ARIZONA STATE UNIVERSITY

Environmental Health & Safety

Chemical Hygiene Plan
(CHP)

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2015 Updates

Page 9 – Add reference to the National Institute of Occupational Safety and Health's Recommended Exposure Limits (RELs) and the American Conference of Governmental Industrial Hygienists (ACGHIH) Threshold Limit Values (TLVs).

Page10 – Add language related to lab security under PI Responsibilities requiring doors to be locked when the lab is not occupied.

Page 20 – Clarify the follow up inspection process as it relates to closing inspection findings open longer than 60 days. .Identify that any immediate safety concerns will be addressed during the inspection

Page 22 - Add guidance related to decontamination of laboratory equipment and reference ANSI Standard.

Page 27 – Added guidance for Select Agent Toxins.

Page 33 - Add reference for lab hood risk assessment form related to determining exemptions for low flow alarms on laboratory hoods available from EH&S.

Page 33 – Added guidance for use of Walk in Hoods and for hoods with on/off switches.

Pages 34 and 35: Emergency Eyewashes and Safety Showers - Add additional guidance for options related to testing and maintaining devices. Identifies tags/labels to be placed on quick drench hoses indicating they are for supplemental use only.

Page 36 - Add language introducing the Lab Safety Manual resource.

Page 37 – Updated labeling guidance changing concentration to a recommendation and combining the first two lines of the label.

Page 40 – Updated chemical transportation guidance related to golf carts. Add more detailed language on transportation of LN2 Dewars in elevators and reference new Appendix L on safe handling of cryogenic materials.

Appendix K – Added information related to vacuum systems in general.

Appendix L – added new appendix on safe handling of cryogenic materials.

Various – Updated language related to PPE Hazard Assessments throughout the document to ensure consistency.

Frequently Asked Questions

Why does ASU need a Chemical Hygiene Plan (CHP) and a Laboratory Safety Program?

Many government regulations require a lab safety program and OSHA requires a CHP for ensuring that work in the laboratory is conducted safely - 29 CFR 1910.1450(e). OSHA requires that we identify hazards considered both physical and health related, and identify how we use hazardous materials safely. We must also identify how we approve new uses of hazardous materials in our laboratories and develop detailed procedures for how we handle what OSHA considers particularly hazardous substances.

What training is required?

At ASU, all employees and volunteers working in laboratories must attend, at a minimum, Laboratory Safety Training and an annual refresher. Please remember that all ASU employees must attend Fire Prevention and Safety training – EHS 108 Environmental Health and Safety Training. Any employee or volunteer who physically places waste into hazardous waste containers must participate in Hazardous Waste Management training. Those who also work with specific classes of hazards must also participate in training programs as described below:

- **Biohazards** - Biosafety training
- **Radiation hazards** – Radiation Safety
- **Class 3B** and **4 Lasers** – Laser Safety
- **Shop tools** such as lathes, drill presses and saws – Machine Shop Safety

Many labs also have their own lab safety training plan. For any SOPs your lab has developed for particularly hazardous substances please check with your lab manager and/or Principal Investigators (PI) and be sure to complete that training.

What PPE is required?

Most labs will have specific rules for use of personal protective equipment (PPE). At a minimum, appropriate attire includes closed toed shoes, long sleeved shirt and long pants. Safety glasses or goggles will also be required in specific areas or for specific operations. In addition, a lab coat and other PPE may be required for specific hazardous materials and will be identified in your lab safety training plan or SOPs for particularly hazardous materials. Please see Personal Protective Equipment (PPE) for more information.

How and why do I register my laboratory?

Laboratories must be registered in order for EH&S to have emergency contact information and to obtain chemical inventories. It also allows EH&S an opportunity to complete start up and periodic inspections to evaluate potential hazards and make recommendations to the lab to address those potential hazards. Please see the EH&S Laboratory Registration web page for more information about the registration process. Please note that Principal Investigators shall provide a current lab registration number on grant applications.

What are labeling requirements?

Ensure that the manufacturer's original container label remains intact – 29 CFR 1910.1201. If the manufacturer's label becomes illegible or is removed, the container must be labeled with the chemical name and the primary hazards identified.

If you transfer a hazardous material (chemical) from an original manufacturer's container into a secondary container, the secondary container must be labeled. Containers that are very small may be labeled with the name or an abbreviation as long as a list of the abbreviations with the chemical name is posted nearby.

Small containers used for samples with potentially hazardous materials need only be labeled with the sample number or other designation provided a key identifying the sample contents (i.e. water samples in 0.1 N sulfuric acid) can be easily located by potential emergency responders.

Hazardous waste containers have specific labeling requirements and only those employees who have completed ASU EH&S Hazardous Waste Management training are to place waste into hazardous waste containers.

In general, the original manufacturer's label is to be left intact and used whenever possible. When chemicals are transferred into secondary containers, those containers must also be labeled.

What documents must I keep?

You should keep records of any lab specific training, copies of Safety Data Sheets (SDSs, formerly referred to as MSDSs), Standard Operating Procedures (SOPs), and any PPE hazard assessments conducted by your lab.

What are "particularly hazardous substances" (PHS)?

This is a term government regulators use for substances that are considered to have a high degree of acute toxicity and are highly toxic or toxic (as defined under the OSHA Hazard Communication Standard) and may be fatal or cause damage to target organs as a result of a single exposure or exposures of short duration. Use of a PHS requires standard operating procedures (SOPs) – 29 CFR 1910.1450(e)(3)(viii). SOP templates for the most commonly used PHSs at ASU are available on the EH&S website. See Appendix C for more information and a list of these substances.

What if I need to use a new chemical?

Government regulations require that ASU specify when a new process or chemical use in the laboratory requires prior approval. Prior approval is recommended for all new processes and new chemical use; however, it is required for a PHS and chemicals that are highly reactive. To meet that requirement please use see **page 16** of the CHP for more information.

INTRODUCTION AND PURPOSE

Arizona State University continually strives to provide a learning, teaching, and research environment free from recognized hazards. The Occupational Safety and Health Administration (OSHA), 29 CFR 1910.1450 and 29 CFR 1910.132, requires the University to establish this Chemical Hygiene Plan (CHP) to protect employees and students from potential health hazards associated with handling, use, and storage of hazardous chemicals in laboratories and to certify, in writing, PPE requirements, respectively. This CHP includes methods designed to protect employees from the health hazards presented by hazardous chemicals and other materials used in laboratories.

SCOPE AND APPLICATION

The purpose of this Chemical Hygiene Plan at Arizona State University is to provide chemical users basic safety information regarding the use of chemicals. It also meets the requirements of EHS 104: Laboratory Use of Hazardous Chemicals**.** This Chemical Hygiene Plan forms the foundation for the safe use of chemicals in the laboratory. The safe storage, use and disposal of chemicals in the laboratory require policies for the protection of students, employees, and the environment. This plan applies to employees in areas where laboratory use of hazardous materials occurs. ASU has academic, research, and clinical laboratories using hazardous chemicals and other materials. Resources and personnel have been dedicated to provide an effective program to prevent, reduce, and control hazards in the work area.

The CHP applies to employees engaged in the laboratory use of hazardous chemicals. The ASU Hazard Communication "Employee Right-To-Know" Program addresses university employees engaged in non-laboratory use of hazardous chemicals, e.g., facilities maintenance and vehicle repair. In addition, the ASU Exposure Control Plan for Blood borne Pathogens is designed to protect the health of employees determined to have potential exposure to human blood and other potentially infectious materials as mandated by OSHA. Copies of these programs are available through the Department of Environmental Health & Safety website.

Permissible Exposure Limits

The ASU Chemical Hygiene Plan strives to ensure that laboratory use of OSHA regulated substances do not exceed the permissible exposure limits (PEL) specified in 29 CFR § 1910, Subpart Z. PEL refers to the eight-hour time-weighted average for airborne concentrations of hazardous chemicals. An action level is a concentration below the PEL for a specific regulated substance that requires certain actions to prevent exposures above the PEL (see definitions). If employee exposure to the OSHA regulated substances exceeds the action level (or the PEL in the absence of an action

level), then the employer must comply with the substance-specific health standards specified in 29 CFR 1910, subpart Z.

In addition, ASU's EH&S staff will review and apply consensus standards and recommendations related to evaluating and controlling potential exposures to hazardous materials. Resources such as the National Institute of Occupational Safety and Health's Recommended Exposure Limits (RELs) and the American Conference of Governmental Industrial Hygienists (ACGHIH) Threshold Limit Values (TLVs) will be applied as applicable.

RESPONSIBILITIES

Deans, Directors, and Chairs

- Deans, Directors, and Chairs are responsible for establishing and implementing department information and training programs for their respective areas, as outlined in the Employee Information and Training section of this plan. Delegation of this responsibility to the Principle Investigator (PI), Laboratory Manager, graduate and post-doctoral students, Compliance Officer and/or safety committee is acceptable.
- Deans, Directors and Chairs are also responsible for assuring that laboratories are properly registered according to EH&S policy. Additionally, Deans, Directors and Chairs must assure that deficiencies found during inspections are addressed within the required 30 day turnaround time. Delegation of this responsibility to the Principle Investigator (PI), Laboratory Manager, graduate or post-doctoral student, Compliance Officer and/or safety committee is acceptable.
- Deans, Directors and Chairs are also responsible for assuring that each Principal Investigator who sets-up, moves, remodels or vacates a laboratory contacted EH&S to ensure the proper transportation and disposition of hazardous materials. Delegation of this responsibility to the Principle Investigator (PI), Laboratory Manager, graduate and post-doctoral students, Compliance Officer, and/or safety committee is acceptable.

Chemical Hygiene Officer (CHO)

- As mandated by the standard, the Chemical Hygiene Officer (CHO) is appointed by the university. The CHO provides technical guidance in the development and implementation of the provisions of the CHP.
- The CHO will serve as a liaison between the university and regulatory agencies relative to Laboratory Standard compliance issues. The CHO for ASU is the EH&S Associate Director for Occupational Health & Safety. The CHO can be contacted at EHS@asu.edu or (480) 965-1823.

Environmental Health & Safety (EH&S)

- EH&S is responsible for ensuring regulatory compliance with the OSHA Laboratory Standard for ASU. EH&S will serve as the custodian of documents required by the standard, e.g., the ASU CHP, a copy of Title 29 Code of Federal Regulations, the OSHA Permissible Exposure Limit (PEL) listing, and the ACGIHTLV listing.
- EH&S will maintain a reference library and provide training equipment, supplies and materials.

Principal Investigator

- Ensures compliance to this plan including: laboratory registration or re-registration, chemical inventory, employee training plan, personal protective equipment hazard assessments, hazardous waste, lab operating procedures, lab specific Standard Operating Procedures (SOP), lab specific training on SOPs and lab operations, compliance to EH&S requirements including federal and state requirements, responsible for corrective action for findings noted after lab inspections including chemical, bio-safety, fire safety and radiation safety reviews. Ensure contractors and vendors comply with said requirements while working in lab areas. Responsible to ensure all assigned laboratories and hazardous materials within are kept secure by ensuring assigned staff lock doors while the laboratory is unattended.

Compliance Officers

- Arizona State University's Environmental Health & Safety Management Policy (EH&S MP) calls for the University to be a model of quality in environmental health and safety. Critical links in the development of this level of quality are the college or department Compliance Officers (COs). COs undergo special

training and develop a unique relationship with Environmental Health & Safety.

- Compliance Officers serve as the major source of coordination for those activities which support the EH&S Management Policy and the activities of the Policy and Operations Committees. The CO has authority delegated from the Provost, Dean, Chair, or Director for managing environmental health and safety activities in the Campus/Institute or Department, including the authority to establish processes, investigate complaints and/or incidents and audit the performance of ASU employees performing their duties. The CO has the responsibility to report questionable activities and unresolved compliance issues to the delegating authority as well as to the Director of EH&S. For the current list of COs to go http://cfo.asu.edu/ehs-compliance-officer-program

Safety Committee

- The EH&S Operations Committee provides oversight for all EH&S programs at ASU. See EHS 005: Management Policy for more information on the set up and function of the EH&S Operations Committee.
- Where individual departments establish safety committees, the primary function should be to provide peer review of all internal safety audits, training reviews, accident investigations, and other safety related actions as deemed necessary by the department and in accordance with regulatory and EH&S mandates. Each department's safety committee should consist of faculty and/or other department representatives, as appointed by the Dean, Director, or Chair.
- Department Compliance Officers should serve on any safety committee established within that department. Department safety committees may implement laboratory safety practices specific to their department but must, at a minimum, meet the requirements of this CHP and all applicable EH&S policies. Established safety committees should consult the CHO on any matter involving interpretation and application of EH&S policies to laboratories.
- It is the responsibility of each Principal Investigator to understand the provisions of this plan and ensure that employees are aware of dangers involved in the handling and use of hazardous chemicals or materials. The Principal Investigator is required to notify EH&S if there is reason to believe

that an employee's exposure level to a hazardous chemical routinely exceeds the action level (or in the absence of an action level, the permissible exposure limit).

- Principal Investigators must ensure that Material Safety Data Sheets (MSDS) are available for every chemical in the workplace. Employee training in the use and comprehension of the MSDS must be provided. Principal Investigators using outside vendors or contractors are responsible for obtaining MSDSs from them and forwarding copies to the designated safety coordinator. They are also responsible for informing any visitor, contractor or vendor of the hazards of the chemicals used in the area they are working in or visiting.

Employees

- Employees are any paid personnel, including graduate students on stipends. Employees are responsible for understanding the hazards involved with the chemicals they use. They must be familiar with the location and contents of the MSDS file in their work area. They must consult their Lab Manager or PI if they are unsure of the safe handling, use, and/or storage of the hazardous chemicals. All applicable safety training must take place before the employee begins working in the laboratory or anywhere hazardous materials are in use.

Vendors, Contractors and Visitors

- Laboratory Principal Investigators are responsible for ensuring that vendors, contractors, and visitors understand the dangers involved in the area they are working in or visiting. The vendors, contractors, and visitors will have all necessary personal protective equipment provided for them by the laboratory or by contractors' management.

LABORATORY REGISTRATION

Laboratory registration is the process the university uses to maintain laboratory emergency contacts and information, develop and maintain laboratory chemical inventories, and establish laboratory safety inspections for ensuring compliance with the ASU Chemical Hygiene Plan.

The laboratory registration process requires the Principal Investigator of the laboratory or her/his designee (Laboratory Manager/supervisor, coordinator, manager, etc.) to complete and annually submit a current Chemical Inventory, and Responsible Party Information (RPI) sheet to EH&S. There are two options for completing the registration process. Registration can be completed online through the EHS Assistant web site OR both the Chemical Inventory and the RPI documents can be submitted as electronic documents through EHSRegistration@asu.edu email. The EHS Assistant web page provides instructions and tutorials regarding the registration process. EH&S will issue a laboratory registration placard for posting either on the door entering the laboratory or immediately adjacent to the door. By using the EHS Assistant process, a temporary door sign can be printed upon completion of the submitted registration.

When physical, personnel or process changes occur in the registered space, the PI is responsible to re-register the laboratory. Multiple signs may be requested where several entrances to a laboratory exist. The registration placard displays the laboratory emergency contact personnel, location of the MSDS, potential hazards located in the laboratory, and displays the “diamond shaped” National Fire Protection Association (NFPA) 704 hazard ratings.

Principal Investigator/Lab Managers must submit the RPI and chemical inventory to register the lab space. When the registration process is complete, a registration placard will be mailed to the laboratory responsible party or designee for posting at the laboratory’s entrance(s).

The registration issued date on the sign signifies the anniversary date to re-register the laboratory. EH&S will send reminder notices related to updating the laboratories registration annually; however, the annual update is the responsibility of the PI or their designee. The laboratory’s annual registration review and update provides each laboratory the opportunity to perform a self-evaluation of their laboratory safety using the laboratory safety inspection checklist. The checklist and other useful information are available at: http://cfo.asu.edu/ehs-labsafety.

Labs in transition between PIs that will continue to house a chemical inventory may be registered to a designated department staff member until a new PI has moved into the lab. This will allow the lab to have a current registration reflecting the chemical inventory and a current emergency contact in the event there are urgent questions about the lab or its contents.

A. General guidelines on registering traditional lab space:

Individual rooms should be registered if:

1. The room is entered from any public access or entrance area (corridor, hallway, etc.)

2. The room is accessed through an adjoining area or room *and* contains special hazards (BSL2, BSL3, OSHA regulated carcinogens, lasers, x-rays, radiation, noise hazards, dust hazards etc.)

3. If the room is part of a series of rooms (i.e. 123, 123A, 123B etc.), only the primary room needs to be registered as long as the other rooms do not contain special hazards or conditions.

***Example*:** Room LSZ 123 includes rooms LSZ 123A and LSZ 123B. Only LSZ 123 needs to be registered unless LSZ123A and LSZ 123B contain special hazards or conditions. If LSZ 123A or LSZ 123B contains special hazards or conditions, then that room will need to be registered separately and in addition to room LSZ 123.

B. General guidelines on registering open shared lab space:

An open shared lab is a large lab room shared by multiple research groups, an example are labs in Biodesign and ISTBI buildings.

1. Each Principal Investigator(s) or designee must complete a separate RPI for their group.
2. Principal Investigator(s) or designee can collaborate and submit a cumulative chemical inventory for the open lab (preferred method). Alternately, each researcher can submit their chemical inventory separately.

Sub rooms in the open shared lab space must be registered separately if they contain special hazards or conditions or if the room has its own entrance from a public access or entrance area (corridor, hallway, etc.) (See item A., above.)

Responsible Party Information Sheet

In order to obtain laboratory registration, the Principal Investigator or designee must submit a Responsible Party Information (RPI) sheet and current Chemical Inventory to EH&S annually **or as changes occur**. The RPI sheet identifies emergency contacts, locations of emergency equipment, and any hazards or special concerns specific to each laboratory. EH&S will maintain this information in a database and has developed a sign for posting outside each laboratory to be used by emergency response personnel.

A Responsible Party Information Sheet (RPI) is available at the EH&S website Forms section. The RPI sheet contains instructions for completing the sheet. EH&S is available to provide assistance if you have questions regarding completing the RPI.

The Principal Investigator or designee may submit both the RPI sheet and current Chemical Inventory to EH&S annually or as changes occur through the EHS Assistant web portal located on the EH&S website. Simply login using your ASURite ID (computer username) and password.

Chemical Inventory

At least annually, each Principal Investigator (PI) or designee will conduct and document a chemical inventory and submit the inventory to EH&S. Identification of all chemicals, including non-hazardous items in the laboratory is required.

The chemical inventory must include a complete account of the chemicals used or stored in the work area or laboratory, *including compressed gases, paints, oils, insecticides, herbicides, fertilizers, aquarium products, cleaning products, etc.*

The inventory requires notation of the following items:

- An alphabetized list of the complete International Union of Pure and Applied Chemistry (IUPAC) names or acceptable trade chemical names for each chemical (abbreviations are not acceptable)
- Chemical Abstracts Service (CAS) number
- Quantity stored
- Location of chemical use or storage (room number)
- National Fire Protection Association (NFPA) Hazard Ratings (found on the MSDS sheets)

A chemical inventory template is located at the EH&S website. The Principal Investigator or designee may submit their current Chemical Inventory to EH&S through the EHS Assistant web portal located on the EH&S website. To submit via the web, log on to the EHSA Portal at https://cfo.asu.edu/ehs-assistant using your ASURite ID (computer username) and password. Instructions for completing the registration are available at the following location: http://www.asu.edu/ehs/documents/responsible-party.pdf.

Maximum Allowable Quantities of Hazardous Materials

The storage, use, and handling of all hazardous materials shall be in accordance with the maximum allowable quantities per control area as defined by Table 2703.1.1(1) of the International Fire Code, 2003 revision. A condensed version of the table is provided in Appendix I.

A control area is defined as a space within a building which is enclosed and bounded by exterior walls, fire walls, fire barriers and roofs, or a combination thereof, where quantities of hazardous materials not exceeding the maximum allowable quantities per control area are stored, dispensed, used, or handled.

The maximum number of control areas and additional quantity restrictions per building level is defined by Table 2703.8.3.2 of the International Fire Code, 2003 revision. A simplified version of this table is provided in Appendix I.

EH&S Lab Registration Follow-up Process

1. Initial requests for Responsible Party Information Sheet (RPI) and a Chemical Inventory complete with NFPA hazard ratings is sent to the Principal Investigator or designee. EH&S will provide links to or attachments of forms necessary for proper registration.

2. If no response is received within 30 days of original request, a second request will be sent via email. If the laboratory conducts research, the Director of Research Integrity & Assurance at ASU's Office for Research and Sponsored Projects Administration (ORSPA) will be included on the email as well as any applicable safety committee, senior compliance officer, or department designee.

3. If no response is received after 30 days (total of 60 days after original request) the information and request is forwarded to the Dean, Director, or Chair of the department and an immediate inspection of the laboratory will be scheduled.

CHEMICAL HYGIENE PLAN REQUIREMENTS

Provisions of the ASU CHP are outlined in the following sections. Individual department or colleges may develop their own version of a CHP provided it meets the requirements of the ASU CHP at a minimum. Additionally, individual laboratories are encouraged to develop Laboratory Specific CHPs utilizing the guidelines provided in Appendix D of the ASU CHP.

Access to the ASU written CHP and the entire OSHA standard requiring the CHP (29 CFR 1910.1450) is available for all employees through the EH&S website. Copies of the CHP can be obtained by contacting EH&S or by downloading the document from the EH&S web site.

A copy of the CHP should be available in the work area. A copy of the OSHA standard is available at the OSHA website 29 CFR 1910.1450.

Standard Operating Procedures (SOP)

Standard operating procedures (SOPs) that are relevant to safety and health considerations must be developed and followed when laboratory work involves the use of hazardous chemicals (examples listed in Appendix C), especially for "particularly hazardous substances" (PHSs). SOPs are written instructions that detail the steps that will be performed during a given experimental procedure and include information about potential hazards and how these hazards will be mitigated. SOPs should be written by laboratory personnel who are most knowledgeable and involved with the experimental process. The development and implementation of SOPs is a core component of promoting a strong safety culture in the laboratory and helps ensure a safe work environment.

While general guidance regarding laboratory work with chemicals is contained in this plan, Principal Investigators/Laboratory Supervisors are required to develop and implement laboratory-specific SOPs for certain hazardous chemicals and PHSs that are used in their laboratories. The Principal Investigator and all personnel responsible for performing the procedures detailed in the SOP shall sign the SOP acknowledging the contents, requirements and responsibilities outlined in the SOP. The SOPs shall be reviewed by qualified personnel and shall be amended and subject to additional review and approval by the Principal Investigator where changes or variations in conditions, methodologies, equipment, or use of the chemical occurs. For certain hazardous chemicals, PHSs, or specialized practices, consideration must be given to whether additional consultation with safety professionals is warranted or required.

Laboratories that have specific hazards such as pyrophorics, flammable solids, toxic gases, toxins, select carcinogens (see definition in Appendix A), teratogens or mutagens must work with these substances in a designated area such as a fume hood, glove box, or a portion of the laboratory designated for use of chronically toxic substances.

Each particularly hazardous substance as identified in Appendix C shall have a written Standard Operating Procedure including any designated area clearly marked with warning and restricted access signs;

- Working location - procedures that may result in a generation of aerosols or vapors shall be performed in a properly working fume or bio safety hood;
- PPE- skin contact shall be avoided by using gloves and other protective apparel as appropriate; inspect equipment prior to use; any protective clothing shall be removed before leaving the designated area and placed in a labeled container; practice good personal hygiene after working with these materials; wash exposed parts of you upper body; and
- Storage - Select carcinogens shall be stored in unbreakable containers in a ventilated area with controlled access.

All containers shall be labeled with the identity and hazard of the substance. Immediately upon completion of the project, all unused carcinogens should be disposed of following standard hazardous waste disposal procedures or transferred to another user along with SOP for use. Examples of select carcinogens are benzene, nickel metal dust, vinyl chloride, and formaldehyde. Examples of reproductive toxins are organomercurial compounds and ethidium bromide, carbon disulfide, xylene, toluene, benzene, mercury, lead compounds, ethyl ethers, vinyl chloride.

Example of a lab-specific standard operating procedure is included in Appendix E.

Inspections and Compliance

EH&S will conduct laboratory inspections determining individual laboratory compliance with the CHP as identified in Appendix B. Provisions for additional employee protection for work with particularly hazardous substances including "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity will be addressed during this process. Inspections may be performed in conjunction with the department's periodic audit conducted by a Compliance Officer and/or safety committee members. Any immediate safety concerns will be addressed during the inspection.

Inspection reports will document inconsistencies with the CHP and opportunities for improvement.

A report identifying deficiencies and areas for improvement will be directed to the laboratory's Principal Investigator, and any applicable safety committee, senior compliance officer, or department designee. These items must be corrected within 30 days of receipt of the laboratory inspection report. If the items cannot be corrected in that timeframe, the Principal Investigator must submit a written corrective action plan detailing the expected corrections and estimated date of completion within the same 30 days. The Principal Investigator may designate a responsible party to submit the report. Any inspection finding AN eminent danger (likely to cause a serious hazard, injury, disability, or death) must be corrected immediately.

Annual laboratory self-inspections performed by Principal Investigators and/or research staff are required as part of the annual registration process. EH&S has provided a laboratory self-inspection checklist in Appendix J. A checklist is made available to the PI or their designee through EH&S communications during the laboratory registration process. The completed checklist is intended to be returned to EH&S in order to complete the registration process.

Note: Identical deficiencies noted on subsequent inspections of the same area will be reported to the Chemical Hygiene Officer for review and possible follow-up with the Dean, Director or Chair of the department.

Lab Inspection Follow-up Process

1. EH&S performs a follow up laboratory safety inspection and issue a report. The inspection report will advise the Principal Investigator to provide a written corrective action plan or proof of corrected findings within 30 days.
2. EH&S and/or an EH&S Compliance Officer conducts a follow up inspection about 30 days after the initial inspection with the exception of administrative paperwork type issues. If no response is received within 30 days of the report EH&S may, as a courtesy, contact the Principal Investigator of the laboratory with a reminder. If the laboratory conducts research, the Director of the Office of Research Integrity & Assurance at ASU's Office for Knowledge Enterprise Development (OKED) may be included on any correspondence. Additional parties such as safety

committee, senior compliance officer, or department designee may also be notified.

3. If no response is received and/or findings remain open after a total of 60 days from receipt of the initial follow up inspection report, the information will be forwarded to the EH&S Director and Chemical Hygiene Officer for review and to determine if any additional follow up may be required.

Safety inspections generate information regarding laboratory health and safety matters. Compliance Officers or the department safety committees may determine a need to conduct their own regular periodic audits of the work areas to evaluate work practices and identify potential hazards.

When this approach is taken, these inspections must be presented to EH&S for review. Departmentally-generated checklists of inspection requirements should include, at a minimum, all of the recommendations on the EH&S inspection checklist and must be approved by EH&S. Once approved, they may be used in place of any scheduled inspection identified in Appendix B.

Program Evaluation

Program evaluation is to be conducted annually by the CHO and reviewed with the EH&S Operations Committee along with any metrics maintained related to the program. This review should be in the form of a systems audit and based upon the effectiveness of the CHP. The EH&S Operations Committee may direct the CHO to propose modifications to existing EH&S policy or initiate new policies. Any changes to EH&S policies affecting the CHP will result in an update to the CHP.

Record Keeping

Required documentation and records are kept to demonstrate compliance with applicable laboratory standard mandates. EH&S uses CHP directives to collect all applicable information regarding these mandates. This information is used to complete reports, questionnaires and permits to various federal, state, and local agencies. Copies of these reports and the associated information collected through inspections and submittals by laboratories are kept on file by EH&S.

Departments must maintain records required by this plan. Records of inspections conducted by the department should be sent to EH&S and include the name of the inspector, the date, any unsafe conditions found, and any corrective actions taken.

Safety committees should document training activities, whether conducted in classes, safety meetings, or one-on-one job safety training sessions. Safety committees should keep records of what training occurred, who did the training, who was trained, and when the training occurred.

EH&S maintains records detailing employee exposure monitoring. These records provide an accurate account of measurements taken to monitor employee exposures if the employee is exposed to any chemical contaminant above the action level. These records must be kept for 30 years past the date the employee ceases working at ASU. These records are available from EHS.

The Student Health Center maintains records detailing employee medical consultations, including an accurate report of examinations, tests, and written opinions by the attending physician. These records must be kept for 30 years past the date the employee ceases work at ASU. Records must be available to employees or their representatives only. The physician's written opinion concerning occupational exposure is available to ASU.

Laboratory Start-up and Close-out Procedure

EH&S will conduct a Lab Check-in Assessment to offer guidance and assistance on lab registration, chemical inventory, and training requirements and ensure that all hazardous material regulations are addressed and satisfied. This allows EH&S to maintain information on all labs, chemicals used and that hazard assessments are completed as well as ensuring equipment issues are addressed.

This same EH&S policy requires that each Principal Investigator who sets-up, moves, extensively remodels, or vacates a laboratory space, contact EH&S to ensure the proper transportation and disposition of hazardous materials. This also allows EH&S to ensure chemicals, hazardous waste, biological waste, and other materials are not left behind in the laboratory. Depending on the situation, the laboratory may need to repeat the laboratory registration process. For further information, please contact EH&S at EHS@asu.edu or (480) 965-6219.

Chemicals no longer needed but still useable can be offered to other laboratories to prevent them from becoming hazardous waste and to ensure their safe handling and

use. The Environmental Protection Agency (EPA) requires that all chemicals must be properly identified and that waste is disposed of correctly. Any unused or unwanted chemicals should be submitted for disposal in accordance with the ASU Hazardous Waste Management Guidelines available at Environmental Affairs.

The Startup/Close out procedures should include the following:

- All chemicals, including hazardous waste, must be identified and properly labeled.
- All containers of hazardous waste, including out of date and/or unusable chemicals, must be disposed of in accordance with ASU's Hazardous Waste Management Compliance Guidelines.
- Any usable chemicals should be stored per lab chemical storage requirements before transferred to another laboratory. The department CO should be contacted for assistance in determining which chemicals can be issued to another laboratory.
- Biological waste and sharps must be disposed of in accordance with ASU's Biological Hazardous Waste Compliance Guidelines.
- Compressed gas cylinders must be removed from the laboratory by contacting Gas Services at gascylinders@asu.edu.
- Any radioactive waste, radioactive materials and radiation producing equipment must be removed from the laboratory. These activities should be coordinated through ASU's Office of Radiation Safety at 965-6140.
- All refrigerators, autoclaves, fume hoods and cabinets should be cleaned.
- Any outdated/unusable equipment should be sent to the ASU Surplus Property Department.

Each department is responsible for making certain that hazards are removed from the laboratory prior to any Principal Investigators departure from the laboratory. The PI should establish an inspection process and sign-off on any laboratory transfer.

Following these procedures will ensure environmental compliance and that the incoming faculty member has a clean, healthy environment in which to work.

All equipment identified for disposal either as part of demolition or through surplus property is to be cleaned and considered decontaminated. Guidance is available in ANSI Z9.11 Laboratory Decommissioning – 2008.

Communication

Each department should establish a system for communicating health and safety issues to employees. The Compliance Officer program should be considered as one method to assist in ensuring effective communication of EH&S issues and programs.

On a regular basis, EH&S will publish Safety Notifications and other topical information for CO's to communicate with their respective groups.

Minors in Laboratories

Minors in Laboratories policy EHS116: Minors in Laboratories, prohibits anyone under the age of 18 from entering an ASU laboratory. Exceptions include minors who are participating in an organized educational program that has been approved by the head of the academic unit where the program will take place. Additional exceptions must be approved by EH&S.

The purpose of the policy is to ensure that persons under the age of 18 have approval to be in a laboratory, are under proper supervision, and receive appropriate training. A parental permission consent form available through the EH&S is required for minors actually working in a laboratory. To facilitate the approval process, EH&S had developed a form is located at http://cfo.asu.edu/ehs-forms.

Note: Exceptions to this policy such as those associated with frequent tours of laboratories or educational programs must be approved by the EH&S Director. Please contact the EH&S office at EHS@asu.edu or (480) 965-1823 for more information on this exemption.

Employee Exposure Determination

If there is a reason to believe exposure levels for the chemical routinely exceeds established acceptable levels, Environmental Health & Safety (EH&S) will ensure sampling and monitoring activities are conducted to measure employee exposure to a hazardous chemical. The decision to conduct monitoring is based on a review of procedures conducted in individual laboratories in response to requests received from deans, directors, chairs, laboratory safety committees, safety coordinators, laboratory manager and employees, or on information obtained during the laboratory registration or inspection process.

EH&S has performed hazard assessments and employee exposure monitoring for typical lab processes involving carcinogens. The typical lab processes we have monitored are lab procedures conducted in fume hoods to sterilization processes and have included chemicals such as arsenic, benzene, chromium, cadmium, ethylene oxide, formaldehyde, and methylene chloride. Engineering controls (i.e. fume hood) and good lab work practices have controlled exposure below recognized exposure limits. EH&S may be contacted to perform hazard assessments and/or exposure monitoring to determine if there is a potential for exposure when regulated or select carcinogens are in use. When carcinogens are used with proper engineering controls (i.e. chemical fume hood) and good lab practices the likely hood of exposure is low.

OSHA has specific mandates for several substances that may pose serious health risks to employees. ASU has established written plans and monitoring programs for those specific substances that are used in the laboratories. Every laboratory that has any of these chemicals in their inventory should contact EH&S to enroll in the chemical-specific monitoring programs.

For any laboratory use of a chemical for which there is a specific OSHA health standard, EH&S may monitor for potential exposures if:

- There is a reason to believe that the exposure levels for that substance routinely exceed the action level or, in the absence of an action level, the permissible exposure limit.
- A request for monitoring is made by the laboratory or employee when there is reason to believe that the exposure levels for that substance routinely exceed the action level, or in the absence of an action level, the permissible exposure limit.
- However, this is not a complete list of OSHA specific programs. For a complete list, please refer to the OSHA website or contact EH&S at ASKEHS@asu.edu or (480) 965-1823.

EH&S may recommend or conduct initial exposure monitoring when:

- there is reason to believe that the maximum airborne concentration of a specific chemical could be above the TLV, REL, short term exposure limit (STEL) action level, or PEL; and
- the combination of chemicals could be above the TLV, REL, STEL, action level or PEL.

Initial monitoring by direct reading methods may be conducted by EH&S. These methods include, but are not limited to, colorimetric tubes, test paper strips and direct reading vapor monitors. Active monitoring may be performed for materials which there are no direct monitoring methods. If initial monitoring reveals employee exposure over the STEL, action level or PEL, EH&S must immediately comply with OSHA exposure monitoring provisions established for the specific contaminant.

If direct measurements indicate exposures may exceed the acceptable limits, additional monitoring may be required and active testing of individual breathing zones will be conducted using accepted OSHA methods and AIHA accredited laboratories.

EH&S may not recommend monitoring if or when:

- initial monitoring does not indicate any exposure above the action levels;
- there is no source of contamination;
- monitoring does not demonstrate exposures above the ceiling or short-term action levels;
- the source is noncontiguous;
- if engineering and/or administrative controls have maintained exposures below action levels.

The employee must be notified in writing by posting the test results in an appropriate location within 15 working days after the receipt of results. Notification and posting will be completed by EH&S.

Process Hazard Analysis

A hazard analysis is a step-by-step review of the procedures used by a laboratory and functions to predict hazards and risks to personnel and property and the environment. The hazard analysis also assists in defining control methods to prevent exposures to hazards.

The analysis should include the following:

- Laboratory Use Evaluation
- Chemical Use Evaluation
- Personal Protective Equipment Evaluation
- Pollution Prevention Analysis
- Evaluation for the need of a Prior Approval form

Process Hazard Analysis should take place during the laboratory registration process or may be scheduled as part of the laboratory inspection. Process Hazard Analysis should be based on information provided during laboratory safety training. EH&S is available to assist with this endeavor. PIs and Lab Managers should conduct Process Hazard Analysis on any new process or procedure. Hazard Analysis reviews shall be reviewed with department Compliance Officers or the Environmental Health and Safety's Laboratory Safety Inspector.

Prior Approval

This process involves the identification of hazards when using chemicals or processes that are new to your laboratory. This is done as part of management of risk and evaluation of pollution prevention/waste minimization. Prior approval is accomplished by completing an ASU Prior Approval Form and submitting it to EH&S or your designated EH&S representative. A copy of the completed forms should be kept at the laboratory for review by EH&S safety inspectors or safety committees.

This process is recommended for all new uses of chemicals but is specifically required for processes involving particularly hazardous substances (see Appendix C) and materials that are highly dangerous. Highly dangerous materials include:

- Reactive, peroxidizable, and explosive chemicals
- Select carcinogens
- Reproductive Toxins
- Highly toxic chemicals
- Sensitizers

Considerations for health and safety should include:

- Use of specific containment devices such as fume hoods or glove boxes
- Procedures for safe removal of waste materials
- Decontamination procedures
- Specific training for personnel
- Establishment of a designated work area
- Additional specific considerations for designated areas may include locking doors, buffer zones, and special authorizations

An alternative to this process is Process Hazard Analysis discussed previously on page 16 of this plan. For questions regarding this process please contact CHO at EHS@asu.edu or (480) 965-1823.

Select Agent Toxins

Select Agent Toxins are certain toxins of biological origin which are to subject to stringent regulatory requirements under 42 CFR 73 for their potential to pose a severe threat to public, animal, or plant health, or to animal or plant products. These toxins, along with specified biological agents (viruses, bacteria, fungi), fall under the oversight of the National Select Agents Registry (NSAR) Program which requires registration for possession, use, and transfer of the listed Select Agents. However, possession of small amounts of Select Agent Toxins as described in ASU's Biological Safety Manual is exempt from registration with the NSAR Program. However, an SOP is still required for use of exempt amounts and the Federal Select Agent Program Due Diligence requirements must still be met. See EH&S's Fact Sheet on Select Agents for additional information.

Chemical and Laboratory Use Evaluation

Each laboratory should conduct a chemical and laboratory use evaluation as part of the process hazard analysis. This evaluation is a general description of the function of the laboratory identifying the hazards including the pollution prevention/waste minimization goals. Laboratory activities that need chemical and laboratory use evaluations are:

- research laboratories,
- academic laboratories using procedures for teaching purposes, and
- projects that require approval by the Institutional Biosafety Committee.

A general description of the function of the laboratory includes:

- a basic outline of all procedures, i.e., standard operating procedures,
- a list of types of reactions expected,
- a list of all reagents including maximum volumes and concentrations,
- MSDS information availability,
- a pollution prevention/waste minimization analysis,
- a hazards analysis with hazard management techniques (engineering type controls), and
- expected methods of chemical and biological waste disposal.

This information demonstrates ASU's efforts to eliminate hazards in the laboratory and its commitment to minimize hazardous wastes generated by the university. If upon review, the information is insufficient or procedures are deemed too hazardous, EH&S may require further analysis or safety measures.

After research is complete, products of the research and the chemicals remaining are also subject to review by EH&S. The researcher must contact EH&S to determine if the chemical waste produced by the experiment is disposable.

There are many rules and regulations controlling disposal of wastes, and this creates many different costs and management problems. The analysis includes a justification for producing these wastes. Analyzing these materials before experimentation begins can prevent many problems not envisioned at the completion of the experiment.

Personal Protective Equipment (PPE)

The PI, with the assistance of the CO or EH&S should perform a hazard evaluation to determine which PPE is required for each laboratory task. PPE requirements are covered during laboratory safety training and must be followed by all employees and visitors to the laboratory. Any deviations from the PPE requirements covered during laboratory safety training are to be documented with a PPE hazard assessment analysis. Prior to each use, verify the PPE is in good working condition.

Standard operating procedures should include methods used to implement control measures for reducing employee's exposures to hazardous chemicals and materials. This includes:

- Engineering controls,
- Administrative Controls, and
- Personal Protective Equipment (hygiene practices are possible control measures).

PPE Hazard Assessment forms may be downloaded from EH&S forms. Copy of a form can be found in Appendix F of this document. Additional information can be obtained by reviewing the OSHA Personal Protective Equipment Standard, 29 CFR § 1910.132.

PPE Criteria

*ANSI criteria for protective equipment are as follows. This information was taken from Arizona State Risk Management training handout for OSHA 1910.132

Protective Equipment	Purchased after July 5, 1994	Purchased before July 5, 1994
Eye & Face Protection	ANSI Z87.1 1989	ANSI Z87.1 1968
Head Protection	ANSI Z89.1 1986	ANSI Z89.1 1969
Foot Protection	ANSI Z41 1991	ANSI Z41.1 1967

PPE is required to be used at all times while in the laboratory. The PPE listed below are the minimum required PPE and the actual required PPE is based on the lab's hazard evaluation.

- Safety goggles or face shield
- Laboratory coat or other suitable clothing which covers the arms and legs completely (long sleeved shirt and long pants). The PI may conduct a PPE assessment to further define suitable lab clothing in a specific lab or when a user is handling a specific hazardous material.
- Closed-toe shoes that protect the entire foot

PPE required to be used at all times when handling potentially hazardous chemicals, reproductive toxins, carcinogens, and sensitizers in the laboratory includes, but is not limited to:

- Appropriate gloves https://cfo.asu.edu/ehs-gloves.
- Approved respirators in the absence of adequate ventilation, e.g., glove boxes or fume hoods
- Hearing protection devices may be required if noise hazards are present in the laboratory.

Lab Coats – Proper Use and Care

Principal Investigators are responsible for ensuring that their staff and students wear laboratory coats at all times. If a risk assessment specifies that protective clothing is necessary, laboratory workers must be supplied with, and wear a lab coat when working with any potentially hazardous materials identified as requiring the lab coat. However, EH&S recommends that lab coats be worn at all times in laboratories where potentially hazardous materials are present.

Lab coats must not be taken home or to public laundries to be cleaned. Laboratory coats used in the laboratory must not be taken out of the laboratory into any meeting room, break area or dining facility.

Lab coats used for flammable materials should be made of 100% cotton or FR rated materials. EH&S recommends the use of flame retardant lab coats for any use or potential exposure to pyrophoric liquids or gases. Many lab coats are made from cotton/polyester fabric blends. These materials should not be used with open flames or pyrophoric materials.

If a hazardous material is splashed on a lab coat, the wearer is to remove it to prevent the splash from coming into contact with wearer's street clothes or skin. If a splash occurs, remove the lab coat immediately and determine if street clothes or skin have been contaminated. If street clothes are contaminated with corrosives, or materials toxic by skin absorption, remove the street clothes and immediately wash the affected area(s) in an emergency safety shower, report the incident to your supervisor, and follow your lab's emergency procedures.

Wearing and storage:

- Wear the right size – One size DOES NOT fit all, laboratory coats should fit wearer properly.
- Lab coats must be buttoned to protect street clothing and body from spattering of reagents or blood and body fluids.
- Sleeves must extend beyond the wrist to protect the arm – Do not roll up the sleeves for ventilation or comfort.
- Do not access pant pockets via side slits available in some laboratory coats – Hazardous or infectious materials may be transferred by dirty hands.
- Remove laboratory coat before leaving the laboratory.
- If a lab coat is needed in another location, you may wear it in the hallway leading to the other location, but not in an elevator or stairwell. If you need to transport your lab coat to another location, verify it is not contaminated and fold it and carry it to the next location it will be needed, preferably in a clean container such as a bag or back pack.
- Hang up in-use laboratory coats on hooks in a designated area.
- Store clean laboratory coats separately from soiled ones or those in-use.

Before sending to contract laundry:

- Check and have laboratory coats cleaned and washed at regular intervals or when they
  are dirty, whichever is earlier.

- The laboratory coat should be either free from obvious contamination or autoclaved
  before sending to the laundry.
- If the laboratory coat cannot be safely decontaminated or satisfactorily made safe to be
  handled by the laundry, it should be disposed of accordingly.
- If the laboratory coat is heavily stained with chemical or biological splash, it should be
  discarded immediately via the appropriate waste route.
- Replace torn or old laboratory coats.

If the laboratory coat is contaminated, the guidelines for pre-laundry treatment are:

- If the chemical spilled on the laboratory coat is safe to be disposed to the sewage (e.g. most acids and alkalis), rinse the laboratory coat with plenty of water.
- If a solvent is spilled on the laboratory coat, it should be completely evaporated in the fume hood first.
- The laboratory coat may have to be disposed of via chemical waste if the contaminant is a particularly hazardous chemical. Consult EH&S for guidance.
- If it is a biological contaminant (e.g. blood, urine, sputum, etc.) or microorganisms, the laboratory coat should be autoclaved first. Do not autoclave lab coats that are contaminated with chemicals.
- Do not send radioactive isotope-contaminated laboratory coats to the laundry. Contact Radiation Safety for guidance.
- Place laboratory coats for laundering in special plastic bags for collection by contract laundry.

If in doubt, consult your EH&S Compliance Officer or EH&S.

Use of Respirators

Respirator use may be necessary in order to maintain exposure levels below permissible limits or short term exposure limits. EH&S can help you determine the necessity for respirator use by evaluating your individual circumstances. Employees may request an evaluation by contacting EH&S or your department's safety committee.

Respiratory protection users must comply with the ASU Respiratory Protection Plan and includes compliance related to all types of respirators and dust masks. Respirator equipment will be provided at no cost to employees by the specific department.

Use of Hearing Protection Devices

Hearing protection devices, such as earmuffs or earplugs may be necessary to maintain employee exposure to noise below OSHA's permissible exposure limits. Departments may request a noise evaluation by contacting EH&S. Any employee using hearing protection devices must comply with the ASU Hearing Conservation Program.

LABORATORY SAFETY EQUIPMENT

Ventilation and Fume Hoods

Laboratory procedures must be conducted using adequate ventilation or other engineering controls such as glove boxes, fume hoods, and safety cabinets. All laboratory fume hoods, glove boxes, special ventilation areas, and biological safety cabinets must perform to measurable efficiencies.

Laboratory work is prohibited where general room ventilation is inadequate. General laboratory ventilation guidelines are located within the ASU Capital Programs Management Group Design Guidelines and ANSI\AIHA Z9.5-2003 American National Standard Laboratory Ventilation guideline. Refer to the ASU EH&S Chemical Fume Hood User Guide for proper use of chemical fume hoods.

All laboratory fume hoods, glove boxes, special ventilation areas, and biological safety cabinets must be monitored by qualified personnel. Fume hoods should be monitored at least annually by measuring the face velocity and other appropriate performance testing by qualified personnel. Call EH&S for questions or to schedule your annual fume hood maintenance. Daily fume hood monitoring must be conducted by laboratory personnel and is accomplished by inspection of the hood prior to use to ensure hood is working correctly. Proper use of hoods equipped with an on/off switch must be addressed in laboratory specific training or in other standard operating procedures.

Aside from the daily operator check of airflow, employees must check hoods to ensure that exhaust slots, sash location, and pressure alarms, are set properly and that they are in good working order. Operators must report all problems with fume hoods to the laboratory immediately. Hood maintenance and proper use includes:

- daily check for airflow,
- maintaining good housekeeping,
- Ensuring hood is not be used for permanent storage of chemicals or other storage,

- Ensuring hood displays a current performance testing sticker, and
- Contacting ASU Facilities Management for fume hood repair when face velocity is less than 80 feet per minute (FPM) or greater than 120 FPM or when daily airflow check shows an obvious drop.

Other special ventilation devices must be certified by outside contractors annually. The laboratory must keep records of all certifications. If the ventilation device is not working within expected efficiencies, the laboratory must repair the device before conducting any work in it. EH&S prohibits the use of ductless fume hoods without prior review and approval by EH&S.

The chemical fume hood shall be equipped with a flow-measuring device. This device may be a flow indicator, flow alarm, or face velocity alarm indicator to alert users of improper exhaust flow or hood failure. The responsible party, Principal Investigator or designee or department in possession of a fume hood not equipped with a flow-measuring device should contact ASU EH&S Department for a risk assessment of the fume hood. A checklist is available from EH&S for use in conducting this risk assessment. Hoods equipped with an on/off switch may be exempted from this requirement if lab-specific training and operating procedures identify proper use and the method to verify proper function of the hood.

Walk-in Hoods

These hoods are designed so that lab personnel can walk into the hood to set up large and bulky equipment. It is not intended that personnel stay in the hood when equipment is operating. Profile sticker sash height settings must be followed when using this type of hood.

Emergency Eyewashes and Showers

All laboratories in which corrosive chemicals are used should have direct access to eyewash stations and safety showers, or have SOPs in place approved by the PI that minimize the potential risks of injury until a suitable emergency eyewash and/or safety shower can be accessed. General guidelines are located within the ASU Capital Programs Management Group Design Guidelines. American National Standards Institute (ANSI Z358.1 2009) and National Research Council *Prudent Practices in the Laboratory* provide detailed information regarding the installation and operation of emergency eyewash and shower equipment. Emergency eyewash and/or safety shower units will meet the requirements of the ANSI Z358.1 2009 standard.

General Information

- Employees who may be exposed to hazardous materials shall be instructed in the location and proper use of emergency shower and eyewash units.
- For a strong acid or caustic (pH <1 or >12) the eyewash should be immediately adjacent to the hazard.
- Where the hazard is not a corrosive, one intervening door can be present so long as the door opens in the same direction of travel as the person attempting to reach the emergency equipment and the door is equipped with a closing mechanism that cannot be locked to impede access to the equipment.
- Personal wash units (portable or squeeze bottle type eyewashes) and drench hoses are considered supplemental to emergency eyewash and shower equipment, and should be tagged or labelled as such. Lab specific training programs and SOPs should identify the nearest suitable emergency eyewash and safety shower if not located within the lab.

Eyewash

- The eyewash unit shall be designed, manufactured and installed in such a manner that, once activated, it can be used without requiring the use of the operator's hands.
- The eyewash units shall provide flushing fluid to both eyes simultaneously.
- Eyewash nozzles shall be protected from airborne contaminants. Whatever means is used to afford such protection, it shall not require a separate movement by the operator when activating the unit.
- Plumbed and self-contained eyewash equipment shall be capable of delivering flushing fluid at a minimum of 1.5 liters per minute (0.4 gpm) for a minimum of 15 minutes.

Shower

- Showers should be checked routinely to assure access is not restricted and the pull down bar to start water flow is within users reach.
- Plumbed and self-contained shower equipment shall be capable of delivering flushing fluid at a minimum of 75.7 liters per minute (20 gpm) for a minimum of 15 minutes.

Eyewash and Shower

- The emergency shower and eyewash shall be located on the same level as the hazard and the path of travel shall be free of obstructions that may inhibit the immediate use of the equipment.
- Emergency eyewash and shower equipment should be available for immediate use, but in no instance should it take an individual longer than 10 seconds (approximately 50 feet) to reach the nearest facility. A door is considered to be an obstruction.
- The water flow valve shall remain open without the use of the operator's hands until intentionally closed. The valve shall be simple to operate and shall go from "off" to "on" in 1 second or less.

Routine Testing

- Plumbed shower and eyewash equipment should be inspected and tested. Eyewashes may be activated weekly or monthly for a period of time long enough to verify operation and ensure that flushing fluid is available. Guidance for routine testing is available from EH&S. Please contact EH&S or your departments EH&S Compliance Officer if there are questions about testing frequency, or if guidance is needed for setting up routine testing by laboratory personnel.

Fire Safety Equipment

Fire safety equipment must be easily accessible to the laboratory and include a fire extinguisher (type ABC) available within 50 feet, and may include fire blanket or automatic extinguishing systems. Fire extinguishers are inspected annually by EH&S staff.

Lab personnel shall maintain fire sprinkler clearance requirements as outlined in the Fire Safety and Prevention training.

EMPLOYEE INFORMATION AND TRAINING

Laboratories must utilize the written information and training program as outlined herein. OSHA states that all laboratory employees must be provided with information and training to ensure communication of the hazards present in their work area in order to prevent work-related injuries and illnesses. Training must be provided for new employees *prior to working in the laboratory* or when a new hazardous chemical is introduced into the work area. The laboratory must assure that training of all laboratory employees occurs.

Employee training must consist of:

- details of the Chemical Hygiene Plan,

- identification of personnel responsible for certain aspects of the CHP,
- information to help employees understand and read labels and MSDSs,
- locations of the MSDSs, lab procedures and other mandated documents,
- physical and health hazards of common chemicals,
- protective procedures from the hazards, e.g., work practices, PPE and emergency procedures,
- methods and procedures to detect the presence of or release of a chemical in the work area (CO monitors etc.), and
- methods and procedures for reporting accidents.

EH&S provides laboratory safety training sessions at all ASU campus locations. Training registration takes place via EH&S web site.

EH&S can provide specific training for individual departments or Principal Investigators upon request. Call EH&S to arrange for special training sessions at 480-965-1823.

PIs or Laboratory Managers must provide additional laboratory-specific safety training to employees relative to the specific hazards associated in their laboratory (i.e., chemicals and equipment) for Risk Category 3 labs.

PIs or Laboratory Managers must also provide laboratory specific safety training relative to specific hazards associated in their laboratory to non-employees (students) working within their laboratories. A Lab Safety Manual template modifiable to include a Laboratory-Specific Training checklist is available for use in Appendix D. The Lab Safety Manual is designed to be customized to each lab and can serve as a single resource to include specific training requirements, procedures, and records specific to each lab. A workshop is available through EH&S for PIs, Lab Managers and others interested in developing a lab safety manual. The workshop also provides credit for Fire and Lab Safety, and Hazardous Waste Management Training.

Specialized training or training for employees with special needs will be provided to employees when necessary. Please include provisions for employees with special needs within your building and/or department specific emergency preparedness plans. The emergency preparedness plan template is available at http://cfo.asu.edu/ehs-emergency-plan-template.

Special needs training can be performed by a department provided it meets the requirements of this CHP. Call EH&S for consultation and approval before conducting such training.

Each employee must complete training as identified on the EH&S Training Determination Tool available at https://ehstrainingtool.asu.edu/. ASU policy EHS 108-01: Health and Safety Training provides discussion of the required health and safety procedures. This includes initial and annual training for all employees involved in activities covered under this CHP.

New training offered by EH&S includes Compressed Gas Safety and Responsible Party Laboratory Safety Workshop. Look for additional course information in the Training Determination Table.

Container Labeling

Hazardous chemicals in the laboratory must be properly and adequately labeled. PIs and or Laboratory Managers must assure that all chemicals have labels with legible writing that indicate:

- Name of contents (the label must be written in English using acceptable IUPAC chemical names).
- Health and Physical Hazard associated with the material (NFPA hazard warnings, corrosive, oxidizer, acid, alkali, radiation, etc.).
- Date of last peroxide test (if the material is a peroxide former after exposure to oxygen such as with Ethyl ether). See **Appendix F** for more details.

Abbreviations are acceptable on labels only if the laboratory maintains an abbreviation document clearly visible and in the vicinity of the container that indicates the chemical name represented by the abbreviations.

Small containers used for samples with potentially hazardous materials need only be labeled with the sample number or other designation provided a key identifying the sample contents (i.e., water samples in 0.1 N Sulfuric acid) can be easily located by potential emergency responders.

Each container of a hazardous chemical received from the manufacturer with a label must have information that gives:

- Name of contents (the label must be written in English using acceptable IUPAC chemical names).
- health and physical hazard associated with the material (NFPA hazard warnings, corrosive, oxidizer, acid, alkali, radiation, etc.).

- Name and address of the chemical manufacturer or distributor must also be on the label.
- If a container arrives without the manufacturer's label, an appropriate label must be affixed to it.

Labels must not be removed, except under the following conditions:

- Container is immediately relabeled.
- Chemical in the container is removed, a new type of chemical is placed in the container, and the container relabeled with the identity of the new chemical.

Special Labeling Practices

- If it is not practical to label a container, appropriate information may be placed on a sign **next** to the container.
- Chemicals that are time-sensitive or that produce peroxides must be dated indicating the date storage began. See **Appendix G** of this document for information on common peroxide crystal forming compounds and how to handle them.

Use the following procedure for chemical substances developed by the laboratory and for which there is no known written hazard information:

- If the chemical developed by the laboratory is produced exclusively for the laboratory's use (new compounds and drugs), the laboratory must determine if the substance is hazardous;
- If the substance is hazardous, the laboratory must label the containers as such, and indicate those hazards on the label;
- If the laboratory is unable to determine the hazards, it must label the chemical as if it were hazardous; and
- If the chemical developed by the laboratory is produced for use by another company, the laboratory must develop an MSDS for that chemical substance.

Safety Data Sheets (SDS)

SDS's must be readily available to laboratory employees for each hazardous chemical used in the work area. The SDS must contain the following information:

- Chemical and common name
- If a mixture:

  - Chemical and common name of ingredients that are health hazards

- Chemical and common name of ingredients that are physical hazards

- Physical and chemical characteristics (vapor, pressure, flash point and color)
- Physical hazards, including potential for fire, explosion, and reactivity
- Health hazards, including signs and symptoms of exposure and medical conditions recognized as being aggravated by exposure
- Primary routes of entry into the body
- OSHA Permissible Exposure Limit (PEL), the Threshold Limit Value (TLV), and any other exposure limit used or recommended by the manufacturer
- Indication if the chemical is a carcinogen or potential carcinogen
- Handling procedures including hygienic practices and recommended protective measures during release clean-up
- Personal protective equipment, engineering controls, and work practices
- Emergency and first aid procedures
- SDS preparation date
- Name, address, and telephone number of the MSDS preparer

All of the above categories must be completed even if no relevant information is found. The same SDS may be used for several chemicals if they contain similar hazards and ingredients. If additional information concerning a chemical becomes available it must be added to the SDS within three (3) months.

The responsible party for the laboratory or their designee must maintain a collection of SDS for all chemicals in the laboratory and ensure that they are readily accessible to all laboratory employees. The location of the collection must be recorded on the RPI sheet. The location and availability of the collection must be shared with the laboratory employees. The collection can either be maintained as an electronic or paper copy. The collection should include the department's current chemical inventory and SDSs arranged alphabetically or other manner suitable to locating an SDS readily.

Note: When SDS are made available electronically, employees must be able to access the SDS without requesting them directly from another employee, and there must be a backup system available in the event of a power failure or computer network connection failure. An example of an acceptable backup system is a computer with a battery back-up and a CD or flash drive with an updated version of the SDS file kept in a location known to all employees. If a laptop computer is

selected as the back-up, measures must be taken to ensure it will not leave the designated location.

Guidelines for Transporting Chemicals (including gas cylinders and cryogenic containers)

- All chemicals should be transported within secondary containers capable of holding all materials in the event of a spill. Transport of any corrosive or heated materials requires secondary containment unless exempted by EH&S. Appropriate personal protective equipment (PPE) is to be used.
- Acceptable secondary containers include plastic bottle carriers with closed tops and handles or non-metal liquid-tight carts with lips on all four sides. Never transport incompatible chemicals in the same secondary containment. Use plastic tubs or separate bottle carriers to prevent incompatibles from mixing.
- Use freight elevators for moving chemicals between floors. If freight elevators are not available, use unoccupied passenger elevators. Stairs should be used only if elevators are not available.
- Wear appropriate Personal Protective Equipment (PPE). Minimum PPE includes safety glasses, lab coat or other appropriate lab attire, and closed toe shoes. Hazardous chemicals must be attended at all times while being transported.
- Individuals transporting chemicals must ensure containers are properly labeled and know what to do in the event of a release or spill. Safety Data Sheets (SDS) are a good source for this information.
- Transport compressed gas cylinders using special compressed gas cylinder handcarts. The cart should be pushed in front of the transporter and not pulled. When transporting cylinders across asphalt, uneven terrain or between buildings, two people must be in attendance to prevent tipping and unanticipated jolting of the gas cart. Cylinders must be securely attached to the cart and valve protection caps must be in place.
- Materials that are unstable, explosive, or unusually hazardous due to size or toxicity should not be moved without first contacting EH&S (e.g., outdated peroxide formers such as THF, dry Picric acid, >20 gal containers of flammable or corrosive liquids).
- Transport on paved paths and sidewalks rather than streets or roads. Two people must be in attendance to prevent tipping cart as it is moved over uneven terrain and changes in elevation.
- Before transporting autoclaved materials, please review the following materials: http://www.asu.edu/ehs/documents/autoclave-sop.pdf.
- Do not transport chemicals in personal vehicles. Transportation must be done only by EH&S or employees authorized to transport hazardous materials. Contact EH&S if a chemical must be transported onto or off of campus.

- Avoid transporting chemicals in a passenger vehicle, but if you must, do not place chemicals in the passenger compartment. Place the containers in the trunk or cargo bed and ensure that they are properly packaged and firmly secured. Never leave chemicals unattended or stored in a vehicle.
- Transport cryogenic materials only in approved storage vessels (e.g. dewar flasks with pressure relief mechanisms). Use appropriate PPE including eye protection in the form of a face shield or goggles, heavy gloves, and closed-toe-shoes. Never transport in the passenger compartment of a vehicle due to the hazard from asphyxiation. Do not transport cryogenic containers with volumes of more than 50 liters in a passenger elevator without setting up a procedure to ensure that no one can access the cab of the elevator during transport.

When transporting chemicals on campus malls, the following additional precautions apply:

- Wear appropriate lab attire (long pants, closed-toe shoes). Bring personal protective equipment (safety glasses, lab coats, appropriate gloves) in case of a spill (and a spill kit).
- Do not transport hazardous materials on the Malls during class change times.
- Segregate materials according to hazard classification for transportation. Each hazard class should have a separate secondary container. For example, do not transport concentrated acids and organic solvents. Also, do not transport oxidizers with organic solvents. Additional guidance on chemical containers and compatibility can be found in Appendix G.
- Where possible transport chemicals in their shipping package. If not possible, use an approved chemical carriers such as that pictured for glass containers. Contact EH&S if additional guidance is needed. Individuals transporting chemicals must ensure containers are properly labeled.
- Care must be exercised when transporting liquid nitrogen containers in elevators. Passengers may not travel in elevators with dewars of cryogenic materials larger than one (1) liter without EH&S approval. For larger containers, transport the container only on a freight elevator if possible. After the container is placed in the elevator, steps are to be taken to keep other personnel from entering the elevator. The sender should remain outside the elevator and activate it. Another person should be available on the receiving floor to take the liquid container off the elevator at its destination. For buildings with three (3) or more levels signage must be posted on the dewar itself with a “Do Not Enter” message to warn anyone that may observe the dewar while it is on the elevator (see Appendix L). If a freight elevator is not available, a passenger elevator can be used following this procedure. If it is absolutely necessary to have an attendant in the elevator with the container, an escape pack supplemental breathing apparatus must be

carried in the elevator. See Appendix L for safe handling procedures for cryogenic materials.

- The transportation of LN2 across public roads is prohibited. Gas Services arranges for pickup and delivery of LN2 Dewars requiring transportation across public roads. Do not transport chemicals on golf carts across public streets unless approved in writing by EH&S. Small quantities of chemicals (i.e., one box may be transported in their original shipping container on a push cart. When crossing public streets two (2) people should be involved, one observing for traffic and the other moving the cart with hazardous materials.
- If transporting more than a single container, use a heavy duty cart and secondary containment (do not carry multiple containers). Acceptable secondary containers include plastic bottle carriers with closed tops and handles, or non-metal liquid-tight carts with lips on all four sides. Never transport incompatible chemicals in the same secondary containment. Use plastic tubs or separate bottle carriers to prevent potential mixing if spilled.
- Transport compressed gas cylinders using special compressed gas cylinder handcarts. The cart should be pushed in front of the transporter and not pulled. When transporting cylinders across asphalt or uneven terrain, two people must be in attendance to prevent tipping and unanticipated jolting of the gas cart. Cylinders must be securely attached to the cart and valve protection caps must be in place.
- Before transporting autoclaved materials, please review the following materials: http://www.asu.edu/ehs/documents/autoclave-sop.pdf.
- Materials that are unstable, explosive, or unusually hazardous due to size or toxicity should not be moved without first contacting EH&S (e.g. outdated peroxide formers such as THF, dry Picric Acid, >20 gal containers of flammable or corrosive liquids).
- Transport cryogenic materials only in approved storage vessels (e.g. Dewar flasks with pressure relief mechanisms). Use appropriate PPE including eye protection in the form of a face shield or goggles, heavy gloves, and closed-toe-shoes. Never transport in the passenger compartment of a vehicle due to the hazard from asphyxiation.
- Be prepared for action in the event of an incident. If there's a minor spill and EH&S assistance is needed call (480) 965-1823 from a cell phone, be prepared to provide your location. If there is a major incident, contact the ASU PD by calling 911 from a cell phone or blue call box.

Eating, Drinking, Smoking, Chewing, and Use of Cosmetics

Many respected institutions including the National Research Council, the Arizona Radiation Regulatory Agency and the Centers for Disease Control and Prevention agree that eating, drinking, smoking, gum or tobacco chewing, applying cosmetics, and

taking medicine in laboratories where hazardous chemicals and materials including unsealed sources of radioactive materials are used must be strictly prohibited. Food, beverages, cups, and other drinking and eating utensils are not to be stored in areas where hazardous chemicals and materials or radioactive materials are handled or stored 29 CFR 1910.141(g)(2).

Additionally, contact lenses should not be worn and are not to be handled in locations where hazardous materials are present.

Each Department Dean, Director, Chair or their designee may designate areas within laboratory facilities where these activities are permitted. Prohibitions related to the use hazardous materials in these locations must be communicated to all laboratory personnel and the requirement must be enforced.

Refrigerators, freezers, ovens, microwaves, and similar appliances in laboratories not intended for use with food or beverage to be used for human consumption must be labeled with the terms "**NOT FOR USE OF FOOD**" or equivalent. Similar appliances in designated locations within laboratories intended for use with food or beverage to be used for human consumption must be labeled "**FOR FOOD USE ONLY**" or equivalent. Areas with refrigerated food for animal use must be labeled as "**FOOD FOR ANIMAL USE ONLY**" or equivalent.

Physical Hazards

Physical hazards associated with each laboratory process must be assessed to determine potential hazards and identify necessary engineering controls, training and required personal protective equipment. Examples of physical hazards include noise, compressed gas uses, explosive or highly reactive chemicals, non-ionizing and ionizing radiation, and potential energy (i.e., springs and hydraulic systems).

Physical hazards are to be assessed during the PPE hazard assessment referenced on page 17 of this plan as part of an overall hazard assessment process. EH&S is available to assist in those evaluations.

All equipment manufacturers' signage related to physical hazards is to be left intact and employees are to be told to read and adhere to all manufacturers' warning labels. In situations where the manufacturer's label has become illegible or missing, physical hazards are to be marked with signage and warnings consistent with the requirements

of ANSI Z535.2 Specifications for Accident Prevention Signs and ANSI Z535.1-6 Safety Color Code for Marking Physical Hazards as follows.

Please be sure to verify the following types of equipment are provided with warning labels associated with physical hazards.

1) The presence of bare electrical conductors greater than 50 volts as defined in EHS118: Electrical Safe Work Practices.
2) Robots, pneumatic lifts, and material handling devices that are not equipped with physical barriers or interlocks engineered to prevent exposure to physical hazards.

Equipment generating excessive noise levels needs to be surveyed by EH&S per the ASU Hearing Conservation Program http://www.asu.edu/ehs/documents/asu-hearing-conservation-program.pdf and appropriate signage used to identify where hearing protection may be required or recommended.

Radiation producing equipment and materials, radio frequency generating equipment and lasers must be labeled. If the equipment manufacturer did not provide labels contact the Radiation Safety Office for assistance at radiationsafety@asu.edu.

Hazards associated with compressed gas are addressed in EHS 122: Compressed Gases http://www.asu.edu/aad/manuals/ehs/ehs122.html. This policy requires training for all ASU employees and volunteers that physically handle compressed gas systems.

Compressed Gases

Arizona State University wants to ensure employees who handle compressed gases understand the health and physical hazards of the compressed gas cylinders, the contents, proper handling, use, storage, and emergency procedures.

Compressed gas cylinders can present a variety of hazards due to their pressure and /or contents. In addition to the standard required work practices for inert gases, hazardous gases may require additional controls and work practices including, but not limited to, the use of gas cabinets, gas monitors, emergency shutoffs, proper equipment design, leak testing procedures, and the use of air supplying respirators for certain highly toxic gases.

The ASU Compressed Gas Safety Program document has been developed to provide guidance which applies to the storage, use, and handling of gases in pressurized

portable containers and gas systems. The program is designed to meet regulatory requirements: 29 CFR 1910.101-111, the Compressed Gas Association CGA P-1-2008 Safe Handling of Compressed Gases in Containers, and ASU policy EHS: 122 Compressed Gases.

Shop Equipment

OSHA requires that machine guarding and other safeguards be provided and maintained to protect employees who may operate machines typically considered shop equipment and other persons present in machine areas from potential hazards – 29 CFR 1910.212 . Hazards include those created by points of operation, in-going nip points, rotating parts, flying chips, sparks, moving belts, meshing gears, cutting teeth, or by any parts that impact or shear or have reciprocating, transverse, cutting, punching, shearing, boring, or bending actions. Risk of injury such as crushed hands and arms, severed fingers, skin lacerations, scalping, hot metal burns, eye injuries, and blindness must be anticipated and addressed.

Responsibilities for ensuring machine safety through hazard identification and evaluation, safeguarding, training, and safe operating procedures fall under the PI for individual labs and under shop supervisors for designated machine shops. To assist with fulfilling these responsibilities EH&S offers web based training for machine guarding and machine shop safety. EH&S also conducts inspections of machines shops at least annually and is available to arrange special training sessions upon request.

Any employee who services equipment in such a way as to potentially be exposed to hazardous source of energy such as electricity, or who needs to remove guards or panels exposing moving parts must be trained in ASU Lockout/Tag Out program. Training for this program is available by contacting EH&S.

In order to prevent potential hazards from exposure to toxic metals such as Beryllium, machining of any metal alloy that is not stocked in shop supplies must be approved through the use of a Prior Approval Form (see Prior Approval).

OSHA also requires that hand and power tools be used in safe condition 29 CFR 1910.242. This chapter describes how the portable tools program implements this requirement at SLAC.

The hazards encountered when using portable tools include striking or contacting part of the body with the tool or the work piece and projectiles flying off the tool or work piece

in the eyes. The most common injuries from the use of portable tools are lacerations or cuts from a knife blade, saw, or other tool with a sharp surface or jagged edge, and contusions or bruises from striking the fingers with the tool

To address these potential hazards, general shop safety rules must be developed that identify required PPE, tool selection (right tool for the work to be performed), inspection and use. Shop safety rules should be customized to the types of equipment in each shop and EH&S is available to assist with developing a posting for your shop or integrating this into your laboratory safety training plan.

Working Alone Procedures

Hazard assessments are to be conducted whenever employees and volunteers are working alone as required in EHS 123 Working Alone with Hazardous Materials, Processes or Equipment. Assessments required by this policy should review the means of entry to the workplace and the means of leaving the workplace, the equipment that may be required to be used, the exact tasks that are required to be undertaken, any substances required to be handled, the environment and the atmosphere in which the employee will work alone.

Departments should assess and prioritize the working alone hazards that have been identified and evaluate possible means of elimination or control. Contact EH&S for additional assistance in evaluating working alone hazards.

Examples of controls implemented after the initial hazard assessments included:

- Restricted access to the building – card key, or “after hours permit” after regular scheduled closing times.
- Department doors are locked when working alone after hours. (Ensure emergency services are able to get into locked buildings).
- Post signage, emergency contact information, and develop a communication system.
- Establish a check-in procedure. Make sure regular contact is kept with all workers. (Personal check by another person, or periodic telephone contact)
- Require the use of a “buddy system” in high-risk situations – ensure that individuals are aware that this option is available to them.
- Where appropriate, consider the use of a security system such as video surveillance cameras, mirrors, observation windows, etc.; however, ensure that informed consent is obtained from employees prior to use.
- Schedule high risk tasks during normal business hours, or when another worker is capable of helping if an emergency situation arises.

Individuals should be trained to increase awareness of methods for identification, hazard reduction and prevention when working alone and dealing with situations or individuals that present a potential risk.

SHIPPING AND RECEIVING HAZARDOUS MATERIALS/DANGEROUS GOODS (HM/DG)

No person may receive a HM/DG without function-specific training. Training must be documented and must be included in the employee's EH&S training records. No person may ship or offer for shipment HM/DG unless that person has received certified 16-hour US DOT training for hazardous materials.

Additionally, shipments or offers to ship HM/DG by air also require certified International Air Transport Association (IATA) regulations training. All training must be current per regulation, must be documented, and must be included in the employee's EH&S training records.

The shipping function may be completed by a properly trained and certified third-party freight forwarder if one is available. Shipping or an offering for shipment shall include any outbound or inbound shipment to or from ASU being made on behalf of or for ASU. This includes but is not limited to, shipments of HM/DG from off-campus locations or persons to any campus location or person, or to any permanent or temporary ASU-affiliated off-campus location or person. For more information see EHS 406 Shipping and Receiving Hazardous Materials.

Pollution Prevention Analysis

Pollution prevention analysis is the systematic review of laboratory procedures which use hazardous chemicals in order to reduce volume and toxicity of waste and to prevent the release of substances into the environment. Replacing hazardous chemicals with less hazardous or non-hazardous chemicals is the most efficient way to reduce waste and minimize pollution potential. *No chemicals of any kind are allowed in the trash or down the drain.* All laboratories must be accountable for all hazardous chemicals and materials to make sure they are not released into the air, sewer, or ground. The safest and most efficient way to dispose of hazardous chemicals is to have wastes picked up by on-campus by hazardous waste management services.

Pollution prevention analysis requires the researcher to review all processes and to identify those chemicals that can be substituted by less hazardous chemicals. Researchers must be able to justify to EH&S and the Arizona Department of Environmental Quality (ADEQ), the use and volumes of hazardous chemicals used in their laboratories.

LABORATORY USE OF ANESTHETICS

Anesthesia commonly used in some research laboratories includes nitrous oxide, halothane, enflurane, trichloroethylene, and urethane. Exposure to waste anesthetic gases and vapors during surgical procedures is harmful to researchers. Open bench surgeries involving gaseous anesthetics should employ waste gas scavenging systems that are connected to non-recirculating exhaust systems.

- Refer to the ASU Anesthetic Gas Usage program for procedures to minimize exposure to waste anesthetic gases.
- Exhaust systems must be used in conjunction with scavenger systems. Contact EH&S prior to installation of scavenger systems to existing building ventilation.

MEDICAL CONSULTATIONS AND MEDICAL EXAMINATIONS

Employees working with hazardous chemicals will be provided medical attention including any follow-up examinations that the examining physician determines necessary, under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical exposure which may have occurred in the laboratory,
- Where monitoring reveals an exposure level routinely above the action level, or in the absence of an action level, the PEL for an OSHA regulated substance, and/or any TLV or REL for which there are prescribed exposure monitoring and medical surveillance requirements,
- Whenever there is a spill, leak or other release resulting in a potential hazardous chemical exposure of an employee above the PEL or action level, or
- Examinations must be conducted under the direct supervision of a licensed physician and provided at no cost or loss of pay to the employee.

ASU will provide the physician with the following:

- The identity of the hazardous chemicals to which the employee may have been exposed,
- A description of the conditions under which the exposure took place, including any quantitative data if applicable, and
- A description of the signs and symptoms the employee is exhibiting.

After the examination, the physician will submit a written opinion to EH&S that must include the following:

- Any recommendations for medical follow-up,
- The results of the medical examination and associated tests,
- Any medical condition revealed that would place the employee at increased risk as a result of exposure to a hazardous chemical found in the work place,
- A statement by the physician that the employee has been informed of the results of the examination and any medical condition that may require further treatment or examination, and
- The written opinion will not reveal specific findings of diagnosis unrelated to the occupational exposure.

HAZARDOUS WASTE MANAGEMENT

Laboratory operations that produce waste chemicals are considered as producing hazardous waste. Hazardous waste is regulated by The Arizona Department of Environmental Quality (ADEQ). All laboratory personnel who produce hazardous waste are required to manage their waste according to ASU's Hazardous Waste Management Compliance Guidelines. State and federal law require the university to manage its hazardous waste. Failure to manage hazardous waste properly may result in criminal prosecution and heavy fines.

All laboratory employees who physically place hazardous waste into designated hazardous waste containers are required to complete Hazardous Waste Management training either in classroom or using the web-based training available through EH&S.

Broken Glass

The following is the procedure recommended for handling broken glass. If the broken glass involves blood, microorganisms or bioresearch materials, please review the following link: http://cfo.asu.edu/ehs-biowaste-compliance-guideline.

If a potentially hazardous chemical is involved please review this link: http://emergency.asu.edu/ep_emergency_guide.

If broken glass is the only issue, then the glass should be carefully picked up using forceps or broom and dust pan and placed in a container such as a cardboard box (or other designated substantial container such as a plastic container designated for broken glass) and clearly labeled as broken glass. Please do not place broken glass in ordinary trash containers as it presents a potential risk to those that need to handle it. Broken glass that is not contaminated may be recycled as indicated at https://cfo.asu.edu/zw-recycling-glass.

EMERGENCY PROCEDURES

Laboratory personnel must be aware of the provisions for emergency procedures and preparedness. Emergency procedures and preparedness include actions or contingencies for:

- Evacuations due to fires, chemical spills, and other situations,
- First aid,
- Procedures for use of special ventilation areas,
- Shut down and lock-out during evacuations, and
- Location of emergency equipment (showers and eyewashes)

Protocols for handing emergencies are outlined in the ASU Emergency Response Guide and Arizona State University Emergency Operations Manual. Laboratories must have their own written plan detailing their specific emergency procedures.

ACCIDENT AND NEAR MISS REPORTING

Principal Investigators or Lab Managers must submit accident/near miss reports to EH&S for any accident or near miss situation per Arizona Administrative Code R2-10-205. Employees will be free from any reprisals for reporting accidents. Accident/Near Miss Reports, corrective actions, and suggestions regarding possible improvements can be of help to safety committees as they strive to improve future laboratory safety.

To report an incident related to an employee, visitor, or student in regards to an injury, illness or near miss refer to the EH&S website and fill out the Accident/Near Miss/Quality Improvement Report. EHS 115: Incident Reporting and Investigation policy

SPILL PREVENTION AND CONTINGENCY

The basis of a CHP follows the reasoning of the National Environmental Policy Act (NEPA) legislation. NEPA calls for an analysis of the projects impact on the environment, referred to as an environmental impact statement. The purpose of this program is to encourage the laboratory's chemical users to investigate their impact on the environment. The project needs to be reviewed for consequences in the following areas:

- The health and safety of personnel due to chemical use
- Exposure of the employees to the chemicals, including:
    - Analysis of the need for medical monitoring for employees
    - Training requirements for chemical use in laboratories
- The impact of the research on the property and nearby community:
    - The impact of the products of the research on the hazardous waste disposal program.
    - Efforts in analyzing procedures to reflect pollution prevention mandates.
    - The impact of the research in user fees and/or permitting requirements
- An analysis of the energies involved:
    - An emergency contingency analysis, including job hazard analysis or fault analysis.

Information discovered by applying EH&S techniques and hazard analysis techniques must be applied by the Laboratory Manager or Principal Investigator in maintaining a safe laboratory.

RELATED WEB DOCUMENTS

Biological Hazardous Waste Compliance Guidelines

Hazardous Waste Management Compliance Guidelines

Hearing Conservation Program

Respiratory Protection Program

Compressed Gas Safety Program

Appendix A

Definitions

ACGIH - American Conference of Governmental Industrial Hygienists is an organization of professional personnel in governmental agencies or educational institutions engaged in occupational safety and health programs. ACGIH develops and publishes recommended occupational exposure limits (see "TLV") for hundreds of chemical substances and physical agents.

Action Level - A concentration designated in 29 CFR § 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.

Acute - Severe, often dangerous conditions in which relatively rapid changes occur.

Acute Exposure – Acute exposure is a single, brief exposure to toxic substances. Adverse effects on the human body, if applicable, are evident soon after the exposure and come quickly to a crisis.

Alloys - A mixture of metals (such as brass), in some cases a metal and a non-metal.

Ambient Temperature - Temperature of the immediate surroundings.

Appearance/Odor - The color, physical state at room temperature, size of particles and characteristics of the material. Odor is described in comparison to common familiar "smells".

Asphyxiant - A chemical (gas or vapor) that can cause death or unconsciousness by suffocation. Simple asphyxiants, such as nitrogen, either use up or displace oxygen in the air. They become especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to the tissues.

Aspiration Hazard – This is the danger of drawing a fluid into the lungs, causing an inflammatory response to occur.

Assistant Secretary - The Assistant Secretary of Labor for Occupational Safety and Health, US Department of Labor, or designee.

Auto ignition Temperature - Lowest temperature at which a flammable gas or vapor-air mixture will ignite from its own heat source or other contacted heat source.

Boiling Point - Temperature at which vapor pressure of a liquid equals atmospheric pressure.

C.A.S. Number - The number assigned to chemicals or products by the Chemical Abstracts Service.

Carcinogen - A substance or agent capable of causing or producing cancer.

Catalyst - A substance which changes the speed of a chemical reaction but undergoes no permanent change itself. An example of a catalyst is the platinum used in automotive catalytic converters on the exhaust system.

Chemical Hygiene Officer - An employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the CHP. This definition is not intended to place limitations on the position description or job classification that the designated individual must hold within the employer's organizational structure.

CHP – (Chemical Hygiene Plan) a written program developed and implemented by the employer. It sets forth procedures, equipment, personal protective equipment, and work practices that:

(i) Are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace, and

(ii) Meet the requirements of CFR 29 1910.1450.

Chronic Effect - An adverse effect on a human or animal in which symptoms develop slowly over a long period of time or recur frequently.

Combustible - A substance capable of fueling a fire. Also a term used to classify certain liquids on the basis of their flashpoints. Also see "flammable".

Combustible Liquid - Any liquid having a flashpoint at or above 100^0F (37.8^0C), but below 200^0F (93.3^0C), except any mixture having components with flashpoints of 200^0F (93.3^0C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

Compressed Gas -

(i) A gas or mixture of gases in a container, having an absolute pressure exceeding 40 psi at 70^0F (21.1^0C) or

(ii) A gas or mixture of gases in a container, having an absolute pressure exceeding 104 psi at 130^0F (54.4^0C) regardless of the pressure at 70^0F (21.1^0C) or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100^0F (37.8^0C) as determined by ASTM D-323-72.

Corrosive or Corrosive Material - As defined by the Department of Transportation (DOT), a corrosive material is a liquid or solid that causes visible destruction or irreversible alterations in human skin tissue at the site of contact or in the cases of leakage from its packaging, a liquid that has a severe corrosion rate on steel. For the purposes of locating emergency eye-wash and safety shower units, liquids with pH ranging from <1 to > 12 shall be considered corrosive.

Cutaneous - Pertaining to or affecting the skin.

Decomposition - Breakdown of a material or substance (by heat, chemical reaction, electrolysis, decay or other processes) into simpler substances.

Dermal - Pertaining to or affecting the skin.

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

Dyspnea - Shortness of breath, difficult or labored breathing.

Emergency - Any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the work place.

Emergency Eye-Wash/Safety Shower – equipment provided in the laboratory for emergency use in treating splashes of corrosive materials meeting the requirement of ANSI Z358.1 2009).

Employee - An individual employed in a laboratory work place who may be exposed to hazardous chemicals in the course of his or her assignments.

Erythema - A reddening of the skin.

Evaporation Rate - The ratio of time required to evaporate the same volume of a reference liquid (ether). A high ratio means a slower evaporation rate.

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

Exposure Limit - Limit set to minimize occupational exposure to a hazardous substance. Recommended occupational exposure limits used are American Council of Governmental Industrial Hygienists' Threshold Limit Values (TLV's) and Occupational Safety and Health Administration Permissible Exposure Limits (PEL's).

Extinguishing Agents - Agent(s) suitable for controlling or putting out a fire, when properly applied.

Flammable Limits - The range of a vapor/gas concentration in air that will burn or explode if an ignition source is present.

Flammable - A chemical that falls into one of the following categories:

(i) Aerosol, flammable means an aerosol that, when tested by the method described in 18 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening

(ii) Gas, flammable:

(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less or

(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

(iii) Liquid, flammable: Any liquid having a flashpoint below 100 F (37.7^{0}C), except any mixture having components with flashpoints of 100 F (37.7^{0}C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

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

Flashpoint - The minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24-1979 (ASTM D 56-79)-for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100^{0}F (37.8^{0}C), that do not contain suspended solids and do not have a tendency to form a surface film under test or

(ii) Pensky-Martens Closed Tester (see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7-1979 (ASTM D 93-79))-for liquids with a viscosity equal to or greater than 45 SUS at 100^{0}F (37.8^{0}C), or that contain suspended solids, or that have a tendency to form a surface film under test or

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

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

General Exhaust - Removal of contaminated air from a large area by an air circulation or exchange system.

Generic Substance - A substance identified by its general chemical name and/or formula.

Hazard Communication Program - The written program employers must develop and use. This program specifies employee training for routine and emergency use of all potentially hazardous chemicals in the workplace. It also specifies details pertaining to

chemical labels, chemical storage, MSDS, and the complete list of all hazardous chemicals in the workplace.

Hazardous Chemical - A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, and neurotoxins, agents which act on the hematopoietic systems and agents which damage the lungs, skin, eyes, or mucous membranes. Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

Health Hazard - Any chemical for which there is at least one scientific study that shows it may cause acute or chronic health symptoms. This includes chemicals which are carcinogens, toxic or highly toxic, irritants, corrosives, sensitizers, or chemicals that effect target organs including the lungs, kidneys, nervous system, pulmonary system, reproductive system, skin and eyes.

Highly Toxic - A chemical which has been found through testing of laboratory animals to cause death when exposed at certain levels.

(i) A chemical is highly toxic to ingest if it has a median lethal dose (LD50) of less than 50 mg/kg. This means that 50 percent of the test animals (rats) died when given an oral dosage of 50 milligrams for each kilogram of body weight.

(ii) A chemical is highly toxic to touch if it has a (LD50) rating of less than 200 mg/kg, meaning that 50 percent of the lab animals (rabbits) die after having continuous skin contact at that dosage for 24 hours or less.

(iii) A chemical is highly toxic to breathe if it has a (LC50) rating of less than 200 PPM for gas or vapor and a 2 mg/m^3 for dust, fume, or mist when exposed for an hour or less.

Ignition Source - Anything that provides heat, sparks, or flame sufficient to cause combustion/explosion.

Incompatible - Materials which could cause dangerous reactions from direct contact with one another are described as incompatible.

Ingestion - The drawing of a substance into the body (stomach) through the nose, mouth, and breathing passages, in the form of a gas, vapor, fume, mist, or dust.

Inhalation - The drawing of a substance into the body (lungs) through the nose, mouth, and breathing passages, in the form of a gas, vapor, fume, mist, or dust.

Irritant - A substance which will cause an inflammatory response or reaction of the eye, skin, or respiratory system, following single or multiple exposures.

Laboratory – A laboratory is defined as a facility or room where the use of potentially hazardous chemicals, biological agents or sources of energy (i.e. lasers, high voltage, radiation, etc.) used for scientific experimentation, research, or education.

Laboratory scale - Work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. "Laboratory scale" excludes those work places whose function is to produce commercial quantities of materials.

Laboratory Startup and Closeout – Process to ensure laboratory operations adhere to Chemical Hygiene program requirements.

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

Laboratory use of hazardous chemicals - Handling or use of such chemicals in which all of the following conditions are met:

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

(ii) Multiple chemical procedures or chemicals are used

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

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

LC50 - Lethal Concentration 50 the concentration in air that causes the death of 50% of the test animals. The concentration is expressed in mg/liter, mg/m^3.

LD50 - Lethal Dose 50 a single dose of material which on the basis of laboratory tests is expected to kill 50% of a group of test animals. The material may be administered by mouth (oral) or applied to the skin (dermal or cutaneous). The dose is expressed in g\kg of body weight.

LEL – (Lower Explosive Limit) LEL is the lowest concentration of a gas or vapor in the air that can produce ignition or explosion.

Local Exhaust – A local exhaust system is used for capturing and exhausting contaminants from the air to point where the contaminants (gases, particulates) are released. Not to be confused with "general exhaust".

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

MSDS – (Material Safety Data Sheet) See definition for Safety Data Sheet (SDS).

Mechanical Exhaust – Mechanical exhaust systems use a powered device, such as a motor-driven fan or air/street venturi tube, for exhausting contaminants from a workplace, vessel, or enclosure.

Narcosis - Stupor or unconsciousness caused by exposure to a chemical.

Neutralize - To render chemically neutral or harmless, e.g., neither acid nor base, to counteract the activity or effect, the addition of a base (sodium hydroxide) to an acid (hydrochloric acid) results in water and a salt (sodium chloride), thus the acid has been "neutralized" or rendered harmless.

Odor Threshold – An odor threshold is the minimum concentration of an airborne, toxic substance whose odor is detectable to the average individual. Depending on whether it is above or below the substance's TLV, it may be indicative of whether additional ventilation is required.

Oral - of, though, pertaining to, or affecting the mouth

Organic peroxide - An organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

OSHA – (Occupational Safety and Health Administration of the U.S. Department of Labor)

OSHA is a federal agency with safety and health enforcement authority for most of U.S. industry and business.

Oxidizer - Department of Transportation defines oxidizer or oxidizing material as a substance that yields oxygen readily to stimulate the combustion (oxidation) of organic matter. Chlorate (CLO_3), permanganate (MnO_4) and nitrate (NO_3) compounds are examples of oxidizers.

Particularly Hazardous Substance – include select carcinogens, reproductive toxins and substances which have a high degree of acute toxicity.

PEL - Permissible Exposure Limit an exposure limit established by OSHA's regulatory authority. PELS may be expressed as either a time weighted average (TWA) limit or a maximum concentration exposure limit.

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

Polymerization - A chemical reaction in which a large number of relatively simple molecules combine to form a large chainlike molecule. A hazardous polymerization is a reaction which takes place at a rate which releases large amounts of energy.

PPM - Parts per million a unit for measuring the concentration of a gas or vapor in contaminated air. Ppm is also used to indicate the concentration of a particular substance in a liquid or solid.

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

Pyrophoric – A pyrophoric is a chemical which ignites spontaneously with air at 130^0F or less.

Regulated Carcinogen – cancer causing agents that are adopted and regulated by OSHA.

Respiratory Protection - Devices for use in conditions exceeding set exposure levels when properly selected, maintained and worn by the user will protect the users' respiratory system from exposure to airborne contaminants by inhalation.

Reproductive toxins - Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Safety Data Sheet (SDS) - Written or printed material about a chemical that specifies its hazards, safe use and other information. It is prepared by the chemical manufacturer, and is required by federal law.

SCBA - Self-contained breathing apparatus.

Select Carcinogen - Any substance which meets one of the following criteria:

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

statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

a. After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m^3

b. After repeated skin application of less than 300 (mg/kg of body weight) per week or

c. After oral dosages of less than 50 mg/kg of body weight per day.

Sensitizer - A substance, which on first exposure, causes little or no reaction in man or test animals, but which on subsequent exposure(s) may cause a marked response not necessarily limited to the contact site. Skin sensitization is the most common form of the problem in the industrial setting, although respiratory sensitization to a few chemicals has been known to occur.

Solubility in Water - The percentage of a material (by weight) that will dissolve in water at a specific temperature.

NEGLIGIBLE LESS THAN 0.1%

SLIGHT 0.1 TO 1.0%

MODERATE 1 TO 10%

APPRECIABLE MORE THAN 10%

COMPLETE SOLUBLE IN ALL PROPORTIONS

Solvents - A substance which dissolves another substance.

Special Ventilation Areas – A special ventilation area is an Environmental room, isolation room, cold room, clean room, or incubator.

Specific Gravity - The specific gravity is the ratio of the weight of a volume of material to the weight of an equal volume of water usually at 60^0F.

Systemic - Spread throughout the body, affecting many or all body systems or organs, not localized in one spot or area.

TLV - Threshold Limit Value (exposure limit for a specific substance as per ACGIH). TLV is a measure of exposure to inhalation only.

TLV "Skin" - This designation sometimes appears alongside a TLV or PEL. It refers to the possibility of absorption of the particular chemical through the skin and eyes. Thus, the protection of large surface areas of skin should be considered to prevent skin absorption so that the TLV is not invalidated.

Target Organ - The specific organs or body systems that sustain hazardous effects from a toxic chemical, either long or short-term. Target organs could be the liver, kidney, central nervous system or skin.

Toxic - A substance which has a median lethal dose (LD50) of 50 to 500 mg/kg for ingestion, from 200 to 1,000 mg/kg within a 24-hour period for contact and from 200 to 2,000 PPM gas or vapor for inhalation.

UEL - Upper Explosive Limit - The highest concentration of a gas or vapor in air that can produce ignition or explosion.

Unstable (Reactive) – An unstable or reactive chemical can go through vigorous polymerization, decomposition or condensation. This process occurs when the chemical undergoes shock or changes in pressure or temperature.

Vapor Density - The ratio of the density of a substances vapor to the density of another substances vapor, usually air. A vapor density of greater than one means that the substance is heavier than air.

Vapor Pressure - The pressure exerted by vapor, in confinement, over its liquid as it accumulates at a constant temperature.

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

Appendix B

EH&S Laboratory Inspection Process

The following laboratory inspection process was approved by the EH&S Operations Committee May 24, 2006, and updated in March 2014.

1. **Purpose** – To define the roles, responsibilities, and process for the EH&S general laboratory safety inspection at ASU campuses.

2. **Internal Reference**
   - **a.** ASU Chemical Hygiene Plan
   - **b.** EHS 104 Laboratory Use of Hazardous Chemicals

3. **External Reference**
   - **a.** OSHA 29 CFR Part 1910.1450

4. **Definitions**
   - **a.** Laboratory Manager – ASU employee responsible for laboratory operations and the employees who work in the lab, usually the Principal Investigator (PI)
   - **b.** EH&S – Environmental Health & Safety
   - **c.** Risk Categories – Defined by ASU EH&S Risk Categories

5. **Equipment – Materials**
   - **a.** EH&S Laboratory Safety Inspection Database
   - **b.** EH&S Laboratory Safety Inspection Checklist

6. **Responsibility**
   - **a.** EH&S Laboratory Inspection Program Manager
     - Coordinate inspections of ASU Laboratories
     - Report metrics of inspections
     - Designate laboratories to be inspected
     - Oversee communication of inspection results to laboratory managers (PI, Department Heads, etc.)
     - Track completed inspections
     - Maintain EH&S inspection database
   - **b.** EH&S Employees
     - Inspect laboratories and provide results as directed by EH&S Laboratory Inspection Program Manager
     - Provide support to Laboratory Managers where applicable
   - **c.** Laboratory Managers
     - Correct and respond to inspection findings as determined by EH&S inspection reports under the guidance of the lab PI.
   - **d.** Compliance Officers
     - Assist with correcting deficiencies as determined by EH&S inspection reports and follow-up

7. **Procedures**
    - **a.** Laboratories to be inspected are designated by EH&S or Senior Compliance Officer
    - **b.** Laboratory inspections for high risk labs will be performed annually at a minimum
    - **c.** EH&S inspector examines an area by physically walking through the location with EH&S Laboratory Safety Inspection Checklist
    - **d.** EH&S Inspection Team or individual EH&S employee note deficiencies in work areas. The Laboratory Safety Inspection Checklist is to be used for guidance, but additional identified safety, health, and environmental deficient issues may be noted as deficiencies.
    - **e.** The inspector (or designee) enters information into the EH&S Laboratory Inspection Database and sends reports to designated Principal Investigator/Laboratory Manager
    - **f.** Principal Investigator is responsible for correcting deficiencies or designating a responsible party to make the corrections
    - **g.** Principal Investigator or Lab Manager may contact EH&S for support, when applicable
    - **h.** Principal Investigator or Laboratory Manager notifies EH&S Laboratory Inspection Program Manager when actions are completed
    - **i.** If appropriate, EH&S will contact the Laboratory Manager for follow-up of non-completed identified deficiencies. If the EH&S does not receive a response within 30-days of initial lab inspection report generation, a follow-up notification will be sent to the PI and/or Laboratory Manager. Department Chair, and College Dean. EH&S may conduct a follow-up inspection.
    - **j.** EH&S Chemical Hygiene Officer tracks metrics and reports as necessary
8. **Forms**
    - **a.** EH&S Laboratory Safety Evaluation Checklist
    - **b.** Chemical Inventory Template
    - **c.** Responsible Party Information Sheet (RPI)
    - **d.** EH&S Safety Registration Placard
    - **e.** Process Hazard Analysis
    - **f.** PPE Hazard Assessment
    - **g.** Standard Operating Procedures

9. **Laboratory Registration Signage**

    EH&S Laboratory Registration Signage update will be issued to each laboratory that returns a completed Responsible Party Information sheet and

a current chemical inventory (preferably in alphabetical order including compressed gas cylinders and biological agents).

10. Records

a. EH&S inspection database, 2 year retention minimum.
b. Standard Operating Procedures

The following Risk Categories were approved by the ASU Compliance Officer Operations Committee October 8, 2008.

ASU EH&S Risk Categories

Risk Categories	Areas Defined (Examples ONLY not all inclusive)
1 (Low)	Areas with general hazardous chemicals that do not have special risks. Examples: 1. Biosafety Level One (BSL1) laboratories 2. Labs with small useable amounts of chemicals 3. Classroom teaching labs (Academic teaching) 4. Lasers (Class 1, 2, 3A)
2 (Moderate)	Areas considered special risk laboratories. This defines the majority of laboratories. These labs use and store Particularly Hazardous Substances as defined in the ASU Chemical Hygiene Plan (select carcinogens, reproductive toxins, and toxic chemicals.) Examples: 1. All radioisotopes (use and storage) 2. Radiation producing equipment (X-rays, accelerators) 3. Biosafety Level Two (BSL2) containment laboratories with Non-Select Agents 4. Lasers (Class 3B, 4) 5. Large volumes of chemicals in storage (flammable cabinets etc.) 6. High voltage electrical equipment (>600 volts) 7. DEA Controlled Substances 8. Lab performing research with vertebrate animals
3 (High)	Areas with extremely hazardous activities and chemical or material use including highly sensitive areas where highest risk conditions exist. Examples:

	1. Select Agent laboratories and Biosafety Level Three (BSL3) facilities 2. Laboratories with security related equipment requiring passwords or security related entries (Select Agent, other highly sensitive or regulated areas)	3. Highly toxic gases or pyrophoric materials or gases (any quantity) 4. Areas whose grant applications require environmental and safety certification
Training/ SOPs	**Risk Category Training and Procedure Requirements** Category 1 All applicable EH&S required training and PI provided lab-specific safety training Category 2 & 3 All applicable EH&S required training and PI provided lab-specific safety training and Standard Operating Procedures (SOPs) for Particularly Hazardous Substances	

"Carcinogens" are chemicals which cause cancer. For the purpose of the CHP, chemicals which are known carcinogens include those which: are regulated by OSHA as carcinogens (29 CFR 1910); are listed under the category, "known to be human carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program, or are listed under group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs.

"Reproductive toxins" are chemicals which affect the reproductive capabilities including chromosomal damage (mutagens) and effects on the fetuses (teratogens). Examples of signs and symptoms include birth defects and sterility. Examples of chemicals which are reproductive toxins include lead and DBCP (dibromochloropropane).

"Highly toxic" are chemicals which have an average lethal dose of:

- Ingestion: LD_{50} of less than 50 mg/kg body weight when administered orally to albino rats;
- Skin Contact: LD_{50} of less than 200 mg/kg body weight when administered by continuous dermal contact over a 24 hour period to albino rabbits, or
- Inhalation: LC_{50} of less than 200 parts per million of gas or vapor or 2 mg/l of mist, fume, or dust, when administered continuously by inhalation for one hour to albino rats.

Extremely Hazardous Activities – a short list of chemicals/activities that are difficult to control and have lethal potential, or could trigger a life-shortening disease, in one low, level exposure, or could cause a lethal event (e.g., explosion). This list is evolving but

will likely include highly toxic, pyrophoric and carcinogenic gases, toxic gases with poor warning properties, beryllium, methyl mercury, etc.

Appendix C

List of Particularly Hazardous Substances
(Dangerous Chemicals)

Particularly Hazardous Substances

Particularly hazardous substances fall into the following three categories: acute toxins, reproductive toxins and carcinogens. All materials referred to in this section require the development and use of lab-specific Standard Operating Procedures (SOPs); more information can be found in **Appendix E**.

Acute Toxins

Substances that have a high degree of acute toxicity are substances that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short durations. For a more complete definition, see "Highly Toxic" materials in Appendix A for more information. A few examples are listed below, a more complete list of acutely toxic compounds is maintained online at EHS list of PHS.

Acutely Toxic Chemicals (examples, more complete list go to EHS list of PHS excel file)

Arsenic (inorganic)	7440-38-2	Formaldehyde	50-00-0
Benzene	71-43-2	Hydrazine	302-01-2
Bromine	7726-95-6	Hydrofluoric acid	7664-39-3
Dimethyl mercury	593-74-8	Perchloric acid	7601-90-3

Acutely Toxic Gases (examples, more complete list go to EHS list of PHS excel file)

Ammonia	7664-41-7	Hydrogen fluoride	7664-39-3
Arsine	7784-42-1	Hydrogen sulfide	2148-87-8
Carbon monoxide	630-08-0	Methyl mercaptan	74-93-1
Diborane	19287-45-7	Phosphine	7803-51-2

Reproductive Toxins

Reproductive toxins include any chemical that may affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis). A list of reproductive toxins is maintained online at EHS list of PHS.

Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally, they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Refer to the more complete definition of "Select Carcinogen" in Appendix A. The following 13 "Listed Carcinogens" are regulated by OSHA and have specific use and handling requirements per 29 CFR 1910.1003.

Listed Carcinogens

2-Acetylaminofluorene
4-Aminodiphenyl
Benzidine (and its salts)
3,3'-Dichlorobenzidine (and its salts)
4-Dimethylaminoazobenzene
alpha-Naphthylamine
beta-Naphthylamine
4-Nitrobiphenyl
N-Nitrosodimethylamine
beta-Propiolactone
bis-Chloromethyl ether
Methyl chloromethyl ether
Ethyleneimine

Air-Reactive Chemicals

Air reactive chemicals can spontaneously and violently react with air, and most are pyrophoric, meaning that they spontaneously ignite with air. These chemicals should be stored tightly in an inert atmosphere or in an inert liquid. A few examples are listed below. A more complete list of air reactive chemicals is maintained online at EHS list of PHS.

Aluminum alkyls
Barium hydride
Boranes
Cesium
Grignard reagents
Magnesium
Organolithium compounds
White and Red Phosphorus
Gases: Silane, Phosphine, Arsine

Water-Reactive Chemicals

Certain chemicals react with water to evolve heat and flammable or toxic gases and should be stored and handled so that they do not come in contact with liquid water or water vapor. A few examples are listed below. A more complete list of water-reactive chemicals is maintained online at EHS list of PHS.

Acetic anhydride
Acetyl chloride
Lithium
Metallic Peroxides

Aluminum phosphide	Metallic phosphides
Aluminum tribromide	Sodium
Calcium carbide	Sodium hydride
Chlorosulfonic Acid	Sodium oxide
Diborane	

Shock-Sensitive Compounds

Common classes of shock sensitive laboratory chemicals are listed below which have potential for producing a violent explosion when subjected to shock or friction.

- Acetylenic compounds, especially polyacetylenes, haloacetylenes, and heavy metal salts of acetylenes (copper, silver and mercury salts are particularly sensitive)
- Acyl nitrates
- Alkyl nitrates, particularly polyol nitrates such as nitrocellulose and nitroglycerine
- Ammine metal oxosalts: metal compounds with coordinated ammonia, hydrazine or similar nitrogenous donors and ionic perchlorate, nitrate, permanganate, or other oxidizing group
- Azides, including metal, nonmetal and organic azides
- Chlorite salts of metals, such as silver chloride or mercuric chloride
- Diazo compounds such as cyanamide
- Diazonium salts, when dry
- Fulminates such as mercury fulminate
- Hydrogen peroxide becomes increasingly treacherous as the concentration rises above 30%, forming explosive mixtures with organic materials and decomposing violently in the presence of traces of transition metals
- N-Halogen compounds such as difluoroamino compounds and halogen azides
- N-Nitro compounds such as N-nitromethylamine, nitrourea, nitroguanidine and nitric amide
- Oxosalts of nitrogenous bases: perchlorates, dichromates, nitrates, iodates, chlorites, chlorates, and permanganates of ammonia, hydroxylamine, guanidine, etc.

- Perchlorate salts. Most metal, nonmetal and amine perchlorates can be detonated and may undergo violent reaction in contact with combustible materials
- Peroxides and hydroperoxides, organic
- Peroxides (solid) that crystallize from or are left from evaporation of peroxidizable solvents
- Peroxides, transition-metal salts
- Picrates, especially salts of transition and heavy metal, such as nickel, lead, mercury, copper and zinc
- Polynitroalkyl compounds such as tetranitromethane and dinitroacetonitrile
- Polynitroaromatic compounds, especially polynitro hydrocarbons, phenols and amines (e.g., dinitrotoluene, trinitrotoluene and picric acid)

Sensitizers and/or Allergens

Sensitizers and/or allergenic chemicals include a wide variety of substances that can produce skin and lung hypersensitivity. Once a person is sensitized, repeated exposures to even the smallest levels of sensitizers can result in life-threatening allergic reactions.

A sensitizer causes a substantial portion of people to develop an allergic reaction in normal tissue after repeated exposure to it. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock. A few examples are listed below:

Epoxides	Nickel compounds
Poison ivy	Toluene diisocyanate
Chlorinated hydrocarbons	Chromium compounds
Formaldehyde	Amines

Appendix D

Laboratory-Specific Training Plan

Department of Environmental Health & Safety, Occupational Health & Safety

Laboratory-Specific Training

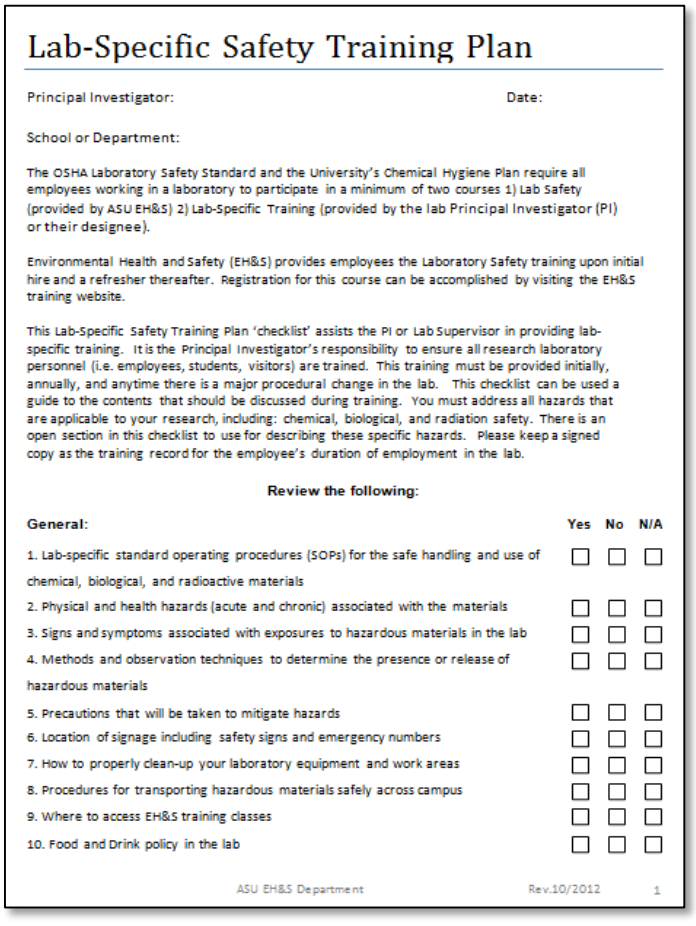
The OSHA Laboratory Safety Standard and the University's Chemical Hygiene Plan require all employees working in a laboratory to participate in a minimum of two courses

1) Laboratory Safety (provided by ASU EH&S), and
2) Lab-Specific Training (provided by the Principal Investigator (PI) or their designee).

Environmental Health & Safety (EH&S) provides employees the Laboratory Safety training course upon initial hire and an annual refresher thereafter. Registration for this course can be accomplished by visiting the EH&S training website.

ASU EH&S provides a Lab-Specific Training Plan template (checklist) designed to assist the PI or Lab Supervisor in the development of lab-specific training. It is the responsibility of the Principal Investigator to ensure all research laboratory personnel (i.e. employees, students, visitors) are trained. This training must be provided initially, annually, and anytime there is a major procedural change in the lab. The checklist can be used as a framework for material to be discussed during training. You must address all hazards that are applicable to your research, including: chemical, biological, and radiological safety. There is an open section in the checklist that can be used in describing these specific hazards. Please keep a signed copy as the training record for the employee's duration of employment in the lab.

Link to the Lab-Specific Safety Training Plan online



Lab-Specific Safety Training Plan

Principal Investigator: Date:

School or Department:

The OSHA Laboratory Safety Standard and the University's Chemical Hygiene Plan require all employees working in a laboratory to participate in a minimum of two courses 1) Lab Safety (provided by ASU EH&S) 2) Lab-Specific Training (provided by the lab Principal Investigator (PI) or their designee).

Environmental Health and Safety (EH&S) provides employees the Laboratory Safety training upon initial hire and a refresher thereafter. Registration for this course can be accomplished by visiting the EH&S training website.

This Lab-Specific Safety Training Plan 'checklist' assists the PI or Lab Supervisor in providing lab-specific training. It is the Principal Investigator's responsibility to ensure all research laboratory personnel (i.e. employees, students, visitors) are trained. This training must be provided initially, annually, and anytime there is a major procedural change in the lab. This checklist can be used a guide to the contents that should be discussed during training. You must address all hazards that are applicable to your research, including: chemical, biological, and radiation safety. There is an open section in this checklist to use for describing these specific hazards. Please keep a signed copy as the training record for the employee's duration of employment in the lab.

Review the following:

General:	Yes	No	N/A
1. Lab-specific standard operating procedures (SOPs) for the safe handling and use of chemical, biological, and radioactive materials	☐	☐	☐
2. Physical and health hazards (acute and chronic) associated with the materials	☐	☐	☐
3. Signs and symptoms associated with exposures to hazardous materials in the lab	☐	☐	☐
4. Methods and observation techniques to determine the presence or release of hazardous materials	☐	☐	☐
5. Precautions that will be taken to mitigate hazards	☐	☐	☐
6. Location of signage including safety signs and emergency numbers	☐	☐	☐
7. How to properly clean-up your laboratory equipment and work areas	☐	☐	☐
8. Procedures for transporting hazardous materials safely across campus	☐	☐	☐
9. Where to access EH&S training classes	☐	☐	☐
10. Food and Drink policy in the lab	☐	☐	☐

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Appendix E

Standard Operating Procedure

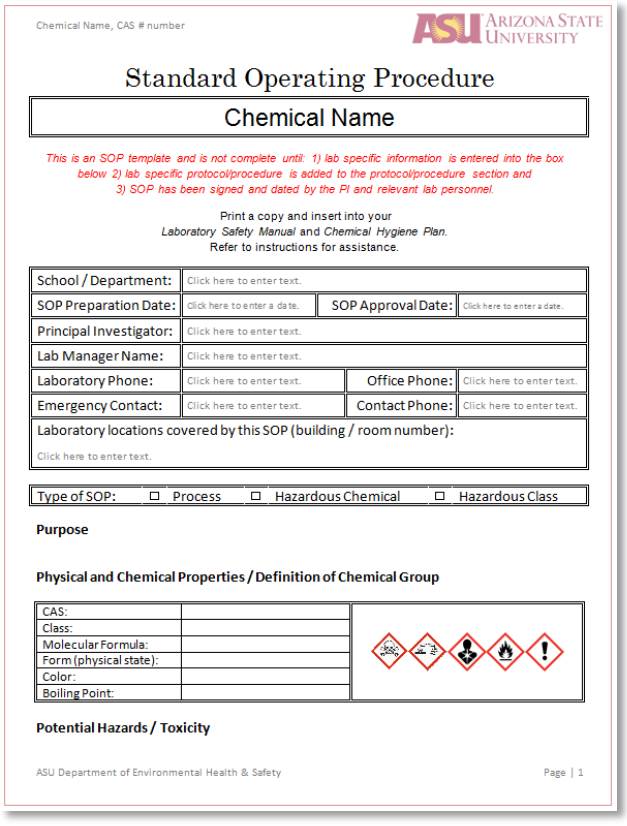
SOP Instructions and Template

Instructions for Completing Standard Operating Procedures

If your laboratory research involves the use of particularly hazardous substances or physically reactive materials such as the ones defined in Appendix C, you must develop laboratory-specific SOPs to supplement the information found in the Chemical Hygiene Plan and the material's Safety Data Sheet. EH&S maintains a library of SOP templates to further aid in the development of laboratory-specific research procedures. Below are instructions for completing the SOP using the corresponding template. Please contact ASU EH&S with any questions or comments you may have while completing your SOPs. Completed SOPs shall be reviewed by the PI and each lab employee prior to working with the material or procedure. The PI must approve changes to the procedure and the newly revised SOP shall again be reviewed by all lab employees prior to work. A sample template, like the one shown on this page, is available through the ASU EH&S website, click here for template.

1. Type of SOP

- **Process**: the SOP will be for a process such as distillation, synthesis, etc.
- **Hazardous Chemical**: the SOP will be for an individual chemical such as arsenic, formaldehyde, nitric acid, etc.
- **Hazard Class**: the SOP will be for a hazard class of chemicals such as oxidizer, flammable, corrosive, etc.



Chemical Name, CAS # number

ASU Arizona State University

Standard Operating Procedure

Chemical Name

This is an SOP template and is not complete until: 1) lab specific information is entered into the box below 2) lab specific protocol/procedure is added to the protocol/procedure section and 3) SOP has been signed and dated by the PI and relevant lab personnel.

Print a copy and insert into your *Laboratory Safety Manual* and *Chemical Hygiene Plan*.
Refer to instructions for assistance.

School / Department:	Click here to enter text.		
SOP Preparation Date:	Click here to enter a date.	SOP Approval Date:	Click here to enter a date.
Principal Investigator:	Click here to enter text.		
Lab Manager Name:	Click here to enter text.		
Laboratory Phone:	Click here to enter text.	Office Phone:	Click here to enter text.
Emergency Contact:	Click here to enter text.	Contact Phone:	Click here to enter text.
Laboratory locations covered by this SOP (building / room number): Click here to enter text.			

Type of SOP: ☐ Process ☐ Hazardous Chemical ☐ Hazardous Class

Purpose

Physical and Chemical Properties / Definition of Chemical Group

CAS:	
Class:	
Molecular Formula:	
Form (physical state):	
Color:	
Boiling Point:	

Potential Hazards / Toxicity

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2. Purpose

Brief description of how the chemical is used in the lab along with any information which describes why an SOP is important for the chemical or interest.

3. Physical and Chemical Properties / Definition of Chemical Group

Provide basic information on the chemical of interest including the CAS#.

4. Potential Hazards / Toxicity

Describe all the potential hazards for each process, hazardous chemical, or hazard class. Describe the potential for both physical and health hazards. Health hazards include carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes. State the potential for chronic and/or acute health hazard effects of the chemical(s).

Physical hazards include radioactivity, cryogen, high temperature, electrical, compressed gas or other pressure systems, UV light, laser, flammable or combustible, corrosive, water-reactive, unstable, oxidizer, pyrophoric, explosive, or peroxide forming chemical(s).

5. Personal Protective Equipment (PPE)

Identify the required PPE for the process, hazardous chemical, or hazard class. PPE includes, but is not limited to: gloves, aprons, laboratory coats, safety glasses, goggles, masks, respirators, or face shields.

6. Engineering Controls

Describe or list engineering controls that will be used to prevent or reduce employee exposure to hazards. Examples of engineering controls are fume hoods, glove boxes, interlocks on equipment, and shielding of various kinds.

7. First Aid Procedures

Describe any emergency first aid procedures that should be followed in case of a chemical exposure. Provide specific detail on responses under specific circumstances of exposure (e.g. inhalation, ingestion, skin contact, etc.).

8. Special Handling and Storage Requirements

Describe the storage requirements for hazardous substances, including special containment devices, special temperature requirements, special storage areas or cabinets, chemical compatibility storage requirements, etc. State the policy regarding access to the substance(s). Provide the exact storage location in the laboratory. Describe any special procedures, such as dating peroxide forming chemicals on receipt, opening and disposal, or testing after an appropriate amount of time has passed. Describe safe methods of transport, such as in a secondary container using a low, stable cart, or using two hands to carry the chemical container.

9. Spill and Accident Procedures

Describe special procedures for spills, releases or exposures (e.g., neutralizing agents, use of fluorescence to detect materials, etc.). Indicate how spills, accidental releases and exposures will be handled. List location of the following emergency equipment: chemical spill clean-up kit, first-aid kit, emergency shower, eyewash, and fire extinguisher.

Indicate the designated area established for experiments using particularly hazardous substances (PHS). A portion of a laboratory bench, a piece of equipment, the fume hood, or the entire laboratory may be considered as a designated area for experiments using PHS.

10. Decontamination Procedures / Waste Disposal Procedures

Describe specific decontamination procedures for equipment, glassware or work areas. Describe the anticipated waste products as well as how waste will be collected and disposed.

11. Safety Data Sheet (SDS) Location

State where the SDSs are kept for the chemicals, or hazardous substances, used in the laboratory. Indicate the location of other pertinent safety information (e.g., references, equipment manuals, etc.).

12. Protocols

Insert a copy of your specific laboratory procedures for the process, hazardous chemical or chemical hazard class.

13. Documentation of Training

A list of personnel who have reviewed the SOP. A signature and date of training are needed to complete the table.

Appendix F

Personal Protective Equipment Risk Analysis

ARIZONA STATE UNIVERSITY

Department of Environmental Health & Safety, Occupational Health & Safety

PERSONAL PROTECTIVE EQUIPMENT (PPE) Risk Analysis

Principal Investigators and Lab Managers must survey the work areas and activities under their control to determine where PPE may be required.

Instructions: Identify the workplace location. Conduct a walkthrough survey of the workplace and list the task or job functions that require PPE. Ensure PPE has an acceptable ANSI rating based on the chart provided on the back of this sheet. Conduct interviews with employees while performing field observations when necessary and complete this form. Sign and date this certificate. The completed certificate should remain on file in your area as well as additional areas required by your department.

Please note: When determining if a potential hazard exists, consideration should be given to the following:

- history of injuries or illnesses related to the workplace or job
- history of employee complaints or concerns
- employees perception of hazards

Location _____ **Department** _____

Task	Potential Hazard	PPE Required

Observation		
Are employees wearing PPE appropriate to tasks? ☐ Yes ☐No	Is PPE worn and adjusted properly? ☐ Yes ☐No	Is PPE maintained in good condition? ☐ Yes ☐No

If no, describe corrective action taken:

I, _____ , certify that the above location has been evaluated for potential hazards and the appropriate PPE, and that training has been performed.

Signature of Assessor _____

Appendix G

Hazardous Material Storage Guide

Arizona State University
Hazardous Material Storage Guide
General Rules and Principles

Stock containers of chemicals in ASU labs must be organized and stored in accordance with this guidance. The primary purpose of this guide is to provide hazardous material users guidance regarding how to control health or physical hazards posed by hazardous materials during storage in the lab. Specifically, it is designed to 1) protect flammables from ignition; 2) minimize the potential of exposure to poisons; and 3) segregate incompatible materials to prevent their accidental mixing.

A Designated Storage Place for Each Compound

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

Do not store excess supplies of chemicals on lab bench tops where they are unprotected from ignition sources or potentially damaged. Only chemicals in use or of low hazard (e.g., salts and buffers) are permitted on bench tops.

Do Not Store In Chemical Fume Hood

Do not keep excessive supplies of chemicals or waste in chemical fume hoods where they clutter space, interfere with the hood's air-flow, and contribute to materials that could become involved in a fire or accidental release of hazardous materials.

Close or Seal All Chemical Containers

All chemical containers must be closed except when adding or removing material including bottles used for hazardous waste chemicals. Hazardous waste containers must remain closed except when actually filling the container. In some instances, potential pressure build-up inside of containers poses a significant hazard, written SOPs should warn users about such a hazard and provide alternative guidance.

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.

Storage Under the Sink

Do not store any chemicals except compatible general cleaning agents under the sink. Chemicals can be stored in a cabinet under a fume hood if the cabinet is designed and manufactured for hazardous material storage.

Label Chemicals and Hazardous Waste Properly

All containers within the lab must be labeled according to the instructions in the ASU Chemical Hygiene Plan. Suspect and known carcinogens must be labeled as such and segregated within secondary trays to contain leaks and spills. Hazardous waste containers must be labeled with the words “Hazardous Waste” and must include a description of the contents.

Liquid Chemicals

Storage of liquid chemicals is more hazardous than storage of solids and are subject to numerous and varied storage requirements.

Safeguard Against Theft

This plan does not require security measures (e.g., locked cabinets) to prevent theft, but lab workers should make sure that lab doors are locked when unattended.

Chemical Storage Groups

Chemicals must be stored in the groups and corresponding facilities described on the following pages. This guide demonstrates nine storage groups. Seven of these groups are for storage of liquids because of the variety of hazards posed by these chemicals. Specific instructions must be followed for metal hydrides (Group 8) and certain individual compounds, but otherwise, all dry solids are in Group 9.

How to Determine Correct Storage Group

Determine the correct storage group by the hazard information on the chemical container label, chemical Safety Data Sheet (SDS), or contact ASU EH&S.

Multi-Hazard Liquids

Many liquid chemicals pose hazards that correspond to more than one storage group. Liquid storage groups are shown in descending order of hazard. The correct storage group for a multi-hazard chemical is the group representing the greatest storage hazard, or the group appearing highest in this list.

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: Metal Hydrides

Group 9: Dry Solids — Least Hazardous

Storage Group Definitions

Group 1: Flammable Liquids

Includes liquids with flashpoints < 100°F Examples: 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: To protect from ignition.

Acceptable Storage Facilities/Methods:

- Flammable cabinet
- Explosion-proof refrigerator/freezer
- In-use containers such as properly labeled squirt bottles may be on benchtops

Compatible Storage Groups: Flammables may be 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: carbon tetrachloride, chloroform, dimethylformamide, dimethyl sulfate, formamide, formaldehyde, halothane, mercaptoethanol, methylene chloride, phenol.

Primary Storage Concern: To prevent inhalation exposures.

Acceptable Storage Facilities/Methods:

- Flammable cabinet
- Refrigerator for containers less than 1 liter

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: nitric, sulfuric, perchloric, phosphoric, and chromic acids.

Primary Storage Concern: Preventing contact and reaction with each other and other substances and corrosive action on surfaces.

Acceptable Storage Facilities/Methods:

- Safety cabinet
- Each oxidizing acid must be double-contained (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 small 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 see section below Group 4.

Group 4: Organic and Mineral Acids

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

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

Acceptable Storage Facilities/Methods:

- Safety cabinet

Compatible Storage Groups: Small amounts of double-contained oxidizing acids 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 these with organic compounds.

Group 5: Liquid Bases

Liquid bases. Examples: sodium hydroxide, ammonium hydroxide, calcium hydroxide, glutaraldehyde

Primary Storage Concern: Preventing contact and reaction with acids.

Acceptable Storage Facilities/Methods:

- Safety cabinet
- In tubs or trays in a standard cabinet

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

Group 6: Liquid Oxidizers

Oxidizing liquids react with everything potentially causing explosions or corrosion of surfaces. Examples: ammonium persulfate, hydrogen peroxide (if greater than or equal to 30%)

Primary Storage Concern: To isolate from other materials.

Acceptable Storage Facilities/Methods:

- Total quantities exceeding 3 liters must be kept in a cabinet housing no other chemicals
- Smaller quantities must be double-contained when stored near other chemicals (e.g., in a refrigerator)

Compatible Storage Groups: None

Group 7: Non-Volatile Liquid Poisons

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

Primary Storage Concern: To prevent contact and reaction with other substances.

Acceptable Storage Facilities/Methods:

- Cabinet or refrigerator (i.e., must be enclosed)
- Do not store on open shelves in the lab or cold room
- Liquid poisons in containers larger than 1 liter must be stored below bench level on shelves closest to the floor; smaller containers of liquid poison can be stored above bench level only if behind sliding (non-swinging) doors.

Compatible Storage Groups: 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

Most metal hydrides react violently with water; some ignite spontaneously in air (pyrophoric). Examples: sodium borohydride, calcium hydride, lithium aluminum hydride

Primary Storage Concern: To prevent contact and reaction with liquids and, in some cases, air.

Acceptable Storage Facilities/Methods:

- Secure, waterproof double-containment according to label instructions
- Isolation from other storage groups

Compatible Storage Groups: If securely double-contained to prevent contact with water and/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: benzidine, cyanogen bromide, ethylmaleimide, oxalic acid, potassium cyanide, sodium cyanide

Primary Storage Concern: To 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- or sulfide-containing poisons (solids); a spill of aqueous liquid onto cyanide- 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.

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.

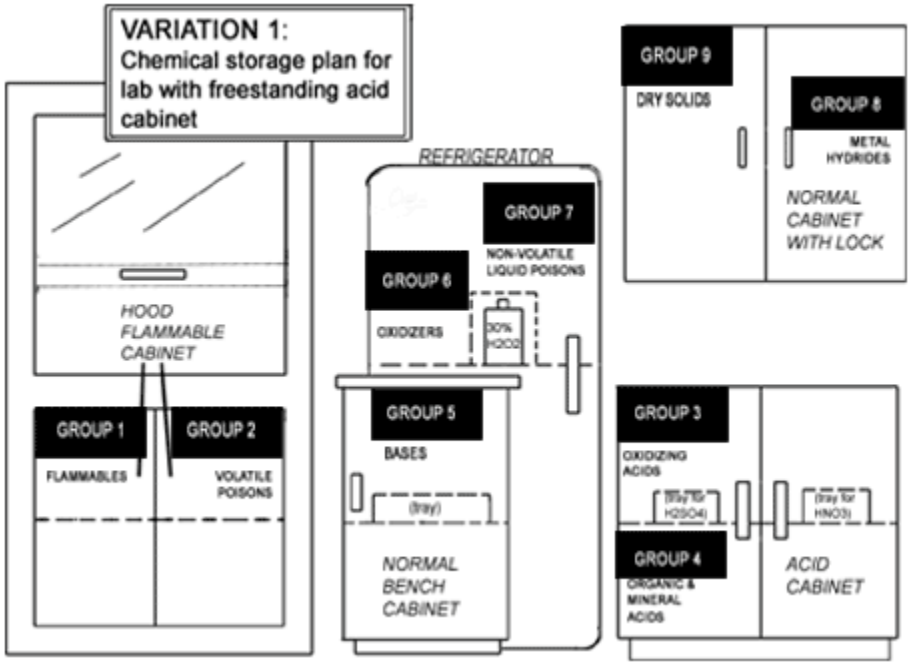
Storage Plan Variations for Different Laboratory Facilities

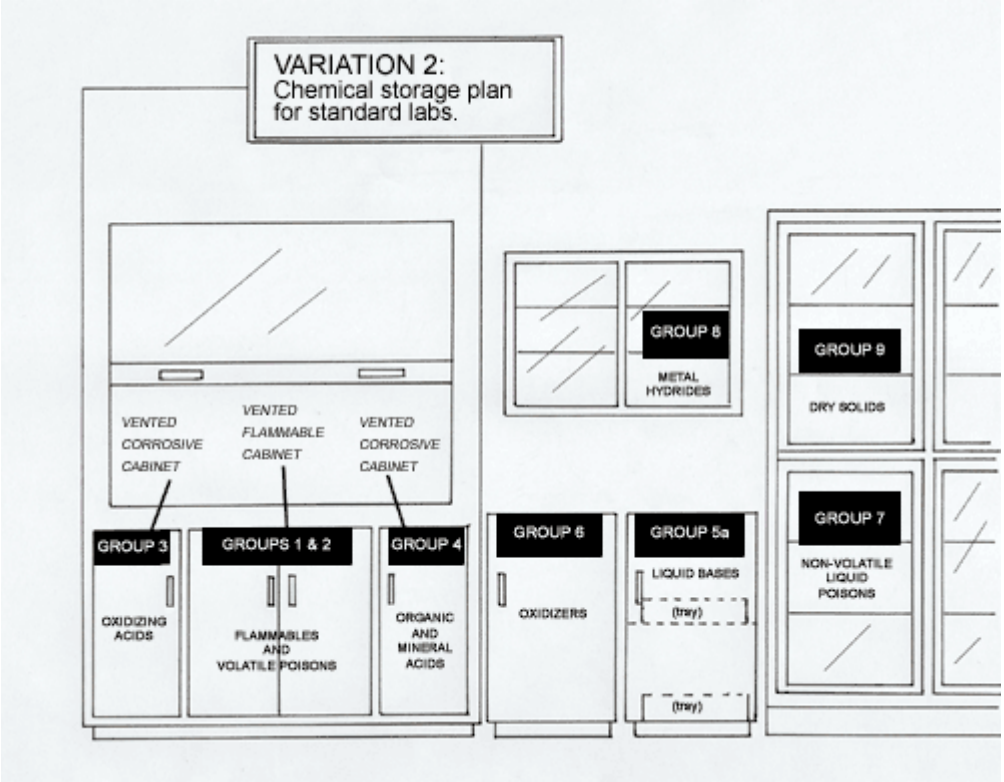
On the following pages are illustrations of possible (non-mandatory) chemical storage arrangements for two types of lab facilities. They are provided merely as examples of arrangements that satisfy the requirements of the chemical storage plan. They are not intended to restrict storage to the particular arrangements and facilities depicted. Refer to Storage Group Definitions for segregation and facility requirements.

The illustrations are titled as follows:

Variation 1: Chemical storage plan for lab with freestanding acid cabinet.

Variation 2: Chemical storage plan for standard labs.





Examples of Incompatible Chemicals

The following is not a complete listing of incompatible materials. It contains some of the more common incompatible materials. Always utilize research materials such as Safety Data Sheets you work with in order to work safely in the lab.

Chemicals listed in Column A should not be stored with or used near those in Column B.

Column A	Column B
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetic anhydride	Hydroxyl-containing compounds such as ethylene glycol, perchloric acid
Acetone	Concentrated nitric and sulfuric acid mixtures, hydrogen peroxide

Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali and alkaline earth metals such as powdered magnesium, sodium, potassium	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury, halogens, calcium hypochlorite, hydrofluoric acid
Column A	**Column B**
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids, heavy metals and their salts, oxidizing agents
Calcium oxide	Water
Carbon, activated	All oxidizing agents, calcium hypochlorite
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible material
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Chromic acid and chromium trioxide	Acetic acid, alcohol, camphor, glycerol, naphthalene, flammable liquids in general
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens, other oxidizing agents
Fluorine	All other chemicals

Hydrides	Water
Hydrocarbons (e.g., butane, propane, benzene)	Fluorine, chlorine, bromine, chromic acid, peroxides
Hydrocyanic acid	Nitric acid, alkalis
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, any flammable liquid (i.e., alcohols, acetone), combustible materials, aniline, nitromethane
Column A	**Column B**
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Metal hydrides	Acids, water
Nitrates	Acids
Nitric acid (concentrated)	Acetic acid, acetone, alcohol, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Mercury and silver and their salts
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, alcohol, bismuth, paper, wood, grease, oils
Permanganates	Concentrated sulfuric acid, glycerol, ethylene glycol, benzaldehyde

Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus, white	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids, ammonium salts, metal powders, sulfur, finely divided organics, combustibles
Potassium perchlorate (see also chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Silver and silver salts	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Column A	**Column B**
Sodium	Carbon tetrachloride, carbon dioxide, other chlorinated hydrocarbons, water
Sodium nitrate	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric acid	Chlorates, perchlorates, permanganates

Adapted from *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*, National Research Council, 1995

Basic Chemical Segregation

Hazard Class of Chemical	Recommended Storage Method	Examples	Incompatibilities

Compressed gases - Flammable	Store in a cool, dry area, away from oxidizing gases. Securely strap or chain cylinders to a wall or bench.	Methane Hydrogen Acetylene Propane	Oxidizing and toxic compressed gases, oxidizing solids.
Compressed gases - Oxidizing	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench.	Oxygen Chlorine Bromine	Flammable gases
Compressed gases - Poisonous	Store in a cool, dry area, away from flammable gases and liquids. Securely strap or chain cylinders to a wall or bench.	Carbon monoxide Hydrogen sulfide Nitrogen dioxide	Flammable and/or oxidizing gases.
Hazard Class of Chemical	**Recommended Storage Method**	**Examples**	**Incompatibilities**
Corrosives - Acids	Store separately in acid storage cabinet. Segregate oxidizing acids (i.e., Chromic, nitric, sulfuric, and perchloric acids) from organic acids	Acetic acid Phenol Sulfuric acid Chromerge Nitric acid Perchloric acid Chromic acid Hydrochloric acid	Flammable liquids, flammable solids, bases, oxidizers
Corrosives - Bases	Store in separate corrosive storage cabinet. Store solutions of inorganic hydroxides in labeled polyethylene containers.	Ammonium hydroxide Sodium hydroxide Calcium hydroxide	Flammable liquids, oxidizers, poisons, and acids

Flammable Liquids	Store in flammable storage cabinet and away from sources of ignition. Store highly volatile flammable liquids in an explosion-proof refrigerator.	Acetone Benzene Diethyl ether Methanol Ethanol Toluene Glacial acetic acid	Acids, bases, oxidizers, and poisons
Flammable Solids	Store in a separate dry, cool area away from oxidizers, corrosives, flammable liquids	Phosphorus, yellow Calcium carbide Picric acid Benzoyl peroxide	Acids, bases, oxidizers, and poisons
General Chemicals - Non-reactive	Store on general laboratory benches or shelving preferably behind glass doors and below eye level.	Agar Sodium chloride Sodium bicarbonate Most non-reactive salts	See specific MSDS.
Water-Reactive Chemicals	Store in dry, cool location, protect from water fire sprinkler.	Sodium metal Potassium metal Lithium metal Lithium aluminum hydride	Separate from all aqueous solutions and oxidizers.
Hazard Class of Chemical	**Recommended Storage Method**	**Examples**	**Incompatibilities**
Oxidizers	Store in a spill tray inside a chemical storage cabinet. Separate from flammable and combustible materials.	Ammonium persulfate Ferric chloride Iodine Sodium hypochlorite Benzoyl peroxide Potassium permanganate Potassium dichromate	Separate from reducing agents, flammables, and combustibles.

		The following are generally considered oxidizing substances: Peroxides, perchlorates, chlorates, nitrates, bromates, and superoxides.	
Poisons/Toxic Compounds	Store separately in vented, cool, dry area, in unbreakable chemically-resistant secondary containers and in accordance with the hazardous nature of the chemical.	Aniline Carbon tetrachloride Chloroform Cyanides Heavy metals compounds, i.e., cadmium, mercury, osmium Oxalic acid Phenol Formic acid	Flammable liquids, acids, bases, and oxidizers. See specific MSDS.
Carcinogens	Label all containers as "Cancer Suspect Agents". Store according to the hazardous nature of the chemical, using appropriate security when necessary.	Benzidine Beta-naphthylamine Benzene Methylene chloride Beta-propiolactone	See specific MSDS.
Hazard Class of Chemical	**Recommended Storage Method**	**Examples**	**Incompatibilities**
Teratogens	Label all containers as "Suspect Reproductive Hazard". Store according to the hazardous nature of the chemical, using appropriate security when necessary.	Lead and mercury compounds Benzene Aniline	See specific MSDS.

Peroxide-Forming Chemicals	Store in air-tight containers in a dark, cool, dry area. See Table 3 for recommended storage time limits.	Diethyl ether Acetaldehyde Acrylonitrile	See specific MSDS.
Strong Reducing Agents	Store in cool, dry, well-ventilated location. Water reactive. Segregate from all other chemicals.	Acetyl chloride Thionyl chloride Maleic anhydride Ferrous sulfide	See specific MSDS.

Suggested Storage Time Limits for Common Peroxide Crystal Forming Compounds

Peroxide formation occurs when certain laboratory chemicals react with air at ordinary temperatures to form peroxy compounds, which are violently reactive or explosive. Organic peroxides are classified as low-power explosives that are hazardous because of the sensitivity to shock, sparks or other ignition sources. Additionally they are sensitive to heat, friction, impact, light and strong oxidizing and reducing agents.

All organic peroxides are flammable and have a specific rate of decomposition under a given set of conditions. Due to unusual stability problems, bulk quantities of peroxides should be approached with caution because they may generate enough heat to auto accelerate up to ignition. Peroxides/Peroxide forming chemicals include, but are not limited to the following lists.

MOST DANGEROUS: Discard after 3 months. Peroxide formation hazard during storage.	
Diisopropyl ether	Potassium metal
Divinyl acetylene	Sodium amide
Isopropyl ether	Vinylidene chloride

DANGEROUS: Discard after one year. Peroxide formation hazard during storage and on concentration (i.e., distillation) of compound.		
Acetal	Dicyclopentadiene	Methyl cyclopentane
Acetaldehyde	Diethyl ether	Methyl isobutyl ketone
Cumene	1,4-Dioxane	Tetrahydrofuran
Cyclohexene	Ethylene glycol dimethyl ether	Tetrahydronaphthalene
Diacetylene	Methyl acetylene	Vinyl ethers

DANGEROUS: Discard after one year. Peroxide formation causes initiation of hazardous polymerization.		
Acrylic acid	Chloroprene	Tetrafluoroethylene

Acrylonitrile	Chlorotrifluoroethylene	Vinyl acetate
1,3-Butadiene	Methyl methacrylate	Vinyl acetylene
2-Butanol	2-Propanol	Vinyl chloride
	Styrene	Vinyl pyridine

Appendix H

Guidelines for Nanotechnologies Related Research

Nanotechnology is an emerging industry and area of research that involves the engineering of items on a molecular level. For years now, experts have been heralding the science as a field with enormous promise. Considerable advancements in nanotechnology have already been made and this is a growing area of research at ASU. Nanotech products can already be found in many consumer products, including food, makeup and other products. Reason for concern related to potential EH&S risks associated with nanotechnologies and in particular, carbon nanotubes, have recently surfaced. For this reason, ASU's EH&S department is recommending an approach referred to as control banding to address the potential risks associated with research in areas concerned with nanotechnologies.

Control banding (CB) is a strategy for qualitative risk assessment and management of hazards in the workplace. The strategy involves a process to group workplace risks into control bands based on combinations of hazard and exposure information. CB strategies are not intended to be predictive exposure models. The table below provides general guidelines for specific nanotechnologies already in use in many areas of research. It is recommended that this table be used a guideline for develops an SOP for all nanotechnology related research. At a minimum, any new research involving nanotechnologies must follow the Prior Approval process identified in this CHP.

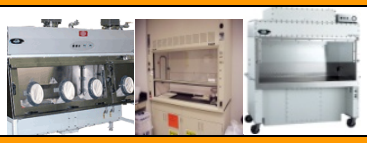
Green – NSL 1 **Nanomaterials consist of Little to no harm - known to be inert**	
Scenario Description	**Name or Description of Nanomaterial**
Gold nanoparticles used to test carbon nanotube filter	Gold nanoparticles
Mixed polystyrene spheres with buffer, etching nanostructures onto semiconductors.	Polystyrene spheres, nanostructures
Deposition of liquid-suspended nanoparticles onto surfaces using low voltage electric fields	Polymer latex, gold, platinum, palladium nanoparticles
Preparation of examples. Activities include cutting, slicing, grinding, lapping, polishing, chemical etching, electrochemical polishing and ion etching	Carbon black, Aluminum (Al) oxide, Mg oxide, polycrystalline diamond suspension, colloidal silica, Palladium (Pd) power, carbon nanotubes

Sample preparation and characterization	Gold, silver nanoparticle, Iron oxide, silicon dioxide, aluminum oxide, carbon, ceramic aerogels and nano-powders
Synthesis of aerogel	Silica, iron, chromium, copper, zinc nanoparticles, titanium nanoparticles
Required: Engineering Controls	**General Ventilation**
	General HVAC
Required: Personal Protective Equipment	**Lab coat, safety glasses/goggles single nitrile gloves**
	

Yellow – NSL 2 Nanomaterials consist of Potential Hazards(s)	
SCENARIO DESCRIPTION	**NAME OR DESCRIPTION OF NANOMATERIAL**
Synthesis of metal oxide nanowires on substrates within a tube furnace	Zinc oxide (ZnO), Tin Oxide (SnO2), Titanium Oxide (TiO2), Lead zirconium titanium oxide (PBZrTiO3), Barium Titanium oxide (BaTiO3) and Strontium Titanium oxide (SiTiO3) nanowires
Synthesis of silver and copper oxide nanoparticles	Silver (Ag) oxide nanoparticles, Copper (Cu) oxide nanoparticles
Addition of quantum dots onto porous glass	Cadmium selenide, lead sulfide
Growth of palladium nanocatalyst	Palladium nanocatalyst
Water is poured into container with liquid-suspended carbon nanotubes	Carbon nanotubes
Analysis of nanomaterial waste samples in to laboratory	Various
Purification and functionalization of carbon nanotubes	Carbon nanotubes
Synthesis and optical characterization of nanoparticles	Cadmium Selenium (CdSe) quantum dots, germanium quantum dots, iron oxide, gold, lead sulfide nanoparticles

Sample preparation and characterization of CdSe Nano dots	Cadmium Selenium (CdSe) quantum dots
Sample preparation and characterization of carbon diamonds	Carbon diamonds
Sample preparation and characterization using laser microscopy	Gold, silver nanoparticles
SCENARIO DESCRIPTION	**NAME OR DESCRIPTION OF NANOMATERIAL**
Preparation of nanofoams sample for microscopy	Gold, copper, aluminum, nickel nanoparticles
Preparation of carbon nanotubes sample for microscopy	Carbon nanotubes
Machining (e.g., turning, milling) of aerogels and nanofoams for target assembly	Silica aerogels, tantulum aerogels, metal nanofoams (copper, gold), carbon nanofoams
Site wide waste sampling activities	Various
Waste accumulation area activities, including waste management, waste packaging, etc.	Various
Radioactive and Hazardous Waste Management field tech activities, including waste management, waste packaging, waste sampling, etc.	Various
Required: Engineering Controls	**Fume hood or BSL**
	 
Required: Personal Protective Equipment	**Lab coat, safety glasses/goggles, single nitrile gloves**
	

Orange – NSL 3
Nanomaterials – limited information is known

SCENARIO DESCRIPTION	NAME OF DESCRIPTION OF NANOMATERIAL
Activities related to operating and maintaining a vertical tube quench furnace and horizontal tube furnace	Gold, (Ag) Copper (Cu) Nickel (Ni) brass, Silver (Au) and Platinum (PT) nanoparticles
Required: Engineering Controls	**Glove box, fume hood with HEPA or hard ducted BSC**
	
Required: Personal Protective Equipment	**Lab coat, safety glasses/goggles, double nitrile gloves**
	

RED – NSL 4 Nanomaterials information is unknown Inhalation hazard	
SCENARIO DESCRIPTION	**NAME OF DESCRIPTION OF NANOMATERIAL**
Nanomaterial is attached to a chemical that is carcinogenic, etc.	
Required: Engineering Controls	**Glove box, fume hood with HEPA or hard ducted BSC**
	
Required: Personal Protective Equipment	**Lab coat, safety glasses/goggles double nitrile gloves and N95/N100 respirator**
	

Appendix I

Maximum Allowable Storage Quantities
International Fire Code, 2003 Revision, Table 2703.1.1(1)

ARIZONA STATE UNIVERSITY

Department of Environmental Health & Safety, Occupational Health & Safety

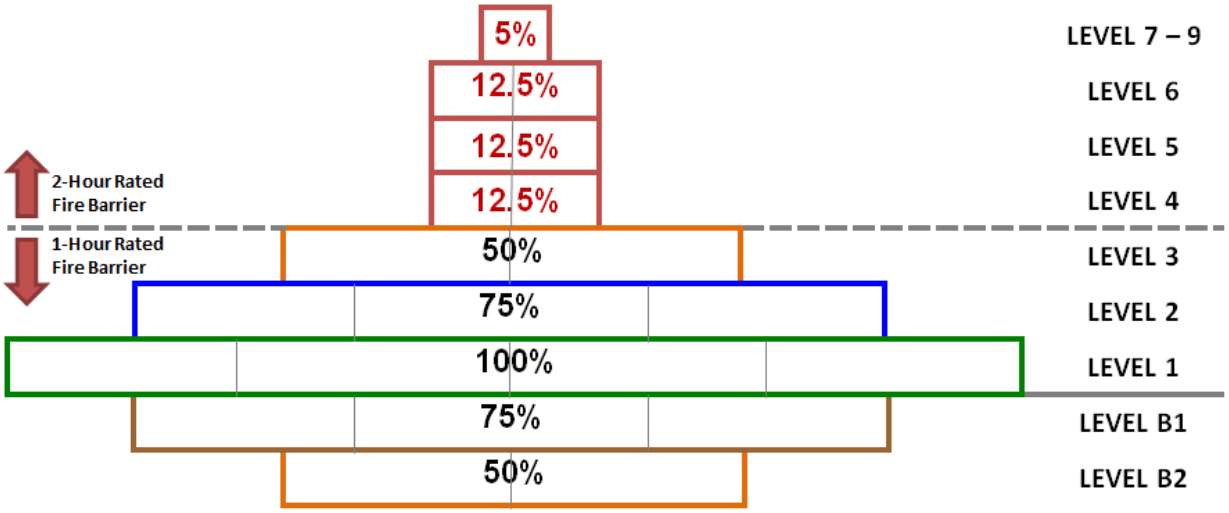
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERAILS POSING A PHYSICAL HAZARD
TABLE 2703.1.1(1), INTERNATIONAL FIRE CODE, 2003, ABRIDGED FOR ACADEMIC AND RESEARCH LABORATORIES

MATERIAL	CLASS	STORAGE [b]			USE – CLOSED SYSTEMS [b]			USE – OPEN SYSTEMS [b]	
		Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)
Combustible liquid [i]	II	N.A.	120 [d, e]	N.A.	120 [d]	N.A.	N.A.	N.A.	30 [d]
	IIIA		330 [d, e]		330 [d]				80 [d]
	IIIB		13,200 [e, f]		13,200 [f]				3,300 [f]
Combustible fiber	Loose	(100)	N.A.	N.A.	(100)	N.A.	N.A.	(20)	N.A.
	Baled	(1,000)			(1,000)			(200)	
Cryogenic Flammable	N.A.	N.A.	45 [d]	N.A.	N.A.	45 [d]	N.A.	N.A.	10 [d]
Consumer Fireworks (Class C Common)	1.4G	125 [d, e, l]	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Cryogenic Oxidizing	N.A.	N.A.	45 [d]	N.A.	N.A.	45 [d]	N.A.	N.A.	10 [d]
Explosives	Division 1.1	1 [e, g]	(1) [e, g]	N.A.	0.25 [g]	(0.25) [g]	N.A.	0.25 [g]	(0.25) [g]
	Division 1.2	1 [e, g]	(1) [e, g]		0.25 [g]	(0.25) [g]		0.25 [g]	(0.25) [g]
	Division 1.3	5 [e, g]	(5) [e, g]		1 [g]	(1) [g]		1 [g]	(1) [g]
	Division 1.4	50 [e, g]	(50) [e, g]		50 [g]	(50) [g]		N.A.	N.A.
	Division 1.4G	125 [d, e, l]	N.A.		N.A.	N.A.		N.A.	N.A.
	Division 1.5	1 [e, g]	(1) [e, g]		0.25 [g]	(0.25) [g]		0.25 [g]	(0.25) [g]
	Division 1.6	1 [e, g]	N.A.		N.A.	N.A.		N.A.	N.A.
Flammable gas	Gaseous	N.A.	N.A.	1,000 [d, e]	N.A.	N.A.	1,000 [d, e]	N.A.	N.A.
	Liquefied		30 [d, e]	N.A.		30 [d, e]	N.A.		
Flammable liquids	IA	N.A.	30 [d, e]	N.A.	N.A.	30 [d]	N.A.	N.A.	10 [d]
	IB and IC		120 [d, e]			120 [d]			30 [d]
Combination Flammable liquid (IA, IB, IC)	N.A.	N.A.	120 [d, e, h]	N.A.	N.A.	120 [d, h]	N.A.	N.A.	30 [d, h]
Flammable solid	N.A.	125 [d, e]	N.A.	N.A.	125 [d]	N.A.	N.A.	25 [d]	N.A.

MATERIAL	CLASS	STORAGE [b]			USE – CLOSED SYSTEMS [b]			USE – OPEN SYSTEMS [b]	
		Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)
Organic peroxide	UD	1 [e, g]	(1) [e, g]	N.A.	0.25 [g]	(0.25) [g]	N.A.	0.25 [g]	(0.25) [g]
	I	5 [d, e]	(5) [d, e]		1 [d]	(1) [d]		1 [d]	(1) [d]
	II	50 [d, e]	(50) [d, e]		50 [d]	(50) [d]		10 [d]	(10) [d]
	III	125 [d, e]	(125) [d, e]		125 [d]	(125) [d]		25 [d]	(25) [d]
	IV	Not limited	Not limited		Not limited	Not limited		Not limited	Not limited
	V	Not limited	Not limited		Not limited	Not limited		Not limited	Not limited
Oxidizer	4	1 [g]	(1) [e, g]	N.A.	0.25 [g]	(0.25) [g]	N.A.	0.25 [g]	(0.25) [g]
	3 [k]	10 [d, e]	(10) [d, e]		2 [d]	(2) [d]		2 [d]	(2) [d]
	2	250 [d, e]	(250) [d, e]		250 [d]	(250) [d]		50 [d]	(50) [d]
	1	4,000 [e, f]	(4,000) [e, f]		4,000 [f]	(4,000) [f]		1,000 [f]	(1,000) [f]
Oxidizing gas	Gaseous	N.A.	N.A.	1,500 [d, e]	N.A.	N.A.	1,500 [d, e]	N.A.	N.A.
	Liquefied		15 [d, e]	N.A.		15 [d, e]	N.A.		
Pyrophoric	N.A.	4 [e, g]	(4) [e, g]	50 [e, g]	1 [g]	(1) [g]	10 [e, g]	0	0
Unstable (reactive)	4	1 [e, g]	(1) [e, g]	10 [e, g]	0.25 [g]	(0.25) [g]	2 [e, g]	0.25 [g]	(0.25) [g]
	3	5 [d, e]	(5) [d, e]	50 [d, e]	1 [d]	(1) [d]	10 [d, e]	1 [d]	(1) [d]
	2	50 [d, e]	(50) [d, e]	250 [d, e]	50 [d]	(50) [d]	250 [d, e]	10 [d]	(10) [d]
	1	Not limited	Not limited	Not limited	Not limited	Not limited	Not limited	Not limited	Not limited
Water reactive	3	5 [d, e]	(5) [d, e]	N.A.	5 [d]	(5) [d]	N.A.	1 [d]	(1) [d]
	2	50 [d, e]	(50) [d, e]		50 [d]	(50) [d]		10 [d]	(10) [d]
	1	Not limited	Not limited		Not limited	Not limited		Not limited	Not limited

b. The aggregate quantity in use and storage shall not exceed the quantity listed for storage.
d. Maximum allowable quantities shall be increased 100 percent in buildings equipped throughout with an approved automatic sprinkler system in accordance with Section 903.3.1.1. Where Note e also applies, the increase for both notes shall be applied accumulatively.
e. Maximum allowable quantities shall be increased 100 percent when stored in approved storage cabinets, gas cabinets, exhausted enclosures or safety cans. Where Note d also applies, the increase for both notes shall be applied accumulatively.
f. Quantities shall not be limited in a building equipped throughout with an approved automatic sprinkler system in accordance with Section 903.3.1.1.
g. Allowed only in buildings equipped throughout with an approved automatic sprinkler system.
h. Containing not more than the maximum allowable quantity per control area of Class IA, Class IB or Class IC flammable liquids.
i. Inside a building, the maximum capacity of a combustible liquid storage system that is connected to a fuel-oil piping system shall be 660 gallons provided such system complies with this code.
k. A maximum quantity of 200 pounds of solid or 20 gallons of liquid Class 3 oxidizers is allowed when such materials are necessary for maintenance purposes, operation or sanitation of equipment when the storage containers and the manner of storage are approved.
l. Net weight of pyrotechnic composition of the fireworks. Where the net weight of the pyrotechnic composition of the fireworks is not known, 25 percent of the gross weight of the fireworks including packaging shall be used.

MAXIMUM ALLOWABLE QUANTITY PER BUILDING LEVEL OF HAZARDOUS MATERIALS POSING A PHYSICAL HAZARD
TABLE 2703.8.3.2, INTERNATIONAL FIRE CODE, 2003 REVISION, TABLE APPEARANCE MODIFIED FOR ASU CHP



EACH BLOCK REPRESENTS ONE CONTROL AREA WITH EITHER A ONE OR TWO HOUR RATED FIRE BARRIER. THE PERCENTAGE IS THE FRACTION OF THE MAXIMUM PRESCRIBED QUANTITY FOR EACH CATEGORY OF HAZARDOUS MATERIAL AS LISTED IN TABLE 2703.1.1(1)

Appendix J

Lab Safety Self-Assessment Checklist

The Lab Safety Self-Inspection Assessment Checklist available at EH&S Lab Safety.

Lab Safety Self Inspection Checklist						
Building			Date		Department	
Room			Inspector			
PI			Cc on report:			

	Y	N	NA		Comments
A. COMMUNICATION & EMERGENCY PREPAREDNESS					
Chemicals					
				All MSDSs are on file in department and readily accessible to employees.	
Training					
				PI or Lab Staff Supervisor has a writtten specialized safety training plan for staff which includes standard operating procedures (SOPs) for particularly hazardous materials. *Note: The minimum items to be included in the plan are: required attendance and documentation of Lab-specific training and EH&S provided safety classes (examples include: Lab Safety, Fire Safety, Hazardous Waste Mgmt., Biosafety), SOP's for particulary hazardous substances such as: pyrophorics, flammable solids, toxic gases, toxins, carcogens, teratogens, mutagens etc.*	
Contingency Planning and Emergency Procedures					
				ASU Emergency Response Procedures posted in lab.	
Exits and Width of Exits					
				Exits and aisles have a 28-inch clearance which is clear and free of potential obstructions in case of emergency.	
B. HAZARDOUS MATERIALS					
Labeling					
				Containers of hazardous materials are labeled per the ASU Chemical Hygiene Plan. Examples of materials may include such items as: raw product, chemical solutions, or synthesized materials. Examples of labels include: original material manufacturer label, secondary labels created by staff, or abbreviations. Abbreviations (i.e. EtOH) have a list or legend including full chemical names and hazards posted for interpretation in the near vicinity.	
Control					
				Incompatible chemicals are segregated and in compatible containers for the chemical.	
				All chemical containers are closed except when actively adding or removing materials from container (i.e. no funnels sticking out of the top of containers for days).	
C. LABORATORY / HAZARDOUS WASTE					
Containment and Storage					
				Waste containers are sturdy, compatible with the waste, and kept closed at all times except when adding hazardous waste.	
Labeling					
				Containers are labeled with the words "HAZARDOUS WASTE," with the waste's physical state, hazardous properties, and full product names (not chemical formulations).	
D. HEALTH & SAFETY EQUIPMENT					
Fire Prevention and Electrical Safety					
				Appropriate fire extinguisher available within 30 feet and inspected within the past 12 months (see tag on fire extinguisher).	
				18 inch vertical clearance maintained from sprinkler heads or 24 inch vertical clearance maintained from ceiling without sprinkler heads.	
Compressed Gas Cylinder Safety					
				Secured to a structural component of the building with chains at 2/3 the cylinder height. *Note: Cylinders must not be strapped together. Carts for transporting cylinders are not to be used for their permanent storage.*	
				Protective caps in place while the cylinders are not in use or connected for use. Cylinder regulators are removed while cylinder is in storage.	
Personal Protective Equipment (PPE) required in lab work					
				Appropriate safety glasses/goggles, face shields, lab coats, closed-toed footwear, aprons, gloves, respirators, PPE for radiological work or other PPE are available and in use by employees. Employee use of respiratory protection has been approved by EH&S Dept.	
E. HOUSEKEEPING & MISCELLANEOUS LABORATORY SAFETY					
Food and Drink					
				Eating, drinking, smoking, gum chewing, applying cosmetics, and taking medication in the lab where possible contamination by toxic, radioactive, or infectious materials is strictly prohibited. *Note: Laboratory employees must perform these activities outside the laboratory. Each Departmental Dean, Director, Chair or their designee may designate areas within laboratory facilities where these activities are permitted. See ASU Chemical Hygiene Plan for details.*	
				Refrigerators, freezers, microwaves, ovens, and so forth used for research are not used for edible food storage or preparation. This equipment must be labeled with appropriate placards for the type of material stored or used in them, such as "NOT FOR USE OF FOOD"- for research materials and "FOR FOOD USE ONLY"- for edible food. *Note: These signs are available from EH&S*	
Housekeeping and Miscellaneous Laboratory Safety					
				Vacuum lines equipped with traps designed specifically to accumulate/filter the hazardous materials being evacuated. Vacuum pumps used for chemical applications have exhaust routed to and exhausted ventilation system (i.e. chemical fume hood).	
				Any other comments or findings	

Appendix K

Vacuum Pump Safety Guidance

GENERAL SAFETY PRACTICES FOR UTILIZING VACUUM PUMPS AND HOUSE VACUUM SYSTEMS WITH CHEMICAL SOLUTIONS

Vacuum Pumps

1) Inspect all laboratory vacuum pumps used with chemicals and verify that they do not vent into general room air. If the system vents into general room air and cannot be vented into the laboratory hood or local exhaust system, contact EH&S for an evaluation.
2) Verify oil condensers are in place for vacuum pumps utilizing oil as a lubricant.
3) Utilize cold traps to protect pumps from corrosive materials and whenever evaporating flammable solvents with pumps that are not intrinsically safe. After completion, immediately disconnect and empty the cold trap into a designated hazardous waste container. Also, please ensure that the cold trap is not set up in such a manner as to allow chemicals to drain or be washed into any drains. This may represent a regulatory compliance issue.
4) Verify that all employees and students working with vacuum equipment are trained and understand how to use vacuum equipment safely and understand that cold traps must be monitored to ensure they do not go dry.

House Vacuum Pumps

House vacuum systems are evaluated by EH&S and CPMG during installation and are designed to vent potentially hazardous materials in a controlled manner to prevent potential exposure to lab personnel. However, this does not eliminate user responsibilities to protect the house vacuum system from potential chemical contaminants. When evacuating potentially flammable, toxic or corrosive materials always use a liquid collection and a cold trap to remove any significant amount of potentially hazardous material from contaminating the house vacuum system. Contamination of the house vacuum system may lead to vacuum system down time and impact all labs in the building.

PROCEDURE FOR WORKING ON CONTAMINATED LABORATORY VACUUM PUMPS AND SYSTEMS

The following information is provided as guidance to minimize potential chemical exposure while performing maintenance or repair on laboratory vacuum pumps. This is a brief overview only. More information is available from EH&S. Please forward an e-mail message to EHS@asu.edu or contact us at (480) 965-1823 if more information is needed.

Contamination of the sealing liquids in vacuum pumps can occur because the liquid (often oil) has direct contact with any contaminant passing through the vacuum system. Depending on the chemistry of the sealing liquid and the contaminant, chemical residues or a byproduct of a chemical reaction between the two may be present. **As a result of this contamination, facilities personnel could potentially be exposed to small amounts of a variety of hazardous materials, during removal, maintenance or reconfiguration of vacuum systems.**

The following guidelines have been developed to minimize risk when working on laboratory vacuum systems:

- For **small vacuum systems using portable pumps**, attempt to identify specific hazardous chemicals entering the system by conferring with laboratory personnel regarding the uses of vacuum systems and the extent that traps or other control devices have been used. If the history of usage indicates that a dangerous material has been used in the system and may have potentially left residue or hazardous byproducts, disconnect the pump and conduct all service operations within a laboratory fume hood. If this is not possible, contact EH&S at (480) 965-1823.
- For **Central Vacuum Systems**, chemical specific information will not be available. In cases where work is conducted on central vacuum systems, or where the use of the vacuum system is unknown, assume that the system components are contaminated with chemical residues and follow this procedure.
- Notify affected personnel if the system maintenance will affect the central vacuum system. Control energy sources when required using appropriate lock out or tag out procedures.
- Close appropriate valves to isolate effected parts of the system.
- **Where possible, purge the system with clean air before beginning work.**
- **Ensure there is proper ventilation to the work area, particularly when working in small areas. Uses of portable ventilation systems or closed systems designed to route displaced air to a safe location are recommended.**
- Latex or nitrile gloves are adequate for most applications. Specialty gloves may be needed if extreme contamination is present. If cut protective gloves are indicated, they should be worn over chemical protective gloves.

- If cutting or other work generates dusts, safety glasses with side shields are indicated. If work generates mists or the possibility of liquid splash, goggles are indicated.
- If applicable, remove sealing liquid carefully. Avoid splashing or excessive pouring. Place in a sealed container. Liquid should be containerized and disposed of as a hazardous waste. Smaller vacuum pumps or systems can be drained in laboratory hoods to avoid exposure.
- Sealing liquid that is removed during the course of service must be disposed of as a hazardous waste. If you have any questions regarding hazardous waste contact EH&S Hazardous Waste at (480) 965-8554.
- Reusable gloves, drop cloths, and/or coveralls may be rinsed or laundered and reused. Disposable or damaged personal protective equipment can be disposed of as regular trash.
- Always wash hands after service activities.

IMPORTANT! Reactions involving highly reactive compounds such acetylene, butadiene, dioxane, ethylene oxide, oxygen and all strong oxidizing agents, must be handled with caution.

What is a Pressure Vessel?

Based on the ASME Code Section VIII, pressure vessels are containers for the containment of pressure, either internal or external. This pressure may be obtained from an external source or by the application of heat from a direct or indirect source, or any combination thereof. Generally, a pressure vessel is a storage tank or vessel that has been designed to operate at pressures above 15 p.s.i.g. Examples include glassware, autoclaves, compressed gas cylinders, compressors (including refrigeration), vacuum chambers, and custom designed laboratory vessels.

What are the Hazards associated with Pressure Vessels?

The pressure differential (whether created from chemical reaction, compressed gas,

heating, chilling or vacuum), cracked/damaged vessels or leakage from vessels are all potential hazards.

Two consequences result from a complete rupture:

- Blast effects due to sudden expansion of the pressurized fluid.
- Fragmentation damage and injury, if vessel ruptures.

For a leakage failure, the hazard consequences can range from no effect to very serious effects:

- Suffocation or poisoning, depending on the nature of the contained fluid, if the leakage occurs into a closed space.
- Fire and explosion (physical hazards for a flammable fluid).
- Chemical and thermal burns from contact with process liquids.

How to Use and Handle Pressure Vessels Safely

1. Select a reactor or pressure vessel which has the capacity, pressure rating, corrosion resistance and design features that are suitable for its intended use.

2. When working with pressurized systems that are not specially constructed and certified to contain the pressure (or systems that may develop pressure due to heat or reaction) take the following steps to prevent personal injury:

- Use a metal or shatter proof glass or plastic screen to protect personnel from physical injury;

- Use a pressure relief valve if the device is connected to an external source (gas cylinder, compressor, pump, etc.) that creates a pressure above 15 psi;

- Make sure the regulator is appropriate or designed for the system;

- Periodically inspect the set up for physical damage or stress. (If not sure what to look for contact EH&S);

- Use a lower pressure or a different system (e.g., a pump) if it will not adversely affect the research;

- Consider all conditions that may affect the pressure vessel (gas versus liquid, heated/cooled, corrosion, etc.);

3. Install and operate the equipment within suitable barricade, if required, using appropriate safety accessories.

4. Establish training procedures to ensure that any person handling the equipment knows how to use it properly.

5. Maintain the equipment in good condition and establish procedures for periodic testing to be sure that the vessel

remains structurally sound.

Ventilation

The room in which a pressure vessel will be operated must be well ventilated. This is particularly important when working with flammable or toxic material. Labs are considered to be well ventilated rooms. The reactors should be located close to a laboratory hood or exhaust fan so that any released gases can be discharged safely. There should be no open flames in adjacent areas. Gases and effluent purposely discharged from pressure vessels must be routed through a fume hood or other local exhaust ventilation system.

Load Limits

One of the most subtle and frequently overlooked hazards that can arise in pressure vessel operation is produced by overfilling the vessel. A vessel must never be filled to more than three-fourths of its available free space, and in some cases the charge must be reduced even further for safe operation. Dangerous pressures can develop suddenly when a liquid is heated in a closed vessel if the available free space is not sufficient to accommodate the expanding the liquid. This is particularly true of water and water solutions which may increase to as much as three times their initial volume when heated from room temperature to the critical point at 374 °C. If the free space in the vessel is not sufficient to accommodate this expansion, destructive pressures will develop very suddenly and unexpectedly.

Maintenance and Training

The user must realize that it is his/her responsibility to keep the vessel in good condition and to use it only within the prescribed temperature and pressure limits. User must be constantly aware of the serious consequences that can result from such things as: opening the wrong valve, mixing combustible vapors with air or oxidizing gases, adding reactants too fast or failing to observe and prevent a sudden increase in temperature or pressure. Supervisors should make frequent checks to be sure that all safety rules are being observed.

For More Information

Contact EH&S at EHS@asu.edu or (480) 965-1823 if you have

questions or need assistance.

Additional information is available through the Arizona Division of Occupational Safety and Health (ADOSH)
Section R20-5-404. Standards for Boilers, Lined Hot Water Heaters and Pressure Vessel
http://www.ica.state.az.us/ADOSH/Forms/ADOSH_Rules_Boilers_2009_rev1.pdf

Appendix L

Safe Handling Procedures for Cryogenic Materials

General precautions for all use of Liquid Nitrogen and other Cryogenic Materials:

Liquid Nitrogen and all other Cryogenic Materials can cause significant burns. Hand protection and goggles (not safety glasses) are to be worn at all times when handling liquid nitrogen. When handling large quantities, a full length apron will minimize the chance of a spill going into your shoes, where it might destroy several cubic centimeters of flesh before you can get your shoes and socks off. Persons using a tipper to dispense liquid nitrogen and other Cryogenic Materials must wear a full face shield over goggles, cryogenic-gloves, full length trousers/pants or a full length apron, and footwear that cover the entire foot.

Guard against pressure build-up by using a pressure relief vessel or a venting lid. Remove metallic jewelry/watches on hand and wrists.

Glass Dewars must be taped solidly around the outside. The plastic mesh with which some small thermoses are sold protects the Dewar itself to an extent, but does not protect against injury from glass shards resulting from implosion.

Asphyxiation -- Nitrogen is not poisonous; the air is already about 78% nitrogen (oxygen makes up about 21%, and trace gases the remaining 1%). However, if sufficient liquid nitrogen or other Cryogenic Material vaporized from a pressurized container into a poorly ventilated space it can reduce the oxygen percentage to below 20%. Personnel in that space are in critical jeopardy due to rapid oxygen deprivation. Rapid venting can cause rapid displacement of normal air, leading to a local concentration of nearly 100% nitrogen or other Cryogenic Material.

All Cryogenic liquids produce large amounts of gas when they vaporize. If a sufficient amount of liquid is vaporized within a closed vessel it will produce enormous pressure that could rupture the vessel. For this reason, cryogenic liquid containers are protected with multiple pressure relief devices.

Expansion Ratio at 20 degrees Celsius for Common Cryogenic Fluids (Liquid to Gas)

Cryogenic Liquid	Liters of Liquid	Liters of Gas Produced	Cubic Feet of Gas Produced
Nitrogen	1	696	24.6
Oxygen	1	861	30.4
Helium	1	754	26.6

Use only vessels designed for extreme cold. **Not all Dewars are rated for liquid nitrogen or other Cryogenics!**

Cryotubes containing samples stored under liquid nitrogen may explode without

warning. Tube explosions are thought to be caused by liquid nitrogen entering the tube through minute cracks and then expanding rapidly as the tube thaws. Serious accidents can occur when a tube fails.

Dispensing Liquid Nitrogen and other Cryogenic Materials:

DO NOT transfer liquid nitrogen from high pressure outside bulk storage containers to low pressure transportable vessels or Dewar containers unless the low pressure container is fully designed and designated to accept high pressure material. Transferring high pressure nitrogen to incompatible containers is very dangerous.

Liquid Nitrogen and other Cryogenic Materials are to be dispensed only into smaller Dewars which either have carrying handles or are on wheels, and which have pressure relief valves or pressure venting lids. *A wide-base Dewar which is stable on a wheeled cart qualifies as "on wheels".*

Persons filling Dewars should wear full length trousers/pants or full length apron, and footwear that covers the entire foot, along with goggles, face shield, hearing protection and cryo-gloves. Persons filling must be in constant awareness of the filling operation.

- To prevent splashing, place the filling hose at or below the mouth of the receiving vessel.

Transporting Cryogenics by hand or cart through a building or between buildings:

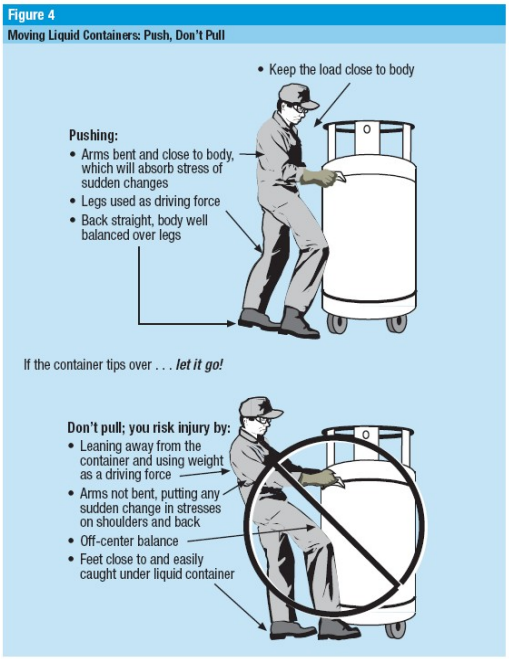
Large mobile Dewars or liquid nitrogen refrigerators (or the trolleys carrying these) used for transporting cryogens within a building or between buildings should be equipped with a braking mechanism. Do not use feet to “brake” wheels. Take care to avoid crushing hands or fingers between the vessel and walls or door frames**. Do not transport Liquid Nitrogen or other Cryogenic Materials in open containers.**

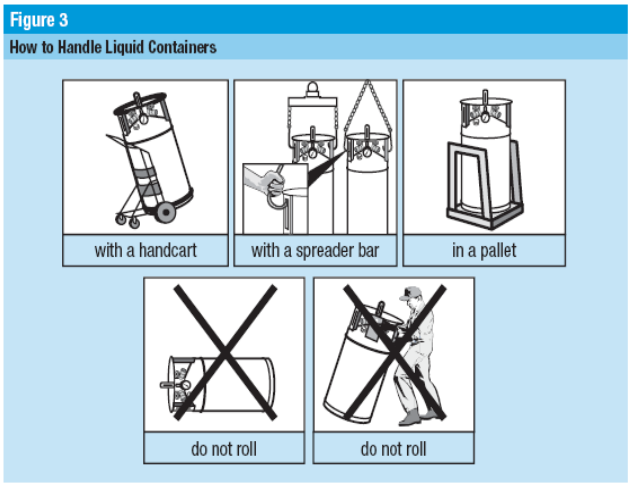
Outside transport of wheeled vessels containing ***any cryogenic material*** should be undertaken by no less than two persons, and care must be taken to stay completely clear of sewer grates, large cracks in the pavement, or any other hazards which could catch the wheels and cause tipping.

Inside buildings the best transport from room to room is by using a Dewar that is equipped with carrying handles or is on wheels, and which have pressure relief valves or pressure venting lids. *Note: A wide-base Dewar which is stable on a wheeled cart qualifies as "on wheels".*

For short distances in hallways it is acceptable to hand-carry **a quart or smaller** Dewar of liquid nitrogen or other Cryogenic Materials which have no handles, **as long as:**

- the Dewar is your only load (no books, no coffee, no other items), and
- the vessel has a venting lid (a cork or loose stopper is fine), and
- you are carefully watching for people who will run into you, and
- you are wearing appropriate PPE, and
- the vessel is carried with both hands and as far away from your face as comfortably possible.





Transport of Nitrogen and other Cryogenic Materials on an Elevator

Care must be exercised when transporting pressurized liquid cryogenic material containers on an elevator. Due to the confined nature of an elevator, a nitrogen gas or other cryogenic material leak from a pressurized container could produce an oxygen deficient atmosphere in a very small amount of time through the displacement of oxygen.

When a **pressurized container** has been placed on an elevator, the elevator must travel between floors unoccupied.

All elevator doors should be manned to prevent entry by person/s, or signage placed on the dewar to prevent riders from entering elevator. The sender should remain outside the elevator and activate it to the desired floor. Another person should be available on the receiving floor to take the liquid container off the elevator at its destination.

If it is absolutely necessary to have an attendant in the elevator with the container, an escape pack supplemental breathing apparatus must be carried in the elevator.

DO NOT transport a pressurized container of Liquid Nitrogen or Cryogenic Material at any time in an elevator with any other person/s in the elevator car. If the elevator cannot be operated to prevent unauthorized entry, then a sign must be posted on the dewar itself to warn anyone observing the dewar in the elevator not to enter. See example below.