CHEMICAL HYGIENE PLAN

Soka University of America

Environmental Health and Safety

1 University Drive, Aliso Viejo, California 92656

Office: 949-480-4000 • Fax: 949-480-4151

Table of Contents

Appendices

Acknowledgements

Soka University of America's (SUA) Chemical Hygiene Plan (CHP) was developed by using examples of *Prudent Practices in the Laboratory* and University of California – Irvine's (UCI) CHP. We would like to thank UCI's Environmental Health & Safety (EHS) Department for allowing us to use their CHP as a reference.

Chapter 1: Introduction

Purpose

Soka University of America (SUA or the University) is committed to providing a safe and healthy environment to its employees and students (referred as “workers” hereafter). In an effort to ensure the protection of workers from the risks associated with the use of hazardous chemicals, the Occupational Safety and Health Administration (OSHA) has promulgated a standard entitled *Occupational Exposures to Hazardous Chemicals in Laboratories* (29 CFR 1910.1450), referred to as the Laboratory Standard. The Laboratory Standard requires the development and implementation of a formal, written, and employee-accessible program, referred to as a Chemical Hygiene Plan (CHP).

The CHP establishes a formal written program for protecting workers against adverse health and safety hazards associated with exposure to potentially hazardous chemicals and must be made available to all workers working with hazardous chemicals. Individuals working with potentially hazardous chemicals in laboratory settings must follow procedures and work practices that are described in this written program.

Scope and Application

This written program applies to all laboratories that use, store, or handle hazardous chemicals and all workers who work in these facilities.

The CHP does not apply to:

1. Activities that exclusively involve radiological or biological materials.

2. Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, SUA shall comply with the relevant regulations in Title 8, California Code of Regulations, even if such use occurs in a laboratory.

3. Laboratory uses of hazardous chemicals which provide no potential for worker exposure. Examples of such conditions might include:

    a) Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

    b) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

It is important to note that SUA’s CHP is not an all-inclusive document. Activities that are not adequately explained in this program may need to be addressed separately by the PIs and/or Environmental Health & Safety (EHS).

Regulations and References

1. Title 8, California Code of Regulations (CCR), Section 5191, "Occupational Exposures to Hazardous Chemicals in Laboratories" (http://www.dir.ca.gov/title8/5191.html)
2. 29 Code of Federal Regulations (CFR) 1910.1450 "Occupational Exposure to Chemicals in Laboratories" (OSHA Lab Standard)
3. Title 8 CCR, Article 110, Sections 5200-5220 regulated carcinogens including, but not limited to:
   a) Section 5203 "Carcinogen Report of Use Requirements" (http://www.dir.ca.gov/title8/5203.html),
   b) Section 5209, "Carcinogens" (http://www.dir.ca.gov/title8/5209.html)
4. Title 8 CCR, Section 5154.1, "Ventilation Requirements for Laboratory-Type Hood Operations" (http://www.dir.ca.gov/title8/5154_1.html)
5. *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards.* Washington, D. C.: National Academics, 2011, Print.
6. National Institutes of Health (NIH) – Chemical Hygiene Plan

Rights and Responsibilities[1]

Individuals who work in or enter laboratories have the right to be informed about the potential health hazards of the chemicals in their work areas and to be properly trained to work safely with or in proximity to these substances. Workers also have the right to file a complaint with Cal-OSHA if they feel they are being exposed to unsafe or unhealthy work conditions and cannot be discharged, suspended, or otherwise disciplined by their employer for filing a complaint or exercising these rights.

The day-to-day responsibility for the management of laboratory safety and adherence to safe laboratory practices rests with the PI/Laboratory Instructor within individual laboratory units. All workers, including PIs/Laboratory Instructors, employees, and students have a duty to fulfill their obligations with respect to maintaining a safe work environment. Safety is everyone's responsibility.

All individuals working with potentially hazardous chemicals have the responsibility to conscientiously participate in training seminars on general laboratory safety and review and be familiar with the contents of the CHP. Those working with chemicals are responsible for staying informed about the chemicals in their work areas, safe work practices, and proper personal protective equipment (PPE) required for the safe performance of their job. Failure to comply with these requirements may result in temporary suspension of laboratory activities until corrective action is implemented.

[1] Source: UCI Chemical Hygiene Plan

SENIOR ADMINISTRATION

SUA's Senior Administration should execute policies and programs that ensure research and teaching activities involving hazardous chemicals are performed in a responsible manner and in accordance with all applicable requirements. While the Vice President for Finance and Administration (VP) has the ultimate responsibility for the implementation of Chemical Hygiene Plan (CHP), certain responsibilities have been delegated to the Director of Environmental Health and Safety (EHS), Principal Investigators (PIs), Laboratory Manager, employees, and students.

PRINCIPAL INVESTIGATORS (PI)/LAB INSTRUCTORS

The Principle Investigators (PIs)/Lab Instructors have the responsibility for the health and safety of all workers who are working with hazardous chemicals in their laboratories. The PI/Laboratory Instructor may delegate safety duties, but remains responsible for ensuring that delegated safety duties are adequately performed**.** PIs/Laboratory Instructors are responsible for:

1. Knowing all applicable health and safety rules and regulations, training and reporting requirements, and standard operating procedures (SOPs) associated with chemical safety for regulated substances;
2. Ensuring that all workers who are working with hazardous chemicals in their labs are adequately trained prior to beginning any laboratory activity and maintain written records of such training thereafter;
3. Providing prior-approval for the use of hazardous chemicals in their laboratory or other facility with hazardous chemicals;
4. Making sure that all workers under their supervision have access to and are familiar with the CHP and other safety documents (e.g., safety data sheets (SDSs), standard operating procedures (SOPs), etc.);
5. Maintaining an updated chemical inventory and enforcing good housekeeping;
6. Ensuring that all workers under their supervision work within the elements of CHP and applicable policies, laws, and regulations.
7. Identifying hazardous conditions or operations in the laboratory or other facility containing hazardous chemicals and determining safe procedures and controls, and implementing and enforcing standard safety procedures thereafter;
8. Establishing SOPs (general and protocol specific) and performing literature searches relevant to health and safety for laboratory-specific work;
9. Maintaining SDSs of all laboratory chemicals;
10. Notifying the Director of EHS when purchasing or using particularly hazardous substances (PHSs) or when performing higher risk experimental procedures so that special safety precautions can be taken;
11. Assuring that all chemical containers adhere to labeling requirements, and all labels are legible and easy to read;
12. Participating in lab safety assessments with EHS on an annual basis and/or as required and provide support thereafter;

13. Notifying non-laboratory workers (e.g., Facilities, contractors and their representatives, visitors) of potential laboratory-related hazards when they are required to work in laboratories;
14. Submitting a list of undergraduate students approved for unsupervised laboratory work to the Directors of Public Safety and EHS;
15. Promptly notifying Facilities and/or the Director of EHS should the PI/Lab Instructor become aware that engineering controls (e.g., fume hoods) and safety equipment (e.g., emergency showers/eyewashes, fire extinguishers, etc.) become non-operational;
16. Promptly reporting of incidents and injuries to EHS. Serious injuries[2] MUST be reported to EHS immediately to allow for compliance within the Cal-OSHA 8-hour reporting time frame. Any doubt as to whether an injury is serious should favor reporting; and
17. Ensuring the availability of all appropriate personal protective equipment (PPE) and ensuring the PPE is maintained in working order.

WORKERS

For the purpose of this written program, a worker is an individual who actively performs work functions with hazardous chemicals or equipment in a laboratory/technical area. A "worker" may be faculty, staff, student volunteer assisting in a non-academic class, or visitor/visiting scholar. For the purpose of this definition, "worker" excludes individuals who only passively participate in tours, lectures, conferences, etc.[3]

All workers in research or teaching laboratories who use, handle, or store potentially hazardous chemicals are responsible for:

1. Completing all required health, safety, and environmental training and providing written documentation to their supervisor and Director of EHS ;
2. Following all verbal and written laboratory safety rules, policies, and regulations, and standard operating procedures required for the task assigned;
3. Seeking an approval of PIs/Lab Instructors and consulting with them before using any particularly hazardous substances (PHSs), pyrophorics, explosives, and other highly hazardous materials or conducting certain higher risk experimental procedures;
4. Planning, reviewing, and understanding the hazards of materials and processes in their laboratory research or other work procedures prior to conducting work;
5. Requesting assistance when unsure of handling hazardous chemicals and/or laboratory operations;
6. Labeling hazardous chemicals in accordance with the CHP;
7. Reviewing, understanding, and following safety guidelines such as SOPs, SDSs, labels, warning signs, etc.;

---

[2] Serious injuries may include, but not limited to, hospitalization, loss of body parts, or death.
[3] Adopted from OSHA and University of California (UC) Policy of Personal Protective Equipment (PPE)

8. Developing good personal chemical hygiene habits, including but not limited to, keeping the work areas safe and uncluttered;
9. Utilizing appropriate control measures (e.g., engineering controls, administrative controls, and PPE) to minimize exposure to hazardous chemicals and knowing the capabilities and limitations of control measures;
10. Immediately reporting all incidents and unsafe conditions to the Director of EHS and PIs/Lab Instructors (e.g., spills, injuries, faulty fume hoods, missing or damaged fire prevention equipment, unsafe storage of hazardous chemicals, etc.);
11. Complying with emergency procedures and responding to alarms in an appropriate manner; and
12. When working autonomously or performing independent research or work:
    a. Reviewing the plan or scope of work for their proposed research with the PI/Lab Instructor or their designee;
    b. Notifying in writing and consulting with the PI/Lab Instructor, in advance, if they intend to significantly deviate from previously reviewed procedures (Note: Significant change may include, but is not limited to, change in the objectives, change in PI, change in the duration, quantity, frequency, conditions or location, increase or change in PPE, and reduction or elimination of engineering controls);
    c. Preparing SOPs and performing literature searches relevant to safety and health that are appropriate for their work; and
    d. Providing appropriate oversight, training, and safety information workers they supervisor or direct.

LABORATORY VISITORS

At SUA, laboratory visitors and contractors are responsible for:

1. Meeting minimum requirements for entry (e.g., no eating/drinking/chewing, proper laboratory attire, etc.) and observing all warning signs and other instructions;
2. Obtaining necessary information and approval to familiarize themselves with potential hazards in order to perform administrative, maintenance, or janitorial tasks in a laboratory;
3. Reporting any unauthorized or unsafe condition that occur in the laboratory; and
4. Cleaning by custodial service should be limited to cleaning floors and windows, blackboards, and emptying non-hazardous trash (e.g., office trash).

Additionally, laboratory visitors and contractors should never attempt to perform tasks which are not permitted or seem unfamiliar. Due to the nature of laboratories and operations undergoing in laboratories, visitors and contractors should only work during business hours so that at least one responsible individual is present for questions.

MINOR IN LABS[4]

Minors may not, under any circumstances, be alone in a University laboratory, even if they are only conducting computational work. The PI or primary supervisor and/or the alternate must closely supervise the minor, i.e., work with or near them in the laboratory.

1. **Minors Under 13:** Minors under the age of 13 may not be present in a laboratory, unless they are touring or visiting a laboratory pursuant to the requirements below.
2. **Touring/Visiting a Lab:** Minors may enter an SUA laboratory as part of a PI-authorized and supervised tour/visit. The PI or primary supervisor of the laboratory will be responsible for proper supervision and for providing any appropriate personal protective equipment for visitors. Laboratory tours may only be conducted at times when all hazardous materials are properly stored and are not being used for experiments. Minors participating in tours or visits must be supervised at all times while on the premises, and may not participate in any laboratory activities.
3. **SUA Academic Programs:** Minors age 13-17 are allowed in a laboratory setting when they are participating in a SUA academic program, provided that:
    a. They have written consent from their parent or guardian.
    b. They have received documented general lab safety training and been trained in the specific hazards to which they may be exposed in the laboratory in the course of their work.
    c. They agree to strictly adhere to the laboratory-specific requirements concerning Personal Protective Equipment ("PPE").
    d. They are at all times under the direct supervision of a qualified adult designated for this responsibility.
4. **Working and Interning in a Lab:** Minors age 16-17 are permitted to work in SUA laboratories as employees or interns (note that unpaid interns must meet the test for intern/trainee status under the Fair Labor Standards Act), provided that:
    a. They have written consent from their parent or guardian.
    b. They have received documented general lab safety training and been trained in the specific hazards to which they may be exposed in the laboratory in the course of their work.
    c. They agree to strictly adhere to the laboratory-specific requirements concerning Personal Protective Equipment ("PPE").
    d. They are at all times under the direct supervision of a qualified adult designated for this responsibility.

[4] Source: Youth Protection at Harvard University (https://youthprotection.harvard.edu/minors-labs-policy)

ENVIRONMENTAL HEALTH AND SAFETY (EHS)

SUA's Director of EHS is responsible for administering and overseeing implementation of this Plan. In case of life threatening situations or imminent danger to life or health, the Director of EHS has the authority to order the cessation of the activity until the hazardous condition is abated. The Director of EHS should provide resources and consultation for a variety of laboratory safety issues, including chemical safety, hazardous waste management, to name few. The Director of EHS is also responsible for:

1. Informing PIs/Laboratory Instructors of all health and safety requirements and assisting with the selection of appropriate safety controls, including laboratory and other workplace practices, personal protective equipment, engineering controls, training, etc.;
2. Conducting periodic laboratory safety assessments and taking appropriate steps to abate hazards that may pose an immediate risk to life or safety upon discovery of such hazards;
3. Performing hazard assessments, upon request;
4. Helping to develop and implement appropriate chemical hygiene policies and practices;
5. Having working knowledge of current health and safety rules and regulations, training, reporting requirements and standard operating procedures associated with regulated substances. Such knowledge may be supplemented and developed through research and training materials;
6. Training workers who handle hazardous chemicals;
7. Developing customized training modules in collaboration with Lab Director and Lab Manager;
8. Providing consultation to Lab Director and Lab Manager for general student training;
9. Working with PIs and Lab Manager to review existing SOPs and assist with developing new SOPs for handling hazardous chemicals;
10. Providing technical guidance and investigation, as appropriate, for laboratory and other types of accidents and injuries;
11. Helping to determine medical surveillance requirements for potentially exposed personnel;
12. Reviewing plans for installation of engineering controls and new facility construction/renovation, as requested; and
13. Reviewing and evaluating the effectiveness of the CHP annually and updating as appropriate.

Chapter 2: Chemical Hazard Identification

Workers handling hazardous chemicals should be familiar with the hazards that are involved in their work area. In some cases, specific hazards associated with new compounds and mixtures will be unknown therefore all chemicals should be treated with care for their potential harm. A hazardous chemical is any chemical which is classified as a physical hazard or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, or a hazard not otherwise classified. Following references include some of the listed hazardous chemicals:

1. Title 8, California Code of Regulations (CCR), Section 339, commonly known as "The Director's List of Hazardous Substances" (*The Hazardous Substances List*);
2. 29 Code of Federal Regulations (CFR) Part 1910, Subpart Z, "Toxic and Hazardous Substances;"
3. Title 8, CCR, Section 5155, "Airborne Contaminants" (https://www.dir.ca.gov/title8/5155.html);
4. *Threshold Limit Values for Chemical Substances in the Work Environment,* American Conference of Governmental Industrial Hygienists (ACGIH), 1991-1992;
5. *Sixth Annual Report on Carcinogens*, National Toxicology Program (NTP), 1991;
6. *Monographs*, International Agency for Research on Cancer (IARC), World Health Organization (WHO) (http://monographs.iarc.fr/ENG/Monographs/PDFs/index.php);
7. *Safety Data Sheets* (SDSs); and
8. Title 22 CCR, Section 12000, under the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65), "Chemicals Known to the State of California to Cause Cancer and or Reproductive Toxicity," a list published at least once a year by Cal/EPA's Office of Environmental Health Hazard Assessment (https://oehha.ca.gov/proposition-65/proposition-65-list).

Additionally, any other substance that presents as a hazard as determined by scientific evidence should also be considered hazardous. In laboratories, hazards can easily be found by referring to information provided on chemical container labels, SDSs, and other form of warnings or knowledge of the chemicals.

Safety Data Sheets (SDSs)

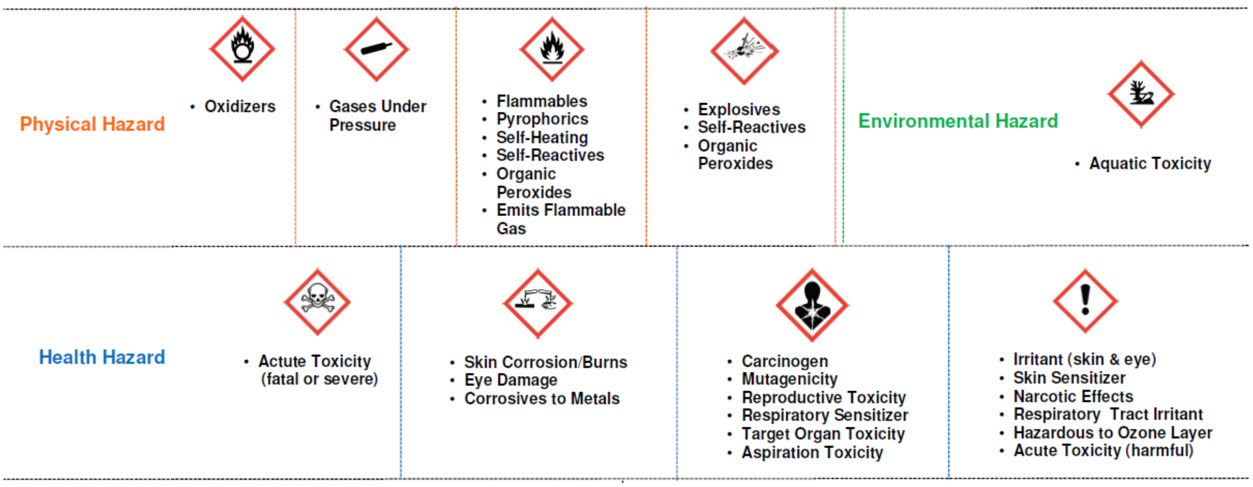
Safety Data Sheets (SDSs), previously known as Material Safety Data Sheets (MSDSs), are written or printed materials concerning a hazardous chemical that is prepared in accordance with Title 8, CCR, Section 5194(g). SDSs provide recognized hazards of chemical(s), precautions for safe handling, storage, and usage, first-aid measures, to name a few. Therefore, PIs/Lab Instructors must maintain updated copies of SDSs for every hazardous chemical that is present in their laboratories. SDSs can be accessed using this link or through SUA Portal (SUA Portal → Areas → Operations → Environmental Health and Safety → Material Safety Data Sheets (MSDSs) → MSDSonline Search). Alternatively, a hard copy database of SDSs may be developed although it is not required.

PIs/Lab Instructors must notify the Director of EHS if an SDS(s) cannot be found or is not supplied by the manufacturer(s)/supplier(s) within 30 days of shipment receipt. SDSs are now standardized under Globally Harmonization System (GHS). To learn more about GHS formatted

SDSs, and GHS, see Appendix C and Appendix H of SUA's Hazard Communication (HAZCOM), respectively.

Labeling and Other Forms of Warning

As of January 2016, all product containers of purchased chemicals must have Globally Harmonized System (GHS) labels. Manufacturer's product labels shall have product identifier, hazard pictograms (shown below), hazard statements, signal word, precautionary statements, supplemental information, and supplier identification. For more information, please refer to "Labeling" in Chapter 6 of this Plan and University's Hazard Communication (HAZCOM) Program.



Globally Harmonized System (GHS) pictograms.

Laboratory signs (e.g., No Food or Drink) are intended to serve as a reminder or to indicate a specific regulated area and/or potential hazards. These signs should not be considered as a substitute for properly disseminating information to workers.

Proposition 65 (Prop 65)

California's Safe Drinking Water and Toxic Enforcement Act of 1986, also known as Proposition 65 (Prop 65), requires the State to publish a list of chemicals known to cause cancer or birth defects or other reproductive harm.

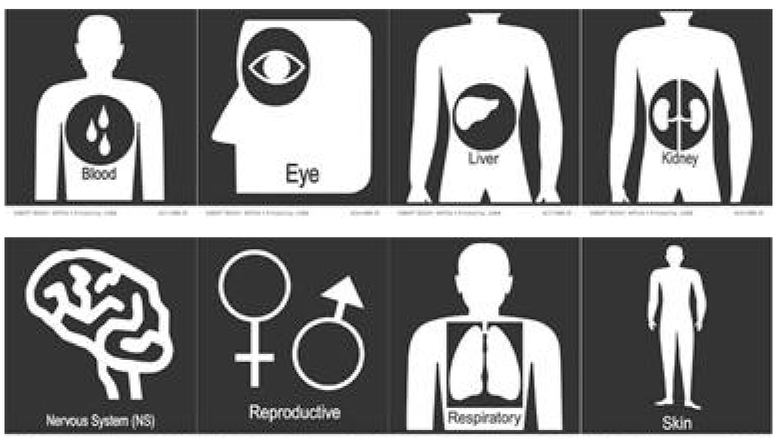
An updated list can be found by calling OEHHA at 916-445-6900 or by visiting http://oehha.ca.gov/prop65/prop65_list/newlist.html. This list can be used to identify hazards in labs.

Additionally, section 15 (Regulatory Information) of GHS formatted SDSs also discloses if a chemical is in Proposition 65 list.

Hazardous Materials Identification System (HMIS)

Workers who handle hazardous chemicals on daily basis can use HMIS® to identify hazards in their workplace. Newly implemented HMIS® III labels list:

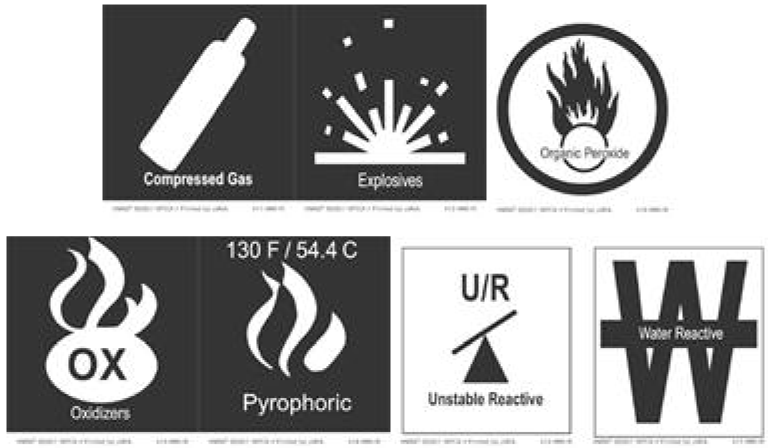
(1) Health (Blue Section) – contains two boxes, right box is for the health code and the left box is for the “chronic” indicator. An (*) asterisk indicates a chronic hazard. Health hazard may also be addressed by target organs as shown below.



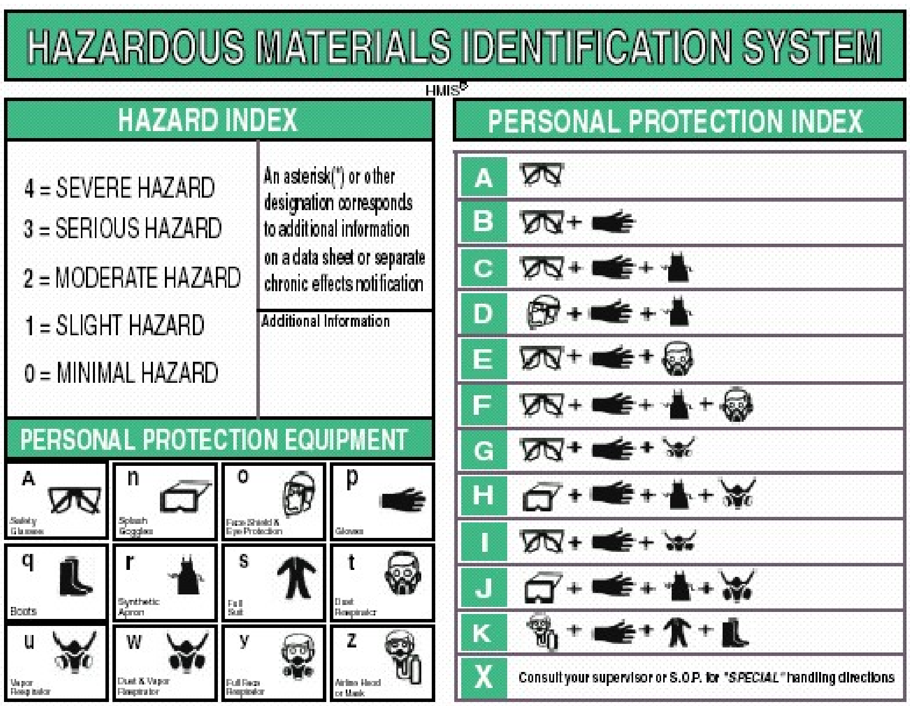
(2) Flammability (Red Section) – third edition of HMIS adopts OSHA’s criteria for “Flammability.”

(3) Physical Hazard (Orange Section) – This section replaces “Reactivity (Yellow Section).” Seven subcategories have been chosen to recognize physical hazards: water reactive,

organic peroxide, explosives, compressed gases, pyrophorics, oxidizers, and unstable reactives. Each of these subcategories can also be addressed by below icons:



(4) Personal Protective Equipment (PPE) (White Section) – Coding system for every individual piece of PPE (N – Z) except X.



For the HMIS ratings, please refer to next page.

Hazard Rating	*Health (Blue)*	*Flammability (Red)*	*Physical Hazard (Orange)*
*	Chronic (long-term) health effects may result from repeated overexposure	N/A	N/A
0 (Minimal)	No significant risk to health	Materials that will not burn	Materials that are normally stable, even under fire conditions, and will NOT react with water, polymerize, decompose, condense, or self-react. Non-explosives.
1 (Slight)	Irritation or minor reversible injury possible	Materials that must be preheated before ignition will occur. Includes liquids, solids, and semi solids having a flash point above 200°F. (Class IIIB)	Materials that are normally stable but can become unstable (self-react) at high temperatures and pressures. Materials may react non-violently with water or undergo hazardous polymerization in the absence of inhibitors.
2 (Moderate)	Temporary or minor injury may occur	Materials which must be moderately heated or exposed to high ambient temperatures before ignition will occur. Includes liquids having a flash point at or above 100°F but below 200°F. (Classes II & IIIA)	Materials that are unstable and may undergo violent chemical changes at normal temperature and pressure with low risk for explosion. Materials may react violently with water or form peroxides upon exposure to air.
3 (Serious)	Major injury likely unless prompt action is taken and medical treatment is given	Materials capable of ignition under almost all normal temperature conditions. Includes flammable liquids with flash points below 73°F and boiling points above 100°F as well as liquids with flash points between 73°F and 100°F. (Classes IB & IC)	Materials that may form explosive mixtures with water and are capable of detonation or explosive reaction in the presence of a strong initiating source. Materials may polymerize, decompose, self-react, or undergo other chemical change at normal temperature and pressure with moderate risk of explosion.
4 (Severe)	Life-threatening, major, or permanent damage may result from single or repeated overexposures	Flammable gases, or very volatile flammable liquids with flash points below 73°F, and boiling points below 100°F. Materials may ignite spontaneously with air. (Class IA).	Materials that are readily capable of explosive water reaction, detonation, or explosive decomposition, polymerization, or self-reaction at normal temperature and pressure.

NFPA (National Fire Protection Association)

Unlike HMIS, NFPA 704 is designed specifically for emergency responders, e.g., fire fighters. However, NFPA ratings can still be useful for hazard identification in labs.

Hazard Rating	Health (Blue)	Flammability (Red)	Reactivity (Yellow)	Special Hazard (White)
0	Non-hazardous	Will NOT burn	Stable	ACID Acid ALK Alkali COR Corrosive OXY/OX Oxidizer ~~W~~ Use NO water CAR Carcinogen ☢ Radioactive SA Simple Asphyxiant P Polymerization
1	May cause irritation; minimal residual injury	Must be preheated for ignition; flash point >200°F (93°C)	May become unstable at elevated temperatures and pressures, may be mildly water reactive	
2	Intense or prolonged exposure may cause incapacitation; residual injury may occur if not treated	Must be moderately heated for ignition, flash point >100°F (38°C)	Unstable; may undergo violent decomposition, but will not detonate. May form explosive mixtures with water	
3	Exposure could cause serious injury even if treated	Ignition may occur under most ambient conditions, flash point below 100°F (38°C)	Detonates with strong ignition source; shock and heat may detonate	
4	Exposure may cause death	**Extremely flammable** and will readily disperse through air under standard conditions, flash point below 73°F (23°C)	Readily detonates	

Standard Operating Procedures (SOPs)

SOPs can be very useful in terms of hazard identification as they are designed to address specific information. PIs are encouraged to develop SOPs for their laboratories that include specific hazards, emergency response, required PPE, engineering controls, decontamination/waste disposal procedures, to name a few.

Chapter 3: Classification of Hazardous Chemicals

Regulations

1. *Title 8, California Code of Regulations (CCR), Section 5194, “Hazard Communication” (https://www.dir.ca.gov/title8/5194.html)*
2. *Title 8, CCR, Section 5209, “Carcinogens” (https://www.dir.ca.gov/title8/5209.html)*
3. *Guidance for Hazard Determination (https://www.osha.gov/dsg/hazcom/ghd053107.html#data-analysis)*

Physical Hazards

FLAMMABLES

Flammability is determined by its flash point – the lowest temperature at which a liquid has a sufficient vapor pressure to form an ignitable mixture with air near the surface of the liquid. OSHA definition (29 CFR 1910.1200) of a flammable liquid is any liquid having a flash point below 100°F (37.8°C), except any mixture having components with flashpoints of 100°F (37.8°C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

COMBUSTIBLES

OSHA definition of (29 CFR 1910.1200) combustible liquids is any liquid having a flash point between 100°F (37.8°C) – 200°F (93.3°C), except any mixture having components with flashpoints of 200ºF (93.3ºC) or higher, the total volume of which makes up 99 percent or more of the total volume of the mixture.

PYROPHORICS

Chemicals that ignite spontaneously in air at a temperature of 130°F (54.4°C) or below shall be categorized as pyrophoric chemical, for example: *tert*-Butyl lithium. Moisture in the air often increases the probability of spontaneous ignition of pyrophoric materials. Many finely divided metals are pyrophoric, and their degree of reactivity depends on particle size, as well as factors such as the presence of moisture and the thermodynamics of metal oxide or metal nitride formation. Other reducing agents, such as metal hydrides, alloys of reactive metals, low-valent metal salts, and iron sulfides, are also pyrophoric.

ORGANIC PEROXIDES


Organic peroxides are compound that contains the bivalent -O-O- structure and which may be considered a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical. The term also includes organic peroxide formulations (mixtures). Such substances and mixtures may:

- Be liable to explosive decomposition;
- Burn rapidly;
- Be sensitive to impact or friction; or
- React dangerously with other substances.

OXIDIZERS

Oxidizers are chemicals other than a blasting agent or explosives as defined in 29 CFR 1910.109(a) that initiate or induce combustion, either by giving off oxygen or through electron-transfer. Most common oxidizer is atmospheric oxygen. Other examples include Nitric acid, Potassium permanganate, to name few.

WATER-REACTIVE

Water-reactive chemicals can: (1) form potentially flammable or explosive mixtures with water and (2) generate toxic gases, vapors, or fumes in a quantity sufficient to present a danger to human health or the environment. Shown icon is adopted from HMIS.

GASES UNDER PRESSURE

Gases under pressure are contained in a receptacle at a pressure not less than 280 Pa at 20°C or as a refrigerated liquid. This endpoint covers four types of gases or gaseous mixtures to address the effects of sudden release of pressure or freezing which may lead to serious damage to people, property, or the environment independent of other hazards the gases may pose. The four types of gasses or gaseous mixtures are: (1) Compressed gas, (2) Liquefied gas, (3) Refrigerated liquefied gas, and (4) Dissolved gas.

Environmental Hazards

HAZARDOUS TO AQUATIC ENVIRONMENT

Release of the chemicals or hazardous waste into sewers or landfills can have drastic effect on the environment. There are two types of environmental toxins: (1) Acute aquatic toxicity (Short exposure) and (2) Chronic aquatic toxicity (Continuous exposure).

Health Hazards

According to Cal-OSHA, health hazards include carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes (e.g., lachrymators), or mucous membranes.

CORROSIVES

Corrosives can cause visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact.

A chemical is also corrosive if it has a pH of ≤2.0 or ≥12.5, as well as the ability to corrode steel (SAE 1020) at a greater than 6.35 mm (0.25 inch) per year at a test temperature of 55°C (130°F).

Typical examples of corrosives include acids and bases (e.g. H_2SO_4 and NaOH).

NOTE: *Even though Nitric acid (HNO_3) and Perchloric acid ($HClO_4$) are corrosive, they should be stored with oxidizers.*

IRRITANTS

Irritants are defined as non-corrosive chemicals that cause reversible inflammatory effects on living tissue by chemical action at the site of contact. A wide variety of organic and inorganic compounds, including many chemicals that are in a powder or crystalline form, are irritants. The most common example of an irritant may be ordinary smoke which can irritate the nasal passages and respiratory system. Consequently, eye and skin contact with all laboratory chemicals should always be avoided. Symptoms of exposure can include reddening or discomfort of the skin and irritation to respiratory systems.

The difference between an irritant and a corrosive is the ability of the body to repair the tissue reaction. With irritants, the inflammatory reaction can be reversed whereas with corrosive damage, it is often permanent or irreparable.

SENSITIZERS

A sensitizer (allergen) is a substance that causes exposed people to develop an allergic reaction in normal tissue after repeated exposure to the substance. Such allergic reactions result from previous sensitization to that chemical or a structurally similar chemical. Once sensitization occurs, allergic reactions result from exposure to extremely low dose of the chemical. Sensitizers can aggravate existing allergies.

A respiratory sensitizer (left pictogram) is a substance that induces hypersensitivity of the airways following inhalation of the substance.

A skin sensitizer (right pictogram) is a substance that will induce an allergic response following skin contact. The definition for "skin sensitizer" is equivalent to "contact sensitizer."

TARGET ORGANS

There are some chemicals that specifically target organs in the body. For example,

- Hepatotoxin – Damages liver (e.g., Carbon tetrachloride)
- Nephrotoxin – Damages kidney(s) (e.g., Carbon tetrachloride)
- Neurotoxin – Damages nervous system (e.g., Hexane, Lead, Mercury, Carbon disulfide, Ethylene dioxide)
- Blood/Hematopoietic Toxins - Agents which act on the hematopoietic system which deprive the body tissues of oxygen. (e.g., Carbon monoxide, hydrogen sulfide, sodium nitrite)
- Respiratory Toxins - Agents that damage lung tissue (e.g., Asbestos and Silica)
- Cutaeneous Hazards – Chemicals that affect the dermal (skin) layer of the body (e.g., Ketones, Dichloromethane, Gasoline)

Particularly Hazardous Substances (PHSs)

Select carcinogens, reproductive toxins, and acute toxins pose a greater health and safety risk than other chemicals; therefore California OSHA (Cal-OSHA) labels them as “Particularly Hazardous Substances (PHSs).” Stricter guidelines and adequate safety controls should always be practiced when handling PHSs. For example, empty containers that previously held PHSs must not be recovered for usage by dumping the rinsate into the waste containers. Instead, these empty containers must be immediately labeled and treated as hazardous waste. These chemicals, associated chemical waste, and storage containers must be handled with extreme care to prevent cross contamination of work areas and unexpected contact. These chemicals must be labeled “toxic.”

CARCINOGENS

Carcinogens are chemical or physical agents that cause cancer. Carcinogens are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may become evident only after a long latency period. Carcinogens are particularly insidious toxins because they may not have immediately apparent harmful effects. These materials are separated into two classes: (1) Select Carcinogens and (2) Regulated Carcinogens. Additionally, any chemical which falls in GHS categories 1A, 1B, and 2 is also considered a carcinogen.

Select Carcinogens: Compounds that are known to pose the greatest carcinogenic hazard are referred to as Select carcinogens.

Regulated Carcinogens: These agents fall into a higher hazard class and have extensive additional requirements associated with them. The use of these agents may require personal exposure sampling based on usage. When working with Regulated Carcinogens, it is particularly important to review and effectively apply engineering and administrative safety controls as the regulatory requirements (for laboratories that may exceed long term (8 hour) or short term (15 minutes) threshold values for these chemicals) are very extensive.

Proposition 65 Chemicals: California's Safe Drinking Water and Toxic Enforcement Act of 1986, also known as **Proposition 65 or Prop 65**, requires the State to publish a list of chemicals known to cause cancer and/or reproductive toxicity on an annual basis. Visit this link to access Prop 65 listed chemicals.

REPRODUCTIVE TOXINS

Any chemical that affects the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis) shall be designated as "Reproductive Toxins." This definition is comprehensive and incorporates toxic effects on all elements of the process of reproduction, including damage to the germ cells of both males and females (sperm and ova). Like carcinogens, some reproductive toxins cause damage after repeated low-level exposures and their effects become evident after long latency periods.

Prior to handling or purchasing these chemicals, PIs/Laboratory Instructors should review safety controls (Engineering Controls, Administrative Controls, and PPE) to minimize exposures to hazardous chemicals. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryolethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. For men, exposure can lead to sterility.

Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., Formamide). Pregnant women and women intending to become pregnant should consult with their PIs/Laboratory Instructor(s) and the Director of EHS before working with substances that are suspected to be reproductive toxins.

A list of reproductive toxins can be seen in Appendix I.

ACUTE TOXINS (HIGHLY TOXIC CHEMICALS)

Chemicals with a high level of acute toxicity whose single dose or exposure of short duration may lead to fatality or damage to target organs. These chemicals, containers, and associated waste must be labeled as “Highly Toxic.” Empty containers that previously held acute toxins must never be recovered for usage by dumping the rinsate into the waste containers. Instead, these empty containers must be immediately labeled and disposed of as hazardous waste.

The median lethal dose (LD_{50}) and median lethal concentration (LC_{50}) values are a measure to determine high toxicity of a chemical.

Acute toxins fall into one of the following criteria:

- LD_{50}: <50mg/kg (Oral)
- LD_{50}: <200mg/kg (Skin Contact)
- Median lethal concentration (LC_{50}): <200ppm in air for 1 hour - For gases and vapors
- LC_{50}: 2 mg/L (or <2,000 mg/m^3) in air for 1 hour - For mists, fumes, or dust

See Appendix E for the list of Acute Toxins (Highly Toxic Chemicals).

Nanomaterials

Nanoparticles are dispersible particles that are between 1 to 100 nanometers in size that may or may not exhibit a size-related intensive property. According to the US Department of Energy, engineered nanomaterials are intentionally created, in contrast with natural (e.g., volcanic ash or forest fires) or incidentally formed, and engineered. Incidentally formed nanoparticles are often called “ultrafine” particles.

Engineered nanoparticles are designed with very specific properties related to shape, size, surface area, chemistry properties, to name a few. These properties are reflected in aerosols, colloids, or powders containing these nanomaterials. Engineered nanoparticles may be bought via commercial vendors or generated via experimental procedures by researchers in the laboratory. Examples of engineered nanomaterials include: carbon buckyballs or fullerenes; carbon nanotubes; metal oxide nanoparticles (e.g., titanium dioxide); and quantum dots, among many others.

Nanoparticles have significantly greater relative surface areas than larger particles of an equivalent mass, and animal studies have demonstrated a correlation between biological effects (toxic response) and surface area. Thus, nanoparticles represent a greater toxic hazard than an equivalent mass of the same material in larger form. For safer handling of nanomaterials, visit NIOSH’s publication as well as Nanotoolkit of California Nanosafety Consortium of Higher Education.

Chapter 4: Exposure Control Methods

Many chemicals and solutions routinely used in laboratories present a significant health risk when handled improperly. Therefore, workers are encouraged to reduce personal risk by minimizing exposure to hazardous chemicals and by eliminating unsafe work practices in the laboratory.

In laboratories, exposures to hazardous chemicals can occur by four routes of entry:

- Inhalation
- Absorption (contact with skin or eyes)
- Ingestion
- Injection

Workers are most likely to be exposed to hazardous chemicals by inhalation. It is also worthwhile to note that exposure can occur through more than one of these routes of entry. Therefore, it is very important that below methods are used to reduce chemical exposures. The preferred methods are, in order of preference:

1. Elimination;
2. Substitution;
3. Engineering Controls;
4. Administrative Controls (Work Practice Controls); and
5. Personal Protective Equipment (PPE).

Elimination

The first step to minimize exposures to hazardous chemicals is to eliminate them. For example, highly toxic chemicals (e.g., Sodium azide or legacy chemicals) should be removed from laboratories when they are no longer needed.

Substitution

Where elimination is not possible or practical, safer alternatives should be sought. For example, dyes such as Ethidium bromide can be substituted with safer and less toxic alternatives like SYBR® Safe, GelRed™, or GelGreen™.

Engineering Controls

Engineering controls are the first and primary line of defense that can eliminate, isolate, or reduce chemical or physical hazards. Examples include chemical fume hoods and other ventilation systems, shields, barricades, and interlocks.

LABORATORY VENTILATION

At minimum, a well-designed laboratory ventilation system should include the following:

- Heating and cooling should be adequate for the comfort of laboratory occupants and operation of laboratory equipment.

- Laboratories must not be part of recycled air systems. A differential should exist between the amount of air exhausted from the laboratory and the amount supplied to the laboratory to maintain a negative pressure between the laboratory and adjacent non-laboratory spaces.
- Exhaust stacks must extend at least 7 feet above the roof and be discharging vertically upward to protect the occupants of the roof.

CHEMICAL FUME HOODS

Chemical fume hoods are the most important components used to protect workers from exposure to hazardous chemicals and agents. Standard chemical fume hood is a fire- and chemical-resistant enclosure with one opening (face) in the front with a movable window (sash) to allow user access to the interior. Large volumes of air are drawn through the face and out the top into an exhaust duct to contain and remove contaminants from the laboratory. The average velocity of air drawn through the face of the laboratory chemical hood is face velocity.

Face velocity of SUA fume hoods must be at least 100 linear feet per minute (fpm) with a minimum of 70 fpm for any measurement. Face velocities between 100 fpm and 120 fpm have been recommended for substances of very high toxicity (i.e. Particularly Hazardous Substances) or where outside influences adversely affect hood performance.

NOTE: Face velocities approaching or exceeding 150 fpm should not be used as they may cause turbulence around the periphery of the sash opening and reduce capture efficiency.

Chemical fume hoods should be inspected upon installation, renovation, when a problem is reported, or a change has been made to the operating characteristics of the hood.

At SUA, routine maintenance, repairs and the annual certification of chemical fume hoods, biosafety cabinets, and vertical flow benches are arranged by Facilities. Records of certification are kept for 5 years by Facilities.

General Rules for Fume Hood Use[1]

The following general rules should be followed when using laboratory hoods:

1. Fume hoods must not be used for work involving hazardous substances unless they have a certification label that confirms certification has occurred within the past year.
2. Always keep hazardous chemicals >6 inches behind the plane of the sash.
3. **Never** put your head inside an operating laboratory hood. The plane of the sash is the barrier between contaminated and uncontaminated air.
4. Work with the hood sash in the **lowest practical position.** The sash acts as a physical barrier in the event of an accident. Keep the sash closed when not conducting work in the hood.
5. Do not clutter your hood with unnecessary bottles or equipment. Keep it clean and clear. Only materials actively in use should be in the hood. Never block or obstruct corners or sides of the hood.
6. Do not make any modifications to hoods, duct work, or the exhaust system without first contacting the EH&S office.
7. Do not use large equipment in laboratory hoods unless the hood is dedicated for this purpose, as large obstructions can change the airflow patterns and render the hood unsafe.
8. Shut your sash! For energy efficiency, make sure to shut your sash when the hood is not in use.

GLOVEBOXES

Unlike a chemical hood, gloveboxes are fully enclosed and are under negative or positive pressure. Gloveboxes usually have multiple openings in which arm-length rubber gloves are mounted. The operator works inside the box by using these gloves.

A rule of thumb is that a chemical fume hood offers protection for up to 10,000 times the immediately dangerous concentration of a chemical. The airflow through the glovebox is relatively low, and the exhaust usually must be filtered or scrubbed before it is released into the exhaust system. Because these devices are designed with very low airflow rates, the rate of contaminant dilution is minimal. Therefore, to ensure adequate protection to workers and other occupants, these devices must be routinely tested for leaks to ensure that enclosure integrity is sufficient.

A glovebox operating under positive pressure may be used for experiments that require protection from moisture or oxygen or a high-purity inert atmosphere. Usually, the chamber is pressurized with argon or nitrogen. If this type of glovebox is to be used with hazardous chemicals, test the glovebox for leaks before each use. A method to monitor the integrity of the system (such as a shutoff valve or a pressure gauge designed into it) is required.

Administrative Controls (Work Practice Controls)

Administrative controls should only be implemented if engineering controls are not feasible or fail to control exposures. Some examples of administrative controls are:

- Policies and procedures (e.g., Chemical Hygiene Plan)
- Labels or warnings or signage
- Training
- Standard operating procedures (SOPs)

These can be non-effective if a worker is not trained and/or fails to obey established procedures. Workers' exposure to hazardous substances can be controlled by:

- Performing maintenance operations when laboratories are unoccupied;
- Rotating workers to eliminate or minimize injuries;
- Restricting access to areas where particularly hazardous substances (PHSs) are stored;
- Requiring workers to take breaks;
- Restricting access to areas where lasers, radiation, energized electrical equipment, or excessive noise are present;
- Posting signage or warnings (e.g., NO SMOKING); and
- Proper housekeeping.

PIs should develop safety procedures for any laboratory activity that involves hazardous chemicals. These safety procedures should be laboratory specific and communicated via lab specific training, SOPs, or other analyses and properly documented.

STANDARD OPERATING PROCEDURES (SOP)[1]

Cal-OSHA requires that standard operating procedures (SOPs) be developed for work that involves the use of hazardous chemicals, especially for particularly hazardous substances (PHSs). This requirement is stated in CCR, Title 8, Section 5191 (e)(3)(A) under the provisions of the Chemical Hygiene Plan. The SOPs document procedures for safe handling, storage, and disposal of hazardous chemicals. PIs are responsible for establishing and implementing SOPs relevant to health and safety hazards for laboratory activities involving hazardous chemicals.

When developing SOPs of PHSs, specific considerations shall be given to the following elements, which shall be included where appropriate:

- The establishment of a designated area.
- The use of containment devices, such as fume hoods or glove boxes.
- Procedures for safe removal of contaminated waste.
- Decontamination procedures.

The PIs and other workers responsible for performing the procedures detailed in the SOP must sign the SOP acknowledging the contents, requirements and responsibilities outlined in it. The SOPs shall be reviewed by qualified personnel and shall be amended and subject to additional review and approval by the Principal Investigator where changes or variations in conditions, methodologies, equipment, or use of the chemical occurs. For certain hazardous chemicals (e.g. PHSs, reactives, pyrophorics, water-reactives) or specialized practices, consideration must be given to whether additional consultation with safety professionals is warranted or required.

Circumstances that require prior approval of the PIs must be explicitly addressed in lab-specific SOPs. These can be based on the inherent hazards of a material being used, the hazards associated with the experimental process, the experience level of the worker, and the scale of the experiment. Some examples of circumstances that may require prior approval of the PIs include working alone in the laboratory, unattended or overnight experiments, the use of toxic gases of any amount, the use of large quantities of toxic or corrosive gases, the use of extremely reactive chemicals (e.g., pyrophorics, water reactives), or the use of carcinogens.

University's Director of EHS will provide SOP templates which then can be used to develop laboratory-specific SOPs. It is important that SOPs are developed prior to initiating any experiments with hazardous chemicals and are maintained in laboratories where they are easily available to all workers.

When drafting an SOP, consider the type and quantity of the chemical being used, along with the frequency of use. The Safety Data Sheet (SDS) for each hazardous chemical that will be addressed in the SOP should be referenced during an SOP development. The SDS lists important information that will need to be considered, such as exposure limits, type of toxicity, warning properties, and symptoms of exposure. If a new chemical will be produced during the experiment, an SDS will not necessarily be available. In these cases, the toxicity is unknown and it must be assumed that the substance is particularly hazardous, as a mixture of chemicals will generally be more toxic than its most toxic component.

Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is the last line of defense, and it should be employed when engineering controls and administrative controls are not enough. Anyone working in SUA laboratories or areas where hazardous chemicals are in use must always wear full length pants (or equivalent) of a sufficient thickness so as to be protective and closed toe/heel shoes at all times. Additionally, the area of skin between the pants and shoes should not be exposed while handling chemicals.

University's PPE policy covers general PPE requirements when working with, or adjacent to, hazardous chemicals. Covered items include, but not limited to:

- Appropriate lab coats
- Suitable eye protection
- Hazard-specific gloves
- Closed-toe/heel shoes
- Full length pants or equivalent

In some cases, additional protective equipment maybe required. For example, safety glasses can provide satisfactory protection from flying particles, but they do not fit tightly against the face and offer little protection against splashes or sprays of chemicals. Chemical splash goggles that conform to ANSI standard Z87.1 are recommended when working in labs and, in particular, when working with hazardous chemicals that present a splash hazard, with vapors or particulates, and with corrosives. Face shields may also be required when there is a possibility of liquid splashes.

If a significant splash hazard exists, heavy gloves, protective aprons and sleeves may also be needed. Gloves should only be used under the specific condition for which they are designed, as no glove is impervious to all chemicals. It is also important to note that gloves degrade over time, so they should be replaced as necessary to ensure adequate protection.

USE AND MAINTENANCE OF PPE[1]

PPE should always be kept clean and stored in contaminant-free areas. Prior to its use, PPE must be inspected to verify if it is in good, clean condition. When using PPE, it should also be inspected, cleaned, and maintained at regular intervals so that it provides the requisite protection. Furthermore, PPE should fit and be worn properly. If PPE becomes contaminated or damaged, it should be cleaned or repaired when possible, or discarded and replaced.

Contaminated clothing/PPE should immediately be removed and placed in a closed container that prevents release of the chemical. Heavily contaminated clothing/PPE resulting from chemical spills should be disposed of as hazardous waste. Non-heavily contaminated laboratory coats should be cleaned and properly laundered, as appropriate. Contaminated items should never be taken home for cleaning or laundering. Persons or companies hired to clean contaminated items must be informed of potentially harmful effects of exposure to hazardous chemicals and must be provided with information to protect themselves.

RESPIRATORY PROTECTION

Under most circumstances, respiratory protection will not be needed in University laboratories. Generally, safe work practices and engineering controls (e.g. fume hoods, biosafety cabinets, gloveboxes) will adequately protect workers from chemical and biological hazards. However, some instances may demand the need to use respiratory protection. These include, but not limited to:

- Chemical and/or biohazardous spills

- Activities that cannot be performed in fume hoods, biosafety cabinets, gloveboxes or other protective enclosure
- Conditions or exposures that cannot be controlled by engineering controls as well as administrative controls
- As required by SOPs or by applicable regulations/policies
- If a worker has developed sensitivity/allergy to specific materials

Respirator users at SUA must be pre-approved by the Director of EHS whether it is required for a job duty or for a voluntary use. Additionally, all respirator wearers shall complete respirator fit-testing, training, and required medical surveillance on an annual basis.

See University's Respiratory Protection Program for more information.

Chapter 5: Chemical Exposure Assessment

Regulations and References

- Title 8, CCR, Section 5155 Cal-OSHA Airborne Contaminants (https://www.dir.ca.gov/title8/5155.html)
- Cal-OSHA's Table of Permissible Exposure Limits for Chemical Contaminants (https://www.dir.ca.gov/title8/ac1.pdf)
- OSHA Annotated Table Z-1
- OSHA Annotated Table Z-2
- OSHA Annotated Table Z-3
- California's Proposition 65 List
- *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. Washington, D. C.: National Academics, 2011, Print.

Overview

1. Airborne contaminants can present a significant threat to workers' health and safety. As a result, exposure guidelines have been listed by governmental and professional organizations to establish safe levels of exposure to airborne contaminants. Exposure limits to airborne contaminants are: **Permissible exposure limit (PEL)** – the concentration of a chemical in the air that most workers can breathe without being harmed for 8 hours a day, day after day.
    a. Established by OSHA. PELs are legally enforceable and cannot be exceeded without the use of PPE.
    b. PELs are usually identified on an SDS as a time-weighted average (TWA). A TWA is the average concentration of a chemical in air that OSHA allows over an 8-hour workshift of a 40-hour work week.
2. **Short Term Exposure Limit (STEL)** - a 15-minute time-weighted average (TWA) exposure which is not to be exceeded at any time during a workday even if the 8-hour TWA is below the PEL. Like PEL, STELs are legally enforceable.
3. **Ceiling Limit (C)** - the maximum concentration of an airborne contaminant to which a worker may be exposed at any time. Exposure above ceiling limit is likely to produce an adverse effect. This effect may be chronic rather than acute, with the results of the exposure not evident until many years following the exposure. Respiratory protection should be required when environments exist above the ceiling limit.
    a. Like PELs and STELs, ceiling limit is legally enforceable.
4. **Threshold limit values (TLV)** – calculated as a TWA of a worker's airborne exposure for 8-hour workday during a 40-hour work week.
    a. Published by the American Conference of Governmental Industrial Hygienists (ACGIH). TLVs are advisory exposure limits and are not enforceable by the law.
5. **Recommended exposure limits (RELs)** – indicate a TWA concentration for up to a 10-hour workday during a 40-hour workweek.
    a. Published by the National Institute of Occupational Safety and Health (NIOSH). RELs are advisory exposure limits and are not enforceable by the law.

Cal-OSHA has listed established exposure limits for chemical contaminants in [CCR, Title 8, Section 5155 Table AC-1](). Cal/OSHA has also promulgated specific standards covering several regulated carcinogens, which may include an Action Level (AL), triggering medical surveillance requirements or the imposition of a specific Excursion Limit (such as for asbestos) with a unique measurement of the duration of an exposure. Additionally, the Safe Drinking Water and Toxic Enforcement Act of 1986 requires Cal/EPA to publish annually a list of Proposition 65 chemicals known to the State to cause cancer or other reproductive toxicity

Initial Monitoring

SUA shall measure workers' exposure to any substance if there is a reason to believe that exposure levels for that substance exceed the action level (or in the absence of an action level, the exposure limit). Action level (AL) is a concentration designated in California Code of Regulations (CCR) Title 8 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.

A competent industrial hygienist shall supervise, direct, or evaluate exposure assessment monitoring. Exposure to hazardous chemicals can be controlled using a combination of engineering controls, administrative controls and personal protective equipment, listed in order of priority. Assessing exposure to hazardous chemicals may be accomplished through a number of methods performed by EHS, including interviews of workers, visual observation of chemical use, evaluation of engineering controls, use of direct reading instrumentation, or the collection of analytical samples from the worker's breathing zone. Personal exposure assessment will be performed under either of the following situations:[1]

1. Based on chemical inventory, standard operating procedures (SOPs), types of engineering controls present, laboratory findings, or risk assessment, the Director of EHS will determine whether an exposure assessment is needed; or
2. A concern or a reason to believe that exposure is not minimized or eliminated through use of engineering controls or administrative practices and the potential for exposure exists. In this case, workers should inform their PIs who will contact the Director of EHS. The Director of EHS will then determine the best course of action in assessing worker exposure, including visual assessment, air monitoring, medical evaluation, examination, or medical surveillance.

In event of any serious injury or exposure, including chemical splash involving dermal or eye contact, immediately call **911** from a campus phone or cell phone and obtain medical treatment immediately! Do not wait for an exposure assessment to be performed before seeking medical care.

Periodic Monitoring

If the initial monitoring prescribed by CCR Title 8 subsection 5191(d)(1) discloses worker exposure over the action level (or in the absence of an action level, the exposure limit), SUA will immediately comply with the exposure monitoring provisions of the relevant regulation.

Exposure Assessment Protocol[1]

Workers have a right to observe testing, sampling, monitoring, or measuring of exposure. They are also allowed to view the findings related to exposure assessment. Exposure assessments may be performed for hazardous chemicals, as well as for physical hazards including noise and heat stress to determine if exposures are within PELs or other appropriate exposure limits that are considered safe for routine occupational exposure. General protocol in conducting an exposure assessment may include any of the following:

1. Worker interviews;
2. Visual observation of chemical usage and/or laboratory operations;
3. Evaluation of simultaneous exposure to multiple chemicals;
4. Evaluation of potential for absorption through the skin, mucus membranes or eyes;
5. Evaluation of existing engineering controls (such as measuring face velocity of a fume hood);
6. Use of direct reading instrumentation; and
7. Collection of analytical samples of concentrations of hazardous chemicals taken from the employees breathing zone, or noise dosimetry collected from a worker's shirt collar or various forms of radiation dosimetry.

If exposure monitoring results reveal that a worker's exposure has exceeded the action level (or PEL) for a hazard for which OSHA has developed a specific standard (e.g., lead), the medical surveillance provisions of that standard shall be followed. It is the responsibility of the PIs to ensure that any necessary medical surveillance requirements are met. When necessary, the Director of EHS will make recommendations to maintain exposure below any applicable PEL. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the University will provide, at no cost to the worker, the proper respiratory equipment and training. Respirators will be selected and used in accordance with the requirements of CCR Title 8 Section 5144 and the University's Respiratory Protection Program.

For any hazardous chemical whose PEL, STEL, or Ceiling limit is not published by Cal-OSHA, worker's exposure will be determined by ACGIH's TLV or NIOSH's recommended exposure limit (REL).

Notification of Monitoring Results

Within 15 working days after the receipt of any monitoring results, workers shall be notified of results in writing either individually or by posting results in an appropriate location that is accessible to all workers. Recordkeeping of results and monitoring will be done in accordance with CCR Title 8 Section 3204 "Access to Employee Exposure and Medical Records."

Exposure Assessment Use to Determine and Implement Controls[1]

Any of the following criteria will be used to determine required control measures to reduce worker's occupational exposure:

1. Verbal information obtained from workers regarding chemical usage;
2. Visual observations of chemical use or laboratory operations;
3. Evaluation of existing engineering control measures or administrative practices;

4. Recommendations expressed in Safety Data Sheets;
5. Regulatory requirements of Cal-OSHA;
6. Recommendations from professional industrial hygiene organizations;
7. Direct reading instrumentation results;
8. Worker's exposure monitoring results; and/or
9. Medical evaluation, examination and/or surveillance findings.

Particular attention shall be given to the selection of safety control measures for chemicals that are known to be extremely hazardous. Per Cal-OSHA CCR Title 8 Section 5141 "Control of Harmful Exposure to Employees," the control of harmful exposures shall be prevented by implementation of control measures in the following order:

1. Engineering controls, whenever feasible;
2. Administrative controls: Whenever engineering controls are not feasible or do not achieve full compliance, administrative controls shall be implemented if practicable; and
3. Personal protective equipment, including respiratory protection, during:
    a) The time period necessary to install or implement feasible engineering controls;
    b) When feasible engineering and administrative controls fail to achieve full compliance;
    c) In emergencies; and
    d) As an extra precaution/option for workers.

Medical Consultation and Examinations

All workers who work with hazardous chemicals shall have an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

- Whenever a worker develops signs or symptoms associated with a hazardous chemical to which he/she may have been exposed in the laboratory;
- Where exposure monitoring reveals an exposure level is above the action level (or in the absence of an action level, regulatory or advisory exposure limit) for a particular hazardous chemical.
- 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; or
- Upon reasonable request of the worker to discuss medical issues and health concerns regarding work-related exposure to hazardous chemicals.
-

All medical examinations and consultations will be provided by or under the direct supervision of a licensed physician and will be provided at no cost to the worker, without loss of pay and at a reasonable time and place.

Workers exhibiting signs and symptoms of adverse health effects from work-related exposure to hazardous chemical should immediately report for a medical evaluation. For more information, please contact University's Human Resources (HR) Department.

Information to Provide to the Physician

Physician or Other Licensed Health Care Professional (PLHCP) shall be provided with the following information as applicable:

- Personal information such as age, weight, and campus employee/student ID;
- The identity of the hazardous chemical(s) to which the worker may have been exposed, including byproducts of chemical mixtures that may have occurred. SDSs, SOPs or any other document that can provide details of the exposure;
- A description of the conditions under which the exposure occurred (e.g., chemical mixtures, amounts, fume hood use), if available;
- A description of the signs and symptoms of exposure that the worker is experiencing, if any;
- History of exposure including previous employment and non-occupational (recreational) hobbies; and
- Any additional information helpful in assessing or treating an exposure or injury such as a biological component of exposure or existence of an antitoxin.

Physician's Written Opinion

For examination or consultation required by Cal-OSHA, SUA shall obtain a written opinion from the examining physician which shall include the following:

- Any recommendation for further medical follow-up;
- The results of the medical examination and any associated tests, if requested by the worker;
- Any medical condition which may be revealed in the course of the examination which may place the worker at increased risk as a result of exposure to a hazardous chemical found in the workplace; and
- A statement that the worker has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

Confidentiality and Individual's Access to Personal Medical Records[1]

All patient medical information is protected by California and federal law and is considered strictly confidential. The examining physician is prohibited from disclosing any patient medical information that is not directly related to the work-related exposure under evaluation and should not reveal any diagnosis unrelated to exposure. Any patient information disclosed by the examining physician to the worker's supervisor will be limited to information necessary in assessing worker's return to work, including recommended restrictions in work activities, if any. Any patient information disclosed by the examining physician to EHS will be limited to information necessary to develop a course of exposure monitoring, or perform hazard assessments and incident investigations, if appropriate. The examining physician will otherwise disclose patient medical information only as required by California and Federal law, such as for Worker's Compensation Insurance claims. Each worker has the right to access their own personal medical and exposure records. The examining physician will provide a worker with a copy of their medical records upon written request.

Medical Surveillance[1]

- Medical surveillance is the process of using medical examinations, questionnaires and/or biological monitoring to determine potential changes in health as a result of exposure to a hazardous chemical or other hazards. Certain Cal/OSHA standards require clinical examination as part of medical surveillance when exposure monitoring exceeds an established Action Level or PEL. Outside vendors may provide medical surveillance services. Medical surveillance is required of employees who are routinely exposed to certain hazards as part of their job description (such as asbestos) and may be offered to other employees based upon quantifiable or measured exposure. Examples of hazards that are monitored through the medical surveillance program may include and not limited to:
- Asbestos
- Beryllium
- Formaldehyde
- Lead
- Methylene chloride (Dichloromethane)
- Noise (Hearing Conservation Program)
- Radioactive chemicals
- Respirator Use
- Other Particularly Hazardous Substances (PHSs)

For more questions, contact EHS or HR Department.

Chapter 6: Chemical Management

Regulations and References

Implementation of work practices, procedures, and policies written in this chapter is required by following regulations:

- Title 8, California Code of Regulations (CCR), Section 5164, "Storage of Hazardous Materials" (http://www.dir.ca.gov/title8/5164.html)
- Title 8, CCR, Section 5191, "Occupational Exposures to Hazardous Chemicals in Laboratories" (https://www.dir.ca.gov/title8/5191.html)
- Title 8, CCR, Section 5194, "Hazard Communication" (https://www.dir.ca.gov/title8/5194.html)
- Title 8, CCR Section 5209, "Carcinogens" (http://www.dir.ca.gov/title8/5209.html)
- Title 8, CCR Section 5154.1 "Ventilation Requirements for Laboratory-Type Hood Operations" (http://www.dir.ca.gov/title8/5154_1.html)
- Title 8, CCR, Section 1930, "Flammable and Combustible Liquids" (https://www.dir.ca.gov/title8/1930.html)
- Assembly Bill 2286 (http://calepa.ca.gov/wp-content/uploads/sites/34/2016/10/CUPA-Documents-eReporting-AB2286.pdf)
- 29 Code of Federal Regulations (CFR) 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories" – OSHA Lab Standard (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106)
- National Institutes of Health (NIH) Chemical Hygiene Plan (https://www.ors.od.nih.gov/sr/dohs/Documents/NIH%20Chemical%20Hygiene%20Plan.pdf)
- *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. Washington, D. C.: National Academics, 2011, Print.

Globally Harmonized System (GHS)

The Globally Harmonized System (GHS) of Classification and Labelling of Chemicals is a worldwide initiative to promote standard criteria for classifying chemicals according to their health, physical and environmental hazards. It uses pictograms, hazard statements, precautionary statements, and signal words to communicate hazard information on product labels and safety data sheets (SDSs) in a logical and comprehensive way. The primary goal of GHS is better protection of human health and the environment by providing chemical users and handlers with enhanced and consistent information on chemical hazards.

The pictogram is a symbol plus other graphic elements, such as a border, background pattern or color that is intended to convey specific information. 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. Under the GHS, there are nine standardized pictograms: eight of them are required, as applicable, and one is an optional pictogram. Signal word is used to indicate the relative level of severity of hazard and alert the reader to a potential hazard on the label. The GHS uses "Danger" and "Warning" as signal words. "Danger" is used for the more severe hazards, i.e., for hazard categories 1 & 2 while “Warning" is used for less severe hazards. Only one signal word corresponding to the class of the most severe hazard should be used on a label.

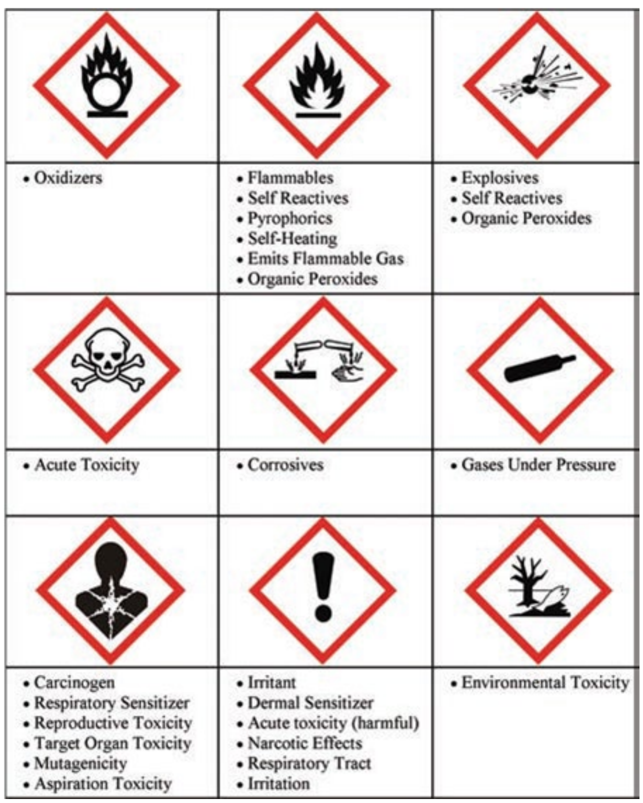
A hazard statement is assigned to a hazard class and category that describes the nature of the hazards of a chemical, including, where appropriate, the degree of hazard. A hazard statement can be outlined as, physical hazard statement, health hazard statement, or environmental hazard statement. Examples are:

- Highly flammable liquid and vapor
- May cause liver and kidney damage
- Hazardous to aquatic environment

A precautionary statement means a phrase (and/or pictogram) that describes recommended measures that should be taken to minimize or prevent adverse effects resulting from exposure to a hazardous product, or improper storage or handling of a hazardous product. Examples are:

- Keep container tightly closed
- Keep away from heat/sparks/open flames and other sources of ignition
- Wash hands thoroughly after handling

Below pictograms will replace the existing pictograms that are used in various countries.



Picture adopted from *Prudent Practices in the Laboratory*, 2011 (p. 49).

For more information on new labeling requirements and SDSs, see one-page summary of GHS.

Under GHS, each hazard class contains at least one category. The hazard categories are assigned a number from 1 to 4; with “1” indicating the most severe hazard and “4” being the least severe hazard. Categories may also be called "types". Types are assigned an alphabetical letter (e.g., A, B, etc.).

In few cases, sub-categories are also specified. Subcategories are identified with a number and a letter (e.g., 1A and 1B). Category 1 is always the greatest level of hazard (that is, it is the most hazardous within that class). If Category 1 is further divided, Category 1A within the same hazard class is a greater hazard than Category 1B.

It is important to note that GHS categories are contradictory to the HMIS and NFPA 704 ratings: GHS rating system ranks “1” as the most severe hazard and “4” as the least severe hazard whereas HMIS and NFPA rank “0” as minimal hazard and “4” as the most severe hazard.

Labeling

All chemical containers shall have legible labels and other form of warnings (e.g., Proposition 65, flammable) which are easy to read quickly and clearly. Defaced or fading labels shall be replaced immediately. Containers should also be dated upon their initial receipt and opening, particularly for peroxide forming chemicals (e.g., ethers).

Peroxide forming chemicals (PFCs) tend to form highly reactive, shock sensitive crystals as a function of age. Therefore, all containers of PFCs must be labeled with a date on receipt and on first opening of the bottle. Also, PFCs should never be stored for more than a year even if they have never been opened or used. Adequate labeling can help to determine the shelf-life of PFCs. For more information on PFCs, please see Appendix B.

Particularly Hazardous Substances (PHSs) require additional labeling to identify the specific hazard associated with each of these chemicals (carcinogen, reproductive toxin, acute toxin). In addition, the storage area where PHSs are kept should be conspicuously marked with warning and restricted access signs. PHSs should also be segregated from less hazardous chemicals to help with proper access control and hazard identification.

Secondary containers such as spray bottles and diluted chemical solutions must have appropriate labeling. Newly developed chemicals, mixtures, or buffers must also follow labeling requirements (see Secondary Containers). Bottles or any container with missing information should have additional information added without obscuring or removing any of the manufacturer’s key label information. Containers, including beakers and flasks, left unattended must also have appropriate hazard warnings, date, and the preparer’s name.

PRIMARY CONTAINERS (ORIGINAL CONTAINERS)

Upon receiving purchased hazardous chemicals, workers shall ensure that labels are easy to read and legible; and not defaced or removed. Containers should also be dated upon their initial receipt and opening. In addition, workers shall check following information on original containers:

- Product identity (Chemical/Product Name)
- Signal word (Danger or warning)
- Globally Harmonized System (GHS) Hazard Pictograms
- Hazard statement
- Precautionary statement (First aid, fire extinguishing media)

- Name and address of the manufacturer, importer, or responsible party
- Supplemental information (e.g., Storage recommendation, Product catalog number, Lot number)

If the original labels lack above elements, label it immediately. Alternatively, EHS can also provide labels that comply with GHS requirements.

SECONDARY CONTAINERS

Hazardous chemicals that are to be transferred or stored into other containers should have following:

- Product identity (Chemical/Product Name)
- Proposed chemical structure or Molecular formula, if possible
- Concentration or purity (ex. Molarity, percent, etc.), if possible
- Date when prepared/transferred
- Name/Initials of the user/owner
- Hazard warnings, if any (ex. Flammable, Corrosive, Prop 65 warnings)
- Size of container or original quantity of chemical (optional)

Alternatively, if abbreviations or codes are used to label secondary containers (e.g. very small vials), ensure that hazard information is readily accessible to workers.

CONTAINERS FOR IMMEDIATE USE[5]

Workers are not required to label portable containers into which hazardous chemicals are transferred from labeled containers and which are intended ONLY for the immediate use of the worker who performs the transfer.

NOTE: If a chemical is produced in the laboratory for another user outside of the laboratory, then the requirements of the OSHA Hazard Communication Standard [29 CFR 1910.1200] must be met including the requirements for preparation of SDSs and labeling. Contact Director of EHS for assistance.

Chemical Inventory

Every laboratory group shall develop and maintain a current inventory of all chemicals, including compressed gas cylinders. In order to facilitate compliance with California Environmental Protection Agency's (Cal-EPA) electronic reporting requirement (Assembly Bill Number 2286), each lab group is required to maintain an up-to-date chemical inventory. This practice will also help to determine if chemicals are stored within approved limits. Moreover, an updated inventory can be useful in identifying potential hazards in emergency response operations. While its template is attached in Appendix J, a chemical inventory, at minimum, must include:

- Name of the chemical as labeled on primary container (no abbreviations);
- Hazard warning (e.g. Flammable, Toxic)
- Size of container or original quantity of chemical (e.g. 2L, 100g); and

[5] Cal-OSHA definition of "Immediate Use" is the hazardous chemical will be under the control of and used only by the person who transfers it from a labeled container and only within the work shift in which it is transferred.

- Exact location where the chemical is stored (e.g. Pauling Hall Room 218 Flammable Cabinet).

Chemical inventories should be updated annually to avoid overcrowding with items that are no longer useful or needed. Older chemicals should be used first before using newly purchased chemicals (i.e., First In First Out). As new chemicals are added to the inventory, each laboratory group must confirm that its workers have an access to Safety Data Sheets (SDSs) for those chemicals.

Storage or accumulation of excessive quantities of hazardous chemicals increases the risk of accident or exposure. The storage of excess hazardous chemicals can be reduced by reviewing existing inventory and storage space prior to acquiring chemicals, and purchasing only the quantities needed.

When reviewing chemical inventories, look for:

- Items that need to be replaced;
- Chemicals and/or containers that may have deteriorated;
- Cloudiness in liquid chemicals;
- Color change in chemicals;
- Evidence of liquids in solids, or solids in liquids;
- Spills around/outside containers;
- Date when chemicals were received and opened;[6] and
- Pressure build-up within containers.

Chemical Storage

All chemicals should be evaluated for compatibility (Appendix D) before storing. Incompatible substances shall be separated from each other in storage by distance, or by partitions, dikes, berms, secondary containment or otherwise, so as to preclude accidental contact between them.

CHEMICAL SAFETY STORAGE PRIORITIES[1]

When chemicals have multiple hazards, the most appropriate storage group should be considered for every single chemical. Priorities should be given in following fashion:

1. Flammability/Combustibility: When establishing a storage scheme, the number one consideration should be the flammability characteristics of the material. If a chemical has multiple hazards, including flammability, it should be stored in an approved flammable cabinet.
2. Isolate: If the material will contribute significantly to a fire (e.g., oxidizers), it should be isolated from the flammables and combustibles. If there was a fire in the laboratory and response to the fire with water would exacerbate the situation, isolate the water reactive material away from contact with water.
3. Corrosivity: Next look at the corrosivity of the chemical, and store it accordingly.
4. Toxicity: Regulated materials should get a particular attention. In some cases, this may mean that certain chemicals will be isolated within a storage area. For example, a material that is an extreme poison but is also flammable, should be

[6] **Very important** for reactives like peroxide formers, water-reactives, and unstables.

locked away in the flammable storage cabinet to protect it against accidental release.

In case of doubt, see Appendix C for the chemical storage guide and list of chemicals that can be stored together.

Access to hazardous chemicals, including particularly hazardous substances (PHSs) and corrosives should be restricted at all times. These chemicals must be stored in laboratories or areas which are kept locked when no one is present. Locked cabinet storages may also be required in the case of controlled substances.

GENERAL CONSIDERATIONS

- Use older chemicals first (First In, First Out).
- Avoid storage on top of cabinets. With all stored items, maintain a vertical clearance of at least 18 inches from the sprinkler heads to allow proper functioning of the sprinkler system. For non-sprinklered rooms, maintain a vertical clearance of 24 inches below ceiling.
- To make chemicals readily accessible and to reduce accidents caused by overreaching, do not store materials above eye level or on shelves higher than 5 feet (~1.5 m). However, use a step stool when retrieving materials stored above head level.
- Always store heavy items on lower shelves.
- Keep exits, passageways, and emergency equipment free of obstruction and stored items to allow for easy access in case of an emergency.
- Containers must be sealed, capped, and in good condition. Flasks with cork, rubber, or glass stoppers should be avoided because of the potential for leaking.
- Label all chemical containers appropriately and adequately. Place worker's or lab group's name and receiving date on all containers to facilitate inventory control. Peroxide-forming chemicals (PFCs) and water reactives must be dated upon receipt and when the containers are initially opened so that they can be disposed according to their shelf-lives or recommendation of SDSs and/or other literature.
- Avoid storing chemicals on benchtops, except for immediate use.[5] Similarly, do not store chemicals on the floor.
- To avoid clutter and to maintain adequate airflow, avoid storing chemicals in chemical hoods, except for those chemicals in current use. Return every chemical to its designated location after each use.
- Store volatile, toxic, or odoriferous chemicals in a ventilated cabinet.
- Chemicals that do not require a ventilated cabinet should be stored inside a closable cabinet or a on a shelf that has a lip or a barrier to prevent containers from sliding off in the event of fire, serious accident, or earthquake.
- Do not expose stored chemicals to heat or direct sunlight. Follow all precautions regarding the storage of incompatible chemicals.
- Where appropriate, use compatible secondary containment to store chemicals. Chemical, biological, and radiological materials should be transported in compatible secondary containment between labs or from other areas.
- Affix "STRICTLY FOR LAB PURPOSE" stickers on appliances that are used for lab experiments (e.g., microwaves, laboratory refrigerators and freezers). Never keep consumables like coffeemakers, food, and beverages, including water bottles in labs.

Place “STRICTLY FOR LABORATORY USAGE. DO NOT CONSUME” labels or warnings if food and beverages are kept for instruction or research purposes.

- Older peroxide forming chemicals (PFCs) should never be handled (i.e. greater than 2 years past the expiration date or if the date of the container is unknown or if the crystals are observed).
- Student drawers must never be used for permanent chemical storage. If a project requires students to store chemicals in drawers, PIs/Lab Instructors must be notified of this. It may also help to place a note or label saying that certain chemicals are stored in student drawers (e.g. Inventory). The label or note should specifically list what chemicals are stored for communication purposes (no abbreviations). Before transferring drawer from one student to another student, PIs should take responsibility of checking and emptying drawers out.
- Safety coating is highly encouraged for glass storage containers in order to minimize the risk of breakage and/or spills.
- Workers accepting the delivery of chemicals must be trained in identifying a label and in spill response. Workers should also be informed of dating all containers upon their initial receipt.
- Appropriate fire extinguishers and spill kits should be kept near chemical storage areas.
- PIs should ensure that hazardous chemicals used by researchers in their laboratories are properly put away or disposed of once that researcher finishes their research activities. Likewise, when a faculty member or worker leaves the University, they should work closely with Laboratory Managers and/or EHS to ensure that all hazardous materials in their laboratories are stored or disposed of properly before they leave.

FLAMMABLES AND COMBUSTIBLES

Only approved containers and portable tanks shall be used for storage and handling of flammable and combustible liquids. Approved safety cans or Department of Transportation (DOT) approved containers shall be used for the handling and use of flammable liquids and liquids with a flashpoint greater than 199.4˚F (93˚C) (formerly designated Class IIIB Combustible liquids) in quantities of 5 gallons or less. Portable tanks shall have emergency venting and other devices as required by the Flammable and Combustible Liquids Code (NFPA 30 – 2012).

Never store flammables and combustibles in exits, stairways, or areas normally used for the safe egress of people. The storage of flammables and combustibles in approved cabinets should be restricted to the maximum capacity of that cabinet. The maximum quantity allowed to be kept outside a flammable storage cabinet, safety can, or approved refrigerator/freezer is **10 gallons per room**. Only the amounts needed for the current procedure should be kept on bench tops. Flammables and combustibles must always be segregated from oxidizers and oxidizing acids; and be shielded from direct sunlight, ignition sources, and away from heat sources. Use only those refrigerators and freezers that are designed and manufactured for flammable liquid storage. Standard household refrigerators and freezers must never be used to store flammables and combustibles as internal parts could spark and ignite.

Keep combustible items such as paper and cardboard boxes away from flammable storage. Flammables and combustibles should be handled in fume hoods or in areas that are free of ignition sources. Always transfer flammable and combustible chemicals from glass containers to glassware or from glass container/glassware to plastic. Transferring these types of chemicals between metal containers may lead to a fire hazard due to static electricity. The transfer of flammable liquid from 5 gallon or larger metal containers should not be done in the laboratory.

Periodically, freezers should be defrosted so that chemicals do not become trapped in ice formations and to ensure their maximum efficiency.

PYROPHORICS AND WATER REACTIVES[1]

Prior to bringing pyrophoric and water reactive chemicals into the laboratory, consider their storage requirements. SDSs or other literature must also be consulted when making decisions about the storage of such reactive chemicals. Only minimal amounts of reactive chemicals should be stored in labs or used in experiments (i.e., less than 3-6 months' supply, depending on the nature and sensitivity of the materials). All chemical containers should be labeled, dated, and inventoried as soon as they are received. Ensure the label states:

DANGER! HIGHLY REACTIVE MATERIAL!

Do not store a container of highly reactive material that is past its expiration date. Determine a review date to reevaluate its need as well as condition and to dispose of material that degrades over time. Subsequently, maintain the test history and date of discard for recordkeeping.

Due to their spontaneous reactivity with air and water, pyrophoric chemicals must be handled and stored in a dry place, under inert atmosphere that excludes air and moisture. Segregate pyrophoric compounds from flammables and combustibles; and water-reactives from water or aqueous solutions. Integrity of specially designed containers (e.g., Aldrich® Sure/Seal™ packaging system) must always be maintained. The metal can shipped with each bottle should be retained as a protective container for each bottle for transportation and storage. Primary containers as well as protective containers must be legibly and accurately labeled, in English, along with a hazard warning.

NEVER return excess reactive chemicals to original containers. Additionally, small amounts of impurities introduced into the container may cause fire or explosion. In case of fire or explosion, use dry fire extinguisher (e.g., Class ABC fire extinguisher).

Reactive chemicals can be stored in inert gas-filled desiccators or glove boxes; however, some pyrophoric materials must be stored in a flammable substance approved freezer. Ensure that sufficient protective solvent, oil, kerosene, or inert gas remains in the container while pyrophoric materials are stored. Never store reactive chemicals with flammable materials or in a flammable liquids storage cabinet.

Storage of pyrophoric gases is described in the California Fire Code. Gas cabinets, with remote sensors and fire suppression equipment, are required. Gas flow, purge and exhaust systems should have redundant controls to prevent pyrophoric gas from igniting or exploding. Emergency back-up power should be provided for all electrical controls, alarms and safeguards associated with the pyrophoric gas storage and process systems.

See Appendix H for the list of pyrophoric chemicals.

OXIDIZERS

Oxidizers, including oxidizing acids (e.g., Nitric Acid, Perchloric Acid), must be segregated from flammables and combustibles as well as organic peroxides. Never contaminate oxidizers as they may introduce explosive mixtures. Do not store oxidizers under sink or direct sunlight. Instead, store them in glass or ceramic trays in cool, dry place. Keep oxidizers away from combustible materials like paper, wooden shelves, cardboard boxes, Styrofoam, plastics and away from reducing agents such as Zinc, alkali metals, and Formic acid.

PEROXIDE FORMING CHEMICALS (PFC)

Like pyrophoric and water-reactive compounds, the purchase of peroxide forming chemicals (PFCs) such as ethers and Cyclohexene should be limited to quantities which are needed for that particular time and in the smallest size of container that is practical (e.g. fewer than 3-6 months' supply, depending on the nature and sensitivity of the materials). Purchase reagents that have a peroxide formation inhibitor (e.g. BHT), where possible. However, be aware that inhibitor may be consumed with time, making the compound sensitive to peroxidation once again. All containers of PFCs must be dated upon receiving as well as on their initial opening. This information, along with chemical identity should face forward to minimize container handling during an inspection.

Ensure to review SDSs, SOPs, and other cautionary materials prior to use. Evaporation or distillation of PFCs may defeat the purpose of having peroxide formation inhibitors. Excess chemicals should **NEVER** be returned back to original containers. Avoid permanent storage of PFCs in secondary containers. Before storing, ensure that bottles and caps are free of chemical residue. Chemical containers should be capped to avoid evaporation and thus minimizing the chance of peroxide formation. Periodically, PFCs should be tested and documented for the presence of peroxide formation.

Minimize the quantity of PFCs stored in the laboratory and dispose of them before peroxide formation. Store PFCs in dark, cool, dry place that is away from heat, ignition source, spark, and direct sunlight. Additionally, segregate PFCs from other classes of chemicals that could potentially create a serious hazard to life and property (e.g., flammables, combustibles, acids, bases, and oxidizers).

Visually inspect containers for peroxide formation before opening or moving. **NEVER** store or open containers that are unknown, past their expiration date, or manufacturer's expiration date. Similarly, **NEVER** open, touch, or otherwise disturb any container if crystalline solids are observed in liquid PFCs or bottle caps. From a safe distance, *immediately contact* EHS (ext. 4979) or Public Safety (ext. 4235).

See Appendix B for the list of peroxide forming chemicals and their recommended shelf-life.

CORROSIVES

Corrosives should be stored below shoulder-level, in a secondary container that can hold up to 10% of total volume in case of accidental spills or container breakage. In other words, liquid corrosives should be kept on lower shelves or in approved acid or caustic storage cabinets. Avoid permanent storage of corrosives above the bench. Additionally, corrosives should be segregated from incompatibles (e.g. Acids from Bases, Acids from Cyanides/Nitriles as well as active metals like Lithium, Sodium, Magnesium). Inorganic acids should also be separated (e.g. HCl) from organic acids.

Oxidizing acids (e.g., HNO_3) must not be stored in corrosives cabinet; as well as with organic compounds, flammables, and combustibles. Perchloric acid and Hydrofluoric acid should be stored by themselves, away from other chemicals. Refer to Appendix C for storage guidelines and Appendix D for chemical incompatibilities.

When handling corrosives, appropriate PPE (i.e. eye/face protection, buttoned lab coat, and gloves) and clothing should always be worn. Additional PPE such as splash apron, elbow length gloves, and face shield may be necessary when handling large quantities. It is highly recommended to use corrosives in fume hoods. <u>ALWAYS ADD ACID/BASE INTO WATER</u>!

Also, slow addition of acids/bases in pre-cooled water is likely to minimize the formation of fumes.

Corrosives can damage or destroy containers made of improper materials, particularly Hydrofluoric Acid. Therefore, only approved containers should be used when transferring corrosives to secondary containers.

COMPRESSED GASES

See Compressed Gas Policy

ON-CAMPUS CHEMICAL DISTRIBUTION

Chemicals should only be received in an area that is designed and properly equipped (e.g., spill kit) to handle such shipments. Only designated and trained workers should be authorized to receive shipments. When distributing chemicals on campus, follow these guidelines:

- Walking is recommended;
- Chemicals should be moved on designated carts, facilitated with secondary containment;
- Chemicals should be transported using break-resistant secondary containers made of materials that are compatible with the chemicals, particularly for corrosives and solvents;
- Secondary containers must have adequate volume to contain primary container volume;
- Avoid high traffic areas (e.g., Residential halls);
- Compressed gas cylinders must be capped and restrained to an approved hand truck during distribution or transportation. Avoid rolling, sliding, or dragging of compressed gas cylinders as well as cryogens;
- Ensure that labels are intact (i.e. not defaced or removed); and
- If you must use a general traffic elevator, ask other passengers to wait until you have delivered the chemicals. Alternatively, deliver chemicals when elevators are least utilized.

OFF-CAMPUS CHEMICAL DISTRIBUTION

US and international regulations apply when transporting or shipping chemicals, biological agents, radioactive materials, samples, and other research materials domestically or internationally. Workers preparing packages for such shipment must have documented evidence that they have completed Department of Transportation (DOT) and International Air Transport Association (IATA) training. Without proper training, it is illegal to ship hazardous materials. Those who violate the hazardous materials shipment regulations are subject to criminal investigation and penalties.

Transportation of hazardous materials in personal vehicles may not be covered by personal vehicle insurance.

Chapter 7: Training and Recordkeeping

In order to promote a safer and healthier environment at SUA, all workers are required to have appropriate training prior to beginning any work. Principal Investigators (PIs) must ensure that all individuals working in their laboratories and work areas have been adequately trained. Workers must also complete training prior to new exposure situations and whenever work conditions or job duties change. In some cases, refresher training may be required. University's Director of EHS provides general safety training to help meet with regulatory requirements.

Regulations

- Title 8, CCR, Section 5191, "Occupational Exposures to Hazardous Chemicals in Laboratories" (https://www.dir.ca.gov/title8/5191.html)
- Title 8, CCR, Section 5194, "Hazard Communication" (https://www.dir.ca.gov/title8/5194.html)
- Title 8, CCR Section 5209, "Carcinogens" (http://www.dir.ca.gov/title8/5209.html)
- 29 Code of Federal Regulations (CFR) 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories" – OSHA Lab Standard (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10106)

General Laboratory Safety Training

Anyone working in a laboratory is required to complete general laboratory safety training prior to beginning any laboratory activity. Topics of this training include, but not limited to:

- Review of Chemical Hygiene Plan (CHP) and its location and availability
- Recognition of laboratory hazards
- How to control exposures to chemicals
- Exposure limits for hazardous chemicals
- Signs and symptoms associated with chemical exposure
- Location and availability of known reference material (e.g., SDS) on the hazards, safe handling, storage, and disposal of hazardous chemicals in the laboratory and work area, but not limited to SDSs received from the chemical supplier.
- How to read and interpret SDSs, GHS pictograms, and labels
- Emergency procedures
- Access to employee exposure and medical records (Title 8 CCR Section 3204)

Laboratory Specific or Operation Specific Training

PIs must provide lab specific or operation specific training to their workers prior to working in the laboratory. Topics that require such training include, but not limited to:

- Availability of CHP, SDSs, chemical inventory, or any safety documents
- Specialized equipment
- Specialized procedures
- Location of emergency equipment, emergency exits, and designated evacuation areas
- Standard operating procedures (SOPs) of chemicals, equipment, and experiments

- Emergency procedures
- Particularly hazardous substances (PHSs) including physical and health hazards, potential exposure, and medical surveillance

PIs are highly encouraged to provide lab specific and operation specific training on a regular basis in order to promote a safer culture.

Incident Reports

Serious occupational injuries, illnesses, and exposures to hazardous substances must be reported to the PIs and EHS within 8 hours. EHS will report the event to Cal/OSHA, investigate the accident (Appendix K), and complete exposure monitoring if necessary. Serious injuries include those that result in permanent impairment or disfigurement, or require hospitalization. Examples include amputations, lacerations with severe bleeding, burns, concussions, fractures and crush injuries. As soon as PIs/Laboratory Managers are aware of a potentially serious incident, they must contact EHS. EHS must ensure that all serious injuries are reported to Cal/OHSA within 8 hours. In the absence of PIs and EHS, University's Department of Public Safety (ext. 4100) must be notified immediately.

Recordkeeping

Training records are to be kept for 3 years from the date it was provided. PIs should maintain laboratory specific or operation specific training records. Additionally, records of any other training that is provided to workers should be maintained.

The Department of HR shall keep medical records for 30 years, starting from the day after the termination/graduation of a worker (or student). Additionally, an accurate record of any measurements taken to monitor worker's exposures, any medical consultation and examinations including tests or written opinions required by this regulation shall be established and maintained. Such records shall be kept, transferred, and made available in accordance with Title 8, CCR, Section 3204. Affected workers and/or their representatives shall have access to medical records.

Chapter 8: Laboratory Safety Assessments and Compliance[1]

Regulations

Implementation of the necessary work practices, procedures, and policies outlined in this chapter is required by the following:

- Title 8, California Code of Regulations (CCR), Section 5191, “Occupational Exposures to Hazardous Chemicals in Laboratories” (http://www.dir.ca.gov/title8/5191.html)

Other applicable regulations include those promulgated by the U.S. Department of Labor including 29 CFR 1910.1450 "Occupational Exposure to Hazardous Chemicals in Laboratories" (the "Laboratory Standard").

Laboratory Safety Assessments

A program of periodic laboratory safety assessments helps to keep laboratory facilities and equipment in a safe, code-compliant operating condition by identifying existing and potential health and safety deficiencies. Safety assessments also help to ensure if regulatory requirements are being met.

The goals of Laboratory Safety Assessments are to:

- Provide a comfortable and safe working environment for all workers and the public;
- Ensure that all laboratory activities are conducted in a manner to avoid exposure to hazardous chemicals; and
- Ensure that trained laboratory workers follow policies and procedures.

In collaboration with the PIs, the Director of EHS conducts scheduled periodic inspections of laboratories and other facilities with hazardous chemicals to ensure the laboratories are operating in a safe manner and to ensure compliance with all regulations and policies.

The Director of EHS has the authority to order the cessation of any activity that is “Immediately Dangerous to Life and Health” (IDLH) until that hazardous condition or activity is abated.

The laboratory safety assessments are comprehensive in nature and look into all key aspects of working with hazardous chemicals. While the assessments are a snapshot in time and cannot identify every accident-causing mistake, they do provide important information on the overall operation of a particular laboratory. They can also help to identify weaknesses that may require more systematic action across a broader spectrum of laboratories, and strengths that should be fostered in other laboratories. Laboratory safety assessments include:

1. Hazard Communication (HAZCOM)
2. Fire safety
3. Means of egress and emergency exits
4. Compressed gases and cylinders
5. General safety
6. Personal protective equipment (PPE)
7. Housekeeping
8. Chemical storage and compatibility

9. Fume hoods
10. Disposal of laboratory waste
11. Seismic, mechanical, and electrical safety

After the completion of laboratory safety assessments, the Director of EHS will submit a report to PIs via e-mail. The report identifies deficiencies in the laboratory, followed by recommendations to correct the findings. The report also includes code reference and individual responsible for correcting the findings. A work order must be placed by the PI or their designee for any deficiency that requires the attention of the Facilities. The PIs should share safety assessment reports with their workers.

Notification and Accountability

PIs are responsible for taking appropriate and effective corrective action upon receipt of laboratory safety assessment findings.

Recordkeeping

The Director of EHS is responsible for maintaining records of laboratory safety assessments, accident investigations, equipment calibration, and training. Per OSHA regulations, departments or laboratories must document health and safety training, including safety meetings, one-on-one training, and classroom and online training. Additionally, the following records must be retained in accordance with the requirements of state and federal regulations:

1. Accident records (5 years);
2. Laboratory Safety Assessment records (5 years);
3. Training records (3 years);
4. Measurements to monitor workers' exposure (30 years);
5. Medical consultation and examinations, including tests and written opinions required by CCR, Title 8, Section 5191 (duration of employment plus 30 years); and
6. Medical records must be retained in accordance with the requirements of state and federal regulations (duration of employment plus 30 years).

Chapter 9: Hazardous (Chemical) Waste Management[1]

Regulations & Reference

- Title 40, Code of Regulations (CFR), Parts 260-273
- Title 22, California Code of Regulations (CCR), Chapters 10-55
    - Title 22, CCR, Chapter 11, Article 4
    - Title 22, CCR, Chapter 11, Appendix X
- http://ccelearn.csus.edu/wasteclass/intro/intro_01.html

Introduction

In California, hazardous waste is regulated by the Department of Toxic Substance Control (DTSC), a division within the California Environmental Protection Agency (Cal/EPA). Federal EPA regulations also govern certain aspects of hazardous waste management, since some of our waste may be treated and disposed out of state. These hazardous waste regulations are part of the Resource Conservation and Recovery Act (RCRA). Local enforcement authority is administered by the Orange County Health Care Agency/Environmental Health Division.

Hazardous Waste Program

University's hazardous waste is managed by the Director of EHS. This chapter only pertains to hazardous waste (chemical waste), and it does not include medical waste nor radioactive waste. For simplicity, "Workers" will be referred as "Hazardous waste generators" or "Generators" in this chapter.

Hazardous waste pick-up service is provided to all generators of the University. However, the Generators are still responsible for identifying hazardous waste, segregating, labeling, and accumulating it properly in the laboratory and/or technical area. Laboratory clean-outs and disposal of high hazard compounds must be scheduled in advance. The PI is responsible for coordinating the disposal of all chemicals and other wastes from their laboratories prior to closing down laboratory operations.

DEFINITION

Hazardous waste is a waste with properties that make it potentially dangerous or harmful to human health or the environment. In regulatory terms, a hazardous waste is a waste that appears on one of the four RCRA hazardous wastes lists (the F-list, K-list, P-list, or U-list) or that exhibits one of the four characteristics of a hazardous waste – ignitability (D001), corrosivity (D002), reactivity (D003), or toxicity (D004 through D043). However, materials can be hazardous wastes even if they are not specifically listed or don't exhibit any characteristic of a hazardous waste.

Ignitability (D001)

- Flashpoint of <140°F (60°C)

- Capable, under standard temperature and pressure, of causing fire at through friction, absorption of moisture, or spontaneous chemical changes
- Ignitable compressed gas
- An oxidizer

Corrosivity (D002)

- Liquid with pH less than or equal to 2 or greater than or equal to 12.5
- Solid with pH less than or equal to 2 or greater than or equal to 12.5 when mixed with equal weight of water

Reactivity (D003)

- Normally unstable and readily undergoes violent change without detonating
- Reacts violently with water or air
- Forms potentially explosive mixtures with water
- Forms toxic gases, vapors or fumes when mixed with water
- Is a cyanide or sulfide bearing waste which, when exposed to pH conditions between 2 and 12.5, can generate toxic gases, vapors, or fumes
- Is capable of detonation or explosive decomposition if subjected to a strong initiating source or heated under confinement
- Is readily capable of detonation or explosive reaction at standard temperature and pressure

Toxicity (D004 through D043)

- Has an acute oral LD_{50} less than 2,500 milligrams per kilogram (mg/kg)
- Has an acute dermal LD_{50} less than 4,300 mg/kg
- Has an acute inhalation LC_{50} less than 10,000 parts per million (ppm) as a gas or vapor
- Has an acute aquatic 96-hour LC_{50} less than 500 milligrams per liter (mg/l)
- Has been shown through experience or testing to pose a hazard to human health or environment because of its ability to cause cancer or mutations (carcinogen, mutagen, teratogen), acute toxicity, chronic toxicity, bio-accumulative properties, or persistence in the environment

Materials containing chemicals are also hazardous waste if they are mislabeled or inadequately labeled, unless the label is corrected within 10 days of discovery. If the chemical container is deteriorated, abandoned, or damaged, it is also considered a hazardous waste, unless the container is repackaged within 96 hours of discovery. Additionally, unused, unwanted chemicals as well as empty containers with visible residues are hazardous wastes.

Extremely Hazardous Waste

Acutely and extremely hazardous wastes are wastes that would cause death, disabling personal injury, or serious illness. These wastes are more hazardous than ordinary hazardous wastes. Acutely hazardous wastes are listed as "P-Listed" wastes in the federal system (Federal EPA). The main difference between P listed wastes and other federally regulated hazardous wastes is the criterion used to identify acutely hazardous chemicals. The criteria:

- Separates highly toxic (acutely hazardous) waste from other toxic wastes (U-listed wastes)
- Establishes management method for containers that held P-listed wastes

In California, the DTSC has identified extremely hazardous wastes with an asterisk in Appendix X. A waste, or a material, is extremely hazardous if it:

1. Has an acute oral toxicity (LD_{50}) less than or equal to 50 mg/kg; or
2. Has an acute dermal toxicity (LD_{50}) less than or equal to 43 mg/kg; or
3. Has an acute inhalation toxicity (LC_{50}) less than or equal to 100 ppm as a gas or vapor; or
4. Contains any of the substances listed in section 66261.24(a)(7) at a single or combined concentration equal to or exceeding 0.1 percent by weight; or
5. Has been shown through experience or testing that human exposure to the waste or material may likely result in death, disabling personal injury or serious illness because of the carcinogenicity, high acute or chronic toxicity, bioaccumulative properties, or persistence in the environment of the waste or material; or
6. Is water-reactive; or
7. Is persistent and bioaccumulative toxic substance.

TRAINING

All individuals who generate or handle hazardous waste must obtain adequate training prior to working with these materials. University's Director of EHS provides hazardous waste training to the campus community.

WASTE IDENTIFICATION

All the chemical constituents in each hazardous waste stream must be accurately identified by knowledgeable generators, including laboratory workers. This is a critical safety issue for operators who handle the waste once it is turned over to the Director of EHS. Mixing of incompatible waste streams has the potential to create violent reactions and is a common cause of laboratory incidents. PIs or the Director of EHS must be notified if there is uncertainty about the composition of a waste stream resulting from an experimental process. In most cases, careful documentation and review of all chemical products used in the experimental protocol will result in accurate waste stream characterization.

The manufacturer's SDS provides detailed information on each hazardous ingredient in laboratory reagents and other chemical products, and also the chemical, physical, and toxicological properties of that ingredient. The UC SDS library (http://www.ucmsds.com) provides an extensive library of research chemicals.

LABELING

All hazardous waste containers shall have appropriate labels as soon as hazardous waste accumulation begins. Each label must be completed accurately, and updated as the contents in waste containers change. Product names or abbreviations for waste container ingredients should not be used. It is extremely important to date when initial accumulation began (i.e. the first drop of waste in a container). Labels must also be legible and noticeable. Defaced or faded labels must be replaced immediately with new labels to reveal the identity of waste.

Contact SUA's Director of EHS (ext. 4979) for labels and labeling guidelines.

ACCUMULATION

There should be at least 10% (of the volume of the container) of headspace in the liquid waste container to avoid a buildup of gas that could cause an explosion or a container to rupture.

The hazardous waste storage area in each laboratory is considered a Satellite Accumulation Area (SAA) by the EPA. According to EPA requirements, this area must remain under the control of the persons producing the waste (i.e. Generators). This means that it should be located in an area that is supervised and is not accessible to the public. Other SAA requirements include:

- Hazardous waste must be disposed of via EHS within 6 months of initial accumulation.
- Hazardous waste containers must be kept closed, except when adding waste.
- Hazardous waste that meets the quantity threshold of 55 gallons of hazardous waste or 1 quart (~1 liter) of **acutely/extremely hazardous waste** must be disposed of within 3 days of reaching these set volumes.
- Report damaged containers to the Director of EHS immediately.
- Inspect containers for signs of leaks, corrosion, or deterioration.
- Do not dispose of chemicals or waste by pouring them down the drain or placing them in the trash.
- Do not use fume hoods to evaporate chemicals.
- Hazardous waste streams must have compatible constituents, and must be compatible with the containers that they are stored in.

SEGREGATION

Like chemicals, hazardous waste must be segregated to prevent incompatible mixtures. Segregation can be done by hazard class. Hazard class examples include: Ignitability (Flammables and combustibles), Oxidizers, Pyrophorics, Reactives, Reducing agents, Acids, Bases, and Toxics. Examples of proper segregation are:

- Segregate acids from bases
- Segregate oxidizers from ignitables and other organic compounds
- Segregate cyanides from acids

For more information on specific chemical incompatibility, refer to safety data sheets (SDSs).

INCOMPATIBLE WASTE STREAMS

Mixing incompatible waste streams, or selecting a container that is not compatible with its contents, is a common cause of incidents in laboratories and waste storage facilities. Reactive mixtures can rupture containers and explode, resulting in serious injury and property damage. All chemical constituents and their waste byproducts must be compatible for each waste container generated. Waste labels must be immediately updated when a new constituent is added to a mixed waste container, so that others in the laboratory will be aware and manage it accordingly.

Some common incompatible waste streams include:

- Oxidizers added to any fuel that can create an exothermic reaction and explode. The most frequent is acids oxidizing flammable liquids. For this reason, all flammable liquids are pH tested before they are consolidated.

- Piranha etch solution is a specific waste stream that contains sulfuric acid and hydrogen peroxide, which form a reactive mixture that is often still fuming during disposal. For this waste stream, and other reactive mixtures like it, vented caps are mandatory.

WASTES THAT REQUIRE SPECIAL HANDLING

Unknowns

Unlabeled/unknown chemical containers and wastes must be labeled with the word “unknown.” If the material cannot be identified either by prior knowledge of the process that produced it or by label, it will be analyzed to determine its waste classification. The cost of analysis or removal of an unknown waste comes with a heavy price and uninviting publicity. Therefore, adequate labeling of every container shall follow.

Peroxide Forming Chemicals (PFC)

Peroxide forming chemicals, or PFCs, include a number of substances that can react with air, moisture or product impurities, and undergo a change in their chemical composition during normal storage. The peroxides that form are highly reactive and can explode upon shock or spark. Peroxides are not particularly volatile and thus tend to precipitate out of liquid solutions. It is particularly dangerous to allow a container of these materials to evaporate to dryness, leaving the crystals of peroxide on the surfaces of the container.

Each container of PFCs should be dated with the date received and the date first opened. There are three classes of peroxide forming chemicals, with each class having different management guidelines. A guide to managing some PFCs commonly found in research labs is provided in Appendix B. Since this Appendix does not provide an exhaustive list of PFCs, review the safety information provided by the manufacturer for any chemicals you purchase.

Stabilizers or inhibitors are sometimes added to extend the storage life of PFCs. Therefore, PFC containers should be kept tightly sealed to avoid unnecessary evaporation. On a periodic basis, visually inspect containers to ensure that they are free of exterior contamination or crystallization. PFC containers must be disposed of prior to expiration date. If old containers of PFCs are discovered in the laboratory, (greater than two years past the expiration date or if the date of the container is unknown), **DO NOT HANDLE** the container. If crystallization is present in or on the exterior of a container, **DO NOT HANDLE** the container. Restrict access to the container and secure the area. From a safe distance, *immediately contact* the Director of EHS (ext. 4979) or the Director of Public Safety (ext. 4235).

Dry Picric Acid

Picric acid (also known as Trinitrophenol) must be kept hydrated with deionized (DI) water at all times, since it becomes increasingly unstable as it loses water content. When dehydrated, Picric acid is not only explosive but also sensitive to shock, heat, and friction. Picric acid is highly reactive with a wide variety of compounds (including many metals) and is extremely susceptible to the formation of Picrate salts. Be sure to label all containers that contain Picric acid with the date received, and then monitor the water content every 6 months. Add deionized water as needed to maintain a consistent liquid volume.

If old or previously unaccounted for bottles of Picric acid are discovered, **DO NOT TOUCH** the container. Depending on how long the bottle has been abandoned and the state of the product inside, even a minor disturbance could be dangerous! Visually inspect the contents of the bottle without moving or touching it to evaluate its water content and look for signs of crystallization inside the bottle and around the lid. If there is even the slightest indication of crystallization, signs of evaporation, or the formation of solids in the bottle, do not handle the container and contact the Director of EHS (ext. 4979) or Public Safety (ext. 4100) immediately. Secure the area and restrict access to the container until it can be evaluated.

Explosives and Compounds with Shipping Restrictions

A variety of other compounds that are classified as explosives or are water reactive or air reactive may be present in research laboratories. These compounds often have shipping restrictions and special packaging requirements. When disposing of these compounds, Generators must ensure that they are stored appropriately for transport. Flammable metals must be completely submerged in oil prior to disposal. Many pyrophoric and reactive compounds can be stabilized using a quenching procedure prior to disposal. Chemicals classified by the Department of Transportation (DOT) as explosives (e.g., many Nitro- and Azo-compounds) will require special packaging and shipping, and may require stabilization prior to disposal.

EMPTY CONTAINERS

Containers that previously held hazardous materials are exempt from further regulations after certain conditions are met. The most important condition is that they be "*empty*." The DTSC has defined "Empty" based on the type of material the container held:

- If the container held a material that could be *readily poured* (like paint thinner), all material left in the container must be removed by any practicable means (e.g. pumping, aspirating, draining).
- If the container held a material that is *non-pourable* (like grease), all material that can be feasibly removed by physical means (e.g. scraping, chipping) must be removed.
- An aerosol container must have its contents and pressure completely dispensed, and the spray mechanism in place and functional.

EXCEPTION: All containers that once held acutely/extremely hazardous materials **ARE** considered hazardous waste and must be disposed of by the Director of EHS. Also, if an empty hazardous material container is greater than five gallons, date when the container was emptied and must be picked up by the Director of EHS.

TRANSPORTATION

It is a violation of DOT regulations to transport hazardous waste in personal vehicles, or to carry hazardous waste across campus streets that are open to the public. As a result, EHS provides pick-up services for all hazardous waste generators.

DISPOSAL

When waste containers are full or are no longer needed, University's Director of EHS must be contacted for a pick-up. However, the Generators must fill out Hazardous Waste Removal Form before contacting the Director of EHS.

Never dispose of chemicals by pouring them down the drain or placing them in a trash. Do not use fume hoods to evaporate chemicals.

Hazardous Waste Minimization

In order to maintain environmental sustainability at SUA, hazardous waste minimization is essential as it leads to reduced liability and disposal costs. Usage of chemicals in the laboratory areas should be reviewed to identify practices which can be modified to reduce the amount of hazardous waste generated.

Labeling

Improper labeling of glassware or containers often leads to unknowns which can subsequently be characterized as “Hazardous Waste” (e.g., Defaced labels). Therefore, it is worthwhile to replace faded or defaced labels with the new ones immediately.

Packaging

Deteriorating or damaged containers must be repackaged in sound, compatible, and undamaged containers immediately.

Purchasing Control

When ordering chemicals, be aware of any properties that may preclude long term storage, and order only exact volumes to be used. Using suppliers who can provide quick delivery of small quantities can assist with reducing surplus chemical inventory. Avoid purchasing in bulk to get better unit-pricing since the disposal of unused material will negate any up-front savings. Also, consider communicating with the Lab Manager and/or other PIs to monitor chemical purchases and avoid duplicate orders.

Inventory Control

Rotate chemical stock to keep chemicals from becoming outdated. Locate surplus/unused chemicals and attempt to redistribute these to other users.

Operational Controls

Review your experimental protocol to ensure that chemical usage is minimized. Reduce total volumes used in experiments and employ small scale procedures when possible. Evaluate the costs and benefits of off-site analytical services. Use proper equipment (e.g. Funnels) when transferring solids/liquids.

Avoid mixing hazardous and non-hazardous waste streams. Use less hazardous or non-hazardous substitutes when feasible. Some examples include:

- Specialty detergents (e.g. Alconox) can be substituted for Sulfuric acid/Chromic acid cleaning solutions.
- Gel Green and Gel Red are recommended in place of Ethidium bromide.
- If possible, avoid using Phosphorus pentoxide and Magnesium perchlorate as drying agents and dehydrating agents, respectively. Instead, seek safer alternatives such as Calcium chloride, Silica, Molecular sieves, and Calcium sulfate (Drierite).

Chapter 10: Emergency Procedures

Laboratory emergencies can occur anytime due to serious injuries, fire, explosions, spills and exposures, natural or man-made disasters, to name a few. Therefore, all workers must be familiar with the emergency procedures, including procedures for communication and response. Laboratory work should never be undertaken without the knowledge of the following points:

- How to report an incident (e.g., fire, injury, chemical spill, or other emergency) and how to announce emergency response;
- The location of emergency equipment such as safety showers and eyewash units;
- The locations of all fire extinguishers, fire alarms, first-aid kit, and spill kits;
- The locations of all available exits as well as staircases and designated evacuation zones from the laboratory;
- Emergency contact numbers; and
- How police, fire, and other emergency personnel respond to laboratory emergencies, and the role of laboratory workers in emergency response.

Initial Notification

Serious incidents must be reported to EHS and/or Public Safety immediately.

Police, Fire Department, and Ambulance	**9-1-1**
Department of Public Safety (Public Safety)	Phone: 949-480-4100 (Available 24/7/365)
Department Environmental Health & Safety (EHS)	Phone: 949-480-4979 (M-F: 9 AM - 5 PM)

When contacting the Department of Public Safety, it is helpful to have the following information ready:

- Type of incident (e.g., chemical spill)
- Extent of any injuries/illnesses. If applicable, inform University's dispatcher that an ambulance is required
- Building/location where the incident occurred
- Your name and phone number where you can be reached
- Name and estimated quantity of chemical spilled (if incident involves chemical spill/release)
- NEVER HANG UP UNLESS THE DISPATCHER TELLS YOU TO DO SO

APPENDIX A: GENERAL RULES FOR LABORATORY WORK

It is the responsibility of every worker to reduce exposures to hazardous chemicals and maintain a safe laboratory environment. It is prudent to assume that all chemicals have hazards, even for substances of no known hazards. Additionally, a mixture of chemicals should be assumed to be more toxic than its most toxic component and all unknown chemicals are toxic thus presenting significant danger to the health, property, and environment.

Prior to performing any laboratory activities, workers must take following into consideration:

- **Chemicals**: Familiarize with all hazards of the chemical(s) before beginning work (e.g., flammability, reactivity, toxicity). Review container labeling, SOPs, SDSs, and other warnings. If required, contact the PI or EHS for further assistance. Always consider eliminating hazards from the lab. However, if it is not possible to do so, explore a less hazardous substitute or using smaller quantities of hazardous chemicals. Upscaling reactions is not always wise and can lead to unprecedented events (Remember Texas Tech Lab Explosion).
- **Equipment**: Check if the equipment is assembled and functioning properly before each use (i.e. not faulty/damaged), and that workers are adequately trained and understand the procedures for safe use. Review specific information in the equipment manual as necessary, especially emergency shut-off button. Use equipment only for its intended use. Those who are not trained to use the laboratory equipment must not be allowed to operate them.
- **Written Protocol**: Develop written experimental protocols and follow them. Step-by-step instructions help to minimize the possibility of errors. Identify steps where special precautions may be necessary.
- **Set-up**: Check if equipment and supplies are present before actual work begins, including protective equipment and waste containers. Ensure there is sufficient working space and that the work area is uncluttered and orderly. Remove unnecessary materials, equipment, and supplies. Avoid placement of chemicals and equipment on the floor of working areas where they may be knocked over or may create a tripping hazard. Verify that emergency equipment (e.g. safety showers, eye wash stations, fire extinguisher, etc.) is available and ready for use.
- **Clean-up**: Consider the necessary steps and materials required for proper clean-up ahead of time, including the accumulation of hazardous waste; surfaces to be decontaminated; glassware to be washed; other disposables to be generated; and similar considerations. All incidents and near-misses must be reported to the PIs.

The PIs should notify EHS when using certain hazardous chemicals or equipment. Examples include:

- Purchase of *Particularly Hazardous Substances (PHSs)*;
- Procurement or handling of highly reactive or pyrophoric chemicals;
- New or modified SOPs presenting a serious risk to workers or property;
- Procedures where exposures exceed or cannot be controlled; or

Safe Laboratory Practices

LABORATORY RULES

Workers must:

- Do not engage in distracting behavior such as practical jokes in the laboratories.
- Use laboratory equipment and chemicals only for its intended purpose as long as trained.
- Never eat, drink, chew gum, smoke, apply cosmetics or take medication in the laboratory. These activities are also prohibited in areas where hazardous materials are stored or used. Additionally, water bottles and other bottled beverages should be kept in backpacks.
- Never use headphones when working in the laboratories.
- Use pipet bulbs or other appropriate equipment to handle chemicals. Pipetting of chemicals by mouth is prohibited.
- Wash hands after working with chemicals, even if gloves were used.
- Never taste or smell laboratory chemicals.
- Never wash lab coats in residential halls or homes. Instead, give them away to professional laundry services (e.g. Cintas, UniFirst, and Mission Linen Supply).
- Wear appropriate and adequate personal protective equipment (PPE).

PETS IN LABORATORIES

Pets are not permitted in the laboratories, with the only exception being service animals.

HOUSEKEEPING

Lab workers must:

- Avoid using laboratory refrigerators or other chemical storage areas to store food or beverages unless it is exclusively stored for teaching or research purposes. Consequently, refrain from using office refrigerators or office space to store chemicals and specimen. Furthermore, food and beverages stored for teaching or research purposes must have “DO NOT CONSUME” or “STRICTLY FOR LAB PURPOSE” labels.
- Maintain work area clean and clutter-free. At the completion of each work day or operation, clean the work area.
- Keep walkways and aisles clear. Ensure all exits remain unobstructed; and no slip/trip hazards (e.g., containers on the floor or outlet strips or extension cords) are present in walkways.

PERSONAL ATTIRE

- Secure long hair and loose clothing (e.g., neckties and baggy clothing) before working in the laboratory.
- Jewelry such as rings, bracelets and watches should be secured while working in laboratories as they may trap or react to chemicals close to the skin or cause shocks when contacted with electrical sources.

- Closed-toe and closed-heel shoes and full length pants must be worn for any kind of laboratory work. Open toed shoes, sandals, clogs, flip-flops, flats, shoe-covers, crocs, etc. are not allowed in the laboratories.
- Unless required to handle hazardous chemicals, avoid wearing lab attire (e.g., lab coats, gloves, safety goggles, etc.) outside of laboratories, especially in the dining halls, offices, and restrooms. Always reduce the risk of contaminating non-laboratory areas.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

It is very important to understand the limitations of PPE. Subsequently, inspect PPE thoroughly before donning them.

Eyes and Face Protection: Safety eyewear must provide impact protection as well as splash protection. Ordinary prescription eye glasses with hardened lenses do not serve as eye protection in the laboratory. Safety eyewear must conform to ANSI Z87.1 standards. Wear specialized eye protection if work in the laboratory could involve exposure to lasers, ultraviolet light, infrared light, or intense visible light.

Use face shields in combination with approved safety glasses or splash goggles when there is a possibility of liquid splash.

Hand Protection: Appropriate gloves must be worn when handling hazardous chemicals. Gloves must be of a material that is compatible with chemicals/hazards. There is no universal glove! For the selection of gloves, please refer to (1) https://ehs.berkeley.edu/workplace-safety/glove-selection-guide or (2) https://chemrest.com/us_region/en/

When handling cryogenics or hot items, cryo-gloves or heat-resistant gloves must be used, respectively.

When a single glove material does not provide adequate protection, double set of gloves may be worn. Damaged gloves should be replaced immediately. Non-disposable gloves should be decontaminated or washed appropriately before removing them.

Foot Protection: Only closed-toe and closed-heel shoes should be worn when occupying labs. The area of skin between the shoe and ankle should not be exposed.

Laboratory Coats: Laboratory coats or chemical protective suits must be worn where chemicals are stored or handled. Care must be taken to ensure that the clothing material provides appropriate protection and that it does not endanger the individual. Synthetic clothing as well as synthetic lab coats (e.g. polyester or polyester-cotton mix) are not recommended when handling flammable chemicals. Clothing that leaves large areas of skin exposed (e.g. tank tops and shorts) must never be worn in labs.

UNATTENDED EXPERIMENTS

Laboratory operations involving hazardous substances are sometimes carried out continuously or overnight with no one present. Although unattended operations should be avoided when possible, PI/Lab Instructors are responsible for designing experiments to prevent the release of hazardous substances if utility services such as electricity, cooling water, and flow of inert gas are interrupted.

For unattended experiments, follow these guidelines:

- Fill out Unattended Experiments Form and place it at the site of the reaction (e.g. on fume hood sash). If possible, leave notebook page number or any related information to correspond to further details.
    - Consider all possible hazards in the labs that could occur as a result of failure, malfunctions, operational methods, environments encountered, maintenance error, and operational error.
        - **Example**: What if water supply was interrupted or a hose pulled out? Would the system overheat, flood the lab, or cause other problems?
- Convey all necessary emergency response information (e.g., HAZMAT spill, responding to fires) to the Department of Public Safety.
- Leave specific signage such as “Leave the Lights On” or “Keep Reaction Vessel Open/Closed.”
- Examine how chemicals and apparatus are stored, considering the possibility for fire, explosion or unintended reactions.
- If appropriate, arrangements should be made for other researchers to periodically inspect the operation.

WORKING ALONE

Working alone on procedures involving hazardous chemicals, biological agents, or physical hazards is not recommended. However, certain experiments or activities may demand the need to work during off-business hours. Workers planning to work in labs during off-business hours (i.e. weekends, holidays, or weeknights) should make necessary arrangements with Department of Public Safety (x 4100) or with peers to check on them.

Additionally, workers who plan to work after business hours must follow these guidelines:

- Obtain a written permission from PI/Lab Instructor prior to working alone.
- If working alone is absolutely necessary, the worker should have a phone immediately available and is encouraged to be in contact with another person (who knows that he or she is being relied upon).
- If the research or operation is particularly hazardous such that a worker could be severely injured or overcome by the process, a capable person must be present at all times and know how to contact Emergency Services (911) or Department of Public Safety (x 4100) in the event of an emergency.

APPENDIX B: LIST OF PEROXIDE FORMING CHEMICALS[7,8]

NOTE: Below list is illustrative, not comprehensive.

Class A: Chemicals known to form explosive levels of peroxides without concentration	
Suggested Safe Storage Period: If unopened from manufacturer, up to **18 months** or stamped expiration date, whichever comes first. After opening, materials should be discarded or evaluated for peroxides within **3 months**. Store under nitrogen if possible.	
Divinyl acetylene	Potassium amide
Divinyl ether	Sodium amide (sodamide)
Isopropyl ether	Butadiene[9]
Vinylidene chloride	Chloroprene[9]
Potassium metal	Tetrafluoroethylene[9]

Class B: Chemicals known to present peroxide hazards upon concentration (distillation/ evaporation). A test should be performed if concentration is intended or suspected.	
Suggested Safe Storage Period: If unopened from manufacturer, up to **18 months** or stamped expiration date, whichever comes first. After opening, materials should be discarded or evaluated for peroxides within **12 months**.	
Acetal	Methylcyclopentane
Acetaldehyde	Methyl isobutyl ketone
Benzyl alcohol	4-Methyl-2-pentanol
2-Butanol	2-Pentanol
Cumene	4-Penten-1-ol
Cyclohexanol	1-Phenylethanol
2-Cyclohexen-1-ol	2-Phenylethanol
Cyclohexene	2-Propanol
Decahydronaphthalene	Tetrahydrofuran (THF)
Diacetylene	Tetrahydronaphthalene
Dicyclopentadiene	Vinyl ethers
Diethyl ether	Other secondary alcohols
Diethylene glycol dimethyl ether (diglyme)	
Ethylene glycol dimethyl eter (glyme)	
4-Heptanol	
2-Hexanol	
Methylacetylene	
3-Methyl-1-butanol	

[7] *Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards*. Washington, D.C.: National Academies, 2011. Print.
[8] Kelly, R.J. "Review of Safety Guidelines for Peroxidizable Organic Chemicals," Chemical Health & Safety – American Chemical Society – 1996, 4(5), 28-36.
[9] When stored as a liquid monomer.

Class C: Chemical that may auto-polymerize as a result of peroxide accumulation if inhibitors have been removed or are depleted	
Suggested Safe Storage Period: If unopened from manufacturer, up to 18 months or stamped expiration date, whichever comes first. • After opening, materials without inhibitors should not be stored for longer than 24 hours. • After opening, materials with inhibitors should be discarded or evaluated for peroxides within 12 months.	
Acrylic acid[10]	Tetrafluoroethylene[11]
Acrylonitrile[10]	Vinyl acetate
Butadiene[11]	Vinylacetylene
Chloroprene[11]	Vinyl chloride
Chlorotrifluoroethylene	Vinylpyridine
Methyl methacrylate[10]	Vinyladiene chloride
Styrene	

Class D: Chemicals that may form peroxides but cannot be clearly placed in Class A–C	
These chemicals have the potential to form peroxides with varying conditions of use but are normally stable. Consult the manufacturer's SDS to determine when peroxide formation is expected and label accordingly.	
Acrolein	Di(1-propynl) ether[14]
Allyl ether[12]	Di(2-propynl) ether
Allyl ethyl ether	Di-*n*-propoxymethane[12]
Allyl phenyl ether	1,2-Epoxy-3-isopropoxypropane[12]
p-(*n*-Amyloxy)benzoyl chloride	1,2-Epoxy-3-phenoxypropane
n-Amyl ether	*p*-Ethoxyacetophenone
Benzyl *n*-butyl ether[12]	1-(2-Ethoxyethoxy)ethyl acetate
Benzyl ether[12]	2-Ethoxyethyl acetate
Benzyl ethyl ether[12]	(2-Ethoxyethyl)-*o*-benzoyl benzoate
Benzyl methyl ether	1-Ethoxynaphthalene
Benzyl-1-napthyl ether[12]	*o,p*-Ethoxyphenyl isocyanate
1,2-Bis(2-chloroethoxyl)ethane	1-Ethoxy-2-propyne
Bis(2-ethoxyethyl)ether	3-Ethoxypropionitrile
Bis(2-(methoxyethoxy)ethyl) ether	2-Ethylacrylaldehyde oxime
Bis(2-chloroethyl) ether	2-Ethylbutanol
Bis(2-ethoxyethyl) adipate	Ethyl-*b*-ethoxypropionate
Bis(2-methoxyethyl) carbonate	2-Ethylhexanal
Bis(2-methoxyethyl) ether	Ethyl vinyl ether
Bis(2-methoxyethyl) phthalate	Furan
Bis(2-methoxymethyl) adipate	2,5-Hexadiyn-1-ol
Bis(2-n-butoxyethyl) phthalate	4,5-Hexadien-2-yn-1-ol

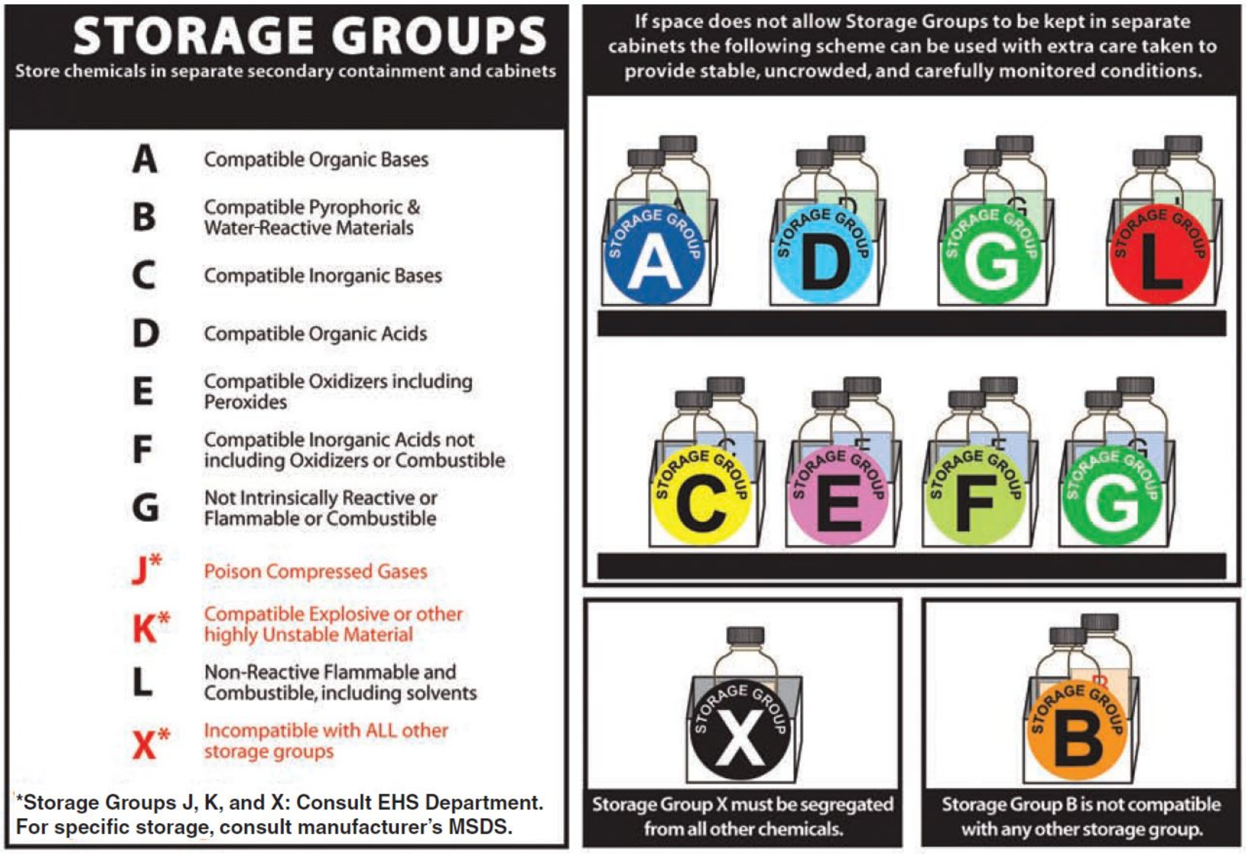
[10] Although these chemicals form peroxides, no explosions involving these monomers have been reported.
[11] When stored in liquid form, these chemicals form explosive levels of peroxides without concentration. They may also be stored as a gas in gas cylinders. When stored as a gas, these chemicals may auto-polymerize as a result of peroxide accumulation.

[12] These chemicals easily form peroxides and should probably be considered under Class B.

Class D: Chemicals that may form peroxides but cannot be clearly placed in Class A–C	
These chemicals have the potential to form peroxides with varying conditions of use but are normally stable. Consult the manufacturer's SDS to determine when peroxide formation is expected and label accordingly.	
Bis(2-phenoxyethyl) ether	*n*-Hexyl ether
Bis(4-chlorobutyl) ether	*o, p*-Iodophenetole
Bis(chloromethyl) ether[13]	Isoamyl benzyl ether[12]
2-Bromomethyl ethyl ether	Isoamyl ether[12]
β-Bromophenetole	Isobutyl vinyl ether
o-Bromophenetole	Isophorone[12]
p-Bromophenetole	*β*-Isopropoxypropionitrile[12]
3-Bromopropyl phenyl ether	Isopropyl-2,4,5-trichlorophenoxy acetate
tert-Butyl methyl ether	*n*-Methylphenetole
n-Butyl phenyl ether	2-Methyltetrahydrofuran
n-Butyl vinyl ether	3-Methoxy-1-butyl acetate
Chloroacetaldehyde diethylacetal	2-Methoxyethanol
2-Chlorobutadiene	3-Methoxyethyl acetate
1-(2-Chloroethoxy)-2-phenoxyethane	2-Methoxyethyl vinyl ether
Chloroethylene	Methoxy-1,3,5,7-cyclooctatetraene
Chloromethyl methyl ether[13]	*β*-Methoxypropionitrile
b-Chlorophenetole	*m*-Nitrophenetole
o-Chorophenetole	1-Octene
p-Chlorophenetole	Oxybis(2-ethyl acetate)
Cyclooctene[12]	Oxybis(2-ethyl benzoate)
Cyclopropyl methyl ether	β, β-Oxydipropionitrile
Diallyl ether[12]	1-Pentene
p-Di-*n*-butoxybenzene	Phenoxyacetyl chloride
1,2-Dibenzyloxyethane[12]	*α*-Phenoxypropionyl chloride
p-Dibenzyloxybenzene[12]	Phenyl-*o*-propyl ether
1,2-Dichloroethyl ethyl ether	*p*-Phenylphenetone
2,4-Dichlorophenetole	*n*-Propyl ether
Diethoxymethane[12]	*n*-Propyl isopropyl ether
2,2-Diethoxypropane	Sodium 8-11-14-eicosatetraenoate
Diethyl ethoxymethylenemalonate	Sodium ethoxyacetylide
Diethyl fumarate[12]	Tetrahydropyran
Diethyl acetal[12]	Triethylene glycol diacetate
Diethylketene[14]	Triethylene glycol dipropionate
m,o,p-Diethoxybenzene	1,3,3-Trimethoxypropene
1,2-Diethoxyethane	1,1,2,3-Tetrachloro-1,3-butadiene
Dimethoxymethane[12]	4-Vinyl cyclohexene
1,1-Dimethoxyethane[12]	Vinylene carbonate

[13] OSHA regulated carcinogen
[14] Extremely reactive and unstable compound

APPENDIX C: CHEMICAL STORAGE GUIDE[7]



Storage Group A: Compatible Organic Bases	
CAS Number	Name
100-46-9	Benzylamine
100-85-6	Benzyltrimethylammonium hydroxide
108-91-8	Cyclohexylamine
111-42-2	Diethanolamine
109-89-7	Diethylamine
75-04-7	Ethylamine
107-15-3	Ethylenediamine
110-89-4	Piperidine
102-71-6	Triethanolamine
121-44-8	Triethylamine

Storage Group B: Compatible Pyrophoric and Water Reactive Materials	
CAS Number	Name
7783-70-2	Antimony pentafluoride
98-88-4	Benzoyl chloride
353-42-4	Boron triflouride compound with methyl ether (1:1)
594-19-4	*Tert*-Butyllithium
156-62-7	Calcium cyanamide
16853-85-3	Lithium aluminum hydride
4111-54-0	Lithium diisopropylamide
7580-67-8	Lithium hydride
7439-93-2	Lithium metal (e.g., in THF)
124-63-0	Methanesulfonyl chloride
917-54-4	Methyllithium solution (and other alkyls)
7440-09-7	Potassium metal
17242-52-3	Potassium amide
16940-66-2	Sodium borohydride
7646-69-7	Sodium hydride
7440-66-6	Zinc (fume or dust)

Storage Group C: Compatible Inorganic Bases	
CAS Number	Name
1336-21-6	Ammonium hydroxide
17194-00-2	Barium hydroxide
1305-62-0	Calcium hydroxide
21351-79-1	Cesium hydroxide
1310-65-2	Lithium hydroxide
1310-58-3	Potassium hydroxide
1310-82-3	Rubidium hydroxide
1310-73-2	Sodium hydroxide
18480-07-4	Strontium hydroxide

Storage Group D: Compatible Organic Acids	
CAS Number	Name
64-19-7	Acetic acid
79-10-7	Acrylic acid
65-85-0	Benzoic acid
98-07-7	Benzotrichloride
98-88-4	Benzoyl chloride
10043-35-3	Boric acid
79-11-8	Chloroacetic acid
627-11-2	Chloroethyl chloroformate

Storage Group D: Compatible Organic Acids	
CAS Number	Name
77-92-9	Citric Acid
79-44-7	Dimethylcarbamyl chloride
64-18-6	Formic acid
6915-15-7	Malic acid
108-31-6	Maleic anhydride
139-13-9	Nitrilotriacetic acid
79-09-4	Propionic acid
7783-00-8	Selenious acid
76-05-1	Trifluoroacetic acid (TFA)
76-03-9	Trichloroacetic acid

Storage Group E: Compatible Oxidizers, including Peroxides	
CAS Number	Name
21205-91-4	9-BBN
13473-90-0	Aluminum nitrate
7789-09-5	Ammonium dichromate
7790-98-9	Ammonium perchlorate
13446-10-1	Ammonium permanganate
7727-54-0	Ammonium persulfate
10022-31-8	Barium nitrate
10124-37-5	Calcium nitrate
1305-79-9	Calcium peroxide
19004-19-4	Cupric nitrate
506-93-4	Guanidine nitrate
937-14-4	3-Chloroperoxybenzoic acid
7722-84-1	Hydrogen peroxide
10099-74-8	Lead nitrate
13840-33-0	Lithium hypochlorite
10377-60-3	Magnesium nitrate
10034-81-8	Magnesium perchlorate
13138-45-9	Nickel nitrate
7697-37-2	Nitric acid
79-21-0	Peracetic acid
7601-90-3	Perchloric acid
7778-50-9	Potassium dichromate
7757-79-1	Potassium nitrate
7722-64-7	Potassium permanganate
7727-21-1	Potassium persulfate
17014-71-0	Potassium superoxide

Storage Group E: Compatible Oxidizers, including Peroxides	
CAS Number	Name
7761-88-8	Silver nitrate
15630-89-4	Sodium carbonate peroxide
7775-09-9	Sodium chlorate
7758-19-2	Sodium chlorite
2893-78-9	Sodium dichloro-s-triazinetrione
10588-01-9	Sodium dichromate
7681-52-9	Sodium hypochlorite
7631-99-4	Sodium nitrate
7632-00-0	Sodium nitrite
10101-50-5	Sodium permanganate
1313-60-6	Sodium peroxide
7775-27-1	Sodium persulfate
7791-10-8	Strontium chlorate
10042-76-9	Strontium nitrate
1314-18-7	Strontium peroxide
87-90-1	Trichloro-s-triazinetrione (Trichloroisocyanuric acid, TCCA)

Storage Group F: Compatible Inorganic Acids, Not Including Oxidizers Or Combustibles	
CAS Number	Name
7790-93-4	Chloric acid
10034-85-2	Hydrioic acid
7647-01-0	Hydrochloric acid
7664-39-3	Hydrogen fluoride solution
7664-38-2	Phosphoric acid
7664-93-9	Sulfuric acid

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
71751-41-2	Abamectin [avermectin b1]
640-19-7	Acetamide, 2-fluoro-
62-74-8	Acetic acid, fluoro-, sodium salt
1752-30-3	Acetone thiosemicarbazide
53-96-3	2-Acetylaminofluorene
79-06-1	Acrylamide
814-68-6	Acrylyl chloride
111-69-3	Adiponitrile
309-00-2	Aldrin
60-09-3	4-Aminoazobenzene
92-67-1	4-Aminodiphenyl

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
82-28-0	1-Amino-2-methylanthraquinone
54-62-6	Aminopterin
101-05-3	Anilazine [4, 6-dichloro-*N*-(2-chlorophenyl)-1, 3, 5-triazin-2-amine]
CAS Number	Name
90-04-0	*o*-Anisidine
7440-36-0	Antimony
7440-38-2	Arsenic
1303-28-2	Arsenic pentoxide
7784-34-1	Arsenic trichloride
1327-53-3	Arsenic trioxide
86-50-0	Azinphos-methyl
7440-39-3	Barium
56-55-3	Benz[a]anthracene
98-87-3	Benzal chloride
55-21-0	Benzamide
98-16-8	Benzenamine, 3-(trifluoromethyl)-
100-14-1	Benzene, 1-(chloromethyl)-4-nitro-
98-05-5	Benzenearsonic acid
108-98-5	Benzenethiol
92-87-5	Benzidine
50-32-8	Benzo[a]pyrene
57-64-7	Benzoic acid, 2-hydroxy-, compound with (3as-cis)-1,2,3,3a,8,8a-hexahydro-1,3a,8-trimethylpyrrolo[2,3,b]indol-5-ylmethylcarbamate ester (1:1)
100-44-7	Benzyl chloride
140-29-4	Benzyl cyanide
7440-41-7	Beryllium powder
91-59-8	Beta-naphthylamine
82657-04-3	Bifenthrin
92-52-4	Biphenyl
534-07-6	Bis(chloromethyl) ketone
542-88-1	Bis(chloromethyl)ether
28772-56-7	Bromadiolone
75-25-2	Bromoform (tribromomethane)
74-83-9	Bromomethane
75-63-8	Bromotrifluoromethane (halon 1301)
81-88-9	C.I. Food red 15 (Rhodamine B)
97-56-3	C.I. Solvent yellow 3
7440-43-9	Cadmium

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
1306-19-0	Cadmium oxide
2223-93-0	Cadmium stearate
7778-44-1	Calcium arsenate
56-25-7	Cantharidin
51-83-2	Carbachol chloride
644-64-4	Carbamic acid, dimethyl-, 1-[(dimethylamino)carbonyl]-5-methyl-1h-pyrazol-3-yl ester
63-25-2	Carbaryl [1-naphthalenol, methylcarbamate]
1563-66-2	Carbofuran
56-23-5	Carbon tetrachloride
57-74-9	Chlordane
115-28-6	Chlorendic acid
532-27-4	2-Chloroacetophenone
4080-31-3	1-(3-Chloroallyl)-3,5,7-triaza-1-azoniaadamantane chloride
75-45-6	Chlorodifluoromethane (HCFC-22)
67-66-3	Chloroform
107-30-2	Chloromethyl methyl ether
5344-82-1	1-(o-Chlorophenyl)thiourea
542-76-7	3-Chloropropionitrile
63938-10-3	Chlorotetrafluoroethane
75-88-7	2-Chloro-1,1,1-trifluoro-ethane (HCFC-133a)
75-72-9	Chlorotrifluoromethane (CFC-13)
1982-47-4	Chloroxuron
10025-73-7	Chromic chloride
7440-47-3	Chromium
64-86-8	Colchicine
56-72-4	Coumaphos
5836-29-3	Coumatetralyl
1319-77-3	Cresol (mixed isomers)
95-48-7	*o*-Cresol
535-89-7	Crimidine
4170-30-3	Crotonaldehyde
123-73-9	(e)-Crotonaldehyde
64-00-6	*m*-Cumenyl methylcarbamate
21725-46-2	Cyanazine
506-68-3	Cyanogen bromide
506-78-5	Cyanogen iodide
675-14-9	Cyanuric fluoride
66-81-9	Cycloheximide

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
94-75-7	2,4-D (2,4-Dichlorophenoxyacetic acid)
2971-38-2	2,4-D Chlorocrotyl ester
94-11-1	2,4-D Isopropyl ester
94-82-6	2,4-DB
919-86-8	Demeton-s-methyl
101-80-4	4,4'-Diaminodiphenyl ether
101-77-9	4,4'-Diaminodiphenylmethane
615-05-4	2,4-Diaminoanisole
95-80-7	2,4-Diaminotoluene
25376-45-8	Diaminotoluene (mixed isomers)
333-41-5	Diazinon
53-70-3	Dibenzo(a, h)anthracene
132-64-9	Dibenzofuran
96-12-8	1,2-Dibromo-3-chloropropane
106-93-4	1,2-Dibromoethane (ethylene dibromide)
84-74-2	Dibutyl phthalate
99-30-9	Dichloran [2, 6-dichloro-4-nitroaniline]
95-50-1	1,2-Dichlorobenzene
541-73-1	1,3-Dichlorobenzene
106-46-7	1,4-Dichlorobenzene
91-94-1	3,3'-Dichlorobenzidine
75-27-4	Dichlorobromomethane
764-41-0	1,4-Dichloro-2-butene
75-71-8	Dichlorodifluoromethane (cfc-12)
111-44-4	Dichloroethyl ether
75-09-2	Dichloromethane (methylene chloride)
91-93-0	3,3'-Dimethoxybenzidine-4,4'-diisocyanate
91-97-4	3,3'-Dimethyl-4,4'-diphenylene diisocyanate
127564-92-5	Dichloropentafluoropropane
97-23-4	Dichlorophene [2, 2'-methylene-bis(4-chlorophenol)]
120-83-2	2,4-Dichlorophenol
105-67-9	2,4-Dimethylphenol
696-28-6	Dichlorophenylarsine
76-14-2	Dichlorotetrafluoroethane (cfc-114)
62-73-7	Dichlorvos
1464-53-5	Diepoxybutane
38727-55-8	Diethatyl ethyl
814-49-3	Diethyl chlorophosphate
297-97-2	*O,O*-Diethyl *O*-pyrazinyl phosphorothioate

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
78-53-5	*O,O*-Diethyl *S*-[2-(diethylamino)ethyl] phosphorothiolate
71-63-6	Digitoxin
101-90-6	Diglycidyl resorcinol ether
94-58-6	Dihydrosafrole
55-91-4	Diisopropylfluorophosphate (DFP)
60-51-5	Dimethoate
60-11-7	4-Dimethylaminoazobenzene
57-97-6	7,12-Dimethylbenz[a]anthracene
91-93-0	3,3'-Dimethoxybenzidine-4,4'-diisocyanate
2524-03-0	Dimethyl chlorothiophosphate
91-97-4	3,3'-Dimethyl-4,4'-diphenylene diisocyanate
105-67-9	2,4-Dimethylphenol
131-11-3	Dimethyl phthalate
77-78-1	Dimethyl sulfate
2300-66-5	Dimethylamine dicamba
534-52-1	4,6-Dinitro-*o*-cresol
78-34-2	Dioxathion
82-66-6	Diphacinone
957-51-7	Diphenamid
122-39-4	Diphenylamine
107-49-3	Diphosphoric acid, tetraethyl ester
541-53-7	Dithiobiuret
72-20-8	Endrin
50-14-6	Ergocalciferol
563-12-2	Ethion
13194-48-4	Ethoprop
541-41-3	Ethyl chloroformate
759-94-4	Ethyl dipropylthiocarbamate [EPTC]
371-62-0	Ethylene fluorohydrin
107-21-1	Ethylene glycol
96-45-7	Ethylene thiourea
542-90-5	Ethylthiocyanate
52-85-7	Famphur
55-38-9	Fenthion [*o*, *o*-dimethyl *o*-[3-methyl-4-(methylthio)phenyl]ester, phosphorothioic acid]
144-49-0	Fluoroacetic acid
359-06-8	Fluoroacetyl chloride
51-21-8	Fluorouracil
944-22-9	Fonofos

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
107-16-4	Formaldehyde cyanohydrin
23422-53-9	Formetanate hydrochloride
76-13-1	Freon 113 [ethane, 1, 1, 2-trichloro-1, 2, 2-trifluoro-]
76-44-8	Heptachlor
87-68-3	Hexachloro-1, 3-butadiene
118-74-1	Hexachlorobenzene
77-47-4	Hexachlorocyclopentadiene
67-72-1	Hexachloroethane
1335-87-1	Hexachloronaphthalene
70-30-4	Hexachlorophene
822-06-0	Hexamethylene-1, 6-diisocyanate
51235-04-2	Hexazinone
51-75-2	Hn2 (nitrogen mustard-2)
555-77-1	Hn3 (nitrogen mustard-3)
79-19-6	Hydrazinecarbothioamide
123-31-9	Hydroquinone
102-36-3	Isocyanic acid, 3,4-dichlorophenyl ester
465-73-6	Isodrin
4098-71-9	Isophorone diisocyanate
108-23-6	Isopropyl chloroformate
80-05-7	4,4'-Isopropylidenediphenol
120-58-1	Isosafrole
78-97-7	Lactonitrile
7439-92-1	Lead
58-89-9	Lindane
554-13-2	Lithium carbonate
121-75-5	Malathion
109-77-3	Malononitrile
93-65-2	Mecoprop
950-10-7	Mephosfolan
149-30-4	2-Mercaptobenzothiazole (MBT)
5124-30-1	1,1-Methylene bis(4-isocyanatocyclohexane)
1600-27-7	Mercuric acetate
7487-94-7	Mercuric chloride
21908-53-2	Mercuric oxide
7439-97-6	Mercury
760-93-0	Methacrylic anhydride
920-46-7	Methacryloyl chloride
30674-80-7	Methacryloyloxyethyl isocyanate

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
558-25-8	Methanesulfonyl fluoride
950-37-8	Methidathion
16752-77-5	Methomyl
94-74-6	Methoxone (4-chloro-2-methylphenoxy) acetic acid (MCPA))
72-43-5	Methoxychlor [benzene, 1, 1'-(2, 2, 2-trichloroethylidene)bis[4-methoxy-]]
151-38-2	Methoxyethylmercuric acetate
80-63-7	Methyl 2-chloroacrylate
56-49-5	3-Methylcholanthrene
74-87-3	Methyl chloride
101-14-4	4,4'-Methylenebis(2-chloroaniline) (mboca)
101-61-1	4,4'-Methylenebis(N,N-dimethyl) benzenamine
60-34-4	Methyl hydrazine
74-88-4	Methyl iodide
924-42-5	*N*-Methylolacrylamide
298-00-0	Methyl parathion
676-97-1	Methyl phosphonic dichloride
556-64-9	Methyl thiocyanate
502-39-6	Methylmercuric dicyanamide
7786-34-7	Mevinphos
90-94-8	Michler's ketone
50-07-7	Mitomycin c
1313-27-5	Molybdenum trioxide
76-15-3	Monochloropentafluoroethane (CFC-115)
6923-22-4	Monocrotophos
3173-72-6	1,5-Naphthalene diisocyanate
54-11-5	Nicotine
65-30-5	Nicotine sulfate
92-93-3	4-Nitrobiphenyl
55-63-0	Nitroglycerine
88-75-5	2-Nitrophenol
100-02-7	4-Nitrophenol
62-75-9	*N*-Nitrosodimethylamine
621-64-7	*N*-Nitrosodi-*N*-propylamine
86-30-6	*N*-Nitrosodiphenylamine
59-89-2	*N*-Nitrosomorpholine
100-75-4	*N*-Nitrosopiperidine
99-55-8	5-Nitro-*o*-toluidine
630-60-4	Ouabain
78-71-7	Oxetane, 3,3-bis(chloromethyl)-

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
104-94-9	*p*-anisidine
56-38-2	Parathion
12002-03-8	Paris green
106-47-8	p-chloroaniline
95-69-2	*p*-chloro-*o*-toluidine
106-44-5	*p*-cresol
100-25-4	*p*-dinitrobenzene
76-01-7	Pentachloroethane
87-86-5	Pentachlorophenol (PCP)
594-42-3	Perchloromethylmercaptan
85-01-8	Phenanthrene
108-95-2	Phenol
88-85-7	Phenol, 2-(1-methylpropyl)-4,6-dinitro- (dinoseb)
58-36-6	Phenoxarsine, 10,10'-oxydi-
95-54-5	1,2-Phenylenediamine
108-45-2	1,3-Phenylenediamine
624-18-0	1,4-Phenylenediamine dihydrochloride
104-49-4	1,4-Phenylene diisocyanate
59-88-1	Phenylhydrazine hydrochloride
62-38-4	Phenylmercury acetate
90-43-7	2-Phenylphenol
2097-19-0	Phenylsilatrane
103-85-5	Phenylthiourea
57-41-0	Phenytoin
947-02-4	Phosfolan
13171-21-6	Phosphamidon
57-47-6	Physostigmine
124-87-8	Picrotoxin
51-03-6	Piperonyl butoxide
100-01-6	*p*-nitroaniline
10124-50-2	Potassium arsenite
506-61-6	Potassium silver cyanide
106-50-3	*p*-phenylenediamine
23950-58-5	Pronamide
1120-71-4	Propane sultone
70-69-9	Propiophenone, 4'-amino
109-61-5	Propyl chloroformate
129-00-0	Pyrene
91-22-5	Quinoline

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
106-51-4	Quinone
82-68-8	Quintozene [pentachloronitrobenzene]
78-48-8	*S,S,S*-tributyltrithiophosphate (DEF)
81-07-2	Saccharin (manufacturing, no supplier notification)
94-59-7	Safrole
7440-22-4	Silver
7631-89-2	Sodium arsenate
7784-46-5	Sodium arsenite, solid
124-65-2	Sodium cacodylate
128-04-1	Sodium dimethyldithiocarbamate
13410-01-0	Sodium selenate
10102-18-8	Sodium selenite
10102-20-2	Sodium tellurite
57-24-9	Strychnine
505-60-2	Sulfur mustard (mustard gas H)
77-81-6	Tabun
79-94-7	Tetrabromobisphenol A
630-20-6	1,1,1,2-Tetrachloroethane
79-34-5	1,1,2,2-Tetrachloroethane
64-75-5	Tetracycline hydrochloride
78-00-2	Tetraethyl lead
3689-24-5	Tetraethyldithiopyrophosphate
597-64-8	Tetraethyltin
119-64-2	Tetrahydronaphthalene
75-74-1	Tetramethyllead
7440-28-0	Thallium
6533-73-9	Thallous carbonate
62-55-5	Thioacetamide
59669-26-0	Thiodicarb
62-56-6	Thiourea
614-78-8	Thiourea, (2-methylphenyl)-
137-26-8	Thiram
1314-20-1	Thorium dioxide
95-53-4	*o*-Toluidine
8001-35-2	Toxaphene
68-76-8	Triaziquone [2, 5-cyclohexadiene-1, 4-dione, 2, 3, 5-tris(1-aziridinyl)-]
24017-47-8	Triazofos
1983-10-4	Tributyltin fluoride

Storage Group G: Not Instrinsically Reactive Or Flammable Or Combustible	
CAS Number	Name
52-68-6	Trichlorfon [phosphonic acid, (2, 2, 2-trichloro-1-hydroxyethyl)-, dimethyl ester]
1558-25-4	Trichloro(chloromethyl)silane
71-55-6	1,1,1-Trichloroethane (methyl chloroform)
120-82-1	1,2,4-Trichlorobenzene
79-00-5	1,1,2-Trichloroethane
75-69-4	Trichlorofluoromethane (CFC-11)
327-98-0	Trichloronate
88-06-2	2,4,6-Trichlorophenol
96-18-4	1,2,3-Trichloropropane
88-05-1	2,4,6-Trimethyl-aniline
824-11-3	Trimethylolpropane phosphite
76-87-9	Triphenyltin hydroxide
51-79-6	Urethane (ethyl carbamate)
1314-62-1	Vanadium pentoxide
81-81-2	Warfarin
129-06-6	Warfarin sodium
87-62-7	2,6-Xylidine
28347-13-9	Xylylene dichloride

Storage Group J: Poison Compressed Gases	
CAS Number	Name
116-15-4	Hexafluoropropylene
7446-09-5	Sulfur dioxide

Storage Group K: Compatible Explosives Or Other Highly Unstable Materials	
CAS Number	Name
556-88-7	Nitroguanidine
88-89-1	Picric acid, dry (<10% water)
288-94-8	Tetrazole
124-47-0	Urea nitrate

Storage Group L: Non-Reactive Flammable And Combustible, Including Solvents	
CAS Number	Name
75-05-8	Acetonitrile
98-86-2	Acetophenone
107-13-1	Acrylonitrile, inhibited
557-40-4	Allyl ether
71-43-2	Benzene

Storage Group L: Non-Reactive Flammable And Combustible, Including Solvents	
CAS Number	Name
103-50-4	Benzyl ether
110-47-4	Beta-isopropoxypropionitrile
106-99-0	Butadiene
78-92-2	2-Butanol
71-36-3	*n*-Butanol
75-65-0	*tert*-Butanol
78-93-3	2-Butanone (MEK)
141-32-2	Butyl acrylate
8001-58-9	Creosote
110-82-7	Cyclohexane
108-93-0	Cyclohexanol
110-83-8	Cyclohexene
931-87-3	Cyclooctene
142-29-0	Cyclopentene
91-17-8	Decahydronaphthalene
75-43-4	Dichlorofluoromethane (HCFC-21)
77-73-6	Dicyclopentadiene
462-95-3	Diethoxymethane
111-96-6	Diethylene glycol dimethyl ether
109-87-5	Dimethoxymethane
124-40-3	Dimethylamine
68-12-2	*N,N*-Dimethylformamide
99-98-9	Dimethyl-*p*-phenylenediamine
51-28-5	2,4-Dinitrophenol
123-91-1	Dioxane
821-08-9	Divinyl acetylene
110-80-5	2-Ethoxyethanol
140-88-5	Ethyl acrylate
75-00-3	Ethyl chloride
107-12-0	Ethyl cyanide
60-29-7	Ethyl ether
100-41-4	Ethylbenzene
74-85-1	Ethylene
110-71-4	Ethylene glycol dimethyl ether
75-34-3	Ethylidene dichloride
115-21-9	Ethyltrichlorosilane
110-00-9	Furan
78-82-0	Isobutyronitrile
98-82-8	Isopropyl benzene

Storage Group L: Non-Reactive Flammable And Combustible, Including Solvents	
CAS Number	Name
108-20-3	Isopropyl ether
126-98-7	Methacrylonitrile
67-56-1	Methanol
109-86-4	2-Methoxyethanol
74-99-7	Methyl acetylene
96-33-3	Methyl acrylate
67-56-1	Methanol
96-37-7	Methyl cyclopentane
108-10-1	Methylisobutyl ketone (MIBK)
80-62-6	Methyl methracrylate
109-06-8	2-Methylpyridine
872-50-4	N-Methyl-2-pyrrolidone
1634-04-4	Methyl *tert*-butyl ether
91-20-3	Naphthalene
1122-60-7	Nitrocyclohexane
79-46-9	2-Nitropropane
67-63-0	2-Propanol
107-19-7	Propargyl alcohol
123-38-6	Propionaldehyde
110-86-1	Pyridine
100-42-5	Styrene
109-99-9	Tetrahydrofuran
108-88-3	Toluene
7440-62-2	Vanadium (except when contained in an alloy)
108-05-4	Vinyl acetate
109-93-3	Vinyl ether
1330-20-7	Xylene (mixed isomers)
95-47-6	*o*-Xylene
106-42-3	*p*-Xylene

Storage Group X: Incompatible With All Other Storage Groups	
CAS Number	Name
107-02-8	Acrolein
107-18-6	Allyl alcohol
107-05-1	Allyl chloride
107-11-9	Allylamine
7429-90-5	Aluminum
62-53-3	Aniline
622-79-7	Benzyl azide

Storage Group X: Incompatible With All Other Storage Groups	
CAS Number	Name
7726-95-6	Bromine
109-72-8	Butyllithium
107-07-3	Chloroethanol
76-06-2	Chloropicrin
104-12-1	*p*-Chlorophenyl isocyanate
10210-68-1	Cobalt carbonyl
334-88-3	Diazomethane
78-88-6	2,3-Dichloropropene
64-67-5	Diethyl sulfate
75-78-5	Dimethyldichlorosilane
57-14-7	1,1-Dimethylhydrazine
99-65-0	*m*-Dinitrobenzene
121-14-2	2,4-Dinitrotoluene
606-20-2	2,6-Dinitrotoluene
25321-14-6	Dinitrotoluene (mixed isomers)
106-89-8	Epichlorohydrin
151-56-4	Ethyleneimine
302-01-2	Hydrazine
74-90-8	Hydrogen cyanide
7664-39-3	Hydrogen fluoride
13463-40-6	Iron, pentacarbonyl-
556-61-6	Isothiocyanatomethane
79-22-1	Methyl chloroformate
624-83-9	Methyl isocyanate
75-86-5	2-Methyllactonitrile
74-93-1	Methyl mercaptan
78-94-4	Methyl vinyl ketone
74-95-3	Methylene bromide
101-68-8	Methylenebis(phenylisocyanate) (MDI)
98-95-3	Nitrobenzene
7601-90-3	Perchloric acid
98-13-5	Phenyltrichlorosilane
7723-14-0	Phosphorus
10025-87-3	Phosphorus oxychloride
10026-13-8	Phosphorus pentachloride
7719-12-2	Phosphorus trichloride
85-44-9	Phthalic anhydride
88-89-1	Picric acid, moist (10-40% water)
151-50-8	Potassium cyanide

Storage Group X: Incompatible With All Other Storage Groups	
CAS Number	Name
57-57-8	®-Propiolactone
7723-14-0	Red phosphorus
26628-22-8	Sodium azide
64568-18-9	Sodium hydrogen sulfide
60-41-3	Strychnine, sulfate
7446-11-9	Sulfur trioxide
584-84-9	Toluene-2,4-diisocyanate
91-08-7	Toluene-2,6-diisocyanate
26471-62-5	Toluenediisocyanate (mixed isomers)
79-01-6	Trichloroethylene

APPENDIX D: CHEMICAL INCOMPATIBILITY GUIDE

Below listed chemicals must never be stored next to each other on shelves or in such a position that accidental rupture of containers may allow mixing.

CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH
Acetic acid	Chromic acid, Nitric acid, Hydroxyl compounds, Ethylene glycol, Perchloric acid, Peroxides, Permanganates
Acetone	Concentrated Nitric and Sulfuric acid mixtures
Acetylene	Chlorine, Bromine, Copper, Fluorine, Silver, Mercury
Alkali and alkaline earth metals (such as powdered aluminum or magnesium, calcium, lithium, sodium, potassium)	Water, Carbon tetrachloride or other Chlorinated hydrocarbons, Carbon dioxide, Halogens
Aluminum (powdered)	Chlorinated hydrocarbons, Halogens, Carbon dioxide organic acids
Ammonia (anhydrous)	Mercury, Chlorine, Calcium hypochlorite, Iodine, Bromine, Hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, Powdered metals, Flammable liquids, Chlorates, Nitrates, Sulfur, Finely divided organic or combustible materials
Aniline	Nitric acid, Hydrogen peroxide
Arsenic materials	Any reducing agent
Azides	Acids
Bromine	See Chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, All oxidizing agents
Carbon tetrachloride	Sodium

CHEMICAL	IS INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH
Chlorates	Ammonium salts, Acids, Powdered metals, Sulfur, Finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, Naphthalene, Camphor, Glycerol, Alcohol, Flammable liquids in general
Chlorine	Ammonia, Acetylene, Butadiene, Butane, Methane, Propane (or other petroleum gases), Hydrogen, Sodium carbide, Benzene, Finely divided metals, Turpentine
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
Fluorine	Everything
Hydrocarbons (such as butane, propane, benzene)	Fluorine, Chlorine, Bromine, Chromic acid, Sodium peroxide
Hydrocyanic acid	Nitric acid, Alkali
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, Chromium, Iron, Most metals or their salts, Alcohols, Acetone, Organic materials, Aniline, Nitromethane, Combustible materials
Hydrogen sulfide	Fuming Nitric acid, Oxidizing gases
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

CHEMICAL	IS/ARE INCOMPATIBLE AND SHOULD NOT BE MIXED OR STORED WITH
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, Oils
Peroxide, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, Oxygen, Alkalis, Reducing agents
Potassium	Carbon tetrachloride, Carbon dioxide, Water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate (see also chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerol, Ethylene glycol, Benzaldehyde, Sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, Oxalic acid, Tartartic acid, Ammonium compounds, Fulminic acid
Sodium	Carbon tetrachloride, Carbon dioxide, Water
Sodium nitrate	Ammonium nitrate and other Aammonium salts
Sodium peroxide	Ethyl or methyl alcohol, Glacial acetic acid, Acetic anhydrite, Benzaldehyde, Carbon disulfide, Glycerin, Ethylene glycol, Ethyl acetate, Methyl acetate, Furfural
Sulfides	Acids
Sulfuric acid	Potassium chlorate, Potassium perchlorate, Potassium permanganate (similar compounds of light metals, such as sodium, lithium)
Tellurides	Reducing agents
Zinc powder	Sulfur

More details can be found here.

Dangerously Incompatible Substances

CHEMICAL	KEEP OUT OF CONTACT WITH:
Chlorine	Acetylene
Chromic acid	Ethyl alcohol
Oxygen (compressed, liquefied)	Propane
Sodium	Chloroform and aqueous solutions
Nitrocellulose (wet, dry)	Phosphorous
Potassium permanganate	Sulfuric acid
Perchloric acid	Acetic acid
Sodium chlorate	Sulfur in bulk

APPENDIX E: HIGHLY TOXIC CHEMICALS (ACUTE TOXINS)[15]

Acute toxins fall into one of the following criteria:

- LD_{50}: <50mg/kg (Oral)
- LD_{50}: <200mg/kg (Skin Contact)
- Median lethal concentration (LC_{50}): <200ppm in air for 1 hour - For gases and vapors
- LC_{50}: 2 mg/L (or <2,000 mg/m^3) in air for 1 hour - For mists, fumes, or dust

Chemical Name	CAS Number	DOT Emergency Response Guide Number	UN ID#
Abrin	1393-62-0	153	3462
N-Acetoxy-2-acetylaminofluorene	6098-44-8		
Acrolein			
Actinomycin D			
Aldicarb	116-06-3		
o-Aminoazobenzene			
2-Aminofluorene	153-78-6		
4-Aminopyridine			
Ammonium vanadate			
Anabasine	13078-04-1		
Apholate	52-46-0		
Arsenious Acid, Monosodium Salt	10103-60-3		
Arsenic acid			
Arsenic oxide			
Arsenic pentoxide			
Arsenic trioxide	1327-53-3		
Atropine	51-55-8		
Barium cyanide			
Benzenethiol or Thiophenol			
Beryllium powder			
N,N-bis(2-chloromethyl)-2-Naphthylamine			

[15] List adopted from http://www.chemistry.ucla.edu/sites/default/files/safety/doc/Acute_Toxins.pdf

Chemical Name	CAS Number	DOT Emergency Response Guide Number	UN ID#
Bromoethyl methanesulfonate			
1,4-Butanediol dimethylsulfonate			
Calcium cyanide			
Canthardin			
2-Chloro-4-dimethyl-amino-6-methylpyrimidine			
2-Chlorophenyl Thiourea			
Copper cyanide			
Cyanide salts			
Cyanogen			
Cyanogen halide			
Cyclophosphamide (2-bis(2-chloroethyl)-aminotetrahydro-2*H*-1,3,2- oxazaphosphorine-2-oxide)			
Diazomethane	334-88-3		
Dichloromethyl ether			
Dichlorophenylarsine			
Diethyl-arsine			
Digalen			
Digifolin			
Digoxin			
7,12-Dimethylbenze[a]anthracene	57-97-6		
3,3'-Dimethoxybenzidine			
3,3'-Dimethylbenzidine			
Dimethylethylenimine			
1,2-Dimethylhydrazine			
3,3'-Dimethoxybenzidine dihydrochloride			
2,4-Dinitrophenol			
1,4-Dinitrosopiperazine			
Duboisine			
Ethionine			
Ethyl cyanide			
Ethylenimine	151-56-4		
Ethylene glycol dinitrate	628-96-6		
Ethyl methanesulfonate	62-50-0		
Fluoroacetamide			

Chemical Name	CAS Number	DOT Emergency Response Guide Number	UN ID#
Fluroacetic acid	144-49-0		
Gitalin			
Heroin			
Hexaethyl tetraphosphate			
Hydrazoic acid	7782-79-8		
Hydrocyanic acid (Hydrogen cyanide)	74-90-8	117 (anhydrous or >20% solution); 154 (≤20% solution)	1051 (anhydrous or >20% solution); 1613 (≤20% solution)
N-Hydroxy-2-acetylaminofluorene			
Hyoscyamine Inorganic arsenic Isobenzan			
K-Strophanthin			
Lanatoside			
Lysergic acid diethylamide			
3-Methylcholanthrene			
Methyl chloromethyl ether			
4,4'-Methylene bis-(2-chloraniline)			
Methylhydrazine			
Methyl methanesulfonate			
Nickel cyanide			
Nicotine salicylate			
N-[4-(5-Nitr o-2-furyl)-2-thiazoly]-formamide			
Nitrogen dioxide			
Nitroglycerin			
N-Nitroquinoline-1-oxide			
N-Nitrosodimethylamine			
N-Nitroso-N-methylurethane			
Pantopon			
Parathion			
Paroxon			
Phenyl-Arsonous dichloride			
Phenyl Thiourea			
Phosgene			
Phosphine	7803-51-2	119	2199

Chemical Name	CAS Number	DOT Emergency Response Guide Number	UN ID#
Phosphorodithioic acid			
Phosphorous (Yellow)			
Potassium cyanide			
Propylenimine			
2-Propylpiperidine			
Ricin			
Scopolamine			
Sarin			
Silver cyanide			
Sodium azide	26628-22-8	153	1687
Sodium selenate	13410-01-0		
Sodium cyanide			
Sulfotepp			
Tabun			
Tepp			
2,3,7,8-Tetrachlorodibenzofuran			
Tetraethyl lead			
Thallic oxide			
Thallium(I) selenite			
Thallium(I) sulfate			
Thimet			
Thiophenol			
m-Toluenediamine			
Uracil mustard			
Vanadium pentoxide			
Zinc cyanide			
Zinc phosphide			

APPENDIX F: CAL-OSHA REGULATED CARCINOGENS[16]

2-Acetylaminofluorene
Acrylonitrile
4-Aminodiphenyl
Asbestos
Benzene
Benzidine (and its salts)
1,3-Butadiene
Cadmium
bis-Chloromethyl ether
Chromium (VI) compounds
Coke oven emissions
1,2-Dibromo-3-chloropropane
3,3'-Dichlorobenzidine (and its salts)
4-Dimethylaminoazobenzene
Ethylene dibromide
Ethylene oxide
Ethyleneimine
Formaldehyde
Inorganic arsenic
Lead
Methyl chloromethyl ether
4,4'-Methylene bis(2-chloroaniline)
Methylene chloride (Dichloromethane)
Methylenedianiline
alpha-Naphthylamine
beta-Naphthylamine
4-Nitrobiphenyl
N-Nitrosodimethylamine
beta-Propiolactone
Vinyl chloride

[16] Above list was taken from University of California, Los Angeles (UCLA). https://www.chemistry.ucla.edu/sites/default/files/safety/doc/OSHA_Regulated_Carcinogens.pdf

APPENDIX G: POTENTIALLY EXPLOSIVE LABORATORY CHEMICALS[17]

- Acetyl peroxide
- Acetylene
- Ammonium nitrate
- Ammonium perchlorate
- Ammonium picrate
- Barium azide
- Benzoyl peroxide
- Bromopropyne
- Butanone peroxide
- Cumene peroxide
- Diazodinitrophenol
- Dinitrophenol
- Dinitrophenylhydrazine
- Dinitroresorcinol
- Dipicryl amine
- Dipicryl sulphide
- Dodecanoyl peroxide
- Ethylene oxide
- Heavy metal azides
- Lauric peroxide
- Lead azide
- Lithium azide
- Mercury azide
- Mercury fulminate
- Methyl Ethyl Ketone peroxide (MEK peroxide)
- Nitrocellulose
- Nitrogen trifluoride
- Organic azides
- Nitrogen triiodide
- Nitroglycerine
- Nitroguanidine
- Nitromethane
- Nitrourea
- Picramide
- Picric acid (trinitrophenol)
- Picryl chloride
- Picryl sulphonic acid
- Potassium azide
- Propargyl bromide (neat)
- Silver fulminate
- Sodium azide
- Sodium dinitrophenate
- Succinic peroxide
- Tetranitroaniline
- Trinitroaniline
- Trinitroanisole
- Trinitrobenzene
- Trinitrobenzenesulphonic acid
- Trinitrobenzoic acid
- Trinitrocresol
- Trinitronaphthalene
- Trinitrophenol (picric acid)
- Trinitroresorcinol
- Trinitrotoluene (TNT)
- Urea nitrate

[17] Above list was taken from University of California, Los Angeles (UCLA). https://www.chemistry.ucla.edu/sites/default/files/safety/doc/Explosive_Chemicals.pdf

Following compound classes can be potentially explosive!

Functional Groups:

Acetylene (-C=C-)
Acyl hypohalites (RCO-OX)
Azide Organic ($R-N_3$)
Azide Metal ($M-N_3$)
Azo (-N=N-)
Diazo (=N=N)
Diazosulphide (-N=N-S-N=N-)
Diazonium salts ($R-N_2^+$)
Fulminate (-CNO)
Halogen Amine (=N-X)
Nitrate ($-ONO_2$)
Nitro ($-NO_2$)
Aromatic or Aliphatic Nitramine ($=N-NO_2$) ($-NH-NO_2$)
Nitrite (-ONO)
Nitroso (-NO)
Ozonides
Peracids (-CO-O-O-H)
Peroxide (-O-O-)
Hydroperoxide (-O-O-H)
Metal peroxide (M-O-O-M)

Explosive Salts:

Bromate salts (BrO_3^-)
Chlorate salts (ClO_3^-)
Chlorite salts (ClO_2^-)
Perchlorate salts (ClO_4^-)
Picrate salts (2,4,6-trinitrophenoxide)
Picramate salts (2-amino-4,6-dinitrophenoxide)
Hypohalite salts (XO^-)
Iodate salts (IO_3^-)

APPENDIX H: PYROPHORIC CHEMICALS

Aluminum alkyls:	R_3Al, R_2AlCl, $RAlCl_2$
Examples:	Et_3Al, Et_2AlCl, $EtAlCl_2$, Me_3Al, Diethylethoxyaluminium
Grignard Reagents:	RMgX (R=alkyl, aryl, vinyl X=halogen)
Lithium Reagents:	RLi (R = alkyls, aryls, vinyls)
Examples:	Butyllithium, Isobutyllithium, sec-Butyllithium, tert-Butyllithium, Ethyllithium, Hexyllithium, Isopropyllithium, Methyllithium, (Trimethylsilyl)methyllithium, Phenyllithium, 2-Thienyllithium, Vinyllithium, Lithium acetylide ethylenediamine complex, Lithium (trimethylsilyl)acetylide, Lithium phenylacetylide
Zinc Alkyl Reagents:	RZnX, R_2Zn
Examples:	Et_2Zn
Metal carbonyls:	Lithium carbonyl, Nickel tetracarbonyl, Dicobalt octacarbonyl
Metal powders (finely divided):	Bismuth, Calcium, Cobalt, Hafnium, Iron, Magnesium, Titanium, Uranium, Zinc, Zirconium
Low Valent Metals:	Titanium dichloride
Metal hydrides:	Potassium Hydride, Sodium hydride, Lithium Aluminum Hydride, Diethylaluminium hydride, Diisobutylaluminum hydride, Dichloro(methyl)silane
Non-metal hydrides:	Arsine, Boranes, Diethylarsine, diethylphosphine, Germane, Phosphine, phenylphosphine, Silane, Methanetellurol (CH_3TeH)
Non-metal alkyls:	R_3B, R_3P, R_3As; Tetramethylsilane, Tributylphosphine

Used hydrogenation catalysts: Raney nickel, Palladium, Platinum

Activated Copper fuel cell catalysts, e.g., $Cu/ZnO/Al_2O_3$

Finely Divided Iron Sulfides (FeS, FeS_2, Fe_3S_4), and Potassium Sulfide (K_2S)

Elements:

- Phosphorus
- Cesium
- Lithium
- Potassium
- Sodium
- Sodium Potassium alloy (NaK)
- Aluminum phosphide (AlP)

APPENDIX I: REPRODUCTIVE TOXINS

See attachment (PDF)

APPENDIX J: CHEMICAL INVENTORY TEMPLATE

Chemical Name	Amount/ Quantity	Hazard Class (ex. Corrosive, Oxidizer, Flammable)	CAS#	Supplier	Location (ex. Shelf, Cabinet)	Date Received (mm/dd/yyyy)	SDS Present? (Y/N)

APPENDIX K: INCIDENT/INJURY REPORT

You **MUST REPORT ALL** injuries or spills of hazardous chemicals, **EVEN MINOR ONES** to your PIs/supervisors. The PI/Lab Instructor is responsible for assessing all such incidents, and should promptly report incidents to EHS or Public Safety if at any time they presented a hazardous situation to laboratory workers, environment, and/or property. All serious[18] injuries and incidents, especially the ones involving loss of body part(s) and/or death, must be reported to EHS and Department of Human Resources (HR) within 8 hours to allow for compliant within Cal-OSHA's 8-hour reporting timeframe. In the absence of PIs and EHS, University's Department of Public Safety (ext. 4100) must be notified as soon as possible.

Who was involved? ☐ **Check here if no one was injured** **Work Related?** ☐**Yes** ☐**No**

	FULL NAME	PHONE NUMBER	EMAIL	Student ID#
Student:	___________________________	_______________	________________________	___________
Professor/Supervisor:	___________________________	_______________	________________________	___________
Anyone else involved:	___________________________	_______________	________________________	___________

Accident Type:

☐**Allergen Exposure**	☐**Bitten By**	☐**Car/Truck/Motorized Vehicle**
☐**Caught In/Between**	☐**Contact with Chemical**	☐**Contact with Hot Surface**
☐**Environmental Exposure**	☐**Ergonomic**	☐**Needle Stick**
☐**Pushing/Pulling**	☐**Slip/Trip/Fall**	
☐**Struck By**	☐**Twist/Turn**	☐**Other**_______________________________

[18] Serious injuries include those that result in permanent impairment or disfigurement, or require hospitalization. Examples include amputations, lacerations with severe bleeding, burns, concussions, fractures and crush injuries.

WHEN & WHERE did the incident take place?

DATE: ______________________ LAB COURSE & SECTION: _______________

TIME: ______________________ BUILDING: ______________________ BUILDING ROOM NUMBER _______

WAS ANYONE INJURED? [Check Here ___ if none]
How? Be specific (*e.g., "right hand burned on hot glass")*

____

____

____

WAS FIRST AID ADMINISTERED? [Check here ___ if none]
Be specific: What aid? Administered by whom? Aid refused?

____

____

____

MEDICAL EVALUATION/TREATMENT:

Suggested? ☐**Yes** ☐**No** By __________________________ **Sought?** ☐**Yes** ☐**No**

Refused? By ____________________________ (Print Name) ________________________ (Sign)

Transportation offered? ☐**Yes** ☐**No** **Transportation provided?** ☐**Yes** ☐**No**

Student escorted to STUDENT HEALTH CENTER? ☐**Yes** ☐**No** By __________________________

CHEMICALS INVOLVED Specify Hazards, as appropriate (Toxic? Corrosive? Flammable? Reactive?)**:**

Substance	**Concentration**	**Approx. Volume**	**Released outside lab?**		**Hazard**
______________________	_____________	__________	☐Yes	☐No	_________________
______________________	_____________	__________	☐Yes	☐No	_________________
______________________	_____________	__________	☐Yes	☐No	_________________

DESCRIBE INCIDENT AS IT HAPPENED: ____

____

____

____

____

____

DESCRIBE INCIDENT RESPONSE: (Spill cleanup? / Evacuation? / Assistance Requested from EHS or Department of Public Safety?)

____

____

____

____

____

Recommendations

Corrective Actions/Preventive Actions	Person Responsible	Due Date
____________________	____________________	__________
____________________	____________________	__________
____________________	____________________	__________
____________________	____________________	__________

By my signature, I acknowledge that this report is substantially correct:

Student/Employee: ______________________________ **Professor/Supervisor:** ______________________________

APPENDIX L: LIST OF REACTIVE CHEMICALS

http://www.himnrbehs.com/himnrbehs/pdf/Unstable.Materials.List.pdf provided by CleanHarbors

APPENDIX M: CHEMICAL HYGIENE PLAN REVIEW LOG

Date	Revision	Brief Description of Any Changes	Signature
October 27, 2015	-	-	Chintan Amin
November 17, 2015	1	Addition of Appendix L	Chintan Amin
November 2017	2	• Replaced CHO with EHS; Added Minors in labs policy • Addition of Chapters 8 (Lab Safety Assessments) and 9 (Hazardous Waste)	Chintan Amin