CENTER FOR HEALTH SCIENCES

CHEMICAL HYGIENE MANUAL

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Oklahoma State University
Center for Health Sciences
CHEMICAL HYGIENE MANUAL

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1.0 INTRODUCTION

The Oklahoma State University Center for Health Sciences (OSU-CHS) is committed to managing chemicals used by lab workers in a responsible, safe, and environmentally sound manner. This manual has been written to define the program adhered to for the management of work performed and chemicals in laboratory activities. It contains requirements specified by the Occupational Safety and Health Administration (OSHA) standard codified in the Code of Federal Regulations (CFR), Title 29, 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories" as agreed to and enforced by Oklahoma Department of Labor Occupational Health and Safety Standards Act in Title 380, Chapter 40. The standard may be requested from the principal investigator (PI) or the research office, Laboratory Safety Coordinator (LSC). A hard copy of the Chemical Hygiene Manual shall be made available in each laboratory by the PI. The Chemical Hygiene Manual will be reviewed annually by the Chemical Hygiene and Radioisotope Use Committee (CHRUC) and updated as necessary.

Inspections, assessments, audits are routine ways to ensure that the procedures outlined in this manual and additional good laboratory practices are being implemented in the laboratory. The checks can be made by laboratory personnel, the LSC, and authorized local, state and federal organizations or agencies that are associated with safety. An inspection checklist that laboratory personnel may use to assist in assuring that lab personnel and laboratories are in compliance with practices required by the OSU-CHS research office, although not "all-inclusive", may be found on the CHS Office of Research URL.

2.0 APPLICABILITY

The Chemical Hygiene Manual shall be implemented by all lab workers who work with hazardous chemicals in laboratories. The procedures herein are mandatory. ***Laboratory use of hazardous chemicals*** means handling or use of such chemicals in which all of the following conditions are met:

> (i) Chemical manipulations are carried out on a "laboratory scale," handling of substances are designed to be easily and safely manipulated by one person;
>
> (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.

All other chemical activities not included by this definition shall follow the requirements of the OSHA regulations found in 29 CFR 1910.1200 "Hazardous Communications." Where the action level (AL) (or in the absence of an action level, the permissible exposure limit(PEL)) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.

Although OSHA regulations are written for employees, the safety precautions contained within this manual are also to be applied to students who are present in laboratories but are not employed by OSU-CHS.

3.0 ABBREVIATIONS

AL	action level
CAS#	Chemical Abstract Services Registry Number
CFH	chemical fume hood
CFR	Code of Federal Regulations
CHRUC	Chemical Hygiene and Radioisotope Use Committee
CIL	chemical inventory list
HMIS	Hazardous Materials Identification System
JHA	job hazard analysis
lab	laboratory
LSC	Laboratory Safety Coordinator
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
OSU-CHS	Oklahoma State University Center for Health Sciences
PEL	permissible exposure limit
PHS	particularly hazardous substance
PI	Principal Investigator
PPE	personal protective equipment
SDS	safety data sheet
SOP	safe operating procedure
STOT	single target organ toxicity

4.0 DEFINITIONS (also see chemical hazard specific definitions in Appendix H)

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

Chemical Abstracts Services Registry number (CAS#): a numeric designation assigned by the American Chemical Society's Chemical Abstracts Service that uniquely identifies a specific chemical compound. This number allows one to conclusively identify a material regardless of the name or naming system used.

Employee: all full-time and part-time faculty, administrative/professional, and hourly staff-may include students; all those who are on the OSU-CHS payroll.

Hazard assessment: development processes to effectively integrate the identification or recognitions of hazards and the evaluation of the risk of those hazards with the aim of using this information to formulate a plan to minimize or manage the risk presented by those hazards prior to the start of work.

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

Job Hazard Analysis (JHA): written guidelines for procedures and tasks involving recognized hazards. Controls are then determined to mitigate the hazards. An effective JHA communicates the hazards and safety of *who* will perform the task, *what* materials are necessary, *where* the task will take place, *when* the task shall be performed, and *how* the person will execute the task.

Particularly Hazardous Substances (PHSs): these include carcinogens, reproductive toxins, and substances which have a high degree of acute toxicity. The OSU-CHS research office, with recommendation from OSHA, has included reactive chemicals as PHSs. (See Section 7.0 and Appendix H for assistance in identifying particularly hazardous substances)

Permissible exposure limit (PEL): the regulatory exposure limit adopted by OSHA in 29 CFR 1910.1000, a concentration usually expressed as a time-weighted average in units of mg/m3 or parts per million based on an 8-hour day, 40-hour week during which nearly all workers may be repeatedly exposed without adverse effects. PEL's can be found in the SDS (Safety Data Sheet) or other reference materials such as 29 CFR 1910.1000 Tables Z1-3 and should not be exceeded.

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

PI: those faculty or employees of OSU-CHS who have responsibility to direct the work of others in a particular laboratory. The department chair is generally listed as the first person in the department phone lists in the CHS Directory located on the OSU-CHS website. The responsibilities outlined in this program for the "PI" are directed toward the department chair or PI; but may be delegated to others in the department or groups who have been assigned supervisory roles by the department chair or PI.

Safe Operating Procedure (SOP): a comprehensive approach to evaluating the safety challenges presented by a scientific experiment, process, or hazardous materials where every aspect of an experiment must be thought out in advance so that the goal is achieved by identifying the risks of harm and controlling the hazards inherent in all steps of an experimental process.

Safety data sheet (SDS): information written by the chemical manufacturer about the hazards of products and materials and the correct safety measures to be followed when using them. Must be retained as "exposure record," reference 29 CFR 1910.1020.

STEL: short term exposure limit determined over a sampling period of 15 minutes.

5.0 RESPONSIBILITIES

President:

- Support OSU-CHS efforts to provide a safe and healthy work environment for all research laboratory workers, in compliance with OSHA standards
- Plan budgeting resources to provide equipment and safety supplies intended to protect lab workers from hazards in the research laboratories

Chemical Hygiene & Radioisotope Use Committee (CHRUC):

- Act as the faculty liaison between the PI's, staff and students and the regulatory compliance arm of the Office of Research.
- Develop, coordinate, implement, and perform annual review of the OSU-CHS Chemical Hygiene Manual.
- Work in concert with regulatory/compliance in the Office of Research to maintain oversight and assure compliance with appropriate regulatory compliance rules regarding the safe and appropriate use of (hazardous) chemicals and radioisotopes.
- Review all research and instructional activities involving radioisotopes and/or other hazardous chemicals performed by individuals acting as agents of OSU-CHS (e.g., faculty, researchers, staff, students, and employees).
- Evaluate and approve applicable protocols for approved use of radioisotopes and hazardous chemicals.
- Work with the Laboratory Safety Coordinator and the Office of Research Regulatory Compliance personnel to stop work where imminent hazards to the health and safety of lab

workers exist until the hazards are eliminated that may require documented assurance of mitigation such as hazard assessments, monitoring, and or training

Laboratory Safety Coordinator:

- Act as OSU-CHS Chemical Hygiene Officer
- Working with the CHRUC, will annually review the OSU-CHS Chemical Hygiene Manual and will revise as needed
- Consult with the CHRUC regarding regulatory or compliance updates and/or modifications
- Assist in reviewing JHAs and SOPs, as needed
- Assess implementation of the Chemical Hygiene Manual, training, JHAs and SOPs during routine inspections both announced and unannounced
- Maintain a centralized online file of SDSs received from chemical manufacturers
- Receive Chemical Inventory Lists (CILs) from PIs and consolidate into an OSU-CHS composite CIL
- Provide materials for Laboratory Safety training, including videos, to be accessed online (see Section 6.10) and maintain training documentation database
- Respond to or assist PI in responding to lab worker concerns regarding laboratory hazards or potential chemical exposures. Lab workers must have a written reply within 15 days
- Work with the CHRUC to stop work where imminent hazards to the health and safety of lab workers exist until the hazards are eliminated that may require documented assurance of mitigation such as hazard assessments, monitoring, and or training
- Arrange for hazardous waste disposal

Principal Investigator (PI):

The PI has accountability for the inclusion of environmental protection, safety and health practices in the lab; in addition to training and performance of lab workers under their supervision. The PI is accountable for the safe operational use of space with authority for start-up and shut-down of activities performed in the work area. The PI shall be familiar with laboratory equipment, ongoing processes, and utilities available in the laboratory. Also the PI shall:

- Place a copy of this manual in laboratory and explain to all lab personnel that procedures herein are mandatory
- Perform a hazard evaluation to identify all work activities where there is exposure or potential for exposure to carcinogens, highly toxic chemicals, reproductive toxins and extreme physical dangers; develop control measures to eliminate or reduce hazards; or prohibit project start where hazards cannot be reduced to an acceptable risk level
- Where hazards cannot be eliminated; provide engineering controls, administrative controls and personal protective equipment (PPE), in that order, where necessary to prevent adverse physical and health effects
- Develop Job Hazard Analysis or Safe Operating Procedures (SOPs) for potentially extreme chemical hazards, hazardous work procedures and processes including equipment operations, that are not adequately addressed by this manual
- Complete "In-Lab Safety Orientation Checklist" and "Worker In-Lab Safety Training" and additional pages (as needed) found in Appendix I for all new workers, including students (see Section 6.10, Laboratory Safety Training and Information); place copies in lab and send a copy of the Orientation Checklist to the LSC
- Ensure spill clean-up material are near-by and eye and body wash facilities are located within a 10 second walk, appropriate to chemicals used or stored in area, and are maintained

- Respond promptly to lab workers concerns regarding chemical hazards or potential chemical exposures. Lab workers must have a written reply within 15 days (see Section 6.5 and Appendix D, "Report of Laboratory Safety Incident")
- Maintain inventory data of all chemicals used or stored on the Chemical Inventory List (CIL) form, keep updated (within 30 days) and send current copy to the LSC (see Section 6.4) annually, at a minimum
- Ensure that all stock chemical containers labels are not defaced; and that transfer containers and laboratory prepared solutions are labeled with chemical name, date of transfer or preparation and initials of person who prepared the solution; hazards must be added where present
- Maintain a hard copy SDS in the work area for each chemical used or stored that is immediately accessible to lab workers during all working hours
    - Periodically audit for compliance with chemical safety policies including:
        - Engineering controls
        - Safe work practices
        - PPE
    - Retrain where inconsistencies are found
- Ensure proper working condition and maintenance (documentation that came with equipment purchase should be immediately available) of hazard controls for equipment such as centrifuge, fume hood, biosafety cabinet, autoclave – post sign where not working properly. Provide training to operate equipment safely and correctly
- Stop work where imminent hazards to the health and safety of lab workers exist until the hazards are eliminated

All Persons Who Work in Labs:

- Assist PI when requested in performing PI specific responsibilities listed above
- Follow all procedures within this manual
- Obtain hazard information; at a minimum, review SDS on all chemicals prior to use
- Wear protective equipment identified by PI and follow safety policies and instructions provided during training and in reviewing this manual
- Keep chemical container labels readable and label all transfer and laboratory prepared solution containers as detailed in Section 6.3, Labels and Safety Data Sheets
- Report noncompliance with these policies, any unsafe work practices or procedures observed, potential chemical exposure incidents, and other concerns promptly to the PI or the LSC
- Know the location and proper use of emergency equipment, such as showers and eye flushing equipment. PI or designee will flush eyewash assembly for 3 minutes every week and document

6.0 CONTROL OF HAZARDS

> For any emergency situation in the laboratory, refer to the "OSU-CHS Laboratory Emergency Response Procedures" manual in lab binder or online.

The purpose of hazard control guidelines in the OSU-CHS Chemical Hygiene Manual is to evaluate and monitor chemical hazards and where possible, design and implement control measures to reduce hazard exposure; and provide training and information to lab workers regarding the hazardous chemicals they may work with. The following sections 6.1 - 6.7 contain procedures and instructions that shall be observed in purchasing, handling, storage, or disposal of hazardous chemicals.

Hazardous chemicals may be used only in laboratory facilities specifically designed, constructed and maintained for such work. Hazardous chemicals may not be used in areas including (but not limited to) offices, non-chemical storage rooms, shared equipment areas, cold rooms, and other areas lacking the appropriate facilities and a proper means of ventilation.

At OSU-CHS, chemical exposures and other hazards associated with lab activities are minimized using elimination or substitution, engineering controls, administrative and work practice controls, and PPE in that order. Section 6.2 discusses the use of hazard assessments to determine what controls need to be addressed. Lab workers must wear appropriate personal protective equipment (e.g. respirator) when other controls are insufficient to prevent an exposure or inhalation hazard.

The following controls should be implemented; however, should not be considered "all inclusive."

Elimination or substitutions include:

- Engineering out the hazard or eliminating the hazard entirely is the most effective method of hazard control.

- Substitute a less hazardous chemical that can provide the desired results.

OSHA has developed a step-by-step toolkit to provide employers and workers with information, methods, tools, and guidance on using informed substitution in the workplace. See https://www.osha.gov/dsg/safer_chemicals/index.html.

Engineering controls include:

Chemical fume hoods (CFHs) and local exhaust ventilation systems (LEVs) such as snorkels, down draft tables, and slot hoods are the primary engineering methods of controlling inhalation exposures to hazardous chemicals in the laboratory. CFH's provide ventilation to carry away airborne contaminants and exhaust them outside of the building. The sash of the fume hood provides shielding to protect the user and may also provide some containment for small fires and explosions.

- Any alteration affecting CFH's and LEV systems or associated ductwork must be approved by the Physical Plant prior to the system's modification. Note that meeting design specifications does NOT ensure the proper functioning of the CFH or LEV devices. The CFH must be tested for proper functioning yearly. Laboratories must work closely with the Physical Plant to ensure safe operation of all ventilation equipment.

- Ductless CFH's must be used with caution in OSU-CHS laboratories. Captured organic vapors begin to desorb from the charcoal filters shortly after adsorption occurs. Some degree of breakthrough or capture failure occurs during introduction of vapor into the hood.

- Conduct all work within the CFH at a distance of at least six inches behind the face opening and position the vertical sliding sash no higher than the height specified on the hood. Avoid blocking the airfoil, baffles, and rear ventilation slot. Support large items on platforms or shelving with legs that raises the item(s) above the ventilation slot to minimize airflow disruption across the work surface.

- Minimize foot traffic around the CFH during use, since passing in front of the hood during operation disrupts the airflow and may pull contaminants out of the hood. Do not use the

CFH for storage. By following these steps, the hood provides adequate containment for most chemical operations.

- CFH's equipped with alarms will alarm when the speed and volume of air moving through the hood falls outside set parameters. It is prudent to verify CFH function before each use by holding a tissue at the bottom edge of the sash and observing that the tissue flutters strongly into the cabinet. If a unit is in alarm or if the 'tissue test' fails, mark the unit as "Do Not Use", and submit a work request to the Tulsa Help Desk at Tulsa.helpdesk@okstate.edu to evaluate the need for repairs. Contact the LSC to have the CFH recertified prior to reuse, or if there is any question about the function of the CFH.

- Unless liquid chemicals are double contained in CFH's; hood drains shall contain standpipes, a vertical lip around the sink's circumference of at least ¼ inch, be completely sealed or the drains sealed by a temporary cover that will prevent accidental drainage of hazardous chemicals.

- Ensure unimpeded access to emergency safety showers and eyewash stations. Flush eyewash stations weekly for 3 minutes to ensure it is clear of any bacteria buildup and document the date and initials of the individual who performed the test. The emergency safety showers will be tested by the LSC at least every 6 months. If any test of a safety device fails, submit a work request to the Tulsa Help Desk at Tulsa.helpdesk@okstate.edu to repair the unit.

Administrative controls include:

- Assigned work schedule procedures should be followed unless a deviation is authorized by the PI or other supervisory authority.

- Keep, use, consume, store or prepare food, beverages, food containers, utensils, etc., cosmetics, and medication outside the lab.

- Keep all doors to the laboratory closed where possible. Open laboratory doors can adversely affect CFH performance and appropriate air flow through the building.

- Use time to your advantage. Plan experimentation so that hazardous chemicals are in use for the least amount of time. Minimize all chemical exposures and avoid underestimating the risk. Avoid unnecessary exposure to chemicals by any route of exposure.

- The PI or their designee should maintain proper oversight of inexperienced personnel working with hazardous substances. Minors, under the age of 18, are not allowed to work with "Particularly Hazardous Substances", radioisotopes, risk group 2 biological materials, or other extremely hazardous materials or equipment.

- The PI, with the approval of the department chair, shall authorize clearance of the workspace when non-laboratory personnel must enter laboratories to perform required services (e.g. renovation or maintenance). Remove hazardous materials from equipment/facilities to be serviced and forewarn personnel of the need for protective equipment or work practices required. Decontaminate the equipment when possible. Ensure that repair and maintenance personnel have access to the appropriate personal protective equipment and have been trained in its use by their employer.

- Do not use or store hazardous chemicals or compressed gas in cold rooms and warm rooms due to inadequate ventilation.

- Know where all written safety documentation is located and follow instructions; policies, postings, labels, etc.

- Study hazard classifications of chemicals (see Appendix H). Learn warning properties of chemicals (see SDS) and how these apply to your health and what associated controls are needed.

- Working alone is dangerous and should be strictly avoided during off-hours (before 7:00 am and after 5:00 pm), in activities involving the use of hazardous materials that have the potential for causing personal injury requiring an emergency response. When working alone is necessary with nonhazardous materials (the worker shall assess equipment and chemicals to ensure that there are no hazards), the PI shall establish a written surveillance procedure, such as a check in with the working lab workers at predetermined times and information provided to security personnel of who will be working and what hours.

Work Practice controls include:

- Be familiar with the chemical characteristics, hazards and exposure limits before using a chemical. **Read the SDS** and consult the National Resource Council's Prudent Practices in the Laboratory Handling and Management of Chemical Hazards, 2011 edition, or other hazard resources as necessary**.**

- Keep work area clean and uncluttered, with chemicals labeled and stored based on chemical compatibility.

- Vacuum lines shall be protected at the point of use (e.g., with an absorbent or liquid trap) to prevent entry of any material into the system. These systems are not appropriate for use with gasses, combustible, flammable or toxic materials and are designed for use with aqueous solutions only. There are special designed vacuum systems available for use with hazardous chemicals.

- Handle glassware properly and carefully. Do not use damaged glassware. Use extra care with Dewar flasks and other glass apparatus intended for use with vacuum or pressure. Consider shielding or wrapping them to help contain chemicals and fragments should implosion or explosion occur.

- Never pipette by mouth.

- Transport laboratory chemicals using bottle carriers, other secondary containment and suitable carts.

- Follow the established procedures for the decontamination and safe movement of research equipment.

- In the event of a hazardous chemical spill, immediately contact PI or designated supervisor and follow lab procedures related to spills.

- When diluting a concentrated acid or base, always add the acid to the water.

- Use a certified CFH when opening, transferring, or handling volatile hazardous chemicals.

- Use a designated container when disposing of broken glass; however, debris contaminated with P-Listed chemicals shall be handled as chemical waste.

- If the laboratory is unattended while work is ongoing with hazardous chemicals place an appropriate sign on the door briefly stating the nature of the experiment, contact person, and phone number. Provide for the containment of the substances in the event of failure of an engineering control such as a fume hood or utility service.

- Don't underestimate risks. Assume that any mixture will be more hazardous than its most hazardous component and that all substances of unknown toxicity are toxic.

- Contact the PI, other supervisor or the LSC with all safety questions, concerns or unsafe conditions immediately.

- Maintain situational awareness and make others aware of special hazards associated with your work.

- Personal mobile devices (e.g. cell phones, handheld tablets) should only be used for assigned lab work, not for social or entertainment purposes without the express permission of supervisor.

- Notify supervisors of chemical sensitivities or allergies.

- Report all injuries, accidents, incidents, and near misses immediately.

- Know waste procedures and properly dispose of all types of waste.

PPE controls include (see Section 6.6 for further information):

- Protect clothes and exposed skin by wearing laboratory coats and gowns, where required by work activity. Open-toed shoes, sandals, shorts, and other apparel that leave skin exposed are not appropriate for wear in any laboratory. Laboratory coats that may be contaminated with hazardous materials must not be worn outside the laboratory.

- Wear the appropriate gloves and eye/face protection whenever handling hazardous chemicals. These items must not be worn outside the laboratory.

- Wearing of contact lenses should be avoided when working with hazardous liquids unless eyes are protected with impermeable goggles.

- Remove gloves carefully (do not reuse disposable gloves) and thoroughly wash hands and forearms upon completion of work and before leaving the laboratory.

- Contaminated laboratory clothing may be washed in the onsite laundry. The clothing shall be first disinfected if contaminated with a biological agent. Clothing shall be transported in a bag or solid container that is clean on the outside. The transport device shall be returned to the laboratory to be disposed according to waste procedures or decontaminated according to laboratory procedures.

6.1 Procurement

Before purchasing new chemicals all efforts should be made to use chemicals already on site by requesting them from others who may have an excess. You may contact the LSC to find out if the chemical is present on campus and to act as a liaison with the chemical's contact person. Each PI responsible, or designee, who will be ordering chemicals shall:

- Ensure that a SDS is available in the work area(s) where the chemical will be used, obtain by 1) checking current files, 2) requesting when ordering from the chemical manufacturer, 3) printing from online search; and,

- The PI responsible shall ensure that all lab workers who will be working with the new material are aware of the hazards associated with the material prior to use and know where to locate the SDS.

6.2 Hazard Evaluation of Work Activity

Each lab worker should use caution in planning and performing activities in the laboratory to ensure the least exposure and physical hazards possible. The PI shall determine the necessity for performing a documented hazard evaluation for activities (or those that are similar may be placed in one evaluation) under their authority. It is recommended that the evaluation be in the form of a Job Hazard Analysis (JHS) or Standard Operating Procedure (SOP).

An evaluation should be done for endeavors that may have high risks for those performing the activity or the facility in which they occur or those that may have extreme hazards that are unusual for OSU-CHS lab activities. Written evaluations may be needed where carcinogens, chemicals with a high degree of acute toxicity, reproductive toxins, or chemicals and equipment with extreme physical hazards are used, i.e. particularly hazardous substances.

The PI shall eliminate or control hazards that are known or found through the hazard evaluation. To do so, the PI shall provide applicable 1) elimination and substitution decisions, 2) engineering controls 3) administration or work practice controls, including information, JHAs and SOPs, and 4) PPE in that order for all above activities following directives contained in this manual and other hazard control resources. Generally JHA/SOP formats include step by step instructions, hazards of each step and controls for the specific hazards. The JHA/SOP may have separate sections for chemicals and equipment that will be used, studying of SDSs and operation manuals, PPE to be worn, and clean-up (including hazardous waste handling). JHA/SOPs or hazard evaluation addendums may be attached to the copy of this manual in applicable laboratory. Ensure that all lab workers are trained on and know where to find the applicable JHA/SOPs.

JHAs and SOPs are in many cases used interchangeably. For purposes of discussing hazard evaluations performed and documented for research activities at OSU-CHS the term "JHA/SOPs" will be used. The American Chemical Society (ACS) as requested by the U.S. Chemical Safety and Hazard Investigation Board commissioned a task force of stakeholders and subject matter experts to create a guide for evaluating hazards in 2013. This guide includes step by step instructions to develop JHAs, SOPs and other useful methodologies to assess and control hazards. The guide can be found at the ACS site and is called "Identifying and Evaluating Hazards in Research Laboratories". This document is an excellent source for PI to use in developing necessary written hazard evaluation documents specific to their lab activities.

SOP examples and a SOP blank template may be found, revised to be CHS appropriate and used, courtesy of Duke University, Occupational Hygiene and Safety Division at https://www.safety.duke.edu/laboratory-safety/chemical-hygiene/chemical-sops.

Some activities with unusual hazards shall require **prior approval** before use of CHS facilities and exposure of personnel. These may be activities requiring JHA/SOPs as explained in this section and that have not been conducted previously in CHS laboratories. The LSC may be consulted to assist in determination of the need for a JHA/SOP and prior approval. The PI may forward a copy of the JHA/SOP to the CHRUC or LSC for review. If needed, the PI may schedule a meeting with the CHRUC or LSC and others that the PI or the LSC would like to include, to ensure all aspects of project hazards have been evaluated and controls are in place. Final written approval of the project and/or the JHA/SOP may need to be obtained from the Research office with a copy sent to the LSC.

6.3 Labels and Safety Data Sheets

The label and the Safety Data Sheet (SDS) (formerly known as a Material Safety Data Sheet or MSDS) associated with a chemical provide information of hazards and precautions that will prepare lab workers to safely use the chemical if carefully studied and precautions are followed.

Original chemical container labels shall not be defaced. If a label is becoming unreadable a new label must be created. OSHA has adopted a new system for manufacturers to label chemicals. The minimum components of a **label** are:

- The name of the chemical
- Supplier identification
- Hazard pictograms
- A signal word
- Hazard and precautionary statements
- Supplemental information may be provided to the label as needed.

When making up a **prepared (working) solution or transferred chemical**, the new container shall be labeled with:

- The chemical name
- Preparer's initials
- Date of preparation and hazards, where they exist

The chemical name written on the new container shall be the same name as that on the original purchased container. Where the container’s size limits the size of the chemical name that can be written, an acronym may be used with the requirement that a visible written key is placed in an obvious place, e.g. by the phone, by the door, near where the solutions are stored and used. All lab workers shall be made aware of where the key is, the meaning of the acronyms and where further information on the hazards may be found, such as the SDS.

Research samples that will be stored shall be labeled with a contact person's name, hazards and some type of identifier of contents that must be tracked to research data to ensure complete identification. Identification information may be placed on a secondary container where the samples have been placed and stored.

Each lab worker shall know where to find the **SDSs** in the laboratory area. The worker shall study the SDSs for the chemicals that they will be working with before beginning a project. All chemicals in the lab should have a corresponding SDS (or older MSDS) in hard copy form in an obvious location in the lab. SDSs provide information on the hazards of the chemical, PELs, and PPE to use when handling the chemical. The PI is responsible for ensuring that each lab worker reads and understands the SDS for each chemical they may be exposed to in their work activities; and that the SDS is available in hard copy form in the work area at all times a lab worker is working. Copies of SDSs may be obtained by contacting the chemical manufacturer or supplier directly or by an online search. A number of OSU-CHS's SDSs for newly purchased chemicals have been scanned and may be requested if necessary.

All chemical manufacturers, distributors, or importers are required to prepare new SDSs in a uniform 16-section format (known as GHS for the system that OSHA adopted- Globally Harmonized System for Classification and Labeling of Chemicals) at least by June 1, 2015. To become familiar with the contents of each of the 16 sections click this link: Hazard Communication Standard: Safety Data Sheets or see Appendix F. By December 30, 2016, the older MSDSs should be replaced with the GHS SDSs in the laboratories. The SDSs you file should be from the company where the chemical was ordered. There are a number of ways to find a SDS. In addition to searching online, you can call or write to the company. CHS has access to a system called MSDSonline (http://centernet.okstate.edu/safety/chemical.php) where you may search for a chemical's data sheet. Click on the "MSDSonline" button on the right side of the page. When the page opens click on the "MSDSonline search" link on the left hand side to open a search window. If the search lists the chemical name with a small GHS+ symbol on the left hand side, the data sheet will be in the SDS format. If possible match the vendor, CAS# and/or product# to ensure that you have the correct SDS.

(M)SDSs should not be thrown away. OSHA (reference 29 CFR 1910.1020) states that employers must keep some record of the identity of a substance or agent such as a hazardous chemical, along with a record of where and when it was used, and that the record must be kept for a period of thirty years. One of the very best ways to comply with that requirement is to be sure not to throw away SDSs, formerly MSDSs. Keep them on file in an archive binder, even after the products they refer to are no longer being used or send them to the LSC to be scanned into long term data storage.

6.4 Inventory Control

The responsible PI or delegate shall maintain a Chemical Inventory Listing (CIL) of chemicals/products under their jurisdiction. The CIL blank form, instructions and an example form can be found on the CHS Office of Research url or may be requested from the LSC. The CIL is in an excel format and is required to be completed and saved in the excel format and a copy returned to the LSC electronically as it is updated or at a minimum, annually.

A copy of the CIL shall be maintained and posted in the laboratory. The CIL will need to be updated as containers are emptied and disposed and also as new items are purchased. A CIL of OSU-CHS shall be maintained at the LSC office by consolidating the excel CIL forms from all laboratories. The LSC shall transfer a copy to a flash drive to be maintained offsite for emergency access.

If the city Fire Department requests, all quantities of chemicals in each building must be maintained below the limits specified for various chemical categories by the city Fire Department, unless a permit has been approved to exceed those limits. Contact the LSC for specific limit information.

Requirements and recommendations on appropriate storage can be found in Appendix C, "Proper Storage of Chemicals." Chemicals and working solutions should be place in adequate storage when not in active use.

6.5 Exposure Monitoring

OSHA has written specific procedures for exposure monitoring (and use) when using any of the following substances above the "action level (AL)" (usually 50% of the PEL) or level indicated below. If the level monitored exceeds that listed below, the OSHA standard is in effect either partially or entirely and must be studied and implemented by the PI. The specific OSHA standards can be found at 29 CFR 1910.1001-1052 Subpart Z, Toxic and Hazardous Substances. It is necessary to use any of the chemicals listed below in a CFH, where possible.

Asbestos (CAS # various);
Vinyl Chloride (CAS # 75014); AL = 0.5 ppm
Arsenic (CAS # 7440382) and inorganic compounds except arsine; AL = 5 µg/m^3
Lead compounds (CAS # various); AL = 30 µg/m^3
Chromium (VI) (CAS # 18540299) in all its forms and compounds; AL = 2.5 µg/m^3
Cadmium (CAS # 7440439) and its compounds; AL = 2.5 µg/m^3
Benzene (CAS # 71432); all uses >0.1% or AL = 0.5 ppm
Coke oven emissions; >150 µg/m^3
Cotton dust
1,2-Dibromo-3-chloropropane (DBCP) (CAS # 96128); >1 ppb
Acrylonitrile (CAS # 107131); AL = 1 ppm
Ethylene Oxide (CAS # 75218); AL = 0.5 ppm
Formaldehyde (CAS # 50000); AL = 0.5 ppm
4,4'-Methylenedianiline (CAS # 101779); >0.1% or AL = 5 ppb
1,3-Butadiene (CAS # 106990); >0.1% or AL = 0.5 ppm or STEL = 5 ppm
Methylene Chloride (CAS # 75092); AL = 12.5 ppm

All work with the above listed materials, that exceed the level indicated, must be coordinated through the LSC. Some of the specific requirements in addition to exposure monitoring may include medical examinations, working within a closed system only, and posting requirements.

If there is reason to believe that the action level; or in absence of an action level, the PEL established by OSHA (these can be found in the SDS), is or will be exceeded during work activities for any chemical for which an action level or PEL has been established, initial exposure monitoring shall be conducted. This includes the PELs listed for chemicals as air contaminants at 29 CFR 1910.1000 and Tables 1-3, Subpart Z, Toxic and Hazardous Substances.

The PI may choose to perform any required exposure monitoring or request assistance from the LSC. In requesting assistance, PI must provide the chemical name, concentration in use, use conditions, and possibly invoice instructions.

The results of all monitoring must be communicated to affected lab workers by the PI responsible within 15 days of receipt either by providing each lab worker an individual copy or posting a copy accessible to the lab workers. A copy must be sent to the LSC to be filed.

If initial exposure monitoring indicates exposure levels above the action level or PEL, the PI shall provide controls to lower the exposure to an acceptable level if at all possible. Where this is not possible, respiratory protection appropriate to use conditions shall be provided and used. The

LSC shall be contacted and the requirements in the OSU-CHS Respiratory Protection Manual, based on the OSHA standard, 29 CFR 1910.134, shall be followed. In addition, periodic monitoring shall continue to be conducted as determined by the LSC.

6.6 Personal Protective Equipment

The PI shall assess the workplace to determine if hazards are present, or are likely to be present, that necessitate the use of PPE. This assessment must be documented. The **Hazard Assessment Tool for Personal Protective Equipment Use** shall be completed for each lab as the documentation for this requirement. If such hazards are present, or likely to be present, the PI responsible shall select, purchase and:

- have each affected lab worker use the types of PPE that will protect the affected lab workers from the hazards identified in the hazard assessment
- communicate selection decisions and location of PPE to each affected lab worker
- ensure PPE properly fits each affected lab worker
- ensure that each lab worker is trained on the proper use, maintenance and disposal of selected PPE
- determine if students (who are not employees) are to purchase their own PPE or it will be purchased by the department/laboratory funds.

The minimum personal street-wear for all persons working in laboratories shall be:

- long pants or equivalent
- shoes that cover the foot (no sandals or sling back shoes)
- socks that cover the ankles
- non-synthetic personal clothing is advisable to decrease fire hazards, cotton is preferred.

The following describes various types of PPE that the lab worker may be required to wear:

Gloves. Disposable gloves are one of the most commonly used types of PPE in the laboratory. The proper use of disposable gloves provides protection to the wearer by providing a barrier to potential hazards. Gloves also provide product protection by protecting experimental materials from enzymes or DNA on the glove wearer's hands.

Since many chemicals are skin-absorbents (i.e., agents that readily pass through the skin) it is important to select gloves that are chemically resistant to the material. Select the correct glove for the task (most product catalogs have glove compatibility charts or you may use the OSU Glove Compatibility Guide at http://ehs.okstate.edu/hazmat/gloves1.htm; Appendix A and Appendix J). Gloves must be selected on the basis of their chemical resistance to the material(s) being handled, their suitability for the procedures being conducted, and their resistance to wear as well as temperature extremes. Improper selection may result in glove degradation, permeation of the chemical through the glove and ultimately, personal exposure to the chemical. This is a potentially serious situation. Certain gloves do not afford appropriate chemical protection and no

single glove is protective against all chemicals. All laboratory personnel are responsible for following the appropriate work practices when using disposable gloves.

- Remove your gloves carefully to avoid contacting the outside of the glove with bare skin; thoroughly wash your hands and forearms upon completion of work and before leaving the laboratory. Do not reuse disposable gloves.

- Gloves should not be worn in common-use areas outside laboratory areas. Common areas include but are not limited to elevators, rest rooms, break rooms, and corridors outside the laboratory wings.

Some types of gloves are reusable. These gloves should be cleaned after each use and inspected prior to each use and replaced as necessary.

Eye and Face Protection. Required eye protection should be available and put on at the door before entering the main laboratory area.

Safety glasses provide protection for the eyes from flying objects. Goggles and possibly a face shield must be worn to protect the face and eyes if there is a potential for a hazardous chemical splash. If a face shield is worn to protect more than just the eyes from damage, goggles must also be worn beneath the face shield.

When ordering, styles should be selected which fit snugly to the user's face and completely cover prescription glasses, if worn. All eye protection must meet requirements of ANSI Z78.

The eye and face protection selection chart located in Appendix A and Appendix J, provides guidelines for determining appropriate protection levels.

Protective Garments. Laboratory coats or other protective garments will help reduce exposures to hazardous materials in the laboratory by covering personal clothing and exposed skin. If there is a possibility that the lab coat may be contaminated with hazardous materials, remove the lab coat before leaving the laboratory to prevent the spread of contamination outside of the laboratory.

Where recommended, a chemical resistant lab coat (preferably with snap fasteners) should be worn. Where flammable hazards are present, e.g. significant amounts of flammable liquids are used or work is with highly flammable liquids, the PI shall provide lab workers with lab coats that are flame proof, in an identifiable color such as blue. Laundering instructions shall be followed to maintain the flame proofing of the garment.

Garments that have been contaminated with hazard materials shall not be taken offsite to launder if there is any possibility of spreading contamination. There is a washing machine and dryer onsite to be used for cleaning laboratory safety garments. The LSC may be contacted to obtain directions to the laundry location. Garments that are contaminated with biological substances shall be decontaminated before moving from the lab. All garments shall be placed in a bag or other secondary container before moving from the lab to the laundry equipment room. Contact the LSC if more laundry supplies are needed.

Respiratory Protection. Prior to use of any type of respiratory equipment, contact the LSC. Where respirators are required to be used in the work area the OSHA standard 29 CFR 1910.134, "Respiratory Protection" shall be followed as detailed in the OSU-CHS Respiratory Protection Manual. The requirements include medical evaluation, fit testing, and training. It is the policy of OSU-CHS to provide respiratory protection, at no cost to an employee.

If using a filtering facepiece (dust mask) voluntarily without there being a medical requirement to do so, complete the form in Appendix E or online "Voluntary Respirator Use" under Laboratory Safety and return a copy to the LSC. OSU-CHS is not required to purchase a filtering facepiece if a lab worker is using it on a voluntary basis.

Appendix B, "Safety and Emergency Equipment Guide," may assist in choosing additional appropriate PPE and emergency equipment. All PPE shall be inspected prior to use and stored in a manner that will prevent damage. Further protection guidelines to be implemented, where applicable, can be found in the SDS and other reference materials. A useful book for more information on PPE that is referenced by the OSHA Lab Standard and other chemical organizations is Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (2011).

6.7 Waste Disposal, Unwanted Chemicals and Effluent Control

A release (e.g. down a sink drain, to the trash, exhausted through a ventilation system) of a regulated hazardous material or waste shall be prohibited, unless an exception has been approved by the LSC. All hazardous material, including waste, having the potential for release to a drain must be double contained. Unless chemicals are double contained in ventilation hoods, hood drains shall be encircled by a standpipe, have a vertical lip around the sink's circumference of at least ¼ inch, be completely sealed or the drains sealed by a temporary cover that will prevent accidental drainage of hazardous chemicals.

All persons working in research laboratories shall use pollution prevention and waste minimization strategies to reduce the quantity and toxicity of waste generated, where possible. Guidelines may be found in the Environmental Management Guide for Small Laboratories, United States Environmental Protection Agency, EPA 233-B-00-001. Initially a determination shall be made by the PI as to whether unwanted chemicals and generated waste is hazardous or not. If this is not readily known through application of definition in above linked guide, section 3.3, "Hazardous Waste," LSC shall be consulted to assist in making the determination.

Solid non-hazardous waste may be placed in the dumpster, after being labeled in large letters with the word "Non-hazardous." Liquid non-hazardous waste shall be poured down the sink and empty glass containers placed in a glass waste container box or taken directly to the dumpster.

Attempts should be made to transfer unwanted chemicals to other PIs for use. If that is not possible the chemicals shall be treated as waste.

The EPA, the OKDEQ and OSHA regulations all have some waste requirements. The OSU-CHS's amount of waste generated allows the site to be considered as a "Conditionally Exempt Small Quantity Generator." As such, all regulated hazardous waste shall be:

- collected in nonreactive containers in good condition
- closed following each addition or removal (evaporation of volatile hazardous waste is prohibited)
- labeled with contents, hazards, the legend "**Hazardous Waste**" and initials of PI or department name; oil waste shall be labeled with the exact words: "**Used Oil**"; handwritten labels must be neat and legible

- collected and stored safely (e.g. flammable liquid waste shall be stored in approved flammable liquid storage containers or cabinet, incompatible wastes separated)

The PI in charge of the process that generates waste or their designee is responsible for proper disposal of regulated hazardous waste coordinated through the office of the LSC. The waste shall be disposed through a certified waste disposal company, predetermined for OSU-CHS by the LSC. The following information shall be provided to the LSC when waste removal from a lab is desired (see instructions and form "Hazardous Waste Pickup"):

- contents (full name), including percentages of each component if a mixture
- size and type of container
- amount of waste
- hazards
- contact name and phone number
- department name and PI

Send the completed form, "Hazardous Waste Pickup", electronically to the LSC. Keep a signed copy of the form with the waste. The items will be scheduled for removal from the laboratory by the LSC to a consolidation site.

OSU-CHS research office may not accept listings of unidentified substance(s) for disposal. However, the research office has made arrangements with our current waste contractor to conduct a hazard characterization for chemicals of unknown composition. Due to costly identification tests the generating department shall make every effort to identify unknown chemicals prior to the characterization. In instances where unknown chemicals have been generated, the generating department shall provide a separate storage area to hold these materials until characterization can be conducted. In addition, the generating department may be required to provide lab space and a fume hood for the characterization procedure.

Sharps are regulated waste, whether biologically contaminated or not. Sharps are offered to be transported offsite by a common carrier, Stericycle. Sharps include, but are not limited to, needles, lancets, syringes, broken glass, scalpels, culture slides, culture dishes, broken capillary tubes, broken rigid plastic, exposed ends of dental wires, slides and cover slips. They shall be placed in puncture-resistant containers designed for sharps waste with the biohazard logo. When the fill mark is reached on the container, generally about 75% full, tightly close and contact the office of research LSC for transport from the area of generation to be readied for transport by Stericycle.

Empty gas cylinders shall be moved as soon as reasonable into the locked gas cylinder cage that is located in the north dock area. The LSC must be notified if toxic gas cannot be returned to the supplier, either in cylinders or lecture bottles.

6.8 Activity Closeout

The nature of activities at OSU-CHS requires set guidelines to be implemented to safely close out activities and ensure that materials are managed in an environmentally sound manner. This will prevent chemicals and solutions from becoming "orphaned", exceeding their shelf life, or being

discovered at a later date with no labeling or historical information. Some projects are short term or have a turnover of persons who were immediately responsible for the project and they were the only persons knowledgeable about the chemicals being left behind.

On program closeout, the chair of the department will be ultimately responsible for ensuring, through set departmental procedures, that all project associated materials such as chemicals, prepared reagents, samples, and waste will be disposed of using the previously described waste disposal guidelines or assigned to another project and custodian. All efforts shall be made to transfer or recycle material that is still usable.

The work area will be decontaminated using methods that will not generate hazardous aerosols or dust. All waste generated during cleanup will be disposed of according to waste disposal guidelines. Detection methods will be used where possible or required to ensure that all hazardous materials have been removed.

6.9 Chemical Hazard Information and References

SDSs provide information on the hazards of the chemical, PELs, and PPE to use when handling the chemical. The PI is responsible for ensuring that each employee/student reads and understands the SDS for each chemical they may be exposed to in their work activities; and that the SDS is available in the work area at all times an employee/student is working, either in hard copy form or through immediate electronic access. Copies of SDSs may be obtained by contacting the chemical manufacturer directly, through an internet search or through the MSDSonline portal at http://centernet.okstate.edu/safety/chemical.php.

Each PI that uses chemicals shall maintain a copy of this Chemical Hygiene Manual and make it available to all lab workers before use of chemicals, to study and to reference. In addition, online documents and resources and other hard copy documents should be used to obtain chemical hazard information such as:

OSU's "Online Safety Resource Library."

Environmental Management Guide for Small Laboratories; United States Environmental Protection Agency; EPA 233-B-00-001

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals (2011); Committee on Prudent Practices for Handling, Storage, and Disposal of Chemicals in Laboratories, National Research Council

School Chemistry Laboratory Safety Guide (2006); Department of Health and Human Services Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health

Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Edition; Center for Disease Control and Prevention

Chemical Safety (NIOSH databases)

The Laboratory Safety Institute's Web Links Resources

OSHA Safety and Health Topics-Laboratories

OSHA Definition - Hazard Types of Chemical

6.10 Laboratory Safety Training

The PI shall determine the method in which laboratory training will be provided and ensure that the training occurs, for themselves and each lab worker under their supervision at the time of the workers initial assignment. The "Research Investigator's Checklist for New Personnel" form is designed to assist the PI in covering all issues needed to have a new person prepared to begin work in a safe manner. A copy of the Checklist shall be sent to the LSC as soon as all the fields are filled in before the new worker begins the training. There are 4 specific areas of laboratory training necessary to be completed before the worker may work independently in a laboratory.

1. General online Laboratory Safety Training, refresher every 3 years after initial, and whenever a lab worker is not demonstrating appropriate safety measures during work activities; required by all persons working in labs and their supervisors

2. "In-Lab Safety Orientation Checklist," required initially for all new lab workers and new supervisory persons (see Appendix I(I) or online)

3. "Worker In-Lab Safety Training Certification" list, ongoing for all persons working in a lab (see Appendix I(II) or online)

4. Verification of PPE Training, required initially and when new PPE is required (see Section 6.6 or online "Hazard Assessment Tool for Personal Protective Equipment Use"), required for all persons working in labs and their supervisors

1. Laboratory Safety Training: Training completion shall be documented and included in the OSU-CHS research training database. The "Pass Notification" that will be sent to the trainee after submitting the quiz from the online training will be considered as documentation of training attendance. The "Pass Notification" shall be sent by the trainee to the supervisor to be maintained in the lab training files. At a minimum, training subjects shall include:

- methods and observations that may be used to detect the presence or release of a hazardous chemical
- physical and health hazards of chemicals in the work area
- signs and symptoms associated with exposures to hazardous chemicals used in the laboratory
- measures lab workers can take to protect themselves from these hazards, such as appropriate work practices, emergency procedures (including spill response), and PPE to be used
- details and location of the OSU-CHS Chemical Hygiene Manual
- study of all SDSs for chemicals trainee will be using in work area, note hazards and permissible or recommended exposure limits

2. In-Lab Safety Orientation Checklist (Appendix I)**:** training is specific to the actual work situation and activities of lab workers. Because of the specificity of the training, it is not practical to develop a generic classroom-training course to comply with the lab specific needs. The PI is responsible for ensuring this aspect of training is completed as applicable to the workers responsibilities. In-lab training shall include such subjects as:

- study of JHA/SOPs associated with work activities
- details of specific procedures where handling of hazardous substances or hazardous activities occurs
- handling laboratory spills
- glass breakage

- disposal of hazardous substances
- location of safety equipment/SDSs
- lab emergency procedures
- how to operate and maintain equipment

3. Worker In-Lab Safety Training Certification (Appendix I)**:** Additional and ongoing in-lab issues shall be documented on a list specific to each worker. The Training Certification shall remain in the lab so that on-going in-lab training shall continue to be added to each workers list, e.g. SDSs read for first time use of a chemical, new JHA/SOPs, revised manuals.

4. Verification of PPE Training: a "Hazard Assessment Tool for Personal Protective Equipment Use" shall be completed by the PI for each lab. Once completed instructions are provided for the PI or designee to train each worker on the PPE they are to wear. (see Section 6.6 for further description)

All persons working with blood, other potentially infectious materials, or human/primate cell lines shall take the Bloodborne Pathogen Training with annual refresher. All persons working with biohazardous materials shall take Biological Safety Training determined by the worker's PI or supervisor.

All training documentation should be maintained in one location such as a safety notebook in each laboratory with a copy sent to the LSC of training 1, 2, and 4 discussed above.

7.0 WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES

PHS's include select carcinogens, reproductive toxins, chemicals that have a high degree of acute toxicity and those that have extreme physical hazards. Substance specific information is contained in SDS and is also available through many other reference materials. Reference lists of suggested PHS's are provided at the end of this section. Many of those for which OSHA has specific standards are listed in Section 11.0. Please note that this list is not inclusive, but represents chemicals of concern that may be found in laboratories. Following are substances that may be categorized as "particularly hazardous substances" or PHSs:

- Acutely toxic/highly toxic (such that the effects may be severe or fatal):
    - Can cause a lethal dose (LD) or lethal concentration (LC) within the following limits: inhalation (albino rats): LC50 $\leq$ 200 ppm / 1 hr or $\leq$ 2000 mg/m3 / 1 hr. vapor or gas or $\leq$ 2 mg/l dust or fume; skin contact (albino rabbits): LD50 $\leq$ 200 mg/kg. Acutely toxic (highly toxic) chemicals are capable of causing serious harm upon a single, brief exposure or from multiple exposures in a short space of time (usually less than 24 hours).
    - categorized in the SDS for the chemical; section 2, "Hazard(s) identification" as "1" or "1A" in any hazard class that results in severe, acute, or lethal effects by inhalation or dermal exposure
    - may be fatal to target organs as a result of a single exposure or exposures of short duration

- Reactive; are highly unstable or, when combined with other compounds in the procedure are explosive

- May undergo chemical or physical changes during routine use and generate by-products that may overcome standard control measures or may penetrate available personal

protective equipment to cause severe, acute, or lethal injuries

- Are used in an operation that requires approval above the level of the laboratory PI (see Section 8.0)
- NFPA or HMIS designation of a "4" in either the health or reactive (physical hazard) section
- Carcinogens and reproductive toxins (see http://oehha.ca.gov/prop65.html for a list of reproductive toxins and carcinogens identified under California Proposition 65)

When one or more of the criteria is met, the PI must determine if the use of such a chemical warrants classification as a PHS. Such determination shall consider the SDS, lab worker exposure potential, volume of chemical used, ability to identify health effects from lab worker exposure, and use of exposure control methods. If the only route of exposure is oral, the chemical is not likely to be a risk in laboratories or considered a PHS, with general good lab techniques and housekeeping.

The PI is responsible for ensuring that chemicals are classified as PHS as criteria applies, appropriate precautions are taken when working with the PHS and that appropriate training is provided before working with these materials.

Prior to Work Start:

When a chemical is classified as a PHS, the PI shall develop a specific written JHA/SOP. Where PHSs are used in the same manner a SOP may be written to include more than one. A safety protocol should include:

- A description of the substance(s) to be used including the potential physical and health effects
- A description of procedure or experiment where PHSs are used
- Inclusion of necessary engineering controls, safe work practices to be utilized, and listing of PPE to be used
- Use of containment devices (such as CFH's, downdraft tables, LEV's, gas cabinets, glove boxes or the equivalent).
- Establish posted designated areas for use and storage. A designated area may be a room, a section of a room, a bench top or a containment device (such as a laboratory hood)
- Provisions for proper labeling, storage, and waste disposal
- Establish decontamination procedures. These are necessary to prevent the spread of contamination to other areas. Decontamination procedures include practicing good housekeeping by wiping down work surfaces at the end of the day and cleaning up drips, residues, and spills. Wash hands, forearms and face. Decontaminate entire use area once

experiment is completed. Cleanup materials used (such as absorbents and cloths) must be disposed of as hazardous waste if 0.1% of the materials are the PHS.

Safe Work Practices using PHS's include but are not limited to the following (in addition to general chemical work practices in Section 6.0, Control of Hazards)

- Use LEV's such as a CFH or glove box when handling PHS's in a manner that may produce an airborne hazard (such as fumes, gases, vapors, and mists). This includes operations such as transfer operations, preparation of mixtures, blending, sonication, spraying, heating, and distilling. It is advisable to use a CFH whenever a PHS is being used. See engineering controls in Section 6.0 for more information.

- Control access to the laboratory through the use of appropriate signs that warn of the hazards and indicate the precautions or approvals necessary for entry. Emergency contact information shall be included.

- PHSs should be maintained in locked storage when not in use or at least the laboratory should be locked when unoccupied.

- Consult the regulations, or contact the LSC to determine if medical surveillance may be warranted if toxicologically significant quantities of a PHS is used on a routine or frequent basis.

- Keep PHS's in a closed secondary container to help prevent breaks and spills. The secondary container should be opened only inside a CFH.

- Attach a suitable hazard warning label to the secondary container to alert others of the chemical contained therein; see Section 9.0, "Labels and Safety Data Sheets", and the need for special precautions, for example: "Warning - Cancer Hazard" or "Highly Toxic."

- Protect work surfaces from contamination through the use of disposable, absorbent, plastic backed paper (plastic side down). Replace paper when contaminated or after each use and handle as hazardous waste if 0.1% of the paper is the PHS. Contact the LSC for further hazardous waste designation information.

- Use additional containment devices (such as shielding or protective filters) to safely handle, store or protect equipment and workers when using these chemicals.

- Transfer containers in bottle carriers or tubs with adequate side height, while cushioning materials to keep container upright; cover with a tight lid

- Wear appropriate PPE to reduce all skin exposure possible, including; gloves, eye/face protection, and other protective apparel or equipment as determined by the PPE Hazard Assessment Tool and the SDS.

- Additional PPE such as chemical goggles, face shields, chemical aprons, disposable coveralls, and respiratory protection must be worn if there is a chemical exposure risk that would require such additional precautions, respiratory protection may be worn using required procedures in OSU-CHS Respiratory Protection Manual.

- Remove all protective apparel and thoroughly wash exposed skin (e.g. face, forearms, etc.) and hands upon completion of work and before leaving the laboratory.

Note: 1.) Duke University has a site with many examples of PHSs, https://www.safety.duke.edu/laboratory-safety/chemical-hygiene/particularly-hazardous-substances, and SOPs with a blank SOP template that may be revised to be used by the CHS PIs for developing SOPs for PHSs used in their labs, https://www.safety.duke.edu/laboratory-safety/chemical-hygiene/chemical-sops. Courtesy of Duke University, Occupational Hygiene and Safety Division

8.0 MEDICAL SURVEILLANCE AND INCIDENTS

OSU-CHS shall make available, at no cost, without loss of pay and at a reasonable time and place, medical consultation, applicable medical examinations, and necessary follow-up examinations performed by or under the direct supervision of a licensed physician to faculty, employees, graduate students and other workers who receive an OSU paycheck under the following conditions:

- Whenever a worker develops signs or symptoms associated with a hazardous chemical to which the person may have been exposed during work activities

- Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements (see Section 6.5, "Exposure Monitoring")

- Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure

- For all physical injuries to the body

Obtain medical care immediately at the OSU Health Care Center (2345 SW Boulevard), if the condition appears serious, when a possible exposure or other medical situation should occur as described. If needed, an ambulance may be requested by dialing 9-911 and contacting security. In all cases, the PI or designee and employee shall:

- contact OSU risk management (Safety Manager-Patty White) at (918) 561-8391, cell (918) 231-5825 as soon as possible, to report the incident and obtain further instructions, as necessary
- complete the "Employee Injury Report", fax to risk management at (918) 561-1261 and take a copy with the employee to seek medical assistance, as needed
- report the incident to the LSC at (918) 561-1403 or by email and send a copy of the Employee Incident Report
- for further instructions see the "OSU-CHS Laboratory Emergency Response Procedures" which can be found in the lab safety binder, posted in the laboratory or online

Students who have exposures or injuries and are not employed by OSU-CHS, but who work in the labs, may also seek medical assistance at the OSU Health Care Center or medical facility of their choice. The PI or supervisor that they report to shall send a report of the incident to the LSC. The "Report of Laboratory Safety Incident" (see Appendix D) shall be completed rather than the "Employee Injury Report". The cost of medical assistance for a work related injury for students who are not employed by OSU-CHS will be incurred by the student's personal insurance.

Incidents that do not involve injuries shall also be reported to the LSC at (918) 561-1403 or by email. Examples of these types of incidents are hazardous chemical spills, property damage,

bomb threats, fires and violence. The PI or person that they designate shall use the "Report of Laboratory Safety Incident" (see Appendix D) to document the incident. Actions shall be taken, as necessary, according to instructions in the "OSU-CHS Laboratory Emergency Response Procedures" which can be found in the lab safety binder in the laboratory or online.

9.0 EMPLOYEE RIGHTS AND RESPONSIBILITIES

Each lab worker has the right to request from supervisory staff (PI) access to the SDS for any chemical being used in the work area and have them provided as soon as possible in a reasonable time, place, and manner. If a request for a copy of the SDS is made by the lab worker, those copies will be provided by the person's PI within fifteen days of the request.

All persons working in areas where exposures to hazardous substances exist shall be required to perform their jobs in accordance with precautions communicated to them during training and education programs, including SDSs, this manual, safety meetings and on the job training. The Department chair or PI may take appropriate disciplinary action, through reporting to human resources and determining a plan of action, when persons working in the labs do not comply with OSU-CHS's policies and procedures that have been communicated to them.

Persons working for the university with toxic chemicals, carcinogens, reproductive toxins, BSL2 biological infectious materials or those with extreme physical hazards must be at least 18 years old and have received the training specified in section 6.10 of this manual. Students younger than 18 years must have the approval of the lab PI and the Compliance Manager.

In addition, all lab workers should use good judgment in maintaining a high level of safety and reducing potential risk factors. The persons working with hazardous materials or operations is the person who is ultimately responsible for following safe work practices for which they have been trained. Lab workers are required to stop work if any unsafe condition exists and report the unsafe condition to PI, or any level of authority necessary to elicit prompt response.

APPENDIX A

EYE AND FACE PROTECTION SELECTION CHART

Category	Source	Assessment of Hazard	Protection (See note 5)
IMPACT	Chipping, grinding machining, masonry work, woodworking, sawing, drilling, chiseling, powered fastening, riveting, and sanding.	Flying fragments, objects, large chips, particles, sand, dirt, etc.	Spectacles with side protection, goggles, face shields. See notes (1), (3), (5), (6), (10). For severe exposure, use face shield.
HEAT	Furnace operations, pouring, casting, hot dipping, and welding	Hot sparks	Face shields, goggles, spectacles with side protection. For severe exposure use face shield. See notes (1), (2), (3)
		Splash from molten metals	Face shields worn over goggles. See notes (1), (2), (3).
CHEMICALS	Acid and chemical handling, degreasing, plating.	Splash	Goggles, eyecup and cover types. For severe exposure, use face shield. See notes (3), (11).
		Irritating mists	Special purpose goggles
DUST	Woodworking, buffing, general dusty conditions.	Nuisance dusts	Goggles, eyecup and cover types. See note (8)
LIGHT and/or RADIATION	Welding: Electric arc	Optical radiation	Welding helmets or welding shields. Typical shades: 10 - 14. See notes (9), (12).
	Welding: Gas	Optical radiation	Welding goggles or welding face shield. Typical shades: gas welding 4 - 8, cutting 3 - 6, brazing 3 - 4. See note (9).
	Cutting, Torch brazing, Torch soldering	Optical radiation	Spectacles or welding face shield. Typical shades, 1.5 - 3. See notes (3), (9).
	Glare	Poor vision	Spectacles with shaded or special purpose lenses, as suitable. See notes (9), (10
	Laser: Class IIIA-IV	Optical radiation	Spectacles with side shields Typical shades: 5 – 8. See notes (3), (9)

Notes to Eye and Face Protection Selection Chart:

(1) Care should be taken to recognize the possibility of multiple and simultaneous exposure to a variety of hazards. Adequate protection against the highest level of each of the hazards should be provided. Protective devices do not provide unlimited protection.

(2) Operations involving heat may also involve light radiation. As required by the standard, protection from both hazards must be provided.

(3) Face shields should only be worn over primary eye protection (spectacles or goggles).

(4) As required by the standard, filter lenses must meet the requirements for shade designations in 29 CFR 1910.133 (a) (5). Tinted and shaded lenses are not filter lenses unless they are marked or identified as such.

(5) As required by the standard, persons whose vision requires the use of prescription (Rx) lenses must wear either protective devices fitted with prescription (Rx) lenses or protective devices designed to be worn over regular prescription (Rx) eyewear.

(6) Wearers of contact lenses must also wear appropriate eye and face protection devices in a hazardous environment. It should be recognized that dusty and/or chemical environments may represent an additional hazard to contact lens wearers.

(7) Caution should be exercised in the use of metal frame protective devices in electrical hazard areas.

(8) Atmospheric conditions and the restricted ventilation of the protector can cause lenses to fog. Frequent cleansing may be necessary.

(9) Welding helmets or face shields, should be used only over primary eye protection (spectacles or goggles).

(10) Non-sideshield spectacles are available for frontal protection only, but are not acceptable eye protection for hazards that may come from the side.

(11) Ventilation should be adequate, but well protected from splash entry. Eye and face protection should be designed and used so that it provides both adequate ventilation and protects the wearer from splash entry.

(12) Protection from light radiation is directly related to filter lens density. See note (4). Select the darkest shade that allows task performance.

Appendix B
Recommended Safety and Emergency Equipment for the Laboratory

The following are safety and emergency equipment that may be used in the laboratory, as needed:

Personal Protective Equipment

- ✓ Chemical splash goggles (labeled ANSI Z87)
- ✓ Safety glasses with side shields (labeled ANSI Z87)
- ✓ Face shields
- ✓ Lab coat (chemical resistant, flame resistant-as applicable)
- ✓ Lab apron (acid resistant)
- ✓ Gloves (selected based on the material being handled and the particular hazard involved-see vendor listings for chemical compatibility)
- ✓ Shoe covers
- ✓ Hair covers
- ✓ Respirators, including filtering facepiece - also known as a "dust mask"

Safety and Emergency Equipment and Supplies

- ✓ Secondary containers with tight fitting lids for transfer of hazardous materials
- ✓ Hand-free eye-wash stations (not eye-wash bottles) that conform to ANSI Z358.1–2004
- ✓ Deluge safety showers that conform to ANSI Z358.1–2004
- ✓ Safety shields with heavy base (specifications applicable to hazards)
- ✓ Fire extinguishers (dry chemical and carbon dioxide extinguishers)
- ✓ Sand bucket
- ✓ Fire blankets
- ✓ Emergency lights
- ✓ Emergency and safety hazard labels, signs and placards
- ✓ Fire or chemical detection or alarm system
- ✓ First-aid kits (additions specific to hazards present in laboratory-no medicine)
- ✓ Spill control kit (absorbent and neutralizing agents) specific to chemicals used
- ✓ Chemical storage cabinet or refrigerator (e.g. flammable, corrosive)
- ✓ Gallon-size (or other) carrier buckets for carrying chemical bottles
- ✓ Chemical fume hood (80–120 ft/minute capture velocity, vented to the outside for fume removal)
- ✓ Ground-fault circuit interrupter for electrical outlets that may be near liquids
- ✓ Container for broken glass and a separate one for sharps
- ✓ Safety Data Sheets (SDSs)
- ✓ Biosafety cabinet
- ✓ Safer sharps devices
- ✓ Automatic External Defibrillator
- ✓ Ergonomically designed equipment and furniture
- ✓ Bags colored and labeled for specific hazards
- ✓ Radiation monitoring equipment
- ✓ Disinfectant
- ✓ Flashlight

Appendix C

Proper Storage of Chemicals in the Lab

Section I: Basic Chemical Storage Guidelines

Section II: Chemical Storage Segregation

Section III: Safe Storage & Use of Peroxide-Forming Chemicals

Section I
Basic Storage Guidelines

This section provides requirements and recommendations for storing chemicals, hazardous and non-hazardous. Refer to Appendix H, hazard classifications definitions for "Health hazard" and "Physical hazard" and the SDS to determine if a chemical, material, product or mixture is hazardous. Hazardous waste storage requirements should be similar to hazardous chemical storage requirements.

Considerations for proper storage

- Ensure all containers of chemicals are properly labeled with the identity of the chemical and appropriate hazard warnings.
- Record the date of receipt on each chemical to assist with inventory management
- Record the date purchased and date of opening on each peroxide former and dispose or test for peroxides as directed (see **Appendix C (III)** for more information)
- Solutions must be labeled when prepared with full name of chemical(s), ID of preparer, date prepared and any applicable hazard warnings (see **Section 6.3**).
- Segregate all incompatible chemicals for proper storage by hazard class. In other words, store like chemicals together and away from other groups of chemicals that might cause reactions if mixed.
- Only store chemicals alphabetically within each group of compatible chemicals.
- Use approved flammable storage lockers or flammable storage containers to store flammable and combustible liquids exceeding 5 gallons in one room.
- Avoid storing chemicals on counter and bench tops; however, if necessary, liquids kept in squeeze bottles and other chemicals in secondary containers may be kept on counter and bench tops.

- Ensure caps and lids are securely tightened on containers. This prevents leaks and evaporation of contents.
- Chemicals should be stored no higher than eye level and never on the top shelf of a storage unit. Do not overcrowd shelves. It is recommended that each shelf should have an anti-roll lip.
- Avoid storing chemicals on the floor, even temporarily, or extending into traffic aisles.
- Chemical liquids should be stored in unbreakable or double-contained packaging, or the storage cabinet tray should have the capacity to hold 110% of the largest container or 10% of the aggregate volume of all containers, whichever is larger if containers break or leak.
- Store acids in a dedicated acid cabinet. Nitric acid, sulfuric acid, perchloric acid, and chromic acid are strong oxidizers. They may be stored in the same acid cabinet only if they are kept isolated from all other acids. Corrosive storage cabinet interiors and hardware (door hinges and shelf brackets) are corrosion resistant.
- CFH's should not be used for storage as containers block proper air flow, reduce available work space, and exacerbate hazards in case of fire or spill. Where it is necessary to store liquids in CFH's, containers shall be stored in secondary containment.

- Do not store hazardous chemicals in a cold room or other storage area with recirculating ventilation.
- Do not store chemicals under a sink, except for water-soluble cleaning solutions.
- Do not stack chemicals.
- Only compressed gas cylinders that are in use and secured in place shall be kept in the laboratory. All others, including empties, shall be sent to the compressed gas cylinder storage area on the OSU-CHS dock.
- Keep all stored chemicals away from heat and direct sunlight. Heat and direct sunlight may impact and degrade chemicals, deteriorate storage containers and labels.
- Ethers and other peroxide formers should be stored in the dark.
- Purchase only what is needed. If possible, borrow chemicals from a colleague.
- Some materials are more stable when stored under an inert gas such as nitrogen. See the manufacturers information/SDS for guidance
- If old containers of peroxide-forming chemicals are found, do not move them. Contact the DEP for assistance in disposing of the container.
- Properly collect, tag and date waste. Keep chemical waste containers closed/sealed. Use secondary containment under waste collection containers to prevent spills.
- First aid supplies, emergency phone numbers, eyewash and emergency shower equipment, fire extinguishers, spill cleanup supplies and personal protective equipment should be readily available and personnel trained in their use.
- Particularly Hazardous Substances (PHS) should be purchased in the smallest quantities possible and must be isolated in compatible groupings and properly labeled. Warning labels specific to the hazard associated with the chemical must be affixed to: storage areas, cabinets, containers, and secondary containers (see **Appendix H for definition**)
- Stored chemicals should be inspected periodically for deterioration and container integrity. Conduct periodic cleanouts to minimize accumulating unwanted chemicals.

Refrigerators Used for Hazardous Material Storage

- Refrigerators used for storing flammable and combustible liquids shall be designed for that purpose. Do not use ordinary domestic units.
- Do not store food in refrigerators located in laboratory areas.
- Label refrigerators used for storing chemicals, samples or media as follows: “Caution—Do Not Store Food or Beverages in This Refrigerator” or similar wording. Labels may be fabricated by users provided they are legible and securely affixed to the refrigerator.
- Refrigerators used for food and beverages outside of laboratory areas require no posting.

Squeeze Bottles, and Wash Bottles

- Hazardous materials are often transferred to squeeze bottles and other plastic containers. These are made of plastics, such as high-density polyethylene, low-density polyethylene and polypropylene and may exhibit varying degrees of resistance to different chemicals. Moreover, they may deteriorate over time, especially when exposed to sunlight or UV sources. Utilize resources such as user knowledge or chemical resistance data such as that provided by the http://plastics.americanchemistry.com/Plastic-Resin-Codes-PDF to determine and select the proper material.

Secondary Containment for Liquids

- Storing liquid hazardous materials in secondary containment is used to organize materials and minimize the impact and spread of spills resulting from broken/leaking containers. Secondary containment capacity must be 110% of the largest container or 10% of the aggregate volume of all containers, whichever is larger.

- Secondary containment is available in different materials which provide varying resistance to different chemicals. Use resources such as user knowledge or the information provided below to select the proper material.

    - Photo Trays

        - Generally, these provide good resistance for acids, aqueous solutions and some organic solvents. But they may not be a good choice for halogenated solvents.

        - Photo trays are available through several commercial sources, including Scientific Plastics. This company provides trays in several depths, with width and length in 1" increments.

    - Polypropylene and Hi Density Polyethylene Trays

        - These may be affected by some aromatic and halogenated hydrocarbons.

        - See http://plastics.americanchemistry.com/Plastic-Resin-Codes-PDF for a chemical resistance database for these materials.

    - Stainless Steel and Pyrex Trays

        - Stainless steel and Pyrex trays are resistant to a broader spectrum of chemicals. However they are more costly than plastic trays and aren't available in as many different sizes and configurations.

    - Larger Capacity Containers

        - Larger containers, bins and boxes are acceptable for larger volumes of chemicals provided they are resistant to the chemicals stored in them.

Section II
Chemical Storage Segregation

Chemical Incompatibility Matrices and Tables

Segregate incompatible chemicals (e.g., storing oxidizing acids and flammable solvents in separate locations). This is to prevent inadvertent mixing of incompatible chemicals which can produce harmful gases/vapors, heat, fire and explosions. The chemical incompatibility matrices and tables presented below provide recommended (optional) guidelines for segregating incompatible chemicals. They may be used in combination with container labels, SDSs, and user knowledge for storing and segregating chemicals.

Table 1: Incompatibilities by Hazard Class

	Acids, inorganic	Acids, oxidizing	Acids, organic	Alkalis (bases)	Oxidizers	Poisons, inorganic	Poisons, organic	Water-reactives	Organic solvents
Acids, inorganic			X	X		X	X	X	X
Acids, oxidizing			X	X		X	X	X	X
Acids, organic	X	X		X	X	X	X	X	
Alkalis (bases)	X	X	X				X	X	X
Oxidizers			X				X	X	X
Poisons, inorganic	X	X	X				X	X	X
Poisons, organic	X	X	X	X	X	X			
Water-reactives	X	X	X	X	X	X			
Organic solvents	X	X		X	X	X			

Table 2: Chemical Incompatibility Table

CHEMICAL	KEEP OUT OF CONTACT WITH
Acetic acid	Chromic acid, nitric acid, perchloric acid, peroxides, permanganates and other oxidizers
Acetone	Concentrated nitric and sulfuric acid mixtures, and strong bases
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Alkali metals	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia, anhydrous	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided

	organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	Same as chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, glycerin, turpentine, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
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
Hydrocarbons	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Acids
Hydrofluoric acid	Ammonia, aqueous or anhydrous, bases and silica
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids
Hydrogen sulfide	Fuming nitric acid, other acids, oxidizing gases, acetylene, ammonia (aqueous or anhydrous), hydrogen
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen; flammable liquids, solids, or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, and oils

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 and perchlorate	Sulfuric and other acids, alkali metals, magnesium and calcium.
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	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	Potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)
Tellurides	Reducing agents

(From Manufacturing Chemists' Association, *Guide for Safety in the Chemical Laboratory,* **pp. 215–217, Van Nostrand**)

Table 3: Basic Chemical Segregation

Store Particularly Hazardous Substances (PHSs-see definitions in appendix H) separately, within each hazard class below. Take into account all hazards of a particular chemical when determining 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.

Corrosives - Acids	Store separately in plastic secondary containers and/or in acid storage cabinet. Segregate inorganic and oxidizing acids (i.e., nitric, sulfuric, hydrochloric and perchloric acids) from organic acids (i.e., acetic acid, propionic, formic acids) from special corrosives (i.e., hydrofluoric, chromic 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, heat, and combustible materials. Store highly volatile flammable liquids in an explosion-proof refrigerator. (PHS flammables: toluene, benzene, carbon disulfide)	Acetone Benzene Diethyl ether Methanol Ethanol Toluene Glacial acetic acid Carbon disulfide	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 - Low-reactive	Store on general laboratory benches or shelving preferably behind glass doors and below eye level.	Agar Sodium chloride Sodium bicarbonate Buffers Most non-reactive salts	See specific SDS.
Oxidizers	Store in a spill tray inside a chemical storage cabinet. Separate from flammable and combustible materials. Very strong oxidizers (chromic acid) should be stored in glass or inert containers. Do not use corks or rubber stoppers. (PHS oxidizers: lead nitrate, osmium tetroxide)	Ammonium persulfate Benzoyl peroxide Ferric chloride Iodine Sodium hypochlorite Potassium dichromate The following are generally considered oxidizing substances: Peroxides, perchlorates, permanganates, halogens chlorates, nitrates, bromates, superoxides.	Separate from reducing agents, organics, flammables, and combustibles.
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	Flammable liquids, acids, bases, and oxidizers. See specific SDS.

		Formic acid	
Water-Reactive Chemicals	Store in dry, cool location such as a desiccator; protect from water fire sprinkler, sink.	Sodium metal Potassium metal Lithium metal Lithium aluminum hydride Hydrides Borohydrides	Separate from all aqueous solutions and oxidizers.
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 SDS.
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 SDS.
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 SDS.
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 SDS.
Air reactive (pyrophoric)	Store in dry, inert atmosphere filled with an inert gas such as helium, argon, or nitrogen	Metal powders Lithium reagents	See specific SDS.
Potentially explosive	Store in a cool, dry area away from heat and ignition sources such as open flames, hot surfaces, spark sources, and direct sunlight	Azides Nitrates Perchlorates See http://en.wikipedia.org/wiki/Category:Explosive_chemicals	See specific SDS.

Additional Chemical Segregation Examples and References

OSU EHS Chemical Guide; http://ehs.okstate.edu/hazmat/gloves1.htm; use “Category” and “DOT Class” columns

Section III

Safe Storage & Use of Peroxide-Forming Chemicals

A wide variety of organic compounds spontaneously form peroxides by a free radical reaction of the hydrocarbon with molecular oxygen. Under normal storage conditions, formed peroxides can accumulate in the chemical container and may explode when subjected to heat, friction or mechanical shock. For this reason, it is imperative that all researchers learn to recognize and safely handle peroxide-forming compounds.

Recommended storage limits and specific guidance for common chemicals that can form peroxides are listed in Table 1. The chemicals listed in List A as ***"peroxide hazard on storage – without concentration"*** in the table can form peroxides that are difficult to detect and eliminate. These peroxides can come out of solution and form crystals or a gel in the bottom of the container. They are extremely unstable and can violently decompose with the smallest disturbance, sometimes even spontaneously. They can be hazardous even if not opened. Do not store these chemicals more than 12 months unless tests taken every 3 months show that they contain less than 80 ppm peroxides. If they have not been opened within 18 months they should be disposed without opening.

The chemicals listed in List B as ***"hazard due to peroxide concentration"*** can undergo explosive polymerization initiated by dissolved oxygen. This class of peroxide-forming chemicals has a propensity for exploding when used experimentally in operations such as distillations. Do not store these chemicals more than 12 months unless tests show that they contain less than 80 ppm of peroxides.

The chemicals listed in List C as ***"autopolymerize as a result of peroxide accumulation***" may explode when relatively small quantities of peroxides are formed. It is common to distill these peroxide-forming solvents before use and this concentrates the dissolved peroxides and subjects them to heat and mechanical shock.

The chemicals listed in Table 2 represent other peroxide-forming chemicals that cannot be placed into the other categories but nevertheless require handling with precautions.

Practices for Control of Peroxide-forming Organic Materials

Inhibitors

Many methods can be used to stabilize or inhibit the peroxidation of susceptible chemicals. If it does not interfere with the use of the chemical and if available, peroxide scavengers (inhibitors) **shall** be added in small quantities, and peroxide-forming chemicals **shall** be ordered with inhibitor added.

Purchase

Ideally, purchases of peroxide-forming chemicals should be restricted to ensure that these chemicals are used up completely before they can become peroxidized. This requires careful experiment planning. Researchers should purchase no more material than is needed to complete an experiment within the chemical's safe shelf life.

Storage

Peroxide-forming chemicals shall be stored in sealed, air-impermeable, light-resistant containers (light can initiate peroxide formation). Peroxide-forming chemicals should be stored in their original manufacturer's container whenever possible. This is very important in the case of diethyl ether because the iron in the steel containers that the material is shipped in acts as a peroxide inhibitor.

Labeling and Shelf-Life Limitation

Peroxides tend to form in materials as a function of age. Therefore, it is imperative that researchers are keenly aware of the age of their peroxide-forming chemicals. Researchers must date each container upon arrival in the

laboratory. Containers must be dated again when opened for the first time. An appropriate expiration date based on the information found in Table 1 should also be on the label.

Testing and Deperoxidation

When the date on the container expires, the peroxide-forming chemical shall either be 1) tested for peroxide content or 2) assumed to contain excessive peroxides and disposed of as hazardous waste. The maximum allowable concentration of peroxide in chemicals is 80 ppm. If a value over 80 ppm is detected, the owner shall deperoxidize the chemical or dispose of it as hazardous waste. Materials that are older than the suggested shelf life but have been tested and have no detectable peroxides or peroxide concentrations less than 80 ppm may be retained but should be tested at least quarterly. All chemicals to be distilled must be tested prior to distillation regardless of age. Researchers should **never** test containers of unknown age or origin. Older containers are far more likely to have concentrated peroxides or peroxide crystallization in the cap threads and therefore can present a serious hazard when opened for testing.

The easiest method to test for peroxides is the use of peroxide test strips. These strips are simple to use and can be obtained from a variety of suppliers including Lab Safety, Grainger and Fisher. For volatile organic chemicals, the test strip is immersed in the chemical for 1 second, then the tester breathes slowly on the strip for 15-30 seconds or until the color stabilizes. The color is then compared with a colorimetric scale provided on the bottle. Test strips must be kept refrigerated and must have an expiration date on the bottle.

Management and disposal of old containers

Older containers of peroxide-forming chemicals, or containers of unknown age or history, must be handled very carefully and should never be opened by researchers. Any peroxide-forming chemical with visible discoloration, crystallization or liquid stratification should be treated as potentially explosive. Older steel containers that have visible rust may also be extremely dangerous. If any of these conditions are observed on a peroxide-forming chemical container or if the origin and age are unknown, do not attempt to move or open the container. Contact LSC to have the container inspected and if necessary disposed of properly.

Safe Distillation

- Eliminate the peroxides with a chemical reducing agent or pass the solvent through activated alumina.
- Add mineral oil to the distillation pot. This has the combined effect of "cushioning" any bumping, maintaining dilution and serving as a viscous reaction moderator in case the peroxides begin to decompose.

Carefully monitor the distillation process to ensure that it does not dry out completely, and then overheat. Distillation can concentrate peroxides, especially if taken to a dry state. Peroxides will be present mainly in the still bottoms.

Reducing Peroxides during Distillation

Small pieces of sodium metal can be added to the distillation vessel to reduce peroxides. Use benzophenone as an indicator for the presence of sodium metal (benzophenone in the presence of sodium metal forms a radical with a deep-blue color). When the blue color disappears, add more sodium metal.

Safe Storage Periods for Peroxide Formers

Unopened chemicals from manufacturer:	18 months
Opened containers:	
Chemicals in Table 1.A.	3 months
Chemicals in Tables 1.B. and 2.D.	12 months
Uninhibited chemicals in Table 1.C.	24 hours

Inhibited chemicals in Table 1.C. (Do not store under an inert atmosphere)	12 months

Table 1. Common chemicals that form explosive levels of peroxides and their storage limits

List A	List B	List C
Form potentially explosive peroxides without concentration[a]. Dispose or test 3 months after opening.	Form potentially explosive peroxides on concentration[b] Dispose or test 12 months after opening.	Autopolymerize as a result of peroxide accumulation. Dispose or test inhibited materials after 12 months.
Butadiene[c]	Acetal	Acrylic acid
Chlorobutadiene (Chloroprene)[d]	Acetaldehyde	Acrylonitrile
Chloroprene	Acrolein	Butadiene[e]
Di-iso-butyl ether	Benzyl alcohol	2-Butanol
Diisopropyl ether (Isopropyl ether)	Cyclohexanol	Chlorobutadiene
Divinyl acetylene	2-cyclohexen-1-ol	Chloroprene
Divinyl ether	Cumene (Isopropylbenzene)	Chlorotrifluoroethylene
Isobutyl ether	Cycloheptanone	Ethyl acrylate
Methacrylate	Cyclohexene	Methyl methacrylate
Potassium amide	Cyclopentene	Stryene
Potassium metal	Decahydronaphthalene (Decalin)	Tetrafluoroethylene[e]
Sodium amide (Sodamide)	Diacetylene (Butadiene)	Vinyladiene chloride
Tetrafluoroethylene[c]	Dicyclopentadiene	Vinyl acetate
Vinylidene chloride (1,1-Dichloro-ethylene; 1,1-DCE)	Diethyl ether (Ethyl ether)	Vinyl acetylene[e] (MVA)
	Diethylene glycol	Vinyl chloride
	Diethylene glycol dimethyl ether (Diglyme)	Vinyl pyridine
	Dimethyl ether	
	Dioxanes	
	Diphenyl ether	
	1,1-Diethoxyethane ether	
	Ethylene glycol dimethyl ether (Glyme)	
	Ethylene glycol ether acetate	
	Ethylene glycol monomethyl ether	
	Furans	
	4-Heptanol	
	Methyl acetylene	
	3-Methyl-1 butanol	
	Methyl cyclopentane	
	Methyl isobutyl ketone (MIBK)	
	2-Pentanol	
	4-Penten-1-ol	
	1-Phenylethanol	
	2-Phenylethanol	
	2-Propanol (Isopropanol, “IPA”)	
	Tetrahydrofuran	
	Tetrahydronaphthalene	
	Vinyl ethers	
	Other secondary alcohols	

[a]Store under nitrogen, if practical.
[b]WARNING! May become unstable if concentrated intentionally or accidentally by user.
[c]When stored as an inhibited liquid monomer.
[d]When stored as a liquid monomer.
[e]When stored as a gas.

R.J. Kelly, "Review of Safety Guidelines for peroxide-forming Organic Chemicals", *Chemical Health & Safety*, September/October 1996, pp 28-36.
M.J. Pitt; E. Pitt, *Handbook of Laboratory Waste Disposal*, Ellis Horwood Publisher, UK, 1985

Table 2

List D – Chemicals that may form peroxides but cannot be clearly placed in Lists A-C

Acrolein	tert-Butyl methyl ether	Di(1-propynl) ether	n-Methylphenetole
Allyl ether	n-Butyl phenyl ether	Di(2-propynl) ether	2-Methyltetrahydrofuran
Allyl ethyl ether	n-Butyl vinyl ether	Di-n-propoxymethane	3-Methoxy-1-butyl acetate
Allyl phenyl ether	Chloroacetaldehyde diethylacetal	1,2-Epoxy-3-isopropoxypropane	2-Methoxyethanol
p-(n-Amyloxy)benzoyl chloride	2-Chlorobutadiene	1,2-Epoxy-3-phenoxypropane	3-Methoxyethyl acetate
n-Amyl ether	1-(2-Chloroethoxy)-2-phenoxyethane	p-Ethoxyacetophenone	2-Methoxyethyl vinyl ether
Benzyl n-butyl ether	Chloroethylene	1-(2-Ethoxyethoxy)ethyl acetate	Methoxy-1,3,5,7-cyclooctatetraene
Benzyl ether	Chloromethyl methyl ether	2-Ethoxyethyl acetate	b-Methoxypropionitrile
Benzyl ethyl ether	b-Chlorophenetole	(2-Ethoxyethyl)-a-benzoyl benzoate	m-Nitrophenetole
Benzyl methyl ether	o-Chorophenetole	1-Ethoxynaphthalene	1-Octene
Benzyl-1-napthyl ether	p-Chlorophenetole	o,p-Ethoxyphenyl isocyanate	Oxybis(2-ethyl acetate)
1,2-Bis(2-chloroethoxyl)ethane	Cyclooctene	1-Ethoxy-2-propyne	Oxybis(2-ethyl benzoate)
Bis(2-ethoxyethyl)ether	Cyclopropyl methyl ether	3-Ethoxypropionitrile	b,b-Oxydipropionitrile
Bis(2-(methoxyethoxy)ethyl) ether	Diallyl ether	2-Ethylacrylaldehyde oxime	1-Pentene
Bis(2-chloroethyl) ether	p-Di-n-butoxybenzene	2-Ethylbutanol	Phenoxyacetyl chloride
Bis(2-ethoxyethyl) adipate	1,2-Dibenzyloxyethane	Ethyl-b-ethoxypropionate	a-Phenoxypropionyl chloride
Bis(2-methoxyethyl) carbonate	p-Dibenzyloxybenzene	2-Ethylhexanal	Phenyl-o-propyl ether
Bis(2-methoxyethyl) ether	1,2-Dichloroethyl ethyl ether	Ethyl vinyl ether	p-Phenylphenetone
Bis(2-methoxyethyl) phthalate	2,4-Dichlorophenetole	Furan	n-Propyl ether
Bis(2-methoxymethyl) adipate	Diethoxymethane	2,5-Hexadiyn-1-ol	n-Propyl isopropyl ether
Bis(2-n-butoxyethyl) phthalate	2,2-Diethoxypropane	4,5-Hexadien-2-yn-1-ol	Sodium 8-11-14-eicosatetraenoate
Bis(2-phenoxyethyl) ether	Diethyl ethoxymethylenemalonate	n-Hexyl ether	Sodium ethoxyacetylide
Bis(4-chlorobutyl) ether	Diethyl fumarate	o.p-Iodophenetole	Tetrahydropyran
Bis(chloromethyl) ether	Diethyl acetal	Isoamyl benzyl ether	Triethylene glycol diacetate
2-Bromomethyl ethyl ether	Diethylketene	Isoamyl ether	Triethylene glycol dipropionate
beta-Bromophenetole	m,o,p-Diethoxybenzene	Isobutyl vinyl ether	1,3,3-Trimethoxypropene
o-Bromophenetole	1,2-Diethoxyethane	Isophorone	1,1,2,3-Tetrachloro-1,3-butadiene
p-Bromophenetole	Dimethoxymethane	b-Isopropoxypropionitrile	4-Vinyl cyclohexene
3-Bromopropyl phenyl ether	1,1-Dimethoxyethane	Isopropyl-2,4,5-trichlorophenoxy acetate	Vinylene carbonate

Appendix D
OSU-CHS Research - Report of Laboratory Safety Incident

Principal Investigator: _____ Department: _____

Location of Incident: _____ Date of Incident: _____ Time: _____

Employee(s) knowledgeable of the incident (name(s) and phone number(s):

Description of incident:

Was medical attention sought? ☐ No ☐ Yes, where: _____
- If YES, complete employee injury report; fax to OSU Safety Office 918-561-1261; copy to Laboratory Safety Coordinator fax 918-561-1416.

Was the department chair (or equivalent) notified? ☐ No ☐ Yes
- If YES, when:

Was the Laboratory Safety Coordinator notified? ☐ No ☐ Yes
- If YES, when:

Was CHS Security notified? ☐ No ☐ Yes
- If YES, when:

Describe the actions of all primary personnel involved, i.e. lab workers, departmental, medical, laboratory safety coordinator.

Additional corrective measures taken or to be taken

Describe policy or security failures contributing to the incident

Signature of Principal Investigator

Printed Name: _____

Signature of Department Chair (or equivalent)

Printed Name: _____

Major incidents must be reported to the Laboratory Safety Coordinator (LSC) (561-1403) immediately. All other incidents must be reported to the LSC, at a minimum, within 48 hours. A copy of this incident report must be submitted to the **LSC office, B143H** within 1 week of the incident. (attach additional pages as necessary)

Appendix E-Voluntary Respiratory Use

Oklahoma State University Center for Health Sciences: Research

Voluntary Respirator Use

Respiratory Protection Standard, OSHA 29 CFR 1910.134
(Mandatory) Information for Using Respirators Voluntarily - When Not Required Under the Standard

Respirators are an effective method of protection against designated hazards when properly selected and worn. Respirator use is encouraged, even when exposures are below the exposure limit, to provide an additional level of comfort and protection for workers. However, if a respirator is used improperly or not kept clean, the respirator itself can become a hazard to the worker. Sometimes, workers may wear respirators to avoid exposures to hazards, even if the amount of hazardous substance does not exceed the limits set by OSHA standards. If your employer provides respirators for your voluntary use, or if you provide your own respirator, you need to take certain precautions to be sure that the respirator itself does not present a hazard.

You should do the following:

1. Read and heed all instructions provided by the manufacturer on use, maintenance, cleaning and care, and warnings regarding the respirators limitations.

2. Choose respirators certified for use to protect against the contaminant of concern. NIOSH, the National Institute for Occupational Safety and Health of the U.S. Department of Health and Human Services, certifies respirators. A label or statement of certification should appear on the respirator or respirator packaging. It will tell you what the respirator is designed for and how much it will protect you.

3. Do not wear your respirator into atmospheres containing contaminants for which your respirator is not designed to protect against. For example, a respirator designed to filter dust particles will not protect you against gases, vapors, or very small solid particles of fumes or smoke.

4. Keep track of your respirator so that you do not mistakenly use someone else's respirator.

5. Watch the videos entitled “Voluntary Use of Respirators” and “The Difference between Respirators and Surgical Masks” online at the OSHA Respiratory Protection web site at https://www.osha.gov/SLTC/respiratoryprotection/training_videos.html.

Signature below indicates the above information has been read and understood.

Worker_____ Date _____

Print Name _____

Copies: 1) Worker, 2) Principal Investigator, 3) Laboratory Safety Coordinator

Hazard Communication Safety Data Sheets

The Hazard Communication Standard (HCS) requires chemical manufacturers, distributors, or importers to provide Safety Data Sheets (SDSs) (formerly known as Material Safety Data Sheets or SDSs) to communicate the hazards of hazardous chemical products. As of June 1, 2015, the HCS will require new SDSs to be in a uniform format, and include the section numbers, the headings, and associated information under the headings below:

Section 1, Identification includes product identifier; manufacturer or distributor name, address, phone number; emergency phone number; recommended use; restrictions on use.

Section 2, Hazard(s) identification includes all hazards regarding the chemical; required label elements.

Section 3, Composition/information on ingredients includes information on chemical ingredients; trade secret claims.

Section 4, First-aid measures includes important symptoms/ effects, acute, delayed; required treatment.

Section 5, Fire-fighting measures lists suitable extinguishing techniques, equipment; chemical hazards from fire.

Section 6, Accidental release measures lists emergency procedures; protective equipment; proper methods of containment and cleanup.

Section 7, Handling and storage lists precautions for safe handling and storage, including incompatibilities.

Section 8, Exposure controls/personal protection lists OSHA's Permissible Exposure Limits (PELs); Threshold Limit Values (TLVs); appropriate engineering controls; personal protective equipment (PPE).

Section 9, Physical and chemical properties lists the chemical's characteristics.

Section 10, Stability and reactivity lists chemical stability and possibility of hazardous reactions.

Section 11, Toxicological information includes routes of exposure; related symptoms, acute and chronic effects; numerical measures of toxicity.
Section 12, Ecological information*
Section 13, Disposal considerations*
Section 14, Transport information*
Section 15, Regulatory information*

Section 16, Other information, includes the date of preparation or last revision.

*Note: Since other Agencies regulate this information, OSHA will not be enforcing Sections 12 through 15(29 CFR 1910.1200(g)(2)).

Employers must ensure that SDSs are readily accessible to lab workers.
See Appendix D of 1910.1200 for a detailed description of SDS contents.

For more information: https://www.osha.gov/Publications/OSHA3514.html

OSHA
(800) 321-OSHA (6742)

U.S. Department of Labor

« Hazard Communication

OSHA QUICK CARD™

Hazard Communication Standard Labels

OSHA has updated the requirements for labeliing of hazardous chemicals under its Hazard Communication Standard (HCS). As of June 1, 2015, all labels will be required to have pictograms, a signal word, hazard and precautionary statements, the product identifier, and supplier identification. A sample revised HCS label, identifying the required label elements, is shown on the right. Supplemental information can also be provided on the label as needed.

For more information: www.osha.gov

OSHA (800) 321-OSHA (6742)

SAMPLE LABEL

PRODUCT IDENTIFIER

CODE _____
Product Name _____

SUPPLIER IDENTIFICATION

Company Name_____
Street Address _____
City _____ State _____
Postal Code _____ Country _____
Emergency Phone Number _____

PRECAUTIONARY STATEMENTS

Keep container tightly closed. Store in cool, well ventilated place that is locked.
Keep away from heat/sparks/open flame. No smoking.
Only use non-sparking tools.
Use explosion-proof electrical equipment.
Take precautionary measure against static discharge.
Ground and bond container and receiving equipment.
Do not breathe vapors.
Wear Protective gloves.
Do not eat, drink or smoke when using this product.
Wash hands thoroughly after handling.
Dispose of in accordance with local, regional, national, international regulations as specified.

In Case of Fire: use dry chemical (BC) or Carbon dioxide (CO_2) fire extinguisher to extinguish.

First Aid
If exposed call Poison Center.
If on skin (on hair): Take off immediately any contaminated clothing. Rinse skin with water.

HAZARD PICTOGRAMS

SIGNAL WORD
Danger

HAZARD STATEMENT

Highly flammable liquid and vapor.
May cause liver and kidney damage.

SUPPLEMENTAL INFORMATION

Directions for use

_____
_____
_____

Fill weight: _____ Lot Number _____
Gross weight: _____ Fill Date: _____
Expiration Date: _____

OSHA QUICK CARD™

Hazard Communication Standard Pictogram

As of June 1, 2015, the Hazard Communication Standard (HCS) will require pictograms on labels to alert users of the chemical hazards to which they may be exposed. Each pictogram consists of a symbol on a white background framed within a red border and represents a distinct hazard(s). The pictogram on the label is determined by the chemical hazard classification.

HCS Pictograms and Hazards

Health Hazard  ▪ **Carcinogen** ▪ **Mutagenicity** ▪ **Reproductive Toxicity** ▪ **Respiratory Sensitizer** ▪ **Target Organ Toxicity** ▪ **Aspiration Toxicity**	**Flame**  ▪ **Flammables** ▪ **Pyrophorics** ▪ **Self-Heating** ▪ **Emits Flammable Gas** ▪ **Self-Reactives** ▪ **Organic Peroxides**	**Exclamation Mark**  ▪ **Irritant (skin and eye)** ▪ **Skin Sensitizer** ▪ **Acute Toxicity** ▪ **Narcotic Effects** ▪ **Respiratory Tract Irritant** ▪ **Hazardous to Ozone Layer (Non-Mandatory)**
Gas Cylinder  ▪ **Gases Under Pressure**	**Corrosion**  ▪ **Skin Corrosion/Burns** ▪ **Eye Damage** ▪ **Corrosive to Metals**	**Exploding Bomb**  ▪ **Explosives** ▪ **Self-Reactives** ▪ **Organic Peroxides**
Flame Over Circle  ▪ **Oxidizers**	**Environment (Non-Mandatory)**  ▪ **Aquatic Toxicity**	**Skull and Crossbones**  ▪ **Acute Toxicity (fatal or toxic)**

For more information:

OSHA® Occupational Safety and Health Administration
U.S. Department of Labor
www.osha.gov (800) 321-OSHA (6742)

OSHA 3491-02 2012

Appendix H

Chemical Hazard Classification Definitions

Aspiration toxin: the entry of a liquid or solid chemical directly through the oral or nasal cavity, or indirectly from vomiting, into the trachea and lower respiratory system. This toxin includes severe acute effects such as chemical pneumonia, varying degrees of pulmonary injury or death following aspiration. It is initiated at the moment of inspiration, in the time required to take one breath, as the causative material lodges at the crossroad of the upper respiratory and digestive tracts in the laryngopharyngeal region.

Acutely toxic (highly toxic agent): a substance with a lethal dose (LD) or lethal concentration (LC) within the following limits. Oral: LD50< 50 mg/kg (oral rat), Inhalation: LC50 < 200 ppm / 1 hr or 2000 mg/m3 / 1 hr. Skin Contact: LD50 < 200 mg/kg (rabbit). Acutely toxic chemicals are capable of causing serious harm upon a single, brief exposure or from multiple exposures in a short space of time (usually less than 24 hours).

Blood/hematopoietic toxin: A chemical that damages the blood or blood production. Blood toxins can prevent the blood from carrying oxygen to cells.

Carcinogen: a substance or a mixture of substances which induce cancer or increase its incidence. Substances and mixtures which have induced benign and malignant neoplasms (tumors) in well-performed experimental studies on animals are considered also to be presumed or suspected human carcinogens unless there is strong evidence that the mechanism of tumor formation is not relevant for humans. Some carcinogens react directly with a cell's genetic information (the DNA), causing changes (mutations) that are incorporated into subsequent generations of that cell. Carcinogenic effects of exposure may have long latency periods, often 20 to 30 years after the initial exposure, before tumors are observed in humans.

A *select carcinogen* is any substance which meets one of the following criteria:

- It is regulated by OSHA as a carcinogen;
- It is listed under the category "Known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP);
- It is listed under Group 1 "Carcinogenic to humans by the International Agency for Research (IARC) Cancer Monographs"; or
- It is listed in either Group 2A or 2B by IARC or under the category "Reasonably anticipated to be carcinogens" by NTP.

Compressed gas: gases which are contained in a receptacle at a pressure of 200 kPa (29 psi) (gauge) or more, or which are liquefied or liquefied and refrigerated. They comprise compressed gases, liquefied gases, dissolved gases and refrigerated liquefied gases.

Combustible liquid: any liquid having a flash point at or above 100ºF (37.8ºC).

Cryogenics: is the study of the production of very low temperature (below −150 °C, −238 °F or 123 K) and the behavior of materials at those temperatures.

Corrosive: materials that cause destruction on contact with living tissue. Precautions for corrosives focus mainly on preventing such contact. Acids with a pH<2 and bases with a pH>12 are especially dangerous. Eye protection that forms a complete seal around the eyes (goggles) and appropriate gloves must always be used when handling corrosive materials. A face shield over safety glasses, a rubber apron and rubber boots may also be appropriate. An eyewash and safety shower must be readily accessible in areas where corrosives are used and stored.

Cutaneous hazards: causes damage to or disease in the skin or dermal layer, which is the body's largest organ.

Explosive: a solid or liquid chemical which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic chemicals are included even when they do not evolve gases.

Flammable aerosol: any non-refillable receptacle designed to eject components at least one of which is a flammable gas, liquid, or solid.

Flammable gas: a gas having a flammable range with air at 20 C and a standard pressure of 101.3 kPa (1 atmosphere).

Flammable liquid: any liquid having a flash point below 100ºF (37.8ºC), except any mixture having components with flashpoints of 100ºF (37.8ºC) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

Flammable solid: a solid, other than a blasting agent or explosive, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard.

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

Hepatotoxin: chemicals which produce liver damage. Signs of hepatotoxicity may include jaundice and liver enlargement. Hepatotoxicity includes not only the liver but also the gallbladder and bile duct. The liver is particularly susceptible to foreign chemicals because of its large blood supply and the major role it plays in metabolism. These factors can result in exposure to high doses of a toxicant and the production and immediate exposure to potentially toxic metabolites.

Irritant: non-corrosive chemicals that cause reversible inflammatory effects (swelling and redness) on living tissue by chemical action at the site of contact.

Mutagen: a chemical or physical agent able to change or damage the genetic material in cells.

Narcotic effect: a state of stupor, unconsciousness, or arrested activity produced by the influence of narcotics or other chemical or physical agents

Nephrotoxin: a poisonous effect of some substances on the kidneys. The primary forms of nephrotoxicity are nephritis (inflammation of the kidneys), glomerulonephritis (damage to the glomerulus portion of the nephron), and acute or chronic renal failure.

Neurotoxin: a poisonous complex especially of protein that acts on the nervous system. Toxins can damage cells of the central nervous system (brain and spinal cord) or the peripheral nervous system (nerves outside the central nervous system).

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.

Oxidizer: a chemical other than a blasting agent or explosive that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases. Oxidation reactions are a frequent cause of chemical accidents. When stored, segregate oxidizers from flammable and combustible materials, organic material and reducers.

Particularly Hazardous Substances: any chemical that may be a carcinogen, reproductive toxin, acutely toxic and/or highly reactive. Careful handling and stringent controls of these chemicals are essential to protect workers and the environment from contamination. For many examples of PHSs see https://www.safety.duke.edu/laboratory-safety/chemical-hygiene/particularly-hazardous-substances, courtesy of Duke University, Occupational Hygiene and Safety Division.

Peroxide-forming chemicals: a class of compounds that have the ability to form shock-sensitive explosive peroxide crystals. See Appendix C(III) for more information.

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

Pyrophoric: a liquid or solid that, even in small quantities and without an external ignition source, can ignite or explode spontaneously or within five minutes after coming into contact with air at a temperature of 130^{o}F (54.4^{o}C) or below. Avoid a flammable spill by storing breakable glass bottles inside a rubber or plastic bottle carrier or other compatible double containment. Use and store all pyrophorics in an inert atmosphere (e.g., stored under nitrogen or argon).

Reproductive toxin: includes adverse effects on sexual function and fertility in adult males and females, as well as adverse effects on development of the offspring. Some reproductive toxic effects cannot be clearly assigned to either impairment of sexual function and fertility or to developmental toxicity. Nonetheless, chemicals with these effects shall be classified as reproductive toxicants. Chemicals that affect an individual's reproductive ability including chromosomal damage (mutations) and/or have an adverse effect on a fetus (teratogenesis).

Respiratory toxin: chemicals which irritate or damage pulmonary tissue. The primary function of the respiratory system is to deliver oxygen to the bloodstream and remove carbon dioxide from the blood. Thus, damage to the respiratory tissues interferes with blood/gas exchange that may cause serious malfunction of all tissues of the body, especially the brain and heart. Respiratory toxicity can occur in the upper respiratory system (nose, pharynx, larynx, and trachea) or in the lower respiratory system (bronchi, bronchioles, and lung alveoli). The primary types of respiratory toxicity are pulmonary irritation, asthma/bronchitis, reactive airway disease, emphysema, allergic alveolitis, fibrotic lung disease, pneumoconiosis, and lung cancer.

Respiratory sensitizer: a substance is classified as a respiratory sensitizer if there is evidence in humans that the substance can lead to specific respiratory hypersensitivity and/or if there are positive results from an appropriate animal test. Hypersensitivity is normally seen as asthma, but other hypersensitivity reactions such as rhinitis/conjunctivitis and alveolitis are also considered. The condition will have the clinical character of an allergic reaction. However, immunological mechanisms do not have to be demonstrated.

Self-heating: a material that, when in contact with air and without an energy supply, is liable to self-heat.

Self-reactive: a chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

Sensitizer: a chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical. A sensitizer (allergen) causes little or no reaction in man or test animals on first exposure. The problem arises on subsequent exposures when a marked immunological response occurs. The response is not necessarily limited to the contact site as it may be a generalized body condition. Mild allergies like hay fever are very common in the human population and cause symptoms such as red eyes, itchiness, and runny nose, eczema, and hives. Severe allergies may result in life-threatening reactions called anaphylaxis.

Simple asphyxiant: loss of consciousness and death due to lack of oxygen, or a chemical that can interfere with the body's use or transport of oxygen.

Target organ effects: effects on specific body systems which may occur as a result of exposure to a hazardous substance. These effects include hepatotoxins, nephrotoxins, neurotoxins, agents which act on the blood or hematopoietic system,

agents which damage the lung, reproductive toxins, cutaneous hazards, eye hazards, effects on the cardiovascular system and immune system.

Teratogen: pertains to irreversible conditions that leave permanent birth defects in live offspring (e.g., cleft palate, missing limbs).

Toxic agent: chemicals which have an average lethal dose (LD_{50}) or lethal concentration (LC_{50}, indicates average lethal inhalation exposure) of:

- Ingestion: LD_{50} between 50 and 500 mg/kg body weight when administered orally to albino rats;
- Skin Contact: LD_{50} between 200 and 1000 mg/kg body weight when administered by continuous dermal contact over a 24 hour period to albino rabbits, or
- Inhalation: LC_{50} between 200 and 2000 parts per million of gas or vapor or between 2 and 20 mg/l of mist, fume, or dust, when administered continuously by inhalation for one hour to albino rats.

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

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

Appendix I

In-Lab Worker Training Documents

Section I: In-Lab Safety Orientation Checklist

Section II: Worker In-Lab Safety Training List

In-Lab Safety Orientation Checklist
Supervisor's Information and Completion Form

(delete or strike through topics that don't apply; return copy to LSC (Laboratory Safety Coordinator) when completed)

WORKER INFORMATION	
Name:	Orientation completion date:
Email:	
Department:	Principal Investigator:

BASICS

☐ Provide lab worker information, hazardous components of research: chemical, biological, physical; warning properties and known symptoms.
☐ Assign designee(s) or self to accompany worker during orientation, monitor work assignments and answer questions.
NA: ☐ or Name:

POLICIES

☐ Review key policies.	• Broad Scope of Project • Review (M)SDS binder, lab inventory and other safety manuals • Lab/Project Specific SOPs • Personal Protective Equipment Use • Equipment and Tool Use (attach list) • Waste Handling • Handling of Spills • Proper Storage of Chemicals, PPE and Instruments	• Attire in the Lab (Street Clothing) • Labeling of Prepared Solutions • Daily: Before Starting/Before Leaving • Security/locking labs • Lab Specific Safety Policies • Emergency procedures and Forms • Rules regarding food, beverages, medication and cosmetic application • Housekeeping • Broken glass

ADMINISTRATIVE PROCEDURES

☐ Review general administrative procedures.	• Office/desk/work station • Keys/building access • Equipment maintenance/calibration • Explanation of Signs	• Purchase Requests • Laboratory Supplies • CHS ID Badge • Telephone (9-911)

INTRODUCTIONS AND TOURS

☐ Give introductions to department staff and key personnel during tour of work area.

☐ Tour of facility, including:	• Lab work area • Eye wash	• Emergency exits routes • Decontamination shower	• Core equipment • Fire response

POSITION INFORMATION

☐ Introductions to team.

☐ Review and complete research safety training, i.e. laboratory safety, bloodborne pathogen, biological safety.

☐ Review job description, performance expectations, standard operating procedures and standards.

☐ Perform dry run (without hazardous chemicals/materials) of procedure(s), then perform full run of procedure(s).

☐ Observe procedure(s); tech may be delegated, principal investigator (PI) shall observe at least one full procedure(s).

☐ Review job schedule and hours expected to be at work.

☐ Determine inclusion on active protocols, i.e. biological, animal, clinical, radiological.

SIGNATURE PRINCIPAL INVESTIGATOR:

Completing safety orientation does not ensure that new and inexperienced workers are competent to work in a laboratory without supervision. The PI is responsible for ensuring that new and inexperienced workers are directly supervised until the PI is confident in the new workers knowledge and practices and that the worker continues to receive ongoing safety training as necessary.

Worker In-Lab Safety Training Certification

page ___of ___

Worker:	Supervisor:	Lab:

Document for each lab worker specific in-lab training or briefing; e. g. safety data sheets before use of chemical, lab Safe Operating Procedures or protocols, spill procedures, hazardous waste procedures, emergency procedures, equipment (e.g. centrifuge, autoclave) use. Continue to provide training and add topics as applicable to changes in lab activities.

Training Topic	Worker Signature – I have read and/or understand the training topics	Date

Supervisor Signature-I have provided access to training materials above:

Appendix J

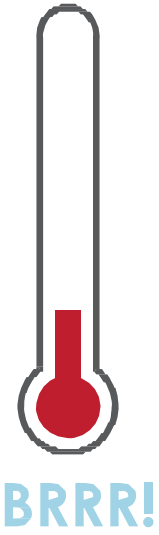
Liquid Nitrogen Handling and Use

LIQUID NITROGEN HANDLING AND USE

OVERVIEW

LN_2

Liquid nitrogen (LN_2) is inert, colorless, odorless, non-corrosive, non-flammable, tasteless, and extremely cold—and it has no warning properties. Special care must be taken by personnel who handle or work in areas where liquid nitrogen is used. The hazards associated with LN_2 include the following:



- Over-pressurization and **explosion** due to LN_2 vaporizing to nitrogen gas (**700x expansion ratio**) in unvented containers (e.g., cryovial) and equipment.
- Severe burns caused by exposure to cold temperatures.
- Asphyxiation due to displacement of oxygen in the air in confined work areas.

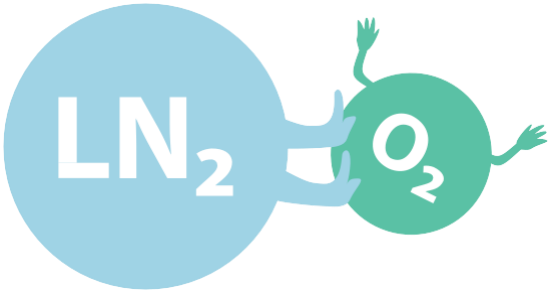
APPLICABILITY

All labs that store or use liquid nitrogen must comply with the Handling and Storage requirements listed in this fact sheet. In addition, this fact sheet provides general hazard warning and safety precaution information to users of LN_2. Laboratory personnel who work with or in areas where LN_2 is used must be familiar with these guidelines.

HEALTH HAZARDS

Humans cannot reliably detect the presence of nitrogen. Liquid nitrogen has a 700x expansion ratio that may create physical hazards and injuries from the explosion of unvented containers (e.g., cryovials), equipment, or other devices.

Extensive tissue damage or burns can result from exposure to LN_2 or cold nitrogen vapors. Asphyxiation may result from the displacement of oxygen in the air with nitrogen to levels where there is insufficient oxygen to support life. Inhalation of oxygen-deficient air can cause dizziness, nausea, vomiting, loss of consciousness, and death.



BEWARE OXYGEN DISPLACEMENT!

LIQUID NITROGEN HANDLING AND USE

FIRST AID

Personnel who have been exposed to LN_2 must seek immediate medical assistance.

Frostbite Exposure: In the event of frostbite from skin contact with LN_2, follow the procedures below:

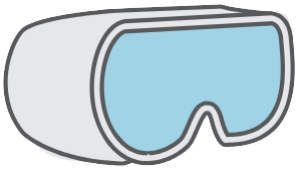
- Remove any clothing that may restrict circulation to the frozen area.
- Do not rub frozen parts, as tissue damage may result.
- Place the affected area in a warm water bath that has a temperature not in excess of 105° F (40° C). Never use dry heat.
- Seek medical attention.

PERSONAL PROTECTIVE EQUIPMENT

The following personal protective equipment is required when handling or using LN_2:

- Waterproof thermal insulated gloves (e.g., cryo gloves)
- Lab coats
- Goggles and Face Shield

Hands must be protected with waterproof thermal insulated gloves that can be quickly removed if LN_2 is spilled on them. Insulated gloves are not intended for submersing hands into LN_2.



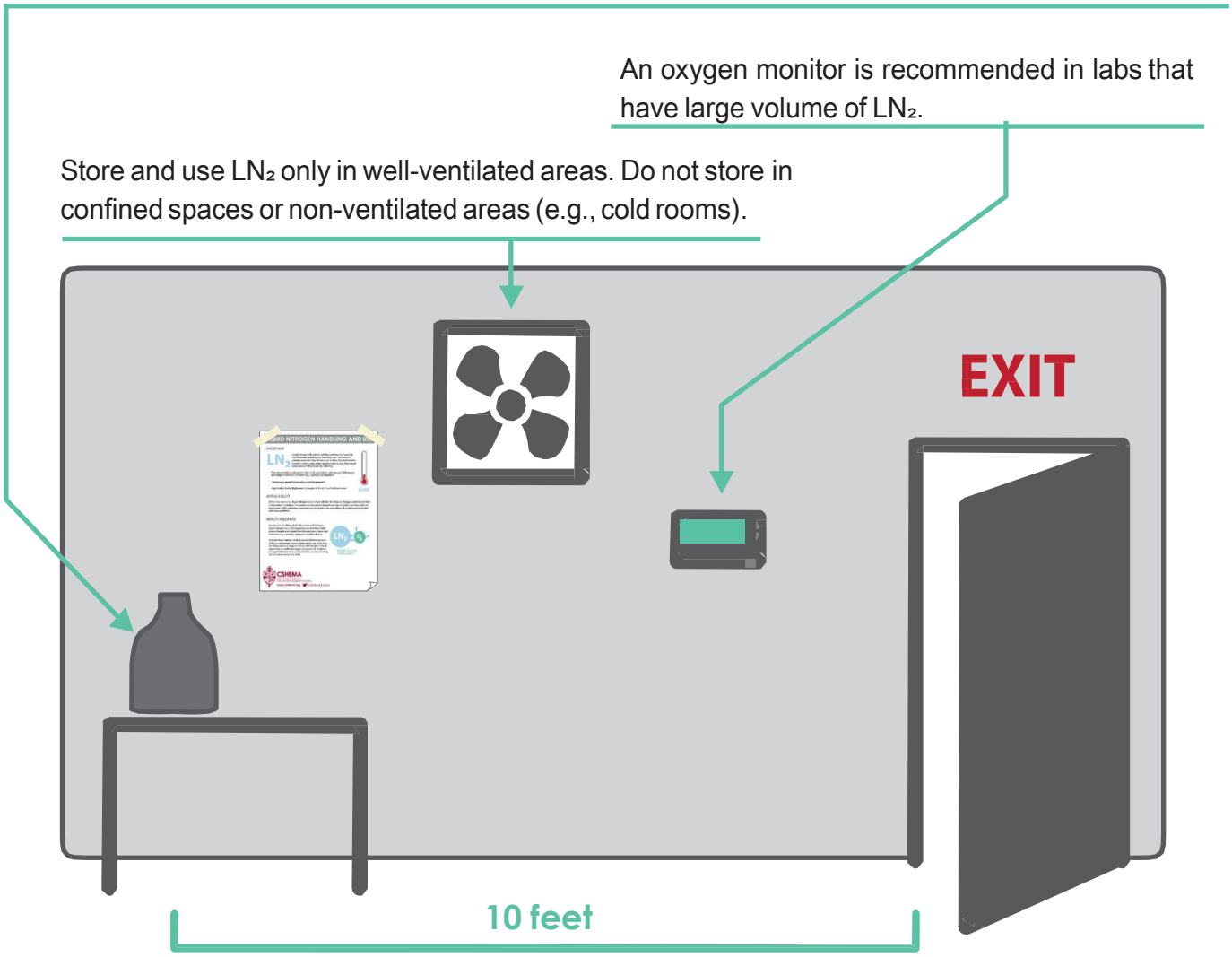
Eyes are most sensitive to the extreme cold of LN_2 and its vapors. Over-pressurization may result in the explosion of improperly vented equipment. Chemical splash goggles must be utilized when handling LN_2 and when handling sealed containers that have been stored in LN_2 (e.g., cryovials). Face shields shall be worn over goggles when filling dewars or other transfer of LN_2.

Body must be protected with pants (or equivalent), lab coats, and closed-toe shoes. Thermal insulated aprons are recommended.

LIQUID NITROGEN HANDLING AND USE

HANDLING AND STORAGE

- Store containers in an upright position. Do not drop, tip, or roll containers on their sides.
- Use only approved containers with lids to store and transport LN_2 (e.g., Thermolyne Thermo-Flask®). Lids must be vented to allow the off gassing of over-pressurized nitrogen gas.
- Never vapor-seal LN_2 storage containers.
- Never plug, remove, or tamper with any pressure relief device. Under normal conditions, these containers are designed to periodically vent gas.



- LN_2 containers/tanks must be kept **at least three feet** from all room or area exits and **at least 10 feet** from building exits.
- The storage and dispensing of LN_2 in public corridors is strictly prohibited.

LIQUID NITROGEN HANDLING AND USE

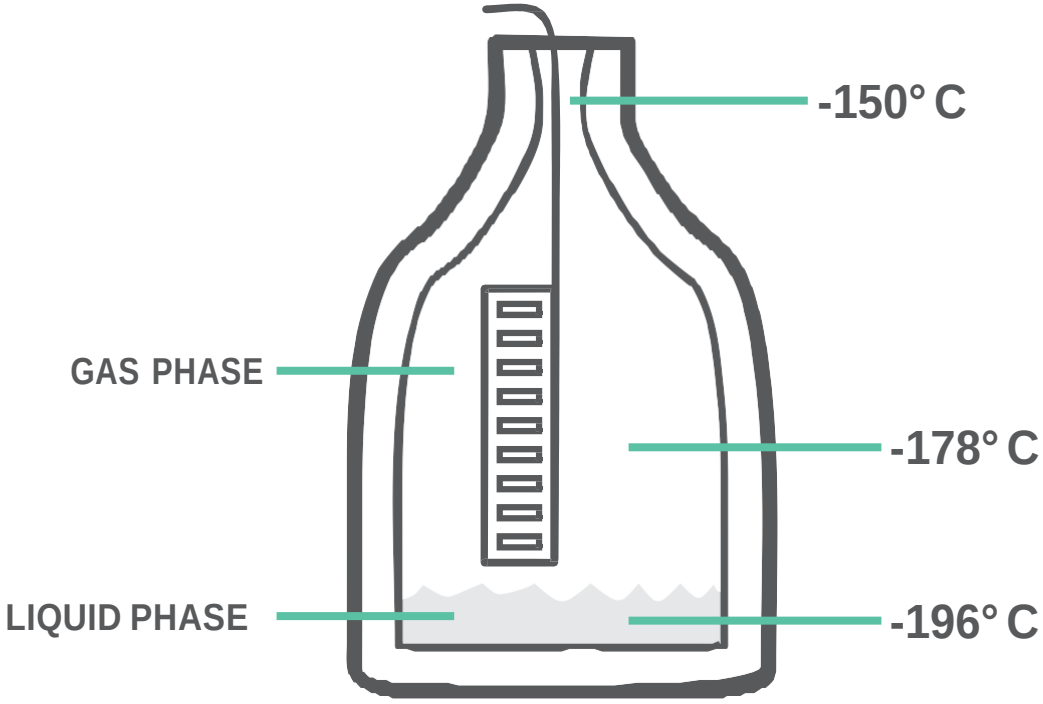
SAMPLE STORAGE PRECAUTIONS

*** WARNING—***Do not store cryovials in the liquid phase of LN_2 unless specifically approved by the manufacturer for liquid phase storage. Liquid can still enter closed screw-top cryovials with o-rings and* ***explode*** *when removed from storage.* *****

Laboratory personnel must use **extreme caution** when preserving samples in LN_2. LN_2 storage consists of a liquid phase and a gaseous phase, as illustrated below. If cryovials are immersed in the liquid phase, LN_2 can still enter the closed screw-top cryovials with o-rings during storage. The cryovial may then **explode** when it is removed from storage due to the vaporization and expansion (700x expansion ratio) of the liquid nitrogen inside the cryovial.

RECOMMENDED TEMPERATURES IN A LIQUID-NITROGEN STORAGE SYSTEM

(information courtesy of Nalge Nunc International)



SAMPLE STORAGE PRECAUTIONS

Safety Precautions

- Use only manufacturer-approved containers (e.g., cryovials) for storage in LN_2.
- If storage in the LN_2 liquid phase is required, utilize either:
  - Manufacturer-approved cryovials specifically designed for liquid phase storage; or
  - Gaseous phase-approved screw-top cryovials that are then hermetically sealed in an outer protective envelope designed for use in LN_2. Nalge Nunc International manufactures CryoFlex™ tubing specifically for hermetically sealing cryovials for liquid phase storage.
- Where feasible, the risk of explosion of cryovials stored in the LN_2 liquid phase can be further reduced by moving cryovials to the gaseous phase in the LN_2 container for at least 24 hours before removing.
- Where feasible, the handling of containers (e.g., cryovails) inside of Biological Safety Cabinets or Chemical Hoods (with the sash lowered) will further reduce the risk of injury from explosions caused by excess pressure within containers.

Thermo-Flask ® containers pictured are manufactured by Barnstead International – Thermolyne and distributed by VWR.

Goggles pictured are manufactured by North Safety Products and distributed by VWR.

Gloves pictured are manufactured by Tempshield, Inc. and distributed by VWR.

REFERENCES

Air Products and Chemicals, Inc., "Safetygram-7: Liquid Nitrogen," http://www.airproducts.com/Responsibility/EHS/ProductSafety/ProductSafety-Information/safetygrams.htm

Barnstead International, http://www.barnsteadthermolyne.com/

Nalge Nunc International, "Nunc Cryopreservation Manual", http://www.nalgenunc.com/

Tempshield, Inc., http://www.cryogloves.com/

Campus Safety Health and Environmental Management, http://www.cshema.org