls and Work Practices

Administrative controls, also called work practices, change the way people work by changing their behavior, rather than removing the hazard or providing PPE. In a research setting, administrative controls consist of various policies and requirements that are established at an administrative level (e.g., by the PI, laboratory supervisor, department chair, department safety committee, or EHS) to promote safety in the laboratory. Administrative controls are recommended when hazards cannot be removed or changed, and engineering controls are not practical.

Some examples of administrative controls include:

* Ensuring that all laboratory personnel have been provided with adequate training to enable them to conduct their research safely.
* Requiring prior approval and additional control measures for certain particularly hazardous operations or activities.
* Posting appropriate signs to identify specific hazards within an area.
* Requiring that various standard practices for chemical safety and good housekeeping be observed at all times in the laboratory.

### Personal Protective Equipment

The Unit Specific Plan shall be used as the hazard assessment tool to plan for the selection of appropriate PPE for research needs. It is the responsibility of the PI/supervisor to purchase most forms of PPE required to safely perform research tasks. OSHA requires the work unit to pay 100% of the cost for items such as respirators, hearing protection, non-prescription eye protection, face protection, head protection, fall protection, electrical PPE, hand protection, chemical resistant PPE, and flame resistant PPE. Further information about purchase of PPE and what Penn State covers can be found in the [**PPE Program**](http://ehs.psu.edu/ppe/overview).

Everyone working in a laboratory or research area has the responsibility to dress sensibly for the research they are performing. Only minimal protection is afforded by ordinary clothing and eyeglasses. PPE provides protection from injury due to absorbing, inhaling, or coming into physical contact with hazardous substances. Laboratory clothing also protects the researchers' own clothing. Researchers are responsible for using special protective clothing and equipment when they are required for safety. Protective wear may include laboratory coats, wraparound gowns, coveralls, aprons, gloves, shoe covers, and respirators. Select garments and fabric based on the nature of the hazard.

PPE shall be used and maintained in a sanitary condition and shall be cleaned regularly to avoid spreading contamination. Damaged and worn PPE shall be replaced.

Laboratory coats shall never be washed at home. Laboratory coats can be washed through University Laundry Services. To arrange for a pickup, contact the Laundry Manager at Hospitality Services, Jerry Gardner at [jlg55@psu.edu](mailto:jlg55@psu.edu), use the subject lab coat cleaning, or by phone at 814-863-5074 (information current as of 1/15/19).

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 [**Pesticide Management Program Manual**](http://ehs.psu.edu/pesticide-management/overview) for further instructions.

#### Clothing

Long pants, or an equivalent, and closed toe shoes are required of every individual working in a laboratory.

**Cover unprotected skin whenever possible.** Suitable clothing shall be worn; 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. Selection of fabric may also be important. 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, 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. Flame resistant (FR) lab coats should be worn when working with pyrophoric, air, or water reactive chemicals. FR lab coats should also be worn when working with flammable chemicals. Persons working with pyrophoric liquids should also considering wearing 100% cotton clothing underneath the FR lab coat on days that they handle these materials in the lab. See Table 7.1.

Table . Properties of Protective Clothing Materials

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 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, third edition, 2007.

#### Eye Protection

**Eye protection that meets American National Standards Institute (ANSI) Z87.1 requirements is mandatory** in laboratory and research areas where there is risk of flying particles, molten metal, liquid chemicals, acidic or caustic liquids, chemical gases or vapors, or potentially injurious light radiation. 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** offers maximum protection, for example, with vacuum systems that may implode. Face shields should be used in conjunction with either safety glasses or goggles.

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

#### Gloves

Gloves are worn to prevent contact with hazardous chemicals 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 hazardous chemicals, including carcinogens. Many gloves are made for specific uses. For adequate protection, select the correct glove for the hazard in question.

**Glove Selection Procedures –** Gloves shall be chosen based on appropriateness for a specific hazard. There are three prime performance factors used to evaluate the chemical compatibility of a glove material with the agents to be handled.

1. *Degradation rating* – the change in one or more of the physical properties of a glove caused by contact with a chemical. Degradation typically appears as hardening, stiffening, swelling, shrinking, or cracking of a glove.
2. *Breakthrough time* – the elapsed time between the initial contact of the test chemical on the surface of the glove and the analytical detection of the chemical on the inside of the glove.
3. *Permeation rate* – the rate at which the test chemical passes through the glove material once breakthrough has occurred and equilibrium is reached (based on absorption of the chemical on the surface of the glove, diffusion through the glove, and desorption of the chemical on the inside surface of the glove).

These characteristics change with each glove manufacturer’s product. A neoprene glove from Ansell Edmont may show different performance results than a Baxter neoprene glove, despite the apparent similarity in composition. Glove efficiency may even vary within a manufacturer’s product line, depending on thickness and coating. For instance, Ansell neoprene unsupported gloves are suitable only for splash protection against cyclohexanone with a “poor” rating, while the supported neoprene gloves are rated for medium protection with a “fair” rating. Chemicals can eventually permeate all glove materials. Select glove materials resistant to the chemical being used, and change gloves periodically to minimize penetration.

Contact the manufacturer to verify that a particular glove material is suitable for the chemical in use.

To arrive at the best glove for your specific operations, consider the points below in the selection process:

* the performance characteristics of the glove relative to the task being performed
* glove thickness versus needs for dexterity
* conditions present
* duration of use
* the potential hazards identified for the operation.

Offer proper hand sizes and length options (wrist/forearm, elbow, shoulder). Cuffs are discouraged since they may inadvertently capture chemicals in the folds.

Do not underestimate the importance of careful glove selection. Inadequate prior inquiry may have serious repercussions, as illustrated by the death of a researcher who suffered from mercury poisoning after contaminating her latex glove with dimethylmercury. Latex was not the correct type of glove to use with this highly toxic agent.

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.

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, applying cosmetics, or handling contact lenses.

#### 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 processes to determine hazards 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 PI or supervisor, 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 required 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. Prescription inserts can be purchased.

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, [**ehs.psu.edu**](http://www.ehs.psu.edu) and respirator wearers must read this document in its entirety.

#### Hearing Protection

Hearing protection is rarely required during laboratory operations. If a laboratory operation generates noise conditions in which researchers have to raise their voices to be heard, contact EHS for an assessment.

**Rule-of-thumb for “noisy” areas or equipment**: If you must raise your voice to clearly communicate with someone 3 feet away, you need hearing protection.

Hearing protectors such as ear muffs or earplugs are required when sound levels exceed 85 decibels. EHS conducts noise monitoring to determine which job tasks may expose employees to excessive noise. Employees who perform tasks where noise may be excessive are enrolled in the EHS Hearing Conservation Program, which includes regular audiograms to monitor their hearing as well as mandatory annual training and the use of hearing protection during those tasks.

## General Laboratory Protocols

### Personal Hygiene

Personal hygiene is extremely important for persons working in a laboratory. Contamination of food, beverages, smoking materials, or contact lenses is a potential route of exposure to hazardous chemicals or biological agents.

**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 hazardous chemicals or biological agents. Always wash your hands before leaving the laboratory, even if you use gloves. Wash your hands after removing soiled protective clothing, before leaving the laboratory, and before eating, drinking, smoking, or using the 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 any contamination off your hands. Turn the tap off with a clean paper towel to prevent recontamination, and dry your hands with clean paper 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 wristwatches, 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.

### 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 arrange to call someone every half hour to provide updates on their status. Likewise, new lab work that presents hazards should never be done alone.

If faced with a situation where you feel it is necessary to work alone in a laboratory:

* Reconsider the need. Is the work really that critical?
* Reconsider the timing and setup of the work. Can the task be accomplished another time when others will be present?
* If the timing of the task cannot be changed and you still feel it must be accomplished is there any other person trained in laboratory procedures who can accompany you?
* If not, is there anyone else within the building who could act as a “buddy” to check on you periodically during the time that you feel you must work alone?
* If no one can accompany you and you cannot find a “buddy,” **do not proceed with the work.** Speak to your PI/supervisor to make arrangements to complete the work in a safe manner.

### Supervision Requirement

Everyone needs to have a supervisor, or someone acting in that capacity, at all times in order to ensure that the supervisory responsibilities listed in Section 3.0 and in [**SY01**](https://policy.psu.edu/policies/sy01) are followed. If a faculty member or supervisor will be out of town, especially long term, 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.

### Housekeeping

In the laboratory and elsewhere, keeping things clean and organized helps provide a safer environment. 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.

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 keep 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, safety shower, or eyewash.

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. Do not store combustibles within 24 inches of the ceiling in areas that do not have sprinklers.

Broken glass and other sharp items shall be disposed of in rigid, puncture-resistant containers to protect persons collecting the waste materials; broken glass boxes can be obtained from custodial services. 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 8.9. Infectious waste management is described in Section 9.8. Additional information on disposal of human body fluids or other potentially infectious materials appears in Section 9.6.

### Cleaning Glassware

When cleaning laboratory glassware, wear appropriate gloves that have been checked for tears or holes. Avoid accumulating too many items in the cleanup area around the sink; space is usually limited, and piling up glassware can lead 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 a sink full of 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 including perchloric acid, ammonium persulfate, etc. If you must use these substances for cleaning, you should be thoroughly familiar with their hazardous characteristics and use appropriate PPE.

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 [**SY40, Disposal of Pollutants in University Sanitary Systems**](https://policy.psu.edu/policies/sy40), shall not be rinsed down the drain during cleaning, but shall be collected for proper disposal.

### Children in Laboratories

Laboratory areas contain many physical, chemical, 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 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 have parental consent and provide insurance documentation to the University on the paperwork available [**here**](http://ehs.psu.edu/sites/ehs/files/high_school_students_in_labs_-_final_3.docx).

## General Laboratory Safety Equipment

### 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. New shower installations shall adhere to the recommendations for shower location and minimum performance requirements established in ANSI 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.

### Eyewashes

New eyewash installations shall adhere to the recommendations for minimum performance requirements established in ANSI 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 type, 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.

PIs 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**](http://ehs.psu.edu/sites/ehs/files/eyewash_inspection_form.doc) for recording testing information is available on the EHS website.

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.

### Fire Extinguisher Policy

Fire extinguishers are provided by Penn State in corridors, public areas, and other locations as required by building and life safety codes as described in [**SY09**](https://policy.psu.edu/policies/sy09). It is the responsibility of the PI or the department head to ensure that appropriate fire extinguishers are purchased and installed in laboratories. Contact the Fire Safety Specialist within 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, fire safety training, and fire extinguisher training can be provided by EHS upon request.

### 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.

## General Laboratory Facilities

### 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 janitorial staff 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 PI or supervisor does not wish a particular laboratory to be disturbed, floor cleaning can be suspended by request of the area occupants. To have the mopping discontinued, contact Area Services and post a sign on the lab.**

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 PI or supervisor shall ensure that the immediate area is decontaminated and any infectious agents or chemicals are 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**](http://ehs.psu.edu/sites/ehs/files/safety_clearance_form.pdf) must be completed, taped to the area, and a copy sent to EHS.

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

### 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.

Problems with general ventilation shall be reported promptly to 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 PI or 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 hazardous materials and properly decontaminated before the work begins. A [**Laboratory/Equipment Safety Clearance Form**](http://ehs.psu.edu/sites/ehs/files/safety_clearance_form.pdf) must be completed, taped to the area, and submitted to EHS.

### 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. Cup sinks on benches and in hoods should also be kept filled with water.

### Relocating or Closing a Laboratory

Laboratories that are relocating within Penn State, moving to other institutions, or closing completely, shall complete the processes of laboratory close out notification and laboratory close out certification. These guidelines are available from the EHS website, [**ehs.psu.edu**](file:///C:\Users\Documents%20and%20Settings\kxl3\Local%20Settings\Temporary%20Internet%20Files\sapanski\My%20Documents\chp\www.ehs.psu.edu), to assist research groups in safely relocating the laboratory chemicals or biological agents.

A chemical waste pick up request shall be submitted for all chemicals that will not be relocated. The pick up request shall be completed before the PI relinquishes possession of the vacated laboratory. Disposition of all unwanted chemicals is the responsibility of the PI. All biological materials shall be autoclaved or chemically disinfected and disposed of before the laboratory is vacated. The department of record is responsible for the safe and lawful cleanup and disposition of all materials that are abandoned.

Surfaces and equipment potentially contaminated with hazardous chemicals or biological agents shall be decontaminated before the laboratory is vacated. The PI or supervisor is responsible for ensuring that the equipment is properly decontaminated. Accessible surfaces (chemical fume hoods, sinks, and benchtops) should be cleaned, when practical, by the PI 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 PI shall provide the contractor with thorough and accurate information pertaining to the past uses of the equipment.

### Laboratory Doors

Fire and life safety codes as well as Penn State 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.

### Signs and Labels for Laboratories

Various signs and labels are required by government regulations and Penn State policy. The PI 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 Penn State facilities:

* A [**Laboratory Information**](http://ehs.psu.edu/sites/ehs/files/laboratory_information_door_sign.docx) sign shall be posted outside all laboratories on the outside of the door. This sign includes blank areas to be filled out by laboratory personnel with information about specific hazards in the laboratory, and telephone numbers of responsible faculty, staff, and emergency contacts. The information provided on these signs shall be updated as necessary.
* An [**Emergency and Laboratory Safety phone numbers**](http://ehs.psu.edu/sites/ehs/files/emergency_laboratory_safety_phone_sign_up.doc) sign shall be posted in a prominent location inside the laboratory, near the door or telephone. This sign lists who to call and their telephone numbers in the event of an emergency.

## General Laboratory Equipment

### Centrifuges

Tabletop centrifuges should be secured so that vibration will not cause bottles or equipment to fall. More modern tabletop centrifuges may do this by design, while some may need to be anchored to its location. Centrifuge rotors shall be balanced each time they are used. Shielding against flying rotors is required. 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. If vibration occurs, stop the centrifuge immediately and check the load balance. Check swing-out buckets for clearance and support.

### Sonicators

Sonicators are high-frequency sound generators used to disrupt cells or shear nucleic acids. Two major hazards are associated with sonicators. The first hazard is hearing damage caused by high frequency sound. The second hazard is the generation of aerosols from the sonication process.

Sonicators generate sound waves in the 20,000 Hz range. These sonicator-generated sound waves are outside the normal range of hearing. Often the sound heard while using a sonicator is produced by cavitations of the liquid in the sample container or vibrations from loose equipment. Actions you can take to reduce the hazards of using sonicators include:

* Ear muffs are required to protect your hearing while sonicating
* If possible, have the sonicator located in a "sound-proof" cabinet while sonicating
* Do not sonicate in a room containing people not wearing hearing protection
* Shut doors of the room where sonication is taking place
* Do not place hands in sonicator while it is turned on
* Wear appropriate PPE, including safety glasses, that protect against splashes.

### 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 hazardous 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 as chemical waste with EHS.

Before using the vacuum pump, ensure that the moving parts are 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.

### 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.

### Needles, 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 9.0. **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 hazard. These sharps containers shall be easily accessible to personnel in the immediate area of use.

### Glassware

Borosilicate glassware, such as Pyrex 7740, is the type preferred for laboratory experimentation, except in special experiments involving ultraviolet (UV) 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 box. Where the integrity of glassware is especially important, it can be examined in polarized light for strains.

### Assembling Equipment

Equipment 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, equipment should not obstruct the area. To avoid overflow, choose containers (glassware, flasks, beakers, etc.) with at least 20% more capacity than would normally accommodate the volume of chemical planned for the operation. All parts of the setup 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 equipment 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 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.

## Electrical Safety in Laboratories

### Electrical Equipment

All laboratory personnel shall know how to shut off equipment in case of fire, emergencies, or other accidents. Only persons who have completed [**Electrical Disconnect/Circuit Breaker Safety Training**](https://apps.opp.psu.edu/ehs_training/course_list.cfm?page_action=ViewClasses&course=291) may operate breakers and disconnects. Any electrical equipment that is not operating properly shall be 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.

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, locked and tagged out, all safety work practices adhered to, and PPE utilized as required by the Penn State [**Energized Electrical Safety Program**](http://ehs.psu.edu/energized-electrical-safety/overview) and [**Lockout Tagout Program**](http://ehs.psu.edu/lockout-tagout/requirements-guidelines) before repairs are made.

If a worker receives an electrical shock and is in contact with the energized device, use non-conductive voltage rated 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.

There are additional requirements for labs and research areas pertaining to electrical equipment, experiments, and equipment that include “homemade” or lab fabricated electrical apparatuses. A safety risk assessment is required. See the document titled Penn State [**Safety Risk Assessment for Lab Electrical Equipment Document**](http://ehs.psu.edu/laboratory-safety/guidelines) for more information.

### 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.

## Machine Shop Equipment

Penn State has a machine shop safety program that is intended to prevent injuries that 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 LRSP.

Shop equipment includes, but is not limited to, items such as band saws, belt sanders, drill presses, lathes, milling machines, miter saws, radial arm saws, routers, and table saws. Labs with this type of equipment must incorporate the necessary requirements contained in the Penn State 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 Penn State [**Machine Shop Safety Program**](http://ehs.psu.edu/sites/ehs/files/machine_shop_safety_program_-_compressed_pics.docx) for more information.

## 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**](http://ehs.psu.edu/hazardous-materials-shipping/overview).

A personal vehicle shall not be used to transport hazardous chemicals, including dry ice or liquid nitrogen. Biological materials shall be shipped in compliance with DOT and Centers for Disease Control and Prevention (CDC) regulations. Transport of regulated plant or animal pathogens shall comply with U.S. Department of Agriculture (USDA) regulations.

# CHEMICAL HAZARDS and chemical hygiene

## Hazardous Chemicals

Chemicals used in research present numerous hazards in terms of handling, storage, and potential risks of exposure. A hazardous chemical is a substance or combination of substances that, because of its quantity, concentration, physical, chemical, or explosive characteristics, poses a substantial present or potential danger to humans or the environment. Generally, such chemicals are classified as explosives, compressed gases (flammable and nonflammable), flammable and combustible liquids, flammable solids, oxidizers, poisons, and corrosives. OSHA also classifies any chemical which poses a health hazard, or may be a simple asphyxiant, as a hazardous chemical. These broad definitions means that many chemicals, including many common to research laboratories, are designated hazardous.

Chemicals that are deemed health hazards pose at least one of the following hazardous effects: acute toxicity (any route of exposure); skin corrosion or irritation; serious eye damage or eye irritation; respiratory or skin sensitization; germ cell mutagenicity; carcinogenity; reproductive toxicity; specific target organ toxicity (single or repeated exposure); aspiration hazard. Health hazard means that exposure to the chemical can cause acute or chronic health effects.

Chemicals that are deemed physical hazards pose at least one of the following hazardous effects: explosive; flammable (gases, aerosols, liquids, or solids); oxidizer (liquid, solid, or gas); self reactive; pyrophoric (gas, liquid, or solid); self-heating; organic peroxide; corrosive to metal; gas under pressure; in contact with water emits flammable gas; or combustible dust. A physical hazard is associated with a chemical that is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable or water-reactive. All these can cause harm as a result of physical reaction.

## Hazard Communication

The US 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 (Table 8.1) identify health, physical, and environmental hazards associated with a chemical.

Table . GHS pictograms and their corresponding chemical hazards.

| **Name** | **Hazard** |  | **Name** | **Hazard** |
| --- | --- | --- | --- | --- |
| **Exploding 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 and Crossbones** | Acute toxicity (Categories 1, 2, and 3) |
| **Flame over Circle** | Oxidizer |  | **Exclamation Mark** | Irritant (Skin Irritation Category 2 and Eye Irritation Category 2A), Skin Sensitizer (Category 1), Acute Toxicity (Category 4, harmful), Target Organ Toxicity/STOT Category 3 = Narcotic Effects, Respiratory Tract Irritant |
| **Gas Cylinder** | Gas under pressure |  | **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) |
| Image result  **Environment** | Aquatic Toxicity |  |  |  |

### 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 employees and students with easy access to SDSs for each of the chemicals in use or stored in their labs. The most expedient way to find an SDS is to search for it on the internet. However, if you have problems obtaining access, contact EHS.

SDSs have a United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS) standardized format consisting of the following sections:

SECTION 1 – IDENTIFICATION

This section provides the following information:

* Product identifier used on the label
* Other means of identification
* Recommended use of the chemical and restrictions on use
* Name, address, and information telephone number of the chemical manufacturer, importer, or other responsible party
* Emergency phone number

The information telephone number is provided to allow the user to obtain information about the substance. The emergency telephone number is intended for use by emergency response and medical personnel.

SECTION 2 – HAZARD IDENTIFICATION

This section provides the following information:

* Classification of the chemical in accordance with paragraph (d) of §1910.1200
* Signal word, hazard statement(s), symbol(s) and precautionary statement(s) in accordance with paragraph (f) of §1910.1200
* Describe any hazards not otherwise classified that have been identified during the classification process.

SECTION 3 – COMPOSITION/INFORMATION ON INGREDIENTS

This section provides the following information for substances:

* Chemical name
* Common name and synonyms.
* CAS number and other unique identifiers
* Impurities and stabilizing additives which are themselves classified and which contribute to the classification of the substance

This section provides the following information for mixtures:

* The information listed for substances
* The chemical name and concentration (exact percentage unless trade secret) or concentration ranges of all ingredients

SECTION 4 – FIRST-AID MEASURES

This section contains the following:

* Description of necessary measures, subdivided according to the first aid instructions for different routes of exposure, i.e., inhalation, skin and eye contact, and ingestion
* Most important symptoms/effects, acute and delayed
* Indication of immediate medical attention and special treatment needed, if necessary

SECTION 5 – FIRE FIGHTING MEASURES

This section provides the following information:

* Suitable (and unsuitable) extinguishing media
* Specific hazards arising from the chemical (e.g., nature of any hazardous combustion products)
* Precautions to be observed when fighting the fire
* Appropriate protective equipment for fire-fighters

SECTION 6 – ACCIDENTAL RELEASES MEASURES

This section provides the following information:

* Personal precautions, protective equipment, and emergency procedures
* Methods and materials for containment and cleaning up

SECTION 7 – HANDLING AND STORAGE

This section provides the following information:

* Precautions for safe handling
* Conditions for safe storage, including any incompatibilities

SECTION 8 – EXPOSURE CONTROLS/PERSONAL PROTECTION

This section provides the following information:

* OSHA permissible exposure limit (PEL)
* American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the safety data sheet, where available
* Appropriate engineering controls
* Individual protection measures such as personal protective equipment
* Recommended work and personal hygiene practices

SECTION 9 – Physical and Chemical Properties

This section provides the following information:

* Appearance (physical state, color, etc.)
* Odor
* Odor threshold
* pH
* Melting point/freezing point
* Initial boiling point and boiling range
* Flash point
* Evaporation rate
* Flammability (solid, gas)
* Upper/lower flammability or explosive limits
* Vapor pressure
* Vapor density
* Solubility(ies)
* Partition coefficient: n-octanol/water
* Auto-ignition temperature
* Decomposition temperature
* Viscosity

SECTION 10 – STABILITY AND REACTIVITY

This section provides the following:

* Reactivity
* Chemical stability (under normal conditions)
* Possibility of hazardous reactions
* Conditions to avoid (e.g., static discharge, shock, or vibration)
* Incompatible materials
* Hazardous decomposition products

SECTION 11 – TOXICOLOGICAL INFORMATION

This section provides the following description of the various toxicological (health) effects and the available data used to identify those effects, including:

* Information on the likely routes of exposure
* Symptoms related to the physical, chemical and toxicological characteristics
* Delayed and immediate effects and also chronic effects from short- and long-term exposure
* Numerical measures of toxicity (such as acute toxicity estimates)
* Carcinogenicy data; Whether the hazardous chemical is listed in the National Toxicology Program (NTP) Report on Carcinogens (latest edition) or has been found to be a potential carcinogen in the International Agency for Research on Cancer (IARC) Monographs (latest edition) or by OSHA

SECTION 12- ECOLOGICAL INFORMATION

This section provides the following information:

* Ecotoxicity (aquatic and terrestrial, where available)
* Persistence and degradability
* Bioaccumulative potential
* Mobility in soil
* Other adverse effects (e.g., hazardous to the ozone layer)

SECTION 13 – DISPOSAL CONSIDERATIONS

Description of waste residues and information on their safe handling and methods  
of disposal, including the disposal of any contaminated packaging

SECTION 14 – TRANSPORT INFORMATION

This section provides the following information:

* UN number
* UN proper shipping name
* Transport hazard class(es)
* Packing group, if applicable
* Special precautions a user needs to be aware of, or needs to comply with, in connection with transport or conveyance either within or outside their premises

SECTION 15 – REGULATORY INFORMATION

Safety, health, and environmental regulations specific for the product in question .

SECTION 16 – OTHER INFORMATION

The date when the SDS was prepared or the last change was made to it.

### Additional Sources of Chemical Hazard Information

EHS maintains a collection of some of the publications listed below which can be provided upon request. Additionally, Penn State Libraries can provide assistance in selecting a number of databases and websites that can provide additional information on chemical hazards.

#### Various Texts

There are several toxicology texts available which are helpful in the evaluation of health hazards of chemicals, including the following:

* Annual Report on Carcinogens: published by The National Toxicology Program (NTP), U.S. Public Health Service.
* IARC Working Group Monographs: A series of monographs published by The International Agency for Research on Cancer (IARC) covering specific agents, groups of agents or selected industries in which cancer has been caused or a suspected relationship exists with the chemicals under study.
* The Merck Index: A Compendium of Chemical Information.
* Sigma-Aldrich Library of Chemical Safety Data: CD-ROM Software.
* The Chemical Abstracts: a serial collection providing detailed bibliographies and abstracts on original research papers on hazards, toxicity and related topics. These citations are based on the Chemical Abstracts Services registry number (CAS number).

#### Manufacturers/Suppliers

In addition to providing the SDS, many manufacturers/suppliers have telephone numbers that access customer service or technical representatives of the company, who may be able to provide additional information about the product. Additionally, many manufacturers/suppliers have websites that will allow you to access information regarding their chemicals.

#### NIOSH and Other Governmental Sources

The National Institute of Occupational Safety and Health (NIOSH), the Centers for Disease Control and Prevention (CDC), and OSHA all have published information related to chemical hazards/exposures which are available on their websites, or can be requested there.

### 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 8.1 for an example of a standard hazard warning label used by manufacturers and others throughout the country.

****

Figure . Standard hazard warning label.

When labeling workplace chemical bottles such as squirt bottles or working solutions, it is acceptable to use standard labels such Hazardous Materials Identification System (HMIS) (Figure 8.2.) or National Fire Protection Association (NFPA) 704 diamond (Figure 8.3). Copying the manufacturer’s label and applying it to the container is also an option. In either case, employees must be fully aware of the hazards of the chemicals used.

For additional information about proper labeling of chemical bottles, see the [**Chemical Container Labeling Guide**](http://ehs.psu.edu/laboratory-safety/resources).

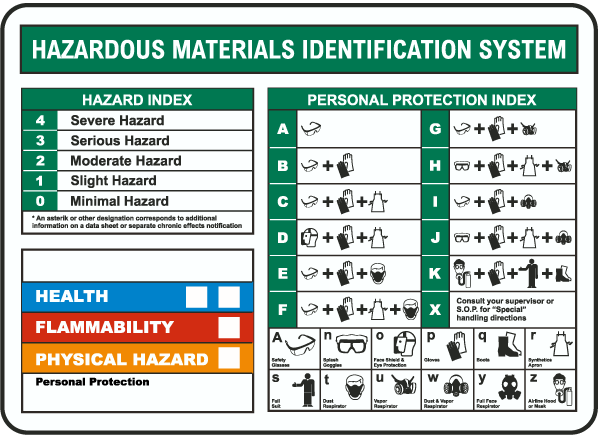
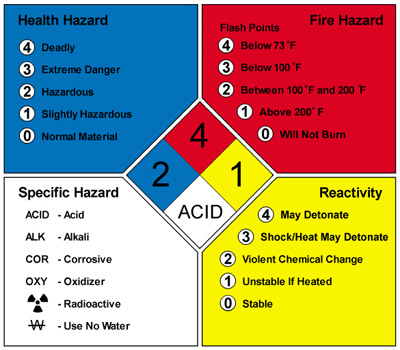


Figure . Alternate labeling using HMIS is allowed for workplace chemical bottles.

Figure . Alternate labeling using the NFPA diamond is also allowed.

### Receiving Chemicals

All chemicals received by the laboratory must be inspected prior to unpacking. It should be noted if there appears to be any leakage on the outside of the box or on the packing material. If the contents appear to be damaged, contact EHS and the company from whom the chemical was ordered. All damaged chemical containers must be considered as spilled material and disposed of as chemical waste. Additionally ensure the following:

* CHIMS is updated to include chemical.
* Chemical label is legible and secure on the container of the chemical. If the container label has been defaced, it should be relabeled.

#### Date Labeling Requirements for Reactive Chemicals

Dates of receipt must be assigned to all chemicals in the following groups by the recipient. The date of the chemical should be noted with each use. Chemicals should not be held past its recommended expiration date or in the specified amount of time from the date of its receipt:

* Picrics
* Perchlorates
* Peroxides
* Peroxidizable materials (aldehydes, ethers and compounds containing benzylic hydrogen atoms)
* Chemicals with polymerization hazards
* Other unstable or reactive chemicals

## Hazards of Chemical Groups

### Corrosives

Gases, liquids, and solids can exhibit the hazardous property of corrosivity. Corrosive materials can burn, irritate, or destructively attack skin. When inhaled or ingested, lung and stomach tissue are affected. Corrosive gases are readily absorbed into the body through skin contact and inhalation. Corrosive liquids are frequently used in the laboratory and have a high potential to cause external injury to the body. Corrosive solids often cause delayed injury. Because corrosive solids dissolve rapidly in moisture on the skin and in the respiratory system, the effects of corrosive solids depend largely on the duration of contact. Materials with corrosive properties can be either **acidic** (low pH) or **basic** (high pH).**** Corrosive acids and bases attack the skin and can cause permanent damage to the eyes.

A chemical which is corrosive to metals means a chemical which by chemical action will materially damage, or even destroy, metals. Containers and equipment used for storage and processing of corrosive materials should be corrosion resistant. Likewise, corrosives can damage PPE such as gloves, lab coats, and eye protection. Ensure PPE is rated to withstand use of corrosives.

#### Acids

**Oxyacids** such as sulfuric and nitric acids 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.

All the **hydrogen halide acids** are serious respiratory irritants. Hydrogen fluoride (HF) 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. Working with hydrofluoric acid carries particular hazards. Labs should follow the [**Hydrofluoric Acid Guidelines**](http://ehs.psu.edu/laboratory-safety/resources).

**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 must be 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.

See Box 8.1 for inorganic acid neutralization procedures.

Box . Procedure for Inorganic Acid Neutralization

|  |
| --- |
| DOES NOT apply to chromic, hydrofluoric, or perchloric acids.  Applicable Acids: Hydrochloric, nitric, and 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. |

#### Bases

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. The heat released when preparing concentrated solutions 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.

### Flammable and Combustible Liquids

****For reference, see: Penn State Safety Policies [**SY08, Storage, Dispensing, and Use of Flammable and Combustible Liquids**](https://policy.psu.edu/policies/sy08) and [**SY11, Refrigerators – Explosion-Proof**](https://policy.psu.edu/policies/sy11).

According to most fire codes and regulations, including those for laboratories, a flammable liquid is a liquid with a flash point below 100 °F and a vapor pressure not exceeding 40 psi (absolute) at 100 °F. These are categorized as Class I liquids. A liquid with a flash point of 100 °F or greater is classified as a combustible liquid and may be referred to as a Class II or Class III liquid (Table 8.2).

Table . Flammable and Combustible 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 |

Flash point is the minimum temperature at which a 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. Solvents commonly used in research are classified as flammable and combustible liquids based on their flash and boiling points. Common solvents, their properties, and flammability class can be found in Table 8.3.

**Handling** – 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 8.4. 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 (containers greater than 5 gallons) of flammable liquids are not permitted in laboratories unless the quantity is necessary for daily use and is approved by EHS.

Table . Characteristics of Common Solvents

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Chemical** | **Flash Point** | | **Boiling Point** | | **Flammability Class** |
| **°C** | **°F** | **°C** | **°F** |
| Acetaldehyde | -40 | -40 | 20.1 | 68.18 | IA |
| Acetic Acid, Glacial | 39 | 102.2 | 118 | 244.4 | II |
| Acetone | -18 | -0.4 | 56.2 | 133.16 | IB |
| Acetonitrile | 2 | 35.6 | 82 | 179.6 | IB |
| Acrylonitrile | 2 | 35.6 | 82 | 179.6 | IB |
| Benzene | -11 | 12.2 | 80.1 | 176.18 | IB |
| Chloroform | none | none | 61.2 | 142.16 | none |
| Cyclohexene | -18.3 | -0.94 | 80.7 | 177.26 | IB |
| Dimethylformamide | 71 | 159.8 | 152.8 | 307.04 | IIIA |
| Dioxane | 12 | 53.6 | 102 | 215.6 | IB |
| Ethanol (absolute) | 16 | 60.8 | 78.3 | 172.94 | IB |
| Ethanol (95%) | 17 | 62.6 | 78.3 | 172.94 | IB |
| Ethyl acetate | -4.4 | 24.08 | 77 | 170.6 | IB |
| Ethyl Alcohol | 16 | 60.8 | 78 | 172.4 | IB |
| Ethyl ether | -45 | -49 | 34.5 | 94.1 | IA |
| Gasoline | -30 | -22 | 85 | 185 | IB |
| Heptane | 3.89 | 39.002 | 98.4 | 209.12 | IB |
| Hexane | -26 | -14.8 | 68.7 | 155.66 | IB |
| Isopropanol | 12 | 53.6 | 83 | 181.4 | IB |
| Isopropyl alcohol | 12 | 53.6 | 82.4 | 180.32 | IB |
| n-Propyl Ether | -18 | -0.4 | 90 | 194 | IB |
| Methanol | 12.2 | 53.96 | 64.5 | 148.1 | IB |
| Methylene chloride | -14 | 6.8 | 40.1 | 104.18 | none |
| Methyl Ethyl Ketone | -9 | 15.8 | 79.6 | 175.28 | IB |
| m-Xylene | 25 | 77 | 138.8 | 281.84 | IC |
| p-Dioxane | 12 | 53.6 | 101 | 213.8 | IB |
| Pentane | -49 | -56.2 | 36.1 | 96.98 | IA |
| Petroleum Ether | -9 | 15.8 | 90 | 194 | IB |
| Propyl Alcohol | 22 | 71.6 | 97.2 | 206.96 | IB |
| Pyridine | 20 | 68 | 115.5 | 239.9 | IB |
| tert-Butyl Alcohol | 11.1 | 51.98 | 82.9 | 181.22 | IB |
| Tetrahydrofuran | -15 | 5 | 66 | 150.8 | IB |
| Triethylamine | -15 | 5 | 8937 | 16118.6 | IB |
| Toluene | 6 | 42.8 | 110.7 | 231.26 | IB |
| Xylenes | 30 | 86 | 135 | 275 | IC |

Lewis, Richard J., and Gessner G. Hawley. Hawley's Condensed Chemical Dictionary / Richard J. Lewis, Sr. 14th ed. New York: John Wiley and Sons, 2011. Print.

Table . Maximum Allowable Size of Flammable and Combustible Liquid Containers in Laboratories

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **FLAMMABLE LIQUIDS** | | | **COMBUSTIBLE LIQUIDS** | |
| CONTAINER | CLASS IA | CLASS IB | CLASS IC | CLASS II | CLASS III |
| Glass | 1 pinta | 1 quarta | 1 gallon | 1 gallon | 5 gallons |
| Metal (other than DOT drums) or approved plastic | 1 gallon | 5 gallonsb | 5 gallonsb | 5 gallonsb | 5 gallons |
| Safety cans | 2 gallons | 5 gallonsb | 5 gallonsb | 5 gallonsb | 5 gallons |
| Metal drum (DOT Spec.) | Not allowed | 5 gallonsb | 5 gallonsb | 60 gallonsb | 60 gallons |
| aGlass 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.  bIn 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.

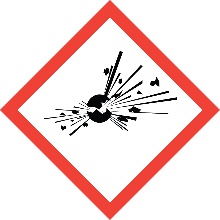
### Oxidizers

****An oxidizing agent is a chemical used to provide oxygen for chemical reactions. Oxidizers spontaneously evolve oxygen at room or slightly elevated temperatures, and can explode violently when shocked or heated. Because they possess varying degrees of chemical instability, oxidizing agents are explosively unpredictable and, therefore, represent a particularly hazardous safety threat.

Examples of oxidizing agents includes: peroxides, hyperperoxides, and peroxyesters.

Oxidizers can react violently when in contact with organics. For this reason, avoid interactions between oxidizers and organic materials. Examples of organic-reactive oxidizers include nitric acid, chromic acid, and permanganates.

### Highly Reactive Chemicals

****

Highly reactive chemicals, including explosives, self-reactive substances, pyrophorics, and water reactive chemicals pose particular storage and handling considerations. Substances in this category may have the GHS symbols at left on their labels, along with the GHS codes in the list below.

* + - **Explosives (GHS #H200,H201, H202, H203, H204, H205)** –An explosive substance (or mixture) is a solid or liquid which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
    - **Flammable Gases (GHS #H220, H221)** –Flammable gas means a gas having a flammable range in air at 20°C and a standard pressure of 101.3 kPa.
    - **Self-Reactive Substances (Type A) (GHS #H251)** –Self-reactive substances are thermally unstable liquids or solids liable to undergo a strongly exothermic thermal decomposition even without participation of oxygen (air).
    - **Pyrophoric Liquids and Solids (GHS #H250)** – A pyrophoric is a material which, even in small quantities, is liable to ignite within five minutes after coming into contact with air.
    - **Water Reactive Chemicals (which emit flammable gases on contact with water) (Category 1) (GHS #H260)** – Substances that, in contact with water, emit flammable gases are solids or liquids which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.

Examples of Explosive and Reactive (Unstable) Chemicals

|  |  |
| --- | --- |
| * + Alkali metals | * + Alkali metal hydrides |
| * + Alkali metal nitrides | * + Anhydrous metal halides (AlCl3, TiCl4) |
| * + Calcium hydride | * + Dinitropheylhydrazine |
| * + Hydrazine | * + Inorganic acid halides ( POCl3, SOCl2, SO2Cl2) |
| * + Lithium aluminum hydride | * + Metal and non-metal hydrides (borane, LiAlH4 ) |
| * + Metal Azides | * + Non-metal Halides (BCl3, BF3, BPCl3, SiCl4) |
| * + Perchloric and Picric Acid (Dry) | * + Sodium Borohydride |
| * + Sodium hydride | * + t-Butyllithium |
| * + White Phosphorous | * + Zinc and zinc nitrate |

#### 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.

#### 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.

Some peroxide-forming chemicals are listed in Table 8.5. Most typical are dioxane, ethyl ether, 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.

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; UV 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.

Several acceptable colorimetric tests for peroxides in ethers are available. Contact EHS for more 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 first. 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 it will also create a larger quantity of waste for disposal. The higher volume of waste may require stabilization because of the presence of the peroxides.

Table . Common Peroxide Forming Chemicals

List A: Severe Peroxide Hazard on Storage with Exposure to Air – Discard after 3 months

|  |  |
| --- | --- |
| Diisopropyl ether (isopropyl ether) | Potassium amide |
| Divinylacetylene (DVA) | Sodium amide (sodamide) |
| Potassium metal | Vinylidene chloride  (1, 1-di-chloroethylene) |

List B: Peroxide Hazard on Concentration – Discard after 1 year

|  |  |
| --- | --- |
| Acetaldehyde diethyl acetal (acetal) | Ethylene glycol dimethyl ether (glyme) |
| Cumene (isopropyl benzene) | Ethylene glycol ether acetates |
| Cyclohexene | Ethylene glycol monoethers (cellosolves) |
| Cylopentene | Furan |
| Decalin (decahydronaphthalene) | Methylacetylene |
| Dicylcopentadiene | Methyl i-butyl ketone |
| Diacetylene (butadiene) | Methylcyclopentane |
| Diethyl ether (Ethyl Ether) | Tetrahydrofuran (THF) |
| Diethylene glycol dimethyl ether (diglyme) | Tetralin (tetrahydronapthalene) |
| Dioxane | Vinyl ethers |
| t- Butyl alcohol |  |

List C: Hazard of Rapid Polymerization Initiated by Internally Formed Peroxides – Discard after 1 year

|  |  |
| --- | --- |
| Chloroprene (2-chloro-1, 3-butadiene) | Vinyl acetate |
| Styrene | Vinylpyridine |
| Chlorotrifluorethylene | 9, 10 Dihydroanthracene |
| Butadiene | Vinylacetylene (MVA) |
| Indene | Dibenzocyclopentadiene |
| Tetrafluroethylene (TFE) | Vinyl chloride |

#### 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% 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 required 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 dinitrophenyl hydrazine or picric acid, do not move them without consulting EHS first. 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. Labs should purchase premixed solutions wherever possible. 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 shall be stored in a separate area, preferably locked. Waste paper, plastic, and glass contaminated with this material shall be given to EHS for proper disposal.

#### 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.

#### 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 PPE.

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.

#### Organometallics

Organometallics are organic compounds that contain a carbon-metal bond. 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.

### 

### Compressed Gases

****For reference, see: Penn State Safety Policy [**SY25**](https://policy.psu.edu/policies/sy25): Compressed Gas Cylinders and the [**Gas Monitoring Program**](https://ehs.psu.edu/laboratory-safety/guidelines).

**Securing Cylinders.** An added hazard of oxidizing, toxic, 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 8.6 for maximum size and quantity limitations for compressed-gas or liquefied-gas cylinders in laboratories.

**Storage**. When a cylinder is not in use, close the main cylinder valve tightly. Promptly remove the regulator from the cylinder, replace the protective cap, and properly store the cylinder. Likewise, if the cylinder is empty close the main cylinder valve tightly, promptly remove the regulator from the cylinder, replace the protective cap, and label the cylinder by using an "empty" tag or write on the side of the cylinder with chalk. Never bleed cylinders completely empty; leave a slight pressure to keep contaminants out. Cylinders, like all other chemicals, should be stored based on chemical compatibility. See Section 8.7 for additional information.

**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 (CGA) 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 (122 °F). Some rupture devices on cylinders release at about 65 °C (149 °F).

Table . Maximum Size and Quantity Limitations for Compressed or Liquefied 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\*\* |
| \*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.  \*\*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. | | | |

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

#### Toxic Gases

For the purposes of this section, the definitions of toxic gas and highly toxic gas in the CGA 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 (ppm) 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.

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

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.

If these alternatives are not possible, alarm systems shall be employed to monitor the toxic gas in use. Respirators or self-contained breathing apparatus (SCBA) 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.

#### 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.

#### Lecture Bottles

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

* Lecture bottles all have identical valve threads, irrespective of the gas contained within. They should be clearly labeled.
* 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.
* Lecture bottles do not have pressure-relief devices to prevent rupturing. They should be handled with this in mind.
* 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.

#### Hydrides Gases

Hydrides are inorganic compounds composed of hydrogen and another element, often a metal. Examples include arsine (AsH3), diborane (B2H6), germane (GeH4), phosphine (PH3), silane (SiH4), and stibine (SbH3). These hydrides are highly toxic and flammable. They react violently with water and oxidizing agents, and pose a dangerous fire risk. Diborane, phosphine, and silane are spontaneously flammable in air. Hydride gases shall be stored in gas cabinets. Systems for gas monitoring should be installed.

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. This plan should be documented in the Laboratory and Research Safety binder as part of the Unit Specific Plan.

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.

### Cryogenic Liquids and Liquefied Gases

Additional information about working with cryogenic liquids can be found in the [**Liquid Nitrogen and Cryogen SOP**](http://ehs.psu.edu/industrial-hygiene-exposure-recognition-control/resources)**.**

Cryogenic liquids pose a number of hazards, including:

* death by asphyxiation where a spill or leakage depletes the atmospheric oxygen.
* cryogenic burns on contact with skin with cryogenic liquids (or even cold gas), the tissue damage that results is similar to that caused by frost bite or thermal burns.
* oxygen enrichment can significantly increase the chance of fire or an explosion.

Cryogenic liquids expand significantly when changing from liquid to gas at ambient temperature, and can rapidly displace oxygen. Ambient air normally contains 20.9% oxygen. Oxygen concentrations below 18% result in numerous health effects including loss of mental alertness and performance combined with distortion of judgment. Death by asphyxiation is rapid at less than 10% oxygen.

Fire or explosion may occur when the liquid form of flammable gases, such as hydrogen, are 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 contact may be intense and painful. Prolonged contact may result in blood clots. Appropriate PPE, including 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.

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.

### Toxic Chemicals

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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 exposure.

**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 alcohols (both ethanol and isopropanol) and chlorinated solvents, such as carbon tetrachloride.

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.

#### Carcinogenicity

Carcinogens are substances, or mixtures of substances, that cause malignant (cancerous) tumors. A list of substances the National Institute for Occupational Safety and Health (NIOSH) considers to be potential occupational carcinogens are listed in Table 8.7.

Carcinogens are any substances that are:

* regulated by OSHA as a carcinogen
* listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition)
* listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC)(latest editions)
* listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP.

Table . NIOSH Carcinogen List

The following is a list of substances [**NIOSH**](http://www.cdc.gov/niosh/topics/cancer/npotocca.html) 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, such as 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.

|  |
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| Asbestos |
| Asphalt fumes |
| Benzene |
| Benzidine |
| Benzidine-based dyes |
| Beryllium |
| Butadiene |
| tert-Butyl chromate; class, chromium hexavalent |
| Cadmium dust and fume |
| Captafol |
| 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-Diaminoanisoleo |
| 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 |
| Proplyene 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 hexavale |
|  |

### 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.

The State of California Safe Drinking Water and Toxic Enforcement Act ([**Proposition 65**](http://www.oehha.ca.gov/prop65/prop65_list/Newlist.html)) maintains a thorough list of chemicals known to the State to cause reproductive toxicity.

## Guidelines for Handling Chemicals

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

1. Minimize chemical exposures,
2. Avoid underestimating risk, and
3. 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.

### General Guidelines

The guidelines in Box 8.2 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.

Box . General Guidelines for Chemical Handling

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| 1. 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. 2. 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. 3. 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. 4. Wear eye protection at all times when handling, working with, or transporting hazardous chemicals. 5. Never pipette or start a siphon by mouth. 6. Never smell or taste chemicals. 7. 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. 8. Use chemical fume hoods or other engineering controls to minimize exposure to airborne contaminants. Use a respirator **ONLY** if engineering controls are not adequate, and you have been granted medical clearance. 9. Keep work areas clean and uncluttered. 10. Label all chemical containers. 11. Obtain an SDS for each chemical, and consult the SDS before you use a chemical. 12. Confine long hair and loose clothing. 13. Wear sturdy shoes that cover feet completely. 14. Wear a laboratory coat or other protective clothing. Remove protective clothing immediately if it becomes significantly contaminated. 15. Know the emergency procedures for the building, the department, and the chemicals being used. 16. Keep personal belongings away from chemicals. |

### 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 Pennsylvania Department of Agriculture must be displayed on the vehicle.

### 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, they are 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 PPE to ensure it is appropriate for the hazard. Personal hygiene and work practices should also be carefully evaluated to minimize exposure. The following guidelines (Box 8.3) should be practiced **in addition** to the general guidelines for handling chemicals.

Box . Guidelines for Handling Acutely Toxic Chemicals

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| * 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 specific emergency procedures for the chemicals in use. Keep emergency supplies at hand for immediate use. * Store and dispose of chemical wastes appropriately. |

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

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.

**In addition** to the general guidelines for handling chemicals, and the information covered in Section 7.2, use the following guidelines in Box 8.4 for handling chemicals with high chronic toxicity, which include most heavy metals, chemicals displaying moderate to high carcinogenic potency in animals, and reproductive toxins.

Box . Guidelines for Handling Chemicals with High Chronic Toxicity, Carcinogens, and Reproductive Toxins

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| * 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 PI shall decide whether impermeable aprons or disposable laboratory coats are required. * Select protective glove material on the basis of the hazard 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 chemical fume hood or glovebox. 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." * 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 and label a “designated area” within the laboratory for use of the materials. Materials shall be kept within the designated area to the extent possible. * To avoid potential inhalation hazards, handle powdered carcinogens and toxins in a chemical fume hood or glovebox, 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 workbench, 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 section of the SDS. * 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. |

### Guidelines for Working with Pesticides

In addition to the general guidelines for working with chemicals, the following (Box 8.5) are specific to pesticide use.

**Box 8.5** Guidelines for Working with Pesticides

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| * 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 7.5.4). * 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 year   + Central posting location (worker safety poster, application records, emergency information)   + Restricted entry intervals followed   + Post pesticide applications |

## Chemical Emergency Procedures

The ability to detect the release or presence of hazardous chemicals is an important skill for safely working in a lab. The methods and techniques of observation used to determine if a hazardous chemical is present or has been released vary widely based on the potential chemical.

* Odor: Some chemicals are vaporized into the air easily and emit a strong odor. Ex: solvents such as isoamyl acetate, which smell like bananas. NOTE: Odor is not necessarily directly related to the toxicity of a chemical.
* Visual Appearance: Release of some chemicals may be observed by the visible appearance of the chemical.
* Air monitoring: In areas where flammable or highly toxic substances are present, there may be air monitoring devices that alarm when the concentration of the substances reaches a certain value, such as 50% of the exposure limit. Examples: arsine air monitors, oxygen monitors in liquid nitrogen areas.

Sensory clues are the least dependable and potentially most dangerous method for identifying the presence of hazardous chemicals. Many hazardous chemicals do not have warning signs such as smell. And in cases of hazardous gas releases, you may not be able to see or notice any changes in the air.

The best preparation for a chemical emergency in your research area is to be familiar with the chemicals in your space and their properties. 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.

Before attempting to clean up a chemical spill, 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, elevator, or on a person) to determine whether evacuation or additional assistance is necessary. For large or toxic spills beyond your ability to control, call 911.

Boxes 8.6-8.10 provide general guidance for cleaning up chemical spills.

Box . Procedure for Small, Low-Toxicity Chemical Spills

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| * Alert persons in the area that a spill has occurred. * Contain any volatile material within a room by keeping doors closed. Increase exhaust efficiency by minimizing sash height of chemical fume hood. * Consult the SDS or procedures in this document, or call EHS for correct cleaning procedures. * Wear PPE 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 PPE, such as gloves. * Neutralize spills of corrosives and absorb, if appropriate. Sweep up waste and place in plastic bags for disposal. * Submit a Chemical Waste Pickup Request on the EHS website, [**ehs.psu.edu**](file:///C:\Users\AXH57\AppData\Roaming\Microsoft\Word\www.ehs.psu.edu). EHS will pick up the waste. * Complete an incident investigation to determine cause and preventive measures for reoccurrence. * Consult the SDS, which has specific information on spill procedures, and your laboratory's Unit Specific Plan. |

Box . Procedure for Spills of Flammable, Toxic, or Volatile Materials

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| * 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 University Police, 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. After cleaning up small spills, place the used absorbent into a plastic bag, place it in a chemical fume hood, and contact EHS for immediate pick up. |

Box . Mercury Spill Procedure

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| In the event of a mercury spill, regardless of volume, contact EHS immediately.  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.  To minimize the spill hazard, place a splash plate beneath all mercury-containing equipment. |

Box . Procedure for Chemical Spill on a Person

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| * 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 PPE. * 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. * 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. |

Box . Procedure for Cryogenic Liquid Spill on a Person

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| 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 oF). 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 medical assistance. |

## Chemical Inventory Management

For reference, see [**SY39, Hazardous Chemical Inventory Management**](https://policy.psu.edu/policies/sy39).

All research groups must use the Chemical Inventory Management System (CHIMS) to maintain an inventory of all hazardous chemicals used in, or stored for, research. The individual with primary responsibility for hazardous chemicals in research labs is the chemical owner. This is usually the PI, but may also be the director or manager of a unit, or other designated individuals in shared spaces. Chemicals owners shall ensure that the chemical inventory in CHIMS is updated at least annually. Research groups that use particular chemicals must ensure that they are entered into CHIMS immediately upon receipt. A dated hardcopy of the inventory must be maintained in the Laboratory and Research Safety binder.

### Chemicals that shall be inventoried in CHIMS

* Chemicals of Interest (COI) as defined in the Department of Homeland Security (DHS) Chemical Facility Anti Terrorism Standard (CFATS)
* Compressed gases (including liquefied gases, and empty cylinders that are still pressurized)
* Controlled substances (e.g., Schedule I or Schedule II substances as listed by the Drug Enforcement Administration)
* Corrosive acids which are corrosive to the skin and other materials having a pH of < 5.5
* Corrosive bases which are corrosive to the skin and other materials having a pH of > 11.0
* Dangerous When Wet (e.g., alkaline earth metal alloys, aluminum powder, barium, calcium hydride)
* Explosives
* Flammable or combustible liquids (e.g., alcohols, lubricants, oil based paints, solvents)
* Flammable solids (e.g., magnesium powder, sodium metal)
* Oxidizers (e.g., concentrated mineral acids, bromates, chlorates, permanganates)
* Organic peroxides (e.g., hydrogen peroxide >8%, benzoyl peroxide)
* Poisons not included in the above categories, e.g.,
  + Adhesives
  + Biological toxins
  + Dyes
  + Pesticides
  + Specimen solutions
* Spontaneously combustibles (e.g., activated carbon, lithium alkyds, phosphorus)
* Miscellaneous hazardous materials (e.g., dry ice, marine pollutants, listed hazardous substances, asbestos)

### Chemicals not required to be inventoried in CHIMS

These chemicals are not required to be inventoried in CHIMS, but may be:

* Biohazardous materials
* Non-hazardous buffer solutions
* Non-hazardous enzyme preparations
* Non-hazardous microbiological growth media
* Radioactive materials
* Retail products used for routine household activities (e.g., common cleansers, dish soap)
* Working solutions that will be used within 1-2 days

### Chemicals of Interest

Some chemicals have additional regulations associated with them in terms of allowable quantities and storage areas. The full list from the Department of Homeland Security can be found in Appendix A of the Chemical Facility Anti Terrorism Standard.

## Chemical Storage

These guidelines present one method of chemical storage. There are several appropriate chemical storage group methods available. Though each are slightly different, they have many overlapping similarities. Additional information on safe chemical storage can be found in the Chemical Storage Guidelines. Within any scheme for compatible storage, there may be exceptions or extra steps that need to be taken to assure safe storage.

Proper chemical storage controls health or physical hazards posed by chemical compounds during storage in the lab. It is designed to:

1. protect flammables from ignition;
2. minimize the potential of exposure to poisons; and
3. segregate incompatible compounds to prevent accidental mixing (via spills, residues, earthquakes, fires, or human error).

### General Principles of Chemical Storage

#### Chemical Dating

Chemicals shall be dated on receipt in the laboratory and again 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 dioxane, ethers, and tetrahydrofuran, which could pose an explosion hazard. Chemicals shall be disposed of through EHS if they are past their expiration date.

#### A Designated Storage Place for Each Compound

Each chemical container should have a designated storage place, and should be returned to that same location after each use. Storage locations can be marked on containers.

Do not store chemicals on benchtops where they are unprotected from ignition sources and are more easily knocked over. Only chemicals in use should be on the benchtop. Do not store any chemicals except bleach and compatible cleaning agents under the sink.

#### Do Not Use Chemical Fume Hoods for Storage

Do not keep chemicals or waste in chemical fume hoods where they clutter space, interfere with the hood's airflow, and may increase the risk of a fire in the laboratory.

#### Seal All Chemical Containers

All chemical containers must be closed, including bottles used for waste chemicals. Containers must remain sealed except when actively being used.

#### Alphabetical Only within Storage Groups

Do not store chemicals in alphabetical order except within a storage group. Alphabetical arrangement of randomly collected chemicals often increases the likelihood of dangerous reactions by bringing incompatible materials into close proximity.

#### Away from Sun and Heat

Storage areas should not be exposed to extremes of heat or sunlight.

#### Liquid Chemicals

Storage of liquid chemicals is generally more hazardous than storage of solids and is subject to numerous and varied storage requirements. Liquids should be stored below shoulder height.

### Chemical Storage Groups

Chemicals should be stored in the groups and corresponding facilities described in the sections below. In this plan, there are nine storage groups. Seven of these groups cover storage of liquids based on the variety of hazards posed by these classes of chemicals. Specific instructions must be followed for reactives, metal hydrides, and pyrophorics (Group 8) and certain individual compounds, but otherwise, all dry solids are in Group 9. In addition to proper storage segregation, some chemicals such as compressed liquids and gases, present particular hazards that have additional handling and storage requirements, detailed in Sections 8.3.5 and 8.3.6.

#### How to Determine the Correct Storage Group for a Chemical

Use the SDS to find information specific to particular chemicals, such as the flash point (in section 9) for flammable liquids. More detailed information about incompatible materials can be found in section 10 of the SDS. Determine the correct storage group by the hazard information on the container label, SDS, or contact EHS.

If incompatible materials must be stored in the same cabinet, provide secondary containment for segregation.

##### Multi-Hazard Chemicals

Many chemicals pose hazards that correspond to more than one storage group. In the following, storage groups are shown in descending order of hazard. The correct storage group for a multi-hazard chemical is the group that represents the greatest storage hazard, or the group appearing highest in the list. The physical hazards of a chemical (ex: flammable) usually takes precedent over the health hazard (ex: highly toxic) for storage considerations.

#### Ranking Chemical Storage Groups

* Group 1: **Flammables** Most Hazardous
* Group 2: **Volatile Poisons**
* Group 3: **Oxidizing Acids**
* Group 4: **Organic and Mineral Acids**
* Group 5: **Liquid Bases**
* Group 6: **Liquid Oxidizers**
* Group 7: **Non-Volatile Poisons**
* Group 8: **Reactives/Metal Hydrides**
* Group 9: **Dry Solids** Least Hazardous

### Storage Group Definitions

#### Group 1: Flammable Liquids

**Includes liquids with flashpoints < 100 °F (38 °C).** Examples include all alcohols, acetone, acetaldehyde, acetonitrile, amyl acetate, benzene, cyclohexane, dimethyldichlorosilane, dioxane, ether, ethyl acetate, histoclad, hexane, hydrazine, methyl butane, picolene, piperidine, propanol, pyridine, some scintillation liquids, all silanes, tetrahydrofuran, toluene, triethylamine, and xylene.

**Primary Storage Concern:** Protect flammable liquids from ignition.

**Acceptable Storage Facilities/Methods:**

* Store in a flammable cabinet, or
* Store in a flammable-storage refrigerator/freezer (see [**SY11**](https://policy.psu.edu/policies/sy11) and section 8.7.6).

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

**Do not** store flammables in cold rooms, which have limited or no ventilation, and are not explosion proof.

**Compatible Storage Groups:** Flammables may be stored with either *Group 2: Volatile Poisons,* or *Group 5: Liquid Bases,* but not with both.

#### Group 2: Volatile Poisons

**Includes poisons, toxics, and select and suspected carcinogens with strong odor or an evaporation rate greater than 1 (butyl acetate = 1).** Examples include carbon tetrachloride, chloroform, dimethylformamide, dimethyl sulfate, formamide, formaldehyde, halothane, mercaptoethanol, methylene chloride, and phenol.

**Primary Storage Concern:** Prevent volatile poison inhalation exposures.

**Acceptable Storage Facilities/Methods:**

* Store in a properly vented storage cabinet; or
* Store containers of less than one liter in a refrigerator.

**Compatible Storage Groups:** Volatile poisons may be stored with flammables if bases are not present.

#### Group 3: Oxidizing Acids

**All oxidizing acids are highly reactive with most substances and each other.** Examples include chromic, nitric, perchloric, and sulfuric acids.

**Primary Storage Concern:** Prevent contact and reaction between oxidizing acids and other substances and prevent corrosive action on surfaces.

**Acceptable Storage Facilities/Methods:**

* Store in a ventilated safety cabinet.
* Each oxidizing acid must be in secondary containment (i.e., the primary container must be kept inside a canister, tray, or tub).

**Compatible Storage Groups:** Oxidizing acids must be double-contained and should be segregated in their own compartment in a safety cabinet. When quantities are small (e.g., 1 or 2 bottles) they do not warrant a separate compartment. Small quantities may be double-contained and stored with *Group 4: Organic and Mineral Acids*. ***Store oxidizing acids on the bottom shelf, below Group 4.*** However, nitric acid and chromic acid shall not be stored together.

#### Group 4: Organic and Mineral Acids

**Organic and mineral acids.** Examples include acetic, butyric, formic, glacial acetic, hydrochloric, isobutyric, mercaptoproprionic, phosphoric, proprionic, and trifluoroacetic acids.

**Primary Storage Concern:** Prevent contact and reaction with bases and oxidizing acids, and prevent corrosive action on surfaces.

**Acceptable Storage Facilities/Methods:**

* Store in a ventilated safety cabinet.

**Compatible Storage Groups:** Small amounts of oxidizing acids in secondary containment can be stored in the same compartment with organic acids *if the oxidizing acids are stored on the bottom shelf.*

**Exceptions:** Acetic anhydride and trichloroacetic anhydride are corrosive. These acids are very reactive with other acids and *should not* be stored in this group. It is better to store them with organic compounds in *Group 7: Non-Volatile Liquid Poisons.*

#### Group 5: Liquid Bases

**Liquid bases.** Examples include ammonium hydroxide, calcium hydroxide, gluteraldehyde, and sodium hydroxide.

**Primary Storage Concern:** Prevent contact and reaction with acids.

**Acceptable Storage Facilities/Methods:**

* In a ventilated safety cabinet; or
* In tubs or trays in normal cabinet.

**Compatible Storage Groups:** Liquid bases may be stored with flammables in the flammable cabinet if volatile poisons are not stored there.

#### Group 6: Liquid Oxidizers

**Oxidizing liquids react with everything, potentially causing explosions or corrosion of surfaces.** Examples include ammonium persulfate and hydrogen peroxide (if ≥ 30%).

**Primary Storage Concern:** Isolate liquid oxidizers from other substances.

**Acceptable Storage Facilities/Methods:**

* Smaller quantities must be in secondary containment when stored near other chemicals (e.g., in a refrigerator).

**Compatible Storage Groups:** None.

#### Group 7: Non-Volatile Liquid Poisons

**Includes highly toxic (LD50 oral rat < 50 mg/kg) and toxic chemicals (LD50 oral rat < 500 mg/kg), select carcinogens, suspected carcinogens, and mutagens.** Examples include acrylamide solutions, Coomassie blue stain, diethylpyrocarbonate, diisopropyl fluorophosphate, uncured epoxy resins, ethidium bromide, and triethanolamine.

**Primary Storage Concern:** Prevent contact and reaction between non-volatile liquid poisons and other substances.

**Acceptable Storage Facilities/Methods:**

* Store in a cabinet or refrigerator (i.e., non-volatile liquid poisons must be enclosed).
* Do not store on open shelves in the lab or cold room.
* Liquid poisons in containers larger than one liter must be stored below bench level on shelves closest to the floor.

**Compatible Storage Group:** Store non-volatile liquid poisons with non-hazardous liquids (e.g., buffer solutions).

**Exceptions:** Anhydrides (e.g., acetic and trichloroacetic) are organic acids; however, it is better to store them with this group, since they are highly reactive with other acids.

#### Group 8: Metal Hydrides, Pyrophorics, and Reactives

**Most metal hydrides react violently with water, some ignite spontaneously in air (pyrophoric).** Examples of metal hydrides are calcium hydride, lithium aluminum hydride, and sodium borohydride. Other pyrophorics are boron, diborane, dichloroborane, diethyl aluminum chloride, 2-furaldehyde, lithium, white or yellow phosphorus, and trimethyl aluminum. Other water reactives include acetyl chloride, aluminum chloride-anhydrous, aluminum tribromide, calcium carbide, calcium oxide, chlorosulonic acid, phosphorous pentachloride calcium, potassium, sodium, and acid anhydrides.

**Primary Storage Concern:** Prevent contact and reaction with liquids and, in some cases, air.

**Acceptable Storage Facilities/Methods:**

* Store using secure, waterproof double-containment according to label instructions.
* Isolate from other storage groups.

**Compatible Storage Groups:** If securely double-contained to prevent contact with water or air, metal hydrides may be stored in the same area as *Group 9: Dry Solids.*

#### Group 9: Dry Solids

**Includes all powders, hazardous and non-hazardous.** Examples include benzidine, cyanogen bromide, ethylmaleimide, oxalic acid, potassium cyanide, and sodium cyanide.

**Primary Storage Concern:** Prevent contact and potential reaction with liquids.

**Acceptable Storage Facilities/Methods:**

* Cabinets are recommended, but if not available, open shelves are acceptable.
* Store above liquids.
* Warning labels on highly toxic powders should be inspected and highlighted or amended to stand out against less toxic substances in this group.
* It is recommended that the most hazardous substances in this group be segregated.
* It is particularly important to *keep liquid poisons below cyanide-containing or sulfide-containing poisons (solids);* a spill of aqueous liquid onto cyanide-containing or sulfide-containing poisons would cause a reaction that would release poisonous gas.

**Compatible Storage Groups:** Metal hydrides, if properly double-contained, may be stored in the same area as dry solids.

**Exceptions:** Solid picric or picric sulfonic acid can be stored with this group, but should be checked regularly for dryness. *When completely dry, picric acid is explosive and may detonate upon shock or friction.*

### Storage Facilities

**Controlled substances** shall be stored in locked cabinets to prevent theft. See section 8.11 for more information.

**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. Examples of peroxide forming chemicals include acetaldehyde, ether (diethyl and isopropyl), and tetrahydrofuran. Additional information about peroxide forming chemicals can be found in section 8.3.4.2.

**Volatile or highly odorous** chemicals shall be stored in a well-ventilated area; a ventilated cabinet is preferable. Chemical fume hoods shall not be used for storage, as containers block proper air flow in the hood and take up work space.

**Carcinogen** storage areas 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).

### Inspection of Stored Chemicals

**Storage Area**. Chemical storage areas shall be inspected at least 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

### Refrigerator Storage

For reference, see: Penn State Safety Policy [**SY11, Refrigerators – Explosion Proof**](https://policy.psu.edu/policies/sy11).

Flammable liquids (flash point < 100 °F/38 °C) 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.

### 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 the Environmental Emergency Plans and, if they are tanks, the Storage Tank Management Program.

Chemicals and oils that are stored improperly could accidentally 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 gallons or more) must have secondary containment 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 or a spill containment pallet that holds 110% of the single largest container 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 covered in Penn State’s Environmental Emergency 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.

## Safety for Specific Chemical Operations

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.

### Unattended/Overnight Operations

An unattended procedure is a process or piece of equipment which is left operating when no one is in the lab. If at all possible, avoid this practice.

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. The "Laboratory Information" posting on the outside of the laboratory shall have current emergency contact information. If an experiment, reaction, or process must be left alone for a long period of time, or overnight, hang a label or sign on the hood or outer lab door that includes information about the hazards of the operation, when it was started, the anticipated finish time, and complete contact information.

### 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 fume 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.

### Temperature Control

#### 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.

#### 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 carry additional risks, see Section 8.3.6 for further information.

### 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. Prior to use, inspect vacuum desiccators for chips, cracks, and defects. Vacuum lines shall be trapped and shielding used whenever apparatus is under reduced pressure. Only chemicals being dehydrated should be stored in a vacuum 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.

### 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.

### Calorimeters

Calorimeters, commonly known as 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 a blast shield. The operator shall wear goggles and 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 gauge.

Parr 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.

## Laboratory and Research Waste

Research at Penn State generates numerous types of waste. Regulations require Penn State to ensure the proper disposition of wastes generated through Penn State activities. It is a federal and state offense to dispose of many of these unwanted materials improperly.

### Laboratory Waste Management Plan

All labs that generate chemical waste shall be familiar with the Laboratory Waste Management Plan, also known as “Subpart K”, which includes requirements for container labeling, accumulation time limit, waste quantity limit, satellite accumulation area signage and inspection, secondary containment, and management of containers. Training for chemical waste generators is included in the standard Laboratory and Research Safety training (initial) and annual refresher training, both of which are required for all individuals working in laboratory and research areas.

### Chemical/Hazardous Waste

For reference, see: Penn State Safety Policy [**SY20, Hazardous Waste Disposal**](https://policy.psu.edu/policies/sy20)**.**

EHS is responsible for disposal of chemicals and shall be contacted to arrange the removal of chemical wastes. Normal hazardous waste disposal costs are funded through EHS.

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.

### Definition of hazardous waste

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

1. 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:
   1. an oral LD50 of less than 50 mg/kg,
   2. an inhalation LC50 of less than 2 mg/l, or
   3. a dermal LD50 of less than 200 mg/kg.
2. A waste is hazardous if it contains any of the toxic constituents listed in the regulations.
3. A waste is hazardous if it exhibits any of the following characteristics:
4. Ignitability
5. Reactivity
6. Corrosivity
7. Toxicity

### Responsibilities

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

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. 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 "Satellite Accumulation Area."
2. Designate an individual who is responsible to oversee the proper storage, labeling, and inspection of this Satellite 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.

The spill or discharge of any hazardous material must be reported to EHS at 814-865-6391 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 and Public Safety at 814-863-1111. EHS 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.

### Chemical Waste Pickup

Chemical wastes are removed by EHS or a contracted vendor. To request a pickup, you must submit a request using the EHS Waste Management System on the EHS website, [**ehs.psu.edu**](file:///C:\Users\Documents%20and%20Settings\kxl3\Local%20Settings\Temporary%20Internet%20Files\sapanski\My%20Documents\chp\www.ehs.psu.edu). Chemicals shall not be brought directly to EHS.

Chemical waste containers shall always be labeled with a green 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.

### Sanitary Sewer Disposal

For reference, see: Penn State Safety Policy [**SY40, Disposal of Pollutants in University Sanitary Systems**](https://policy.psu.edu/policies/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 indiscriminate drain-disposal of chemicals/materials is not permitted. Drain disposal of chemical waste materials shall be permitted only with specific written approval by EHS.

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.

### 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 Penn State policy require investigators to make every effort to minimize the amount and toxicity of waste removed from University facilities.

### Storage

Storage of waste chemicals shall include separation of incompatible materials, as in "Chemical Storage," Section 8.7.

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.

### Containers

Chemically contaminated laboratory waste is stored in plastic tubs supplied by EHS to prevent it from 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.

### Collection of Sharps

Chemically contaminated sharps such as broken glass, syringes, pipettes, needles, 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. Sharps containers can be purchased from a number of different scientific or medical supply vendors. EHS does not supply sharps containers to research groups.

### Mixed Waste

Mixed waste is any waste that contains radioactive material and 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.

### Waste Minimization

The EPA's regulations and Penn State Safety Policy [**SY20**](https://policy.psu.edu/policies/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 Penn State 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.

## Nanomaterials

Exposure standards have not been established for engineered nanoparticles in the US. 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 PPE 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 8.9. 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.

Table . Exposure Risks and Control Measures for Common Laboratory Operations Involving Nanomaterials

|  |  |
| --- | --- |
| Activity types, by Risk of Exposure | Primary Control Measures |
| Low Probability:   * Non-destructive handling of solid nanoparticle composites or nanoparticles permanently bonded | * Disposable nitrile or PVC gloves. Do not reuse gloves. * Wet cleaning procedures and/or HEPA vacuum for surfaces/equipment. |
| Medium / High Probability:   * Working with 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 | * 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 (plus face shield if splash potential exists) * Wet cleaning procedures for surfaces/equipment |
| High Probability:   * Generating nanoparticles in the gas phase or in aerosol (spill or liquid) * Manipulation of nanoparticles in gas stream | * Work in enclosed systems only (e.g., glovebox, glovebag, or sealed chamber). |

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

### 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, or 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 researcher. Consult with EHS if engineering controls are not feasible.

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

### Work Practices

**Selection of Nanomaterials:**

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

Consult the 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:**

Eating, drinking, smoking, gum or tobacco chewing, application of lip balm or cosmetics, handling of contact lenses, and food storage is prohibited where chemicals or nanomaterials are used or stored since this practice increases the likelihood of exposure.

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 secondary containment, such as sealed, double-contained containers, 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.

### 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 regarding the need for respiratory protection or other alternative controls.

### 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 SDS (if available), and the lab's SOP for the experiment.

### Standard Operating Procedures

Prepare a SOP for operations involving nanomaterials. A general use SOP for working with nanomaterials is available. 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.

### Consultation

Consult with your PI prior to procuring or working with nanomaterials. For additional assistance, contact EHS.

## Controlled Substances in Research

Penn State 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 Drug Enforcement Administration (DEA).

### Licensing

All faculty and staff who wish to work with controlled substances must be licensed by the DEA, a division of the Department of Justice, to do so. Penn State 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.deadiversion.usdoj.gov/drugreg/reg\_apps/225/225\_instruct.htm#6**](http://www.deadiversion.usdoj.gov/drugreg/reg_apps/225/225_instruct.htm#6)

Information on various drug schedules is available at:

[**http://www.deadiversion.usdoj.gov/drugreg/reg\_apps/225/225\_instruct.htm#3d**](http://www.deadiversion.usdoj.gov/drugreg/reg_apps/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).

### 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.

### Storage

Controlled substances must be stored in a manner that prevents theft or diversion of the material. Schedule 1 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.

### 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**](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.

### Recordkeeping

Licensees must maintain detailed inventory records as specified in [**21 CFR 1304.03**](http://www.deadiversion.usdoj.gov/21cfr/cfr/1304/1304_03.htm). 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 [**21 CFR 1304.11**](http://www.deadiversion.usdoj.gov/21cfr/cfr/1304/1304_11.htm). 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.

### Disposal

Unwanted or outdated controlled substances should be disposed of through 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.

### Contacting the DEA

**PITTSBURGH DISTRICT OFFICE**

1781 McKees Rocks Road   
Pittsburgh, PA 15136

Phone (412) 777-6940

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

Phone (215) 861-3474

Diversion Number: (215) 238-5160   
Diversion Fax: (215) 238-5170

**Jurisdiction**: Delaware and Eastern Pennsylvania

## Explosive Materials in Research

Various activities at Penn State that involve the research or use of energetic materials considered “explosives” by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) must follow the guidelines set down in the [**ATF Explosives Materials Management Program**](http://ehs.psu.edu/explosive-materials-management/overview). Federal and state licenses MUST be in place prior to acquisition, possession, storage, and use of any explosive material that falls under this program.

### Applicability Assessment

The list of [**Explosive Materials**](http://ehs.psu.edu/explosive-materials-management/requirements-guidelines) is a comprehensive, but not exhaustive, list of the chemicals that fall under this program. An applicability assessment shall be performed prior to the application for an ATF License/Permit, or purchase, possession, storage, or use of explosive material. The license/permit may only be applied for once this applicability assessment is complete and indicates that the proposed activity is covered by this program. Contact EHS for further guidance if the research and chemicals used in your research fall under this program.

# BIOLOGICAL AGENTS

## 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 Penn State Policy [**RP11**](https://policy.psu.edu/policies/rp11). The laboratory procedures described in Section 7.0, "General Safety," and Section 8.0, "Chemical Hazards," also apply to laboratories using biological agents, and that information is not repeated in this section. Most of the information in this section is taken from the book [**Biosafety in Microbiological and Biomedical Laboratories**](https://www.cdc.gov/biosafety/publications/bmbl5/) (BMBL) (HHS Publication No. (CDC) 21-1112, Revised 2009). A copy of the book is also 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 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.

## Responsibilities

### General

The responsibilities of the department head, PI, and others working with biological hazards include all those described in Section 3.0 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.

### Institutional Biosafety Committee Application

A PI wishing to use a regulated or biohazardous material, as per [**RP11**](https://policy.psu.edu/policies/rp11), in research shall complete an IBC Application form, which may be obtained from the [**ORP**](https://www.research.psu.edu/orp). ORP determines the biosafety level of the agent, notifies the PI of the biosafety level, and then the laboratory space is inspected for compliance.

## 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.

### Laboratory Practice and Technique

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.

### Safety Equipment (Primary Barriers)

Safety equipment includes biological safety cabinets (BSC), 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.

#### Biological Safety Cabinets

The BSC is the principal device used to provide containment of infectious splashes or aerosols. There are three types of BSCs: 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.

BSCs 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 BSCs.

#### Other Safety Equipment

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

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

In some situations in which it is impractical to work in a BSC, PPE 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.

### Facility Design (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 (BSL) 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 BSCs. 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 BSL-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 BSL-4 facility; it is not applicable to activities at Penn State.

## Biosafety Levels

The following guidelines are recommended by the CDC and the National Institutes of Health (NIH) and have been adopted as required procedures at Penn State. See [**BMBL**](https://www.cdc.gov/biosafety/publications/bmbl5/) for listings of which biosafety level various agents should be worked with at. Agent summaries are also available in the BMBL.

### Biosafety Level 1

BSL-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.

#### Standard Microbiological Practices

1. The laboratory supervisor must control access to the laboratory to authorized individuals.
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:
   1. 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.
6. Used disposable needles and syringes must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal.
7. Non-disposable sharps must be placed in a hard walled container for transport to a processing area for decontamination, preferably by autoclaving.
8. 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.
9. Perform all procedures to minimize the creation of splashes and/or aerosols.
10. Decontaminate work surfaces after completion of work and after any spill or splash of potentially infectious material with appropriate disinfectant.
11. 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.
    1. Materials to be decontaminated outside of the immediate laboratory must be placed in a durable, leak proof container and secured for transport.
    2. Materials to be removed from the facility for decontamination must be packed in accordance with applicable local, state, and federal regulations.
12. A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents are present. The sign should include the name of the agent(s) in use, and the name and phone number of the laboratory supervisor or other responsible personnel.
13. An effective [**IPM**](http://ehs.psu.edu/pesticide-management/pesticide-integrated-pest-management-university-park) program is required.
14. 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 university’s healthcare provider for appropriate counseling and guidance.

#### Special Practices

None required.

#### Safety Equipment (Primary Barriers and Personal Protective Equipment)

* 1. Special containment devices or equipment, such as BSCs, are not generally required.

1. Protective laboratory coats, gowns, or uniforms are recommended to prevent contamination of personal clothing.
2. 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.
3. 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:
   1. Change gloves when contaminated, glove integrity is compromised, or when otherwise necessary.
   2. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory.
   3. Not wash or reuse disposable gloves. Dispose of used gloves with other contaminated laboratory waste. Hand washing protocols must be rigorously followed.

#### 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.
  5. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals.
  6. Chairs used in laboratory work must be covered with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.

1. Laboratory windows that open to the exterior should be fitted with screens.

### Biosafety Level 2

BSL-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.

#### Standard Microbiological Practices

1. The laboratory supervisor must control access to the laboratory to authorized individuals.
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:
   1. 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.
   2. Used disposable needles and syringes must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal.
   3. Non-disposable sharps must be placed in a hard walled container for transport to a processing area for decontamination, preferably by autoclaving.
   4. 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:
   1. Materials to be decontaminated outside of the immediate laboratory must be placed in a durable, leak proof container and secured for transport.
   2. 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.
10. An effective [**IPM**](http://ehs.psu.edu/pesticide-management/pesticide-integrated-pest-management-university-park) program is required.
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 university’s healthcare provider for appropriate counseling and guidance.

#### 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. At Penn State, this is considered part of the Unit Specific Plan.
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.
   1. Spills involving infectious materials must be contained, decontaminated, and cleaned up by staff properly trained and equipped to work with infectious material.
8. Equipment must be decontaminated before repair, maintenance, or removal from the laboratory.
9. Incidents that may result in exposure to infectious materials must be immediately evaluated and treated according to procedures described in the Unit Specific Plan. All such incidents must be reported to the laboratory supervisor. Medical evaluation, surveillance, and treatment should be provided and appropriate records maintained.
10. Animals and plants not associated with the work being performed must not be permitted in the laboratory.
11. All procedures involving the manipulation of infectious materials that may generate an aerosol should be conducted within a BSC or other physical containment devices.

#### Safety Equipment (Primary Barriers and Personal Protective Equipment)

* + 1. Properly maintained BSCs, other appropriate PPE, or other physical containment devices must be used whenever:
  1. 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.
  2. 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.
     1. Protective laboratory coats, gowns, smocks, or uniforms designated for laboratory use must be worn while working with hazardous materials. Remove protective clothing before leaving the laboratory. Dispose of protective clothing appropriately, or deposit it for laundering. Laboratory clothing must not be taken home.
     2. 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.
     3. 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:
  3. Change gloves when contaminated, glove integrity is compromised, or when otherwise necessary.
  4. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory.
  5. Not wash or reuse disposable gloves. Dispose of used gloves with other contaminated laboratory waste. Hand washing protocols must be rigorously followed.

1. Eye, face, and respiratory protection should be used in rooms containing infected animals as determined by the Unit Specific Plan.

#### Laboratory Facilities (Secondary Barriers)

1. Laboratory doors should be self-closing and secured.
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.
   1. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals.
   2. 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), as per [**SY29**](https://policy.psu.edu/policies/sy29).

### Biosafety Level 3

BSL-3 work must be conducted in accordance with the facility safeguards, standard microbiological practices, special practices, and safety equipment described in BMBL.

BSL-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 BSCs or other physical containment devices, or by personnel wearing appropriate PPE. 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 BSL-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 BSL-2 facilities. However, the recommended standard microbiological practices, special practices, and safety equipment for BSL-3 must be rigorously followed.

### Biosafety Level 4

University use of biological agents requiring BSL-4 containment practices is not currently permitted. Should an investigator wish to conduct research with these agents, a description of the research shall be submitted to the IBC for review and approval prior to the initiation of research. Approval is also required by the vice president for research prior to the initiation of research.

## 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 BSL-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 BSL-2 or higher occurs in a public area, evacuation of the area shall be immediate. The PI 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 PPE (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.

### Sterilization, Disinfection, and Decontamination

An appropriate chemical disinfectant should be chosen that is effective against the organisms involved in the spill (Table 9.1). The EPA 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).

* **Sterilizer or Sterilant**: An agent intended to destroy **all** microorganisms and their spores on inanimate surfaces.
* **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.
* **Hospital Disinfectant**: An agent shown to be effective against specific organisms such as *Pseudomonas* *aeruginosa, Salmonella choleraesuis,* and *Staphylococcus aureus*. 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.
* **Antiseptic**: A chemical germicide formulated for use on skin or tissue. Antiseptics should not be used as disinfectants.
* **Decontamination**: 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 Hepatitis B virus (HBV) but are not recommended for this purpose because of their rapid evaporation and the consequent difficulty of maintaining proper contact times.

**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.

**Formaldehyde** is an OSHA-regulated chemical that is a suspect carcinogen, 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.

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

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | DISINFECTANTS | | | | | | | | |
|  |  | LIQUID | | | | | | | GAS\* | |
|  |  | Quaternary Ammonia Compounds | Phenolic Compounds | Chlorine Compounds | Iodophor | Alcohol, Ethyl & Isopropyl | Formal-dehyde | Glutaral-dehyde | Ethylene Oxide | Paraformal-dehyde |
| Practical Requirements | Use Dilution | 0.1-2.0% | 1.0%-5.0% | 500 ppm a | 25-1600 ppma | 70 -85% | 0.2-8.0% | 2% | 8 – 23 g/ft3 | 0.3 g/ft3 |
| Contact time (min) – Lipovirus | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 60 | 60 |
| Contact time (min) – Broad Spectrum | NE | NE | 30 | 30 | NE | 30 | 30 | 60 | 60 |
| Temperature (°C) |  |  |  |  |  |  |  | 37 | 30 |
| Relative Humidity, % |  |  |  |  |  |  |  | > 23 | > 60 |
| Inactivates | Vegetative Bacteria | + | + | + | + | + | + | + | + | + |
| Lipoviruses | + | + | + | + | + | + | + | + | + |
| Nonlipid Viruses |  | b | + | + | b | + | + | + | + |
| Bacterial Spores |  |  | + | + |  | + | + | + | + |
| Important Characteristics | Effective Shelf Life > 1 week c | + | + |  | + | + | + | + | NA | NA |
| Corrosive |  | + | + | + |  |  |  |  |  |
| Flammable |  |  |  |  | + |  |  | + d | + e |
| Explosion Potential |  |  |  |  |  |  |  | + d | + e |
| Residue |  | + | + | + |  | + | + |  |  |
| Inactivated by Organic Matter | + |  | + | + |  |  |  |  |  |
| Compatible for Optics f | + |  |  |  |  |  | + | + | + |
| Compatible for Electronics |  |  |  |  |  |  |  | + | + |
| Skin Irritant | + | + | + | + |  | + | + | + | + |
| Eye Irritant | + | + | + | + | + | + | + | + | + |
| Respiratory Irritant |  |  | + |  |  |  |  | + | + |
| Toxic g | + | + | + | + | + | + | + | + | + |
| Potential Applications | Work Surfaces | + | + | + | + | + | + | + |  |  |
| Dirty Glassware | + | + | + | + | + | + | + |  |  |
| Large Area Decontamination |  |  |  |  |  |  |  |  | + |
| Air Handling Systems |  |  |  |  |  |  |  |  | + |
| Portable Equipment Surface Decontamination | + | + | + | + | + | + | + |  |  |
| Portable Equipment Penetrating Decontamination |  |  |  |  |  |  |  | + | + |
| Fixed Equipment Surface Decontamination | + | + | + | + | + | + | + |  |  |
| Fixed Equipment Penetrating Decontamination |  |  |  |  |  |  |  |  | + |
| Optical and Electronic Instruments |  |  |  |  |  |  |  | + | + |
| Liquids for Discard |  |  | + |  |  |  |  |  |  |
| Books, Papers |  |  |  |  |  |  |  | + |  |

Table . Summary of Practical Disinfectants

Note: NA – Not Applicable

NE – Not Effective

a. Available halogen.

b. Variable results dependent on virus.

c. Protected from light and air.

d. Neither flammable nor explosive in 90% CO2 or fluorinate hydrocarbon, the usual use form.

e. At concentrations of 7-73% by volume in air, solid-exposure to open flame.

f. Usually compatible, but consider interferences from residues and effects on associated materials, such as mounting adhesives.

g. By skin or mouth or both – refer to manufacturer’s literature and/or Merck Index.

h. Space limitations preclude listing all products available. Individual listings (or omissions) do not imply endorsement or rejection of any product by NIH.

Examples of Proprietary Disinfectants h

Quaternary Ammonia Compounds: A-33, CDQ, End-Bac, Hi-Tor, Mikro-Quat

Phenolic Compounds: Hi-Phene, Matar, Mikro-Bac, O-Syl

Chlorine Compounds: Choramine T, Clorox, Purex

Iodophor: Hy-sine, Ioprep, Mikroklene, Wescodyne

Formaldehyde: Sterac

Glutaraldehyde: Cidex

Ethylene Oxide: Carboxide, Cryoxicide, Steroxcide

\* Must be preapproved by EHS prior to use or hiring a contractor to perform the work.

Adapted from “Safety by Design” 2015 Biosafety Monograph, NIH.

### Decontamination of Spills

The following procedure is recommended for decontaminating spills of agents used at BSL-2 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.

### 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.

If a spill of a larger volume of hazardous material that could generate an aerosol occurs, evacuate the room and contact EHS. Wait for aerosol reduction, don PPE (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.

### Biological Spill within a Biological Safety Cabinet

A spill that is confined within a BSC 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 9.1 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.

### 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 PI, allow aerosols to settle, and decontaminate following the principles described above.

### 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.

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

Penn State complies with the OSHA Occupational Exposure to Bloodborne Pathogens Standard found in [**29 CFR 1910.1030**](https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=10051&p_table=STANDARDS). The information in this section summarizes the requirements of the standard. Additional information on the [**Bloodborne Pathogen Program**](http://ehs.psu.edu/bloodborne-pathogen/overview) 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.

### Exposure Control Plan

The standard requires a written [**Exposure Control Plan**](http://ehs.psu.edu/bloodborne-pathogen/bloodborne-pathogen-resources), Penn State’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 update 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.

### Unit Specific Plan

PIs 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 IBC.

### 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 or 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 EHS if you are unsure whether your laboratories qualify and for information about additional requirements for these facilities.

### 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.

### 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 PPE shall also be used. Human blood, blood products, and other potentially infectious materials shall be used with BSL-2 work practices, containment, and facilities.

1. **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 PI shall ensure that employees wash hands immediately or as soon as feasible after removing gloves or other PPE 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.

1. **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 **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.

1. **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.
2. **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.
3. **Mouth Pipetting**. Mouth pipetting of blood or other potentially infectious materials is prohibited.
4. **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.
5. **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.
6. **Other Engineering Controls**. Other engineering controls include BSCs (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. OPP inspects and maintains chemical fume hood fan and duct systems.

BSCs 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.

### Personal Protective Equipment

1. **Responsibility**. The PI shall provide or ensure provision of appropriate PPE 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, and other ventilation devices.

The PI shall either directly or by delegation ensure that each employee uses PPE when warranted.

1. **Availability**. PPE 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.
2. **Maintenance**. The department head shall ensure that PPE be cleaned, laundered, or disposed of at no cost to the employee. PPE shall be repaired or replaced as needed to maintain its effectiveness.
3. **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.

1. **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.
2. **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.
3. **Implementation for Personal Protective Clothing and Equipment**. Appropriate PPE 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.

### Housekeeping

* 1. **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.
  2. **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 Table 9.1 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 Unit Specific Plan.

* 1. **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.

### Waste Disposal

* + - 1. **Contaminated Sharps**. Contaminated sharps shall be discarded immediately or as soon as feasible in containers that are closable, puncture-resistant, and leakproof. 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.

* + - 1. **Other Biohazardous Wastes**. Waste containers that contain blood or other potentially infectious material shall be sealable, large enough to contain all intended contents, leakproof, 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 placed in the white barrels found in autoclave rooms.

### 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 PPE.

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. See Section 7.3.3 for more information.

### Hepatitis B Vaccination and Postexposure Evaluation and Follow-up

1. **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.
2. **Hepatitis B Vaccination**. HBV 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 HBV 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 HBV vaccination.

Vaccinations are provided through Occupational Medicine. HBV vaccination programs have been established on each campus. Contact EHS for specific instructions.

1. **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.
2. **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.

### Communication of Hazard to Employees: Labels

Warning labels are required on containers of biohazardous waste (including red or orange biohazardous waste 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."

### Communication of Hazard to Employees: Information and Training

* 1. **Responsibility**. The PI 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.
  2. **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.
  3. **Additional Training**. The PI 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.
  4. **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.
  5. **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.
  6. **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.

## Recombinant DNA Activities

Recombinant DNA research shall comply with the NIH’s "[**Guidelines for Research Involving Recombinant DNA Molecules**](https://osp.od.nih.gov/biotechnology/nih-guidelines/)"and Penn State Policy [**RP11**](https://policy.psu.edu/policies/rp11). The recombinant DNA guidelines are applicable to all recombinant DNA research conducted at or sponsored by an institution that receives any support from NIH for recombinant DNA research. 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. The IBC is responsible for implementing the guidelines and overseeing recombinant DNA research.

NIH defines recombinant DNA molecules as:

1. molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell
2. molecules that result from the replication of those described above.

PIs intending to use recombinant DNA molecules shall notify the IBC by contacting ORP for information and appropriate registration forms. The PI shall prepare registration documents according to the nature of the research. PIs 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 in BMBL. However, the NIH Recombinant DNA guidelines take precedence.

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.

## Infectious Waste Management

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 Penn State Policy [**SY29**](https://policy.psu.edu/policies/sy29).

Infectious Waste is any laboratory-generated waste that is or may be contaminated with disease-causing bacteria, viruses, fungi, or other pathogens; OR any item that has been used in recombinant DNA work.

Infectious waste includes, but is not limited to:

* *Cultures and stocks.* Cultures and stocks of infectious agents and associated biologicals, including the following: cultures from medical and pathological laboratories; cultures and stocks of infectious agents from research and industrial laboratories; wastes from the production of biologicals; discarded live and attenuated vaccines except for residue in emptied containers; and the culture dishes, assemblies and devices used to conduct diagnostic tests or to transfer, inoculate and mix cultures.
* *Pathological wastes.* Human pathological wastes, including tissues, organs, body parts, and body fluids that are removed during surgery, autopsy, other medical procedures, or laboratory procedures. The term does not include hair, nails, or extracted teeth.
* *Human blood and body fluid waste and items contaminated with the same.*
* *Animal wastes.* Contaminated animal carcasses, body parts, blood, blood products, secretions, excretions and bedding of animals that were known to have been exposed to zoonotic infectious agents or nonzoonotic human pathogens during research (including research in veterinary schools and hospitals), production of biologicals or testing of pharmaceuticals.
* *Isolation wastes.* Biological wastes and waste contaminated with blood, excretion, exudates, or secretions from:
  + Humans who are isolated to protect others from highly virulent diseases.
  + Isolated animals known or suspected to be infected with highly virulent diseases.
* *Used sharps.* Sharps that have been in contact with infectious agents or that have been used in animal or human patient care or treatment, at medical, research, or industrial laboratories, including hypodermic needles, syringes (with or without the attached needle), Pasteur pipettes, scalpel blades, blood vials, needles with attached tubing, culture dishes, suture needles, slides, cover slips, and other broken or unbroken glass or plasticware.

### 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 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.

### 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.

### 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 that present no additional hazards may be discarded by pouring down the drain.

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 BSL-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.

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

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**](http://www.research.psu.edu/arp/) (ARP).

#### Steam Sterilization

Most infectious wastes are autoclaved 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 *Geobacillus stearothermophilus*. The frequency of monitoring depends on the hazards of the organisms 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.

#### 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 PI and approval by EHS.

Section 9.5.1 and Table 9.1 summarize information on practical disinfectants. Commercially available chlorine bleach is 5.25% 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.

#### 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.

# Research Involving Animals

Federal regulations require that the IACUC review and approve, prior to the initiation of work, the use of animals in research. 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.

## Chemical Hazards

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.

Anaesthetic agents used in laboratory animals may also pose hazards to researchers. These agents should be treated as hazardous chemicals.

## Biological Hazards

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 IACUC and the ARP. In general, the practices for Animal Biosafety Levels presented in BMBL 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 both IBC and IACUC.

## Physical Hazards

Research involving animals may present numerous physical hazards including

* Bites
* Scratches
* Kicks
* Crushing or pinning injuries (large animals)
* Protocol-associated hazards

Researchers should be properly trained in animal handling, general restraint techniques, and environmental factors for the species they will work with. In addition, researchers should be familiar with first aid procedures specific to each species and the incident reporting process.

## Allergens

Allergic reactions to animals are among the most common conditions that adversely affect the health of workers involved in the case 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

## 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, viral, 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)

# Radiation Protection

While radiation safety is covered under the purview of the LRSP, more extensive requirements for working with radioactive material can be found in [**SY14**](https://policy.psu.edu/policies/sy14) and the [**Rules and Procedures for the Use of Radioactive Material**](https://ehs.psu.edu/radioactive-materials/radioactive-materials-requirements-guidelines). This Safety Policy and the Rules and Procedures require all users of radioactive material to obtain prior authorization from the UIC before acquiring any radioactive material. Contact EHS for details on how to apply for this authorization. The possession, use, and disposal of these materials are strictly regulated by federal and state regulations.

## Radioactive Materials

The [**Rules and Procedures for the Use of Radioactive Material**](https://ehs.psu.edu/radioactive-materials/radioactive-materials-requirements-guidelines) covers the possession, use, and transfer of all licensed radioactive material on University-controlled property by University personnel or others and by University personnel at other locations. Users of radioactive material must be familiar with the contents of this document; the information contained in that document is not duplicated here.

## Lasers

The requirements for working with Lasers can be found in [**SY17**](https://policy.psu.edu/policies/sy17). 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.

## Non-ionizing Radiation

This program applies to all users of devices and equipment designed to generate radiofrequency (RF), microwave, or magnetic fields (static or time varying). Examples include radio transmitters, microwave sources for research, MRI (magnetic resonance imagining), SQUID (superconducting quantum interface device), particle accelerators, computer drive erasers, etc. Further information, available on the [**EHS webpage**](https://ehs.psu.edu/non-ionizing-radiation/overview), will assist users in ensuring safety and regulatory compliance for non-ionizing radiation sources.

## Radiation Producing Equipment

The purpose of this [**program**](https://ehs.psu.edu/radiation-producing-equipment/overview) is to ensure that Penn State employees and students work safely with machines that produce ionizing radiation and comply with all Federal and Commonwealth regulations and Penn State polices.

Radiation producing equipment (RPE) consists of the following types of equipment and examples:

* X-ray diffraction (XRD), x-ray flourescence (XRF), x-ray photo spectroscopy (XPS), and other application with x-ray tubes
* Radiographic such as x-ray imaging for human or non-human use
* Electron microscopes (SEM and TEM) and electron beam equipment such as probes, welders, or other applications with e-beam sources
* Accelerators such as LINACs, ion implanters, cyclotrons, or other electron or ion accelerators

## Special Precautions against Ultraviolet Light

Germicidal lamps using UV light are common fixtures in BSCs, where they serve to destroy microbes. These lamps are considered a high-level source of UV radiation. Other common lab equipment such as UV light transilluminators or UV light wands can also be significant sources of UV radiation exposure.

Exposure to the UV lamps without adequate PPE 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 4-6 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. If exposure to the face is unavoidable, a face shield shall be worn. 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.

Face shields made of polypropylene are generally sufficient for short term exposure to UV, but products with increased protection factors do exist.

## X-rays

The requirements for working with radiation producing equipment (x-rays) can be found in [**SY15**](https://policy.psu.edu/policies/sy15). This Penn State Safety Policy has specific registration, general training, and device specific training.

# REFERENCES

Numerous laws and regulations govern materials used in research and the responsibilities of employers and employees. A list of the major regulatory acts follows.

## Federal Laws

* 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
* NIH Guidelines for Research Involving Recombinant DNA Molecules.
* Resource Conservation and Recovery Act of 1976. Governs hazardous waste disposal.
* Regulations of the U.S. Department of Transportation.
* Regulations of the U.S. Department of Agriculture.

**OSHA**

Occupational Health and Safety Administration 29 CFR 1910

* 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.

1910.95 Occupational Noise Exposure Standard

1910.132 General PPE Requirements

1910.133 Eye and Face Protection Standard

1910.133 Respiratory Protection Standard

1910.135 Head Protection Standard

1910.136 Foot Protection Standard

1910.138 Hand Protection Standard

1910.147 Control of Hazardous Energy Standard

1910.151 Medical and First Aid Standard

1910.1000 Air contaminants Standard

1910.1030 Bloodborne Pathogens Standard - Governs workplace exposure to human blood, blood products, and other potentially infectious material in any occupational setting.

1910.1047 Ethylene Oxide Standard

1910.1048 Formaldehyde Standard

1910.1200 Hazard Communication Standard - Governs chemical safety in the workplace

1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories Standard

1910 Subpart O Machinery and Machine Guarding

## Penn State Policies and Programs

SY01 – Environmental Health and Safety

SY08 – Storage, Dispensing and Use of Flammable Liquids on Pennsylvania State University Property

SY11 – Refrigerators – Explosion Proof

SY14 – Use of Radioactive Materials

SY15 – Radiation-Producing Materials

SY17 – Lasers

SY20 – Hazardous Waste Disposal

SY24 – Use of Regulated and Biohazardous Materials in Research and Instruction

SY25 – Compressed Gas Cylinders

SY29 – Infectious Waste Disposal

SY40 – Disposal of Pollutants in University Sanitary Systems

SY43 – Laboratory and Research Safety Plan

Respiratory Protection Program

Hearing Program

Energized Electrical Safety Program

Pesticide Management Program

# REVISION SUMMARY TABLE

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Version No.** | **Doc. No.** | **Revision Summary** | **Issued Date** | **Revision Originator** |
| 1 |  | Plan developed | 2009 |  |
| 2 |  | Revised Plan to include updated *Biosafety in Microbiological and Biomedical Laboratories* 2009 information | Sep 2012 |  |
| 3 |  | Revised Plan to included Machine shop information | Jan 2013 |  |
| 4 |  | Added information regarding LRSP policy | Apr 2013 |  |
| 5 |  | NIOSH Carcinogen table updated  Added information on Global Harmonization System | Jul 2013 |  |
| 6 |  | Updated ANSI shower flow requirements | Oct 2013 |  |
| 7 |  | Added link to Fisher Scientific chemical storage guidance | Jun 2014 |  |
| 8 | EHS-0004 | Significant revisions to content to align EHS programs and practices. Major formatting changes. | 1/17/2019 | ASH |

# 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.*

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**CHEMICAL SPILLS YOU CAN HANDLE YOURSELF**

PIs, 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:

1. the need to evacuate employees in the area
2. the need for response from outside the immediate release area
3. the release poses, or has potential to pose, conditions that are immediately dangerous to life and health
4. the release poses a serious threat of fire and explosion
5. the release requires immediate attention due to imminent danger
6. the release may cause high levels of exposure to toxic substances
7. there is uncertainty that the worker can handle the severity of the hazard with the PPE and equipment that has been provided and the exposure limit could be exceeded easily
8. 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**

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**ALL SPILLS THAT REQUIRE OUTSIDE INTERVENTION**

**Emergency Response Procedures.** Call 911 to report fires, explosions, medical emergencies, and hazardous material spills. Police dispatch will contact EHS and appropriate emergency response personnel at any time 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, PPE (to the level of training of the workers), and safety instructions.

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**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:

1. evacuate the zone
2. activate the fire alarm, if needed
3. call Police Services and report the incident
4. 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.

**B. 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**](https://ehs.psu.edu/accident-reporting-and-investigation)

**C. Signs.** The following signs and labels are required for **all** laboratories in Penn State facilities:

1. A [**Laboratory Information Door sign**](https://ehs.psu.edu/laboratory-safety/forms) 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.
2. A [**Laboratory Emergency Contact Information**](https://ehs.psu.edu/laboratory-safety/forms) 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.
3. 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**](https://policy.psu.edu/policies/sy08) (SY08) and [**Hazardous Waste Disposal**](https://policy.psu.edu/policies/sy20) (SY20). *Based on 29 CFR 1910.1450, Occupational exposure to hazardous chemicals in laboratories.*

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**EXPOSURE**

This section describes responses 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** 800-222-1222

**In all cases, seek immediate medical assistance.**

**Inhalation:** Get to a source of fresh air.

**Ingestion:** 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:** Seek immediate medical assistance.

**Dermal Contact:** 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 calcium gluconate as soon as possible.

**Eye Contact:** 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).

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**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 spill. 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.

Select and wear the appropriate PPE 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.

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.

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**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.
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 lunchrooms 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, applying of cosmetics, or handling contact lenses are prohibited in the work area.
9. Food storage is prohibited in the work area. Food is stored in cabinets or refrigerators designated for such use only.
10. 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 and formulas 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, including chemical waste, 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 secondary containment 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. All employees and students working with or supervising those working with chemicals or chemical waste must receive training within 90 days of hire and annually thereafter.
2. A satellite accumulation area (SAA) must be designated near the point of waste generation and posted with a Satellite Accumulation Area sign.
3. An individual working in the area must be assigned the responsibility for oversight of the accumulation area.
4. Weekly, the SAA must be checked for the following:

* Chemicals are not leaking.
* Chemicals are labeled with green tags provided by EHS. Information on the tag includes generator name; container start date; 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 gallons.
* Waste is not kept in the SAA for longer than 11 months.

1. Three years of weekly SAA inspection sheets must be kept in the Laboratory and Research Safety binder.
2. Wastes are collected in compatible containers which are sealed. Food containers are not appropriate.
3. Sharps (razors, needles, thin pipettes) are collected in puncture-resistant, leakproof containers.
4. Waste pump oil is collected for disposal as hazardous waste.
5. 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 gallon 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:
7. closed doors
8. restricted access – only authorized personnel permitted
9. written access procedures posted on the outer door.
10. Dry sweeping and mopping are prohibited if powdered carcinogens or mutagens (e.g., acrylamide and ethidium bromide) are used.
11. Waste containers for carcinogens are labeled as follows: “Cancer Hazard,” compound name, concentration, and amount.
12. 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 II**B** found in the [Unit Specific Plan](https://ehs.psu.edu/laboratory-safety/forms).

2-Acetylaminofluorene

Acrylonitrile

alpha-Naphthylamine

4-Aminodiphenyl

Asbestos

Benzene

Benzidine

beta-Naphthylamine

beta-Propiolactone

bis-Chloromethyl ether

1,3-Butadiene

Cadmium

1,2-dibromo-3-chloropropane

3,3’-Dichlorobenzidine (and its salts)

4-Dimethylaminoazobenzene

Ethyleneimine

Ethylene oxide

Formaldehyde

Inorganic arsenic

Lead

Methyl chloromethyl ether

Methylene chloride

Methylenedianiline

N-Nitrosodimethylamine

Vinyl chloride

**F. Explanation of Medical Surveillance Provisions.** If exposure to an OSHA-specified carcinogen is measured to be above the action level or the 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

University Safety Policy [**Compressed Gas Cylinders**](https://policy.psu.edu/policies/sy25) (SY25). *Based on 29 CFR 1910.1450, Occupational exposure to hazardous chemicals in laboratories, by reference to Prudent Practices in the Laboratory, National Research Council.*

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**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:

1. pressure hazards causing equipment failure and leakage
2. rapid diffusion, causing dangerous toxic or anesthetic effects, asphyxiation, and rapid formation of explosive concentrations
3. low boiling-point materials, cryogenic materials, or liquefied gases causing frostbite
4. the same hazards as those associated with solid or liquid chemicals, including corrosion, irritation, flammability, and high reactivity.

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**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".
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 General Stores or 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.*

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**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, and 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).

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**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):

1. Air-reactive chemicals (e.g., palladium or platinum on carbon, platinum oxide, Raney nickel)
2. Cryogenic materials/liquefied gas, supercritical fluids (e.g., oxygen, nitrogen, helium)
3. Explosive dusts (e.g., magnesium powder, zinc dust, carbon powder, flowers of sulfur)
4. Explosives, other (e.g., diazomethane, hydrogen peroxide, hydrogen, chlorine, polymerizing acrolein, trinitrotoluene)
5. Highly water-reactive chemicals (e.g., aluminum bromide, metal hydrides, phosphorus pentachloride, tin tetrachloride, titanium tetrachloride)
6. Metal hydrides (e.g., lithium aluminum hydride, sodium borohydride)
7. Organic peroxides (e.g., acetyl peroxide, benzoyl peroxide)
8. Organometallic chemicals and active metals (e.g., trimethyl gallium, sodium, magnesium, lithium, potassium)
9. Oxidizing agents (e.g., halogens, oxyhalogens, peroxyhalogens, permanganates, nitrates, chromates, persulfates, peroxides)
10. Perchloric acid and perchlorates (e.g., sodium perchlorate)
11. Peroxide-forming chemicals (e.g., acrylonitrile, dioxane, ether, tetrahydrofuran)
12. Polymerization reactions (e.g., acrylate monomers)
13. Polynitro organic chemicals (e.g., picric acid, dinitrophenylhydrazine, methyl nitronitrosoguanidine)
14. Pyrophoric chemicals (e.g., boranes, white phosphorus, alkyl metals such as n-butyllithium and dibutyl magnesium)
15. 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.

**Explosive dusts**

1. Suspensions of oxidizeable 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 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 grams, 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.

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**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.

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**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 shrapnel released during an implosion. Other hazards may include:

1. the toxicity of the chemicals in the vacuum system
2. fire following breakage of a flask containing flammable solvents
3. toxicity from the mercury in manometers and gauges
4. over- or under-pressurization arising with thermal conductivity gauges
5. 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 is 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 as chemical waste.
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**](https://policy.psu.edu/policies/rp11) (RP11). *Based on 29 CFR 1910.1030, Bloodborne pathogens.*

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**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 (BSL2) 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. HBV, *Salmonella*, and *Toxoplasma* spp. are representative of microorganisms assigned to this containment level.

**B. Applicability of Biosafety Level 2.** The BSL2 requirements apply to research work:

1. studying known infectious agents classified as requiring BSL2 precautions by the CDC/NIH in [Biosafety in Microbiological and Biomedical Laboratories (BMBL)](http://www.cdc.gov/biosafety/publications/bmbl5/BMBL.pdf), and
2. involving the handling of vertebrate animals experimentally or naturally infected with agents classified as requiring BSL2 controls byBMBL.

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, BSL2 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:

1. Human blood, blood components, and blood products
2. Semen
3. Vaginal secretions
4. Cerebrospinal fluid
5. Synovial fluid
6. Pleural fluid
7. Peritoneal fluid
8. Amniotic fluid
9. Saliva in dental procedures
10. Any body fluid visibly contaminated with blood
11. All body fluids in situations where it is difficult or impossible to differentiate between body fluids
12. Any unfixed tissue or organs from a human (living or dead)
13. HIV-containing cell or tissue cultures, organ cultures, and HIV- or HBV-containing culture medium or other solutions
14. Blood, organs, or other tissues from experimental animals infected with HIV or HBV
15. Human albumin
16. 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 HBV, HIV, 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 Unit Specific 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 PI would need to document that the package was protected from environmental contamination during transport and arrived at the lab undamaged.

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**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:

1. the volume of material spilled
2. the potential concentration of organisms in the material spilled
3. the hazard of the organisms involved
4. the route of infection of the organisms
5. 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 PI 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 PPE (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.

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**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, PI’s name and phone number, and special entry requirements.
5. Animals and plants 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 procedures are 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 rotar 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:

1. repeated insertion and withdrawal of worker's arms
2. opening and closing lab doors or isolation cubicle
3. improper placement or operation of equipment or materials in the cabinet
4. brisk walking past the cabinet during use.

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**ADDITIONAL PRACTICES SPECIFIC TO THE USE OF HUMAN BLOOD, BLOOD PRODUCTS, OR OTHER POTENTIALLY INFECTIOUS MATERIALS**

**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 and Research Safety 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:

1. be included in the group’s exposure determination
2. practice universal precautions
3. have the opportunity to receive HBV vaccination
4. sign a waiver or consent form for vaccination
5. be offered postexposure evaluation and follow-up
6. 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 PPE, 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.

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**RECOMBINANT DNA SAFETY PROGRAM**

Research involving recombinant DNA shall comply with the NIH'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:

1. molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell
2. 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.