

LABORATORY SAFETY MANUAL

University of California, Davis



v1.3
Sept 2017

UNIVERSITY OF CALIFORNIA, DAVIS

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SANTA BARBARA • SANTA CRUZ

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Chancellor

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August 23, 2017

TO: All UC Davis Students, Employees, and Faculty

A culture of safety in our work environments is embraced and expected at UC Davis. The most valuable UC Davis resource are its people, whose wellbeing and productivity is supported by a safe working environment. In 2008, UC Davis formalized its Principles of Safety, which are shown on the following page. Additional information on Occupational and Research Safety programs and expectations at UC Davis can be found at <http://safetyservices.ucdavis.edu>. We would like to take this opportunity to reaffirm our strong commitment to safety at UC Davis.

While safety is a responsibility of everyone, it is particularly important for managers, supervisors, and faculty to recognize their responsibility to assure that the employees and students they supervise have received the appropriate safety training and have access to the safety equipment necessary to perform their jobs.

The desired culture necessitates that safety consciousness become integrated into all aspects of our lives, not just for time spent in the laboratory and completing research. Accidents cost time, money, and productivity, but most of all, accidents may cost lives. We encourage you to report any new hazards or unsafe conditions you observe on campus or at your work or research locations to <http://safetyservices.ucdavis.edu/form/report-incident-or-concern>. Our safety culture is a reflection of our actions, attitudes, and behaviors. We hope that you will share our desire to provide a safe place in which to work every day. In order for our safety programs to be successful please join us and help each other in practicing safe work habits.

Sincerely,

Handwritten signature of Gary S. May in black ink.

Gary S. May
Chancellor

Handwritten signature of Ralph J. Hexter in black ink.

Ralph J. Hexter
Provost and Executive Vice Chancellor

Think Safe. Act Safe. Be Safe.

PRINCIPLES of SAFETY

The University of California, Davis is committed to the safety and well being of its community. Our ultimate goal is to provide a safe environment for our students, faculty, staff and visitors by implementing policies and procedures that protect people, facilities and resources.

OUR VISION

A Culture of Safety

We envision an incident-free campus where students and employees alike are educated and equipped to work safely. With support from campus safety professionals, they are empowered to take responsibility for safety at work, at home and in their communities.

OUR MISSION

Think Safe. Act Safe. Be Safe.

AS A CAMPUS: We actively support programs at all levels of the organization that promote health, security and the protection of resources.

AS INDIVIDUALS: We learn and follow safe practices. We take the initiative to identify unsafe or unhealthy conditions and to resolve them with a sense of urgency.

VALUES FOR A SAFETY CULTURE



Community Spirit

We recognize our professional and personal obligation to our community. By engaging in safe behaviors we show our respect for the well-being of those in our community.



Collaboration

We value collaboration in cultivating a sustainable culture of safety on our campus. We are open and responsive to individual concerns and ideas for improvement.



Adherence to Law and Policy

We follow all applicable laws and University policies regarding safe working conditions and procedures that protect people, facilities and the campus and its surroundings.



Investment

We allocate appropriate resources to safety programs.



Continuous Improvement


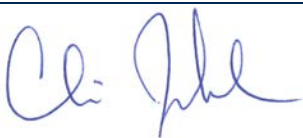
We recognize that safety and health can always be further enhanced, and we believe in continuous improvement in advancing a safety culture.



Accountability

We hold ourselves accountable for reporting our performance and progress.

Revision History

Laboratory Safety Manual		
Version: 1.3	Approved by: Chemical and Laboratory Safety Committee	
Next Review: 07/2018	Committee Chair: Chris Calvert, Ph.D.	Signature:  Date: 09/09/2014
	Author: Chris Jakober, Ph.D.	Signature:  Date: 09/09/2014
This document replaces UC Davis Laboratory Safety Manual v1.2.		

Version	Date Approved	Author	Revision Notes:
1.0	09/09/2014	Chris Jakober	New campus laboratory safety manual; replaces the Chemical & Laboratory Safety Manual, Revised 11/01/2001.
1.1	09/18/2015	Chris Jakober	Updates to v1.0 are summarized in Appendix G .
1.2	10/06/2016	Chris Jakober & Lindy Gervin	Updates to v1.1 are summarized in Appendix G
1.3	09/20/2017	Chris Jakober & Pauline Serrano	Updates to v1.2 are summarized in Appendix G

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LIST OF ACRONYMS

Acronym	Definition
ACGIH	American Conference of Governmental Industrial Hygienists
ACS	American Chemical Society
AL	Action Level
APLU	Association of Public & Land-Grant Institutions
BSC	Biological Safety Cabinet
BUA	Biological Use Authorization
Cal/EPA	California Environmental Protection Agency
Cal/OSHA	California Occupational Safety & Health Administration
CCR	California Code of Regulations
CFR	Code of Federal Regulations
CHO	Chemical Hygiene Officer
CHP	Chemical Hygiene Plan
CIS	Chemical Inventory System
CLSC	Chemical and Laboratory Safety Committee
CUPA	Certified Unified Program Agencies
DOT	Department of Transportation
DSC	Department Safety Coordinator
DTSC	Department of Toxic Substances Control
EFR	Employer's First Report
EH&S	Environmental Health and Safety
EPA	Environmental Protection Agency
FM	Facilities Management
EPCRA	Emergency Planning and Community Right-to-Know Act
FR	Flame-resistant
GHS	Globally Harmonized System
IACUC	Institutional Animal Care and Use Committee
IARC	International Agency for Research on Cancer
IATA	International Air Transportation Association
IBC	Institutional Biosafety Committee
IDLH	Immediately Dangerous to Life or Health
IIPP	Injury and Illness Prevention Program
IUPAC	International Union of Pure and Applied Chemistry
JSA	Job Safety Analysis
LHAT	Laboratory Hazard Assessment Tool
LMS	Learning Management System
LOTO	Lockout-Tagout
LSP	Laboratory Safety Plan
NIOSH	National Institute of Occupational Safety & Health

NFPA	National Fire Protection Association
NTP	National Toxicology Program
OSHA	Occupational Safety & Health Administration
PEL	Permissible Exposure Limit
PFC	Peroxide-Forming Chemical
PHS	Particularly Hazardous Substance
PI	Principal Investigator
PPE	Personal Protective Equipment
PO&M	Plant Operation and Maintenance
PPM	Policy and Procedure Manual
RCRA	Resource Conservation and Recovery Act
QAC	Qualified Applicator Certificate
QAL	Qualified Applicator License
REL	Recommended Exposure Limit
RSC	Radiation Safety Committee
SAA	Satellite Accumulation Area
SDS	Safety Data Sheet
SIT	Safety Inspection Tool
SOP	Standard Operating Procedure
STEL	Short-term Exposure Limit
STOT	Specific Target Organ Toxicity
TLV	Threshold Limit Value
TWA	Time-Weighted Average
UC	University of California
UCDHS	UC Davis Health System
UCDMC	UC Davis Medical Center
WHO	World Health Organization

UC DAVIS LABORATORY SAFETY MANUAL

A. Introduction

Safety is an integral part of laboratory research and an essential component of workplace practice. Safety is also critical to achieving the University's goals of teaching, research, and public service, as well as preventing workplace injuries and illnesses, environmental incidents, and property losses or damage. Health and safety policies and procedures within the UC Davis Policy and Procedure Manual (PPM) relating to laboratory safety include:

Safety Management Program	<i>PPM 290-15</i>
Hazardous Chemical Communication Program	<i>PPM 290-27</i>
Care and Use of Animals in Research and Teaching	<i>PPM 290-30</i>
Minors in University Facilities	<i>PPM 290-32</i>
Protective Clothing and Equipment	<i>PPM 290-50</i>
Biological Safety	<i>PPM 290-55</i>
Chemical Safety	<i>PPM 290-56</i>
Shop Safety Program	<i>PPM 290-58</i>
Hazardous Chemical Use, Storage, Transportation, and Disposal	<i>PPM 290-65</i>
Controlled Substances	<i>PPM 290-70</i>
Radiological Safety - Health Physics	<i>PPM 290-75</i>
Lockout Tagout	<i>PPM 290-84</i>
Pesticide Applications	<i>PPM 290-95</i>
Procurement and Use of Tax-Free Alcohol	<i>PPM 350-20</i>
Campus Emergency Policy	<i>PPM 390-10</i>
Fire Safety	<i>PPM 390-40</i>

It is also essential to comply with all applicable health and safety, and environmental protection laws, regulations, and requirements, including California Code of Regulations (CCR), Title 8, Section 5191 ([8 CCR §5191](#)), also known as the "Laboratory Standard".

The risks associated with laboratory research are greatly reduced or eliminated when proper precautions and practices are followed in the laboratory. To better manage hazards and mitigate their associated risks, UC Davis has developed this Laboratory Safety Manual. The manual is intended to be the cornerstone of your safety program and is designed to aid faculty, staff, and students



in maintaining a safe environment to teach and conduct research. Given the complexity of laboratory safety, a glossary of relevant terminology has been provided in [Appendix A](#).

Each laboratory using hazardous materials is required to have a copy of this manual or all components of this manual readily available to all laboratory personnel (hardcopy and/or electronic is acceptable). Each laboratory worker must be familiar with the contents of the manual and the procedures for obtaining additional safety information needed to perform their duties safely.

B. How to Use This Laboratory Safety Manual

1. Department Chairs or Unit Heads

1. Make sure your department's Injury and Illness Prevention Program (IIPP) is complete, current, and readily available. A [template](#) is available from EH&S. Ensure all departmental employees have been trained on an annual basis on your [IIPP](#).
2. Review the entire Chemical Hygiene Plan, especially [your responsibilities](#) on pages 13-14.

2. Principal Investigators/Laboratory Supervisors

1. Familiarize yourself with your department's IIPP. Ensure that the department IIPP is available to all laboratory personnel.
2. Review the entire Chemical Hygiene Plan, especially [your responsibilities](#) on pages 14-16.
3. Prepare a [LSP](#) that details the structure of the safety program for your laboratory if you choose to formally delegate any of your identified responsibilities to a qualified individual for completion, or if your laboratory has any of the criteria that require development of a LSP.
4. Complete and maintain your laboratory-specific SOPs. Ensure they are readily available and laboratory personnel have been trained. SOPs must be reviewed and updated as described on [Pg. 38](#).
5. Make sure all laboratory-specific training and all other required safety training documentation (*e.g.* [Safety Orientation and Training Checklist for New Laboratory Personnel](#) or equivalent) is complete, current, and readily available. Maintain related documentation and ensure it is readily available.
6. Conduct at least annual [inspections](#) of your laboratory or other work environments and maintain all associated records, and ensure they are readily available.
7. Conduct laboratory [hazard and PPE assessments](#) as described and make sure all related documentation is maintained and readily available. Review any new information with your staff.

3. Personnel

1. Review your department's Injury and Illness Prevention Program. Familiarize yourself with your department contacts, how to report a hazard in your work environment, and how to report injuries.
2. Review the entire Chemical Hygiene Plan:
 - a. Specifically [your responsibilities](#) listed on pages 17-18.
 - b. [Chapter II](#) to refresh your knowledge on how to identify hazardous chemicals which are described in greater detail in [Chapter III](#).
 - c. [Chapter IV](#) to understand how to reduce your potential for exposure to hazardous chemicals (engineering controls, administrative controls and PPE).

3. Review [Chapter XI](#) with your PI/Laboratory Supervisor to ensure you know what to do to prepare for and respond to an emergency.
4. Review laboratory hazard and PPE assessments with your PI/Laboratory Supervisor, ensure you know how to properly use, maintain, and acquire additional or replacement PPE, and document your PPE training.
5. Review the laboratory-specific SOPs with your PI/Laboratory Supervisor and document your training. **All training, whether formal or on-the-job, must be documented.**
6. Ask for clarification if there are any questions related to your laboratory work before you begin a new task, and seek prior approval for applicable work activities.

C. Laboratory Safety Manual Sections

This Laboratory Safety Manual is comprised of the following sections ¹.

1. Injury and Illness Prevention Program
2. Chemical Safety
3. Biosafety
4. Radiation Safety
5. Animal Care and Use
6. Safety Training and Recordkeeping
7. Inspections, Safety Reviews, and Recordkeeping
8. Hazard Assessments

This manual includes information on safe laboratory practices, the use of engineering controls, selection and proper use of personal protective equipment, emergency procedures, use and storage of chemicals, and the proper methods of waste disposal. This information is intended to be a resource and to help laboratory personnel manage hazards and mitigate associated risks.

In view of the wide variety of chemical products handled and equipment used in laboratories, it should not be assumed that the precautions and requirements stated in this manual are all-inclusive. Faculty, staff, and students are expected to learn about the hazards of chemical products and laboratory equipment before handling or using them. Principal Investigators (PIs) and Laboratory Supervisors must provide laboratory-specific supplemental information to augment the manual (*e.g.* written standard operating procedures (SOPs), laboratory equipment manuals, safety data sheets, training records, etc.).



¹ Each laboratory must provide supplemental laboratory-specific documents, as needed and required. Maintenance of this information may be hardcopy and/or electronic at the discretion of each laboratory provided that all components are readily available.

Laboratory operations that use lasers, radioactive materials, radiation producing machines, or include biological hazards, or shop activities must follow additional guidelines outlined in the associated hazard-specific UC Davis Safety Manuals and Programs (e.g. [Radiation Safety Manual](#), [Laser Safety Manual](#), [Biosafety Program](#), [Shop Safety Manual](#), etc.). Content covered by other UC Davis Safety Manuals is not included in this manual except as necessary.

1. Departmental Injury and Illness Prevention Program

The development and implementation of the Department's Injury and Illness Prevention Program (IIPP) is a key step in strengthening the safety culture in the research laboratories. Every California employer is required by CCR, Title 8, Section 3203 to have an effective written IIPP ([8 CCR §3203](#)). An effective Injury and Illness Prevention Program must be in writing and include the following elements:

1. Management commitment/assignment of responsibilities
2. Safety communications system with employees
3. System for assuring employee compliance with safe work practices
4. Scheduled inspections/evaluation system
5. Accident Investigation
6. Procedures for correcting unsafe/unhealthy conditions
7. Safety and health training and instruction
8. Recordkeeping and documentation

An IIPP provides a framework for departments to provide their employees with equipment and information necessary to work safely within their specific work environments. A well-integrated IIPP provides the information required to monitor activities and resources to reduce the risk of workplace injury and illness to maintain a safe work environment.

Each UC Davis department is required to establish and implement an IIPP. To assist in this process, an [IIPP template](#) has been prepared by the Office of Environmental Health & Safety (EH&S) in accordance with University Policy ([PPM 290-15](#)) and [CCR, Title 8, Section 3203](#).

To complete this template, enter the requested information in each text box. Upon completion, print the document, obtain the necessary signatures, and review with departmental employees on an annual basis. Note that the Job Safety Analysis (JSA) examples provided in the template are for reference only. JSA's are specific to individual employees and their job requirements. Please contact EH&S (530) 752-1493 or your Department Safety Coordinator (DSC) if you need additional assistance.

2. Chemical Safety

The UC Davis Chemical Hygiene Plan ([CHP](#)) establishes a formal written program for laboratory personnel – including, but not limited to, faculty, staff, students and visiting scholars – for use to protect against adverse health effects and safety hazards associated with the use, storage, and disposal of chemicals. The campus CHP must be made available to all laboratory personnel working with hazardous chemicals as required in [CCR, Title 8, § 5191](#) “The Lab Standard”. Personnel within a laboratory, or those whose work activities are research-related and involve the use of hazardous chemicals, are subject to the requirements of the campus CHP. The

campus CHP is now a component of this laboratory safety manual, providing general guidelines for managing laboratory *hazardous chemicals*. Any changes to the campus CHP are reviewed and approved by the Chemical and Laboratory Safety Committee (CLSC). **Most laboratories are not required to develop or reproduce this information in a site-specific Laboratory Safety Plan (LSP).** More information on the LSP is available in the *CHP I.D.5*. However, individual laboratories will need to augment this document with their specific *SOPs* and training records to satisfy the campus CHP components necessary for their specific work environment, activities, and hazards.

Note in instances where a laboratory maintains accreditation through other state or federal agencies, the requirements of those accreditations augment the campus CHP for that work environment. Additional *guidance for clinical medical diagnostic laboratories* is provided by the Centers for Disease Control and Prevention based on recommendation of the Biosafety Blue Ribbon Panel.

3. Biosafety

The *Biological Safety (Biosafety) Office* oversees the safe use of infectious biological agents, recombinant or synthetic nucleic acids (rDNA), and the propagation and release of recombinant organisms including plants, animals, and microbial agents as part of research at UC Davis, as required by *PPM 290-55*. No work with infectious biological agents or rDNA is permitted on the UC Davis campus prior to approval of a *Biological Use Authorization (BUA)*. The BUA approval process by the Institutional Biosafety Committee (*IBC*) is based on guidelines from the Centers for Disease Control and Prevention and the National Institutes of Health. Contact EH&S for additional information on the Biosafety program by *email* or at (530) 752-1493.

4. Radiation Safety

The *Radiation Safety Program* oversees the safe use of radioactive materials, x-ray producing machines, and high intensity light sources that include lasers. Three areas of radiological safety covered by this program include:

- A. *Radioactive Materials*
- B. *X-ray Producing Machines*
- C. *High Intensity Light Sources/Lasers*

NO WORK with these materials and equipment can be performed on campus prior to approval of a Radiation Use Authorization, as required by *PPM 290-75*. Contact EH&S *by e-mail* or at (530) 752-1493 for more information regarding these programs, manuals, and the application/approval process.

5. Animal Care and Use

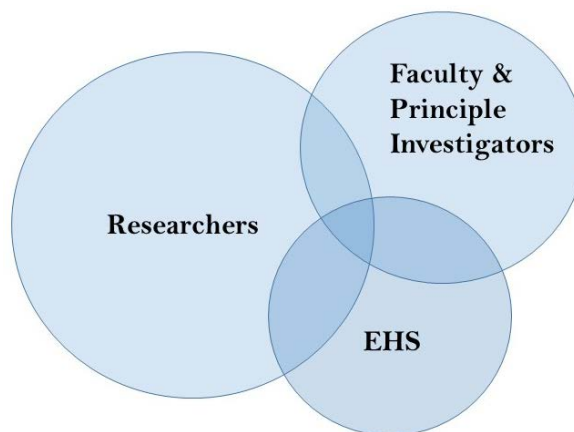
Use of animals in research and teaching activities at UC Davis is governed by the Institutional Animal Care and Use Committee (*IACUC*). This committee is tasked with assuring complete and adequate review of animal facilities, laboratory/study areas, procedures, and animal care and use protocols, consistent with the requirements of *PPM 290-30*. Contact the IACUC office by *e-mail* or at (530) 752-2364 for additional guidance.

6. Shop Safety

Use of hazardous materials and equipment in shop environments is governed by the UC Davis Shop Safety Committee. This committee is tasked with establishing campus policies and procedures for the acquisition and safe use of equipment in shop settings, including engineering and administrative control measures and required personal protective equipment to minimize occupational injuries or illnesses, consistent with the requirements of *PPM 290-58*. Contact shopsafety@ucdavis.edu or (530) 752-1493 for additional guidance.

7. Safety Training & Recordkeeping

Effective training is a critical component of a safe work environment. All employees must be trained in general safe work practices and be given specific instructions on hazards unique to their job assignment and laboratory. Achieving safety training requirements is a cooperative effort between Departments, PIs, Laboratory Supervisors, Laboratory Safety Officers, Laboratory Personnel, and EH&S. It is *strongly recommended* that PIs assign a designated safety person for their lab, and support and empower this person/role. The designated safety person should coordinate initial and refresher training and be a point of contact for inspections. The UC Davis Chemical and Laboratory Safety Committee (CLSC) approved a *Safety Training Matrix for Laboratory Personnel* for PIs and Laboratory Supervisors to use in determining the required safety training courses for their research activities. Furthermore, CLSC approved a *Safety Orientation & Training Checklist for New Laboratory Personnel* to document that all personnel have been trained on topics that include the location and use of fire alarms, eye washes and safety showers, emergency action plans, engineering controls, CHP, SOPs, and more.



An effective health and safety training program must include appropriate oversight, proper recordkeeping, instruction on the proper use of equipment and personal protective equipment (*PPE*) and safe work practices. Accurate recordkeeping of training activities demonstrates a commitment to the safety and health of the UC Davis community, integrity of research, and protection of the environment. EH&S is responsible for maintaining completion records of training conducted by EH&S staff members in the Learning Management System (*LMS*). Departments or laboratories are required to document and maintain records of all health and safety training, including safety meetings, one-on-one training, classroom training, and online training. Safety training records, including records of EH&S conducted training, should be kept: A) with the Laboratory Safety Manual, B) with departmental training records, or C) be readily available via the LMS.

8. Inspections, Safety Reviews, and Recordkeeping

EH&S conducts a comprehensive *Laboratory Safety Review* program for all UC Davis laboratories. These Laboratory Safety Reviews are performed on an annual basis by EH&S Laboratory Safety Professionals to assist PIs/Laboratory Supervisors in maintaining a safe laboratory environment

and to aid in compliance with Federal, State, County regulations and University policies. Most of the applicable standards are contained in CCR, Title 8, Sections 3380-3385 and 5191, Title 19, State Fire Marshal, and in Title 40 of Code of Federal Regulations, Environmental Protection Agency. The EH&S Laboratory Safety Professionals conduct safety reviews, issue reports, assist investigators with regulatory compliance, conduct follow-up reviews to ensure timely corrective actions, and provide training and advice on laboratory safety.

PIs/Laboratory Supervisors are required to inspect their own laboratory on a routine basis, at least annually. A [self-inspection checklist](#) has been prepared for guidance, which addresses items covered by the Laboratory Safety Review program. Regular inspections performed by internal personnel have been shown to substantially improve safety conditions and will help to ensure fewer findings when safety reviews or inspections are performed by EH&S personnel or regulatory inspectors. All internal inspection reports must be maintained for a period of five years by the PI or Laboratory Supervisor, while records of the Laboratory Safety Review will be maintained by EH&S.

9. Hazard Assessments

Workplace hazard and PPE assessments are required, see [8 CCR §3380](#) “Personal Protective Equipment”, for all locations where: A) there is use or storage of hazardous materials, or B) where equipment may present a physical hazard. Detailed UC Davis policy requirements and guidance are provided in *Protective Clothing and Equipment* ([PPM 290-50](#)). Related requirements include:

- Written hazard assessments
- Identification of required PPE
- Training and refresher training
- Posting of area hazards and required PPE

The Laboratory Hazard Assessment Tool ([LHAT](#)) categorizes chemical and other types of hazards and specifies the appropriate PPE for each hazard. Note that the LHAT does not identify all the hazards present in a particular work environment. PIs/Laboratory Supervisors must evaluate whether there are additional hazards in their laboratories not addressed by the LHAT. Once the appropriate PPE is identified for the active worker and individuals in the adjacent area, the PI/Laboratory Supervisor must provide the required PPE to all personnel and conduct and document training on the proper use of the PPE. PIs and Laboratory Supervisors are required to provide information to EH&S concerning: the laboratory location; laboratory personnel roster, identity of the Laboratory or Facility Supervisor; the Laboratory Safety Coordinator, if applicable; and certify the assessment and training was successfully completed. [LHAT instructions and forms](#) are provided on the UC Davis Safety Services website. The LHAT must be updated whenever hazards in the laboratory or facility change or new hazards are identified, and certified at least annually. The PI/Laboratory Supervisor is responsible to keep the laboratory location and personnel roster within LHAT updated at all times. The laboratory or facility’s most recent hazard assessments must be maintained by the PI/Laboratory Supervisor and be readily available.

D. Questions

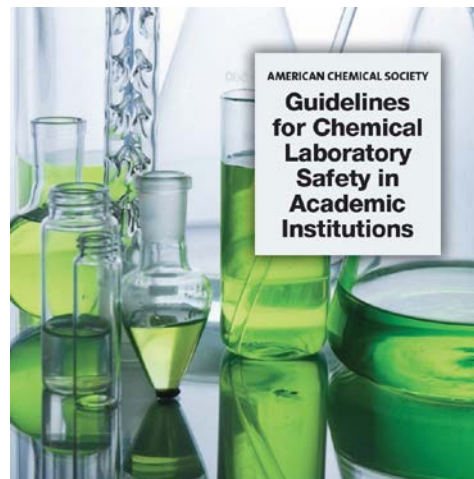
For further information on this Laboratory Safety Manual or on any health and safety related topics, please contact [EH&S](#) at (530) 752-1493 or researchsafety@ucdavis.edu.

CHEMICAL HYGIENE PLAN

I. Introduction

A. Purpose

UC Davis is committed to providing a healthy and safe working environment for the campus community, in accordance with UC Davis *Safety Management Program* ([PPM 290-15](#)), *Care and Use of Animals in Research and Teaching* ([PPM 290-30](#)), *Minors in University Facilities* ([PPM 290-32](#)), *Protective Clothing and Equipment* ([PPM 290-50](#)), *Biological Safety* ([PPM 290-55](#)), *Chemical Safety* ([PPM 290-56](#)), *Shop Safety Program* ([PPM 290-58](#)), *Hazardous Chemical Use, Storage, Transportation, and Disposal* ([PPM 290-65](#)), *Controlled Substances* ([PPM 290-70](#)), *Radiological Safety - Health Physics* ([PPM 290-75](#)), *Lockout Tagout* ([PPM 290-84](#)), *Pesticide Applications* ([PPM 290-95](#)), *Procurement and Use of Tax-Free Alcohol* ([PPM 350-20](#)), *Campus Emergency Policy* ([PPM 390-10](#)), and *Fire Safety* ([PPM 390-40](#)).



This campus Chemical Hygiene Plan establishes a formal written program for managing the risks posed by health and safety hazards associated with the use of hazardous chemicals in laboratories and research. The CHP describes the proper use, handling, storage and disposal practices and procedures to be followed by faculty, staff, students, visiting scholars, and all other personnel working with hazardous chemicals at UC Davis. This plan is based on best practices identified in, among others sources, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, published by the National Research Council, and the American Chemical Society's (ACS) *Guidelines for Chemical Laboratory Safety in Academic Institutions*, *Safety in Academic Chemistry Laboratories*, and *Creating Safety Cultures in Academic Institutions*, which are highly recommended reading for all laboratory personnel and are available to all from the provided hyperlinks.

The Association of Public & Land-Grant Institutions ([APLU](#)) has recently released a guiding document to serve as a roadmap for higher-education institutions to enable and foster a culture of safety for academic research activities. The [entire report is available electronically](#), and is a great resource for all administrators and researchers. In addition to the report, the APLU has issued:

1. A [set of core institutional values](#).
2. A [set of actions by role that support a culture of laboratory safety](#).
3. [Twenty recommendations to implement and sustain a culture of laboratory safety](#).

All UC Davis research personnel are encouraged to review and implement these actions wherever possible. If assistance is needed, please contact chem-safety@ucdavis.edu for support and guidance on implementing these recommendations.

B. Scope

The CHP applies to personnel within a laboratory where hazardous chemicals are used or stored, or those whose work activities are research-related and involve hazardous chemicals. Use or storage of the hazardous chemicals must be consistent with “laboratory use” to be covered by [8 CCR §5191](#) and the CHP. “Laboratory use,” means that:

1. Chemical manipulations are carried out on a “[laboratory scale](#)”.
2. Multiple chemicals or chemical procedures are used.
3. Activities are not part of or simulating a production process.
4. Protective laboratory practices and equipment are available and in common use.

At a minimum, this definition includes employees who use chemicals in teaching and research laboratories at the UC Davis Campus and the Medical Center. Also, it is UC Davis policy that students in laboratories, while not legally covered by this standard, are afforded the same level of protection as UC Davis employees.

The CHP does not apply to research involving exclusively radiological or biological materials, as these safety procedures and regulatory requirements are outlined in the [Radiation Safety Manual](#) and [Biosafety Program](#) respectively. Research involving more than one type of hazard must comply with all applicable regulatory requirements and follow guidance outlined in the relevant safety manuals, authorizations, or programs.

UC Davis has also established a Hazard Communication Program ([PPM 290-27](#)) that complies with CCR, Title 8, Section 5194 ([8 CCR §5194](#)), which is directly applicable to personnel who may handle hazardous chemicals in most non-laboratory workplaces. Consult EH&S with questions regarding the applicability of the [Hazard Communication Program](#). Per the HazCom Program workplace signage must be displayed in all areas where hazardous chemicals are used, handled or stored. Information that would be helpful in case of an emergency (to be included on the signage):

- PI Name
- Designated Safety Person
- Room Number
- Contact information
- Hazards associated with lab

Signage should be updated as needed.

The information presented in the CHP represents best practices and provides a broad overview of the information necessary for the safe operation of laboratories that utilize hazardous chemicals. **It is not intended to be all inclusive.** Laboratories, technical areas, or other work units engaged in activities with hazardous chemicals possessing unusual characteristics, or are

otherwise not sufficiently covered in the written CHP and supporting materials, must augment the CHP with a laboratory-specific Laboratory Safety Plan ([LSP](#)) addressing the hazards and how to mitigate their associated risks, as appropriate. Contact EH&S at chem-safety@ucdavis.edu for assistance with determining the need for a LSP and assistance with development of these materials.

C. Regulatory Requirements

The necessary work practices, procedures, and policies outlined in this CHP are required by the following State of California regulations:

- [8 CCR §3203](#), “*Injury and Illness Prevention Program*”
- [8 CCR §3380](#), “*Personal Protective Devices*”
- [8 CCR §5143](#), “*General Requirements of Mechanical Ventilation Systems*”
- [8 CCR §5154.1](#), “*Ventilation Requirements for Laboratory-Type Hood Operations*”
- [8 CCR §5164](#), “*Storage of Hazardous Substances*”
- [8 CCR §5191](#), “*Occupational Exposures to Hazardous Chemicals in Laboratories*”
- [8 CCR §5194](#), “*Hazard Communication*”
- [8 CCR Article 110](#), “*Regulated Carcinogens*”

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”). These regulations require that the CHP be readily available wherever potentially hazardous chemicals are used, handled or stored. Also applicable is the [General Duty Clause](#) of the Occupational Safety and Health Act which states:

“Each employer:

- 1. Shall furnish to each of his employees employment and a place which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employee.*
- 2. Shall comply with occupational safety and health standards promulgated under this Act.*

Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.”

EH&S will review and evaluate the effectiveness of the CHP at least annually and update it as necessary. Any updates to the CHP will be reviewed and approved by the [Chemical and Laboratory Safety Committee](#).

D. Rights and Responsibilities

Employees and other personnel who work in University facilities 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 these substances. This includes custodial staff and other personnel who work to clean and maintain laboratories. Employees have the right to file a complaint with California Occupational Safety and Health Administration (Cal/OSHA) if they feel they are being exposed

to unsafe or unhealthy work conditions, and they cannot be discharged, suspended, or otherwise disciplined by their employer for filing a complaint or exercising these rights. *All personnel working with hazardous chemicals are encouraged to report (anonymously, if preferred) any concerns about unsafe work conditions to EH&S at (530) 752-1493 or by using the [online Hazard Report](#) on the Safety Services website.*

Responsibility for the health and safety of the campus community extends to the highest administrative levels of UC Davis. The Chancellor and Vice Chancellors are responsible for the implementation of UC Davis's Environmental Health and Safety policies at all facilities and properties under campus control. College Deans, Department Chairs, and Unit Heads are responsible for establishing and maintaining programs in their areas and for providing a safe and healthy work environment.

While the Chancellor, Vice Chancellors, Deans, Department Chairs, and Unit Heads are responsible for the broad implementation and enforcement of UC Davis's EH&S policies, the day-to-day responsibility for the management of laboratory safety and adherence to safe laboratory practices rests with the PI/Laboratory Supervisor within individual workplace units and associated departments. All personnel have a duty to fulfill their obligations to maintain a safe work environment and minimize the risks associated with their workplace hazards.

All employees and other personnel working with hazardous chemicals have the responsibility to conscientiously participate in training classes on general laboratory safety and read 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 (including available engineering controls), and proper PPE required for the safe completion of their work activities. Failure to comply with these requirements will result in progressive disciplinary action in accordance with University policy, and may result in temporary suspension of work activities until corrective action is implemented.

Specific duties and responsibilities of personnel who work in areas where potentially hazardous chemicals are present have been compiled in the document entitled General Rules for Laboratory Work with Chemicals and Equipment, found in [Appendix B](#).

1. Responsibilities of the Chancellor and Provost

The Chancellor and Provost of the University have the ultimate responsibility for the overall campus Environmental Health and Safety Program at UC Davis. Campus policies relating to laboratory and chemical safety have been described in the UC Davis Policy and Procedure Manual (PPM [290-15](#), [290-30](#), [290-32](#), [290-50](#), [290-55](#), [290-56](#), [290-58](#), [290-65](#), [290-70](#), [290-75](#), [290-84](#), [290-95](#), [350-20](#), [390-10](#), and [390-40](#)) and this UC Davis Laboratory Safety Manual. The Chancellor and Provost are responsible for the development and interpretation of these policies.

The Chancellor and Provost have delegated their responsibility for laboratory and chemical safety to the Office of Environmental Health and Safety, the campus Chemical and Laboratory Safety Committee, and specific individuals described below.

2. Responsibilities of School/College Deans and Vice Chancellors

Deans and Vice Chancellors are responsible for supporting Departments under their jurisdiction and ensuring compliance with all safety related policies, including, but not limited to, [PPM 290-15](#). Such support demonstrates willingness of the School/College or Administrative Unit's to provide the necessary resources to promote a healthy and safe work environment as well as aid the enforcement of UC Davis policies and procedures.

3. Responsibilities of Chemical and Laboratory Safety Committee

The [CLSC](#) is responsible for developing, facilitating, and implementing campus policies and procedures for the safe acquisition, storage, use, and disposal of hazardous chemicals and engineered nanomaterials in laboratories and research activities, as well as establishing laboratory processes that enhance safety. CLSC policies and procedures do not include radiological materials, biological materials, lasers, or animal care and use, all of which are covered under the auspices of their appropriate committee.

The CLSC is responsible for the following chemical and laboratory safety program areas:

1. Developing ways to share safety policies with the campus community.
2. Reviewing the chemical and laboratory safety classes and developing a long-term training plan.
3. Developing, facilitating, and implementing the campus-wide Chemical Hygiene Plan and associated SOPs.
4. Developing, facilitating, and implementing the Laboratory Safety Review Program, Laboratory Hazard Assessment Tool, and Personal Protective Equipment (PPE) policy.
5. Promoting the development of environmentally sustainable laboratories.
6. Reviewing the Facilities Planning and Laboratory Design Guide as it relates to Environmental Health and Safety.
7. Reviewing the Hazardous Waste Management Program.
8. Reviewing any special Program Areas (e.g. carcinogens, nanotechnology, chemical recycling, and physical hazards) associated with teaching and research.
9. Formulating strategy and policy to reduce risks from processes that are identified as posing a significant risk to the campus community.
10. The CLSC shall have the ability to enforce policy [PPM 290-56](#). Policy enforcement may include any of the following:
 - a. Supporting and participating in the progressive resolution procedure for [Laboratory Safety Review](#) Program when items of non-compliance are left unresolved.
 - b. Suspending any laboratory activities that pose an unacceptable level of risk to laboratory personnel health and safety or University property.

4. Responsibilities of Department Chairs or Unit Heads

The Department Chairperson or Unit Head assumes the ultimate responsibility for personnel engaged in the laboratory or research use of hazardous chemicals within their Department or Unit. While the Chairperson or Unit Head has the ability to delegate some of these responsibilities, he or she must ensure that they are carried out to completion. The Department Chairperson or Unit Head is responsible for:

1. Establishing and maintaining Department/Unit programs that provide a safe and healthy work environment.
2. Providing resources necessary to mitigate risk from potential hazards, assuring appropriate training, and assisting in enforcement of campus policies and procedures.
3. Providing the Chemical Hygiene Officer with the support necessary to implement and maintain the CHP.
4. Assigning and supervising a Department/Unit Safety Coordinator (DSC) to perform the roles and responsibilities detailed in [SafetyNet #125 - Safety Management Guidelines for Department Safety Coordinators](#).
5. May serve as the Chairperson of a Department/Unit Safety Committee (if one exists and so desired).
6. Ensuring that:
 - a. The Department/Unit IIPP is reviewed, and updated if needed, on an annual basis.
 - b. All new employees receive initial documented IIPP training.
 - c. All employees receive documented annual refresher IIPP training.
7. Ensuring that all chemical inventories for the Department/Unit are entered and maintained in the Chemical Inventory System.
8. Reviewing the results of inspections, safety reviews and audits for Department/Unit areas.
9. Ensuring corrective actions are completed to address any identified deficiencies, and working to maintain compliance with all applicable Department/Unit, university, local, state and federal codes and regulations.
10. Reviewing injury and illness reports that originated within the Department/Unit no less frequently than quarterly.
11. Paying fines resulting from citations as a result of action or failure of department to comply with health/safety or environmental laws and regulations.

5. Responsibilities of Principal Investigators & Laboratory Supervisors

The PI/Laboratory Supervisor has responsibility for the health and safety of all personnel in his or her workplace who handle hazardous chemicals. The PI/Laboratory Supervisor may delegate safety duties, but remain responsible for ensuring that delegated safety duties are successfully completed. The PI/Laboratory Supervisor is responsible for:

1. Discussing the safety expectations for new employees and students on their first day.
2. Identifying hazards in the laboratory or other facility, determining safe procedures and controls, and implementing and enforcing standard safety procedures. Maintaining current information on laboratory activities, laboratory personnel and laboratory locations within [LHAT](#).
3. Training all laboratory or other personnel he/she supervises to work safely with hazardous materials, which includes:
 - a. Providing and documenting a safety orientation for the workplace and training on common processes on the first day an individual is granted access to or assigned work activities within the PI/Laboratory Supervisor's laboratory. The CLSC has developed a [Safety Orientation & Training Checklist for New Laboratory](#)

- Personnel* to document this expectation; existing equivalent checklists are also acceptable.
- b. Ensuring all personnel successfully complete the *UC Laboratory Safety Fundamentals* training prior to receiving unescorted access to the laboratory.
 - c. Conducting laboratory-specific or other specialized training where applicable. Laboratory safety training must include information of the location and availability of hazard information.
 - d. Training records must be maintained; electronic records are encouraged.
4. Requiring laboratory personnel have access to and comply with the CHP, applicable Safety Manual(s), and any Laboratory Safety Plan(s), and ensuring they do not operate equipment or handle hazardous chemicals without proper training.
 5. Ensuring the availability of all appropriate PPE (*e.g.* laboratory coats, gloves, safety eyewear, etc.) and that the PPE is maintained in working order.
 6. Knowing all applicable health and safety rules and regulations, training and reporting requirements, and SOPs associated with chemical safety for regulated substances. EH&S is currently reviewing and revising *SafetyNet #131 - Safety Program Guidelines for Principal Investigators* for guidance on the requirements and consistency with recent program and policy changes.
 7. Establishing SOPs (general and protocol specific) and performing literature searches relevant to health and safety for laboratory-specific work. Providing prior-approval for the use of restricted hazardous chemicals once personnel are appropriately trained.
 8. Consulting with the campus Chemical Hygiene Officer (CHO) and/or the CLSC on use of higher risk materials, such as the use of particularly hazardous substances, or conducting higher risk experimental procedures so that special safety precautions may be taken.
 9. Consulting with *Fire Prevention Services* regarding instructions or suggestions for precautionary risk mitigation measures concerning projects having inherent fire or explosion potential.
 10. Monitoring the safety performance of personnel. Actions to correct deficient work practices must be taken if they may lead to illness or injury, these actions shall be documented.
 11. Requiring visitors follow laboratory rules, and assuming responsibility for laboratory visitors.
 12. Maintaining an updated chemical inventory for the laboratory or facility.
 13. Promptly disposing of unwanted or excess hazardous chemicals and materials following UC Davis, state, and federal waste disposal requirements.
 14. Complying with all state and federal regulations for shipment of any hazardous materials. Consult with EH&S for further information on the requirements.
 15. Restricting laboratory activities of undergraduates with respect to hazardous materials, equipment, or activities which may pose risks of injury or death. Written approval may be granted following completion and review of a risk assessment in conjunction with the individual.
 16. Requiring the proper operation of appropriate workplace engineering controls (*e.g.* fume hoods) and safety equipment (*e.g.* emergency showers/eyewashes, fire extinguishers, etc.), and promptly notifying EH&S and/or Facilities Management should they become non-operational.
 17. Conducting periodic *self-inspections* of laboratory or facility, at least annually, and maintaining records of inspections.

18. Ensuring the availability of appropriate resources and procedures for responding to an accident, including the cleanup of small chemical spills.
19. Immediately reporting *serious injuries* to EH&S to comply with the Cal/OSHA 8-hour reporting time frame. Any doubt as to whether an injury is serious should favor reporting.
20. Immediately reporting any fires or fire extinguisher discharge to the Fire Department, even if the fire is extinguished.
21. Reporting all *accidents* and injuries requiring medical care to EH&S within 24 hours, and completing the *Employer's First Report* if the injured person is a paid employee.
22. Investigating all *accidents*, *incidents*, and *near-misses* to determine the cause and implement corrective action for prevention of future occurrences. Near-misses should be discussed collectively within the laboratory/research group. Contact EH&S for assistance with investigation and development of corrective actions.
23. Informing facilities personnel, other non-laboratory personnel, and any outside contractors of potential workplace-related hazards when they are required to work in the environment. Identifies and manages potential hazards to provide a safe environment for repairs and renovations.
24. Paying fines resulting from citations as a result of action or failure to comply with health/safety or environmental laws and regulations.
25. In the event that the PI/Laboratory Supervisor will be on extended leave (*i.e.* more than 14 days) provisions must be made to designate a responsible person for the workplace. In addition, the PI/Laboratory Supervisor may want to place limitations on the type or scope of work that is performed during the absence and review emergency procedures with all personnel. Exceptions can be made where the PI/Laboratory Supervisor is easily contacted by telephone or e-mail, and maintains weekly interactions with the laboratory personnel.

Laboratory Safety Plan: Most PIs/Laboratory Supervisors have the option to create a site-specific LSP to augment the campus *CHP*. However, a LSP is required for any of the following situations:

- A. The PI/Laboratory Supervisor chooses to formally delegate any of their identified responsibilities to a qualified individual. Note that the responsibility can be delegated but the ultimate liability cannot.
- B. The laboratory in question has:
 - i. Atypical engineering controls not described in the CHP (e.g. down draft tables, floor-mounted fume hoods, specialized ventilation control).
 - ii. Atypical laboratory equipment (e.g. industrial/shop equipment, high voltage equipment.). Modifications to the *LSP template* to include required elements of the Shop Safety Plan have been completed such that a single plan can be managed to meet obligations under both programs if desired.
 - iii. Unique PPE expectations/policies (e.g. clean room).
 - iv. A formally approved exception to the bare minimum attire required to enter a laboratory under the *UCOP PPE policy*.

The LSP can be customized to the exact workplace hazards present in the laboratory or facility and outline the safety program structure and expectations for the laboratory. A LSP will include information detailing the methods for completion of the identified CHP responsibilities and procedures to mitigate the risks associated with the laboratory hazards. While there are only

certain specified situations where a LSP is required, safety awareness and management in all laboratory environments will benefit from a LSP. These documents should be reviewed by qualified individuals, including any of the following: A) Laboratory Manager; B) Department Safety Coordinator; C) School/College Safety Officer; D) PI/Laboratory Supervisor; or E) campus Chemical Hygiene Officer. Materials in the LSP must receive approval from the PI/Laboratory Supervisor prior to implementation. The campus Chemical Hygiene Officer is available for assistance in the development of site-specific LSPs, and a [LSP document template](#) approved by the CLSC is available. Contact EH&S at researchsafety@ucdavis.edu for further assistance.

6. Responsibilities of All Personnel Who Handle Potentially Hazardous Chemicals

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

1. Reviewing, understanding, and following requirements of the: CHP; all applicable Safety Manual(s), Programs, and Policies; and any applicable individual Laboratory Safety Plans.
2. Following all required verbal and written workplace safety rules, regulations, and SOPs.
3. Developing good personal chemical hygiene habits, including but not limited to, keeping work areas safe and uncluttered, cleaning up following work activities, and practicing good housekeeping in the workplace.
4. Planning, reviewing, and understanding the hazards of materials and processes in their laboratory research or other work procedures prior to conducting work.
5. Utilizing appropriate measures to control identified hazards, including consistent and proper use of engineering controls, administrative controls, and PPE.
6. Understanding the capabilities and limitations of PPE issued to them, and properly maintaining this PPE.
7. Being prepared for laboratory accidents and knowing emergency response procedures.
8. Gaining prior approval from the PI/Laboratory Supervisor for the use of restricted chemicals and other materials or equipment.
9. Gaining prior approval from the PI/Laboratory Supervisor for the purchase of any new chemicals for the laboratory or research activities.
10. Consulting with PI/Laboratory Supervisor before using higher risk chemicals (*e.g.* particularly hazardous substances, explosives and other highly reactive chemicals), or conducting certain higher risk experimental procedures. Notifying other laboratory members of the hazards posed by the chemicals/activities prior to beginning work.
11. Immediately reporting all [accidents](#), [incidents](#) (including *near-misses*), injuries, and unsafe laboratory conditions/activities to the PI/Laboratory Supervisor.
12. Immediately reporting any fires or fire extinguisher discharge, even if the fire is extinguished, to the Fire Department and the PI/Laboratory Supervisor.
13. Immediately reporting any new or previously unrecognized workplace hazards within their department to their PI/Laboratory Supervisor or EH&S (via [Employee Hazard Report](#)).
14. Completing all required health, safety, and environmental training and providing documentation to their supervisor.
15. Participating in Medical Surveillance, when required.

16. Informing the PI/Laboratory Supervisor of any work modifications ordered by a physician as a result of medical surveillance, occupational injury, or exposure.
17. Discussing with the PI/Laboratory Supervisor, and receiving prior approval for, any activities and procedures that are to be conducted while alone in the laboratory.
18. When performing independent research or work:
 - a. Reviewing the written plan or scope of work for their proposed research with the PI/Laboratory Supervisor.
 - b. Notifying in writing and consulting with the PI/Laboratory Supervisor in advance if they intend to deviate from previously reviewed procedures (Note: changes may include, but are not limited to, change in the objectives, change in PI, change in the duration, quantity, frequency, temperature 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 appropriate for their work.
 - d. Providing appropriate oversight, training, and safety information to laboratory or other personnel they supervise or direct.
19. On termination or transfer of laboratory personnel, all their related hazardous materials (including chemicals and samples) shall be properly disposed, or transferred to the PI/Laboratory Supervisor or a designee, with the chemical inventory updated appropriately.

7. Responsibilities of Fire Prevention Services and campus Fire Marshal

UC Davis *Fire Prevention Services*, which includes the campus Fire Marshal, is responsible for plan review, construction inspections, fire clearance, fire prevention inspection, testing and consultative services to ensure that all facilities, programs, fire protection systems, and events are managed in compliance with applicable fire and life safety statutes, rules, and regulations, and that potential fire and life safety liabilities are brought to the attention of those who are responsible (department heads, PIs, safety coordinators, facility managers, etc.) for abatement actions. Fire Prevention Services also completes activities related to fire investigations including, but not limited to, determining origin and cause of the fire or explosion, malicious transmission of a fire alarm, tampering with or damage to fire protection equipment, damage or attempted damage of property by fire, suspicion that arson or attempted arson has been committed, and injury or death as a result of a fire. The campus Fire Marshal, with support from Fire Prevention Services staff, is specifically responsible for:

1. Ensuring that the campus complies with California statutes, and fire and life safety rules and regulations of the California State Fire Marshal as adopted or referenced in Title 19 and Title 24 (Parts 2, 3, 4, 5, and 9) of the California Code of Regulations.
2. Controlling access to, or initiating either complete or partial evacuation from a building or complex in any unsafe, dangerous, or hazardous circumstance not involving an emergency response.
3. Inspecting assigned UC Davis facilities, processes, and fire protection systems to ensure conformance with State statutes, rules, regulations, and UC fire safety policy.
4. Providing training, upon request, in fire prevention and use of fire extinguishers.

8. Responsibilities of EH&S and campus Chemical Hygiene Officer

UC Davis EH&S, which includes the campus Chemical Hygiene Officer (CHO), is responsible for administering and overseeing institutional implementation of the *Chemical and Laboratory Safety Program* including the campus CHP. EH&S provides technical guidance to personnel at all levels of responsibility on matters pertaining to the use of hazardous materials. If situations are immediately dangerous to life or health (IDLH), EH&S Safety Professionals, including the campus CHO, have the authority to order the cessation of the activity until the hazardous condition is abated and risk sufficiently mitigated. The campus CHO, with support from other EH&S personnel, is specifically responsible for:

1. Informing PIs/Laboratory Supervisors of all health and safety requirements, and assisting with the selection of appropriate safety controls, including engineering controls, laboratory and other workplace standard practices, training, PPE, etc. to minimize the risks posed by laboratory hazards.
2. Assisting the PI/Laboratory Supervisors in the development of their SOPs and LSPs.
3. Assisting the PI/Laboratory Supervisors in their laboratory hazard assessments, upon request.
4. Providing consultation to the EH&S Laboratory Safety Professionals on the results of their safety reviews and appropriate actions to abate hazards that may pose a risk to life or safety.
5. Providing technical consultation to the Chemical and Laboratory Safety Committee in the development and implementation of appropriate chemical hygiene policies and practices and development of SOPs.
6. 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.
7. Providing technical guidance and investigation, as appropriate, for laboratory and other types of accidents, incidents, and injuries.
8. Promoting safety training offered by UC Davis (*i.e.* fire extinguisher training, equipment training, general workplace training, etc.) where appropriate.
9. Assisting Occupational Health Physicians in determining the appropriate medical surveillance requirements for personnel, if any.
10. Reviewing and evaluating the effectiveness of the campus CHP at least annually and updating it as appropriate. Continually seek ways to improve the CHP.
11. Supporting other units within EH&S by providing technical consultation and assistance with *environmental compliance*, *transport and disposal of hazardous waste*, and the campus *chemical inventory system*. Note: hazardous materials spill/release response is provided by the *UC Davis Fire Department*.

II. Chemical Hazard Identification

A. Introduction

UC Davis is responsible for providing information about the hazardous substances and activities in our workplaces including laboratories, the associated risks, and the measures to mitigate those risks. Proper hazard communication involves the active participation of the PI/Laboratory Supervisor, the campus Chemical Hygiene Officer, the EH&S Hazardous Communication Program Professional, the School/College Laboratory Safety Professionals, and the Department Safety Coordinators, who are each responsible for providing consultation and safety information to employees working with hazardous chemicals.

B. List of Hazardous Substances

All laboratories, technical areas, or shops are required to maintain an accurate chemical inventory using the UC Davis online Chemical Inventory System ([CIS](#)). For each hazardous substance on their inventory, specific information on any associated health or safety hazards must be made readily available to all personnel. Compressed gases must also be included in the inventory list. Additional information related to storage and management of laboratory chemicals is provided in [SafetyNet #42 – General Guidelines for Storage and Management of Laboratory Chemicals](#).

C. Hazard Determination

PIs/Laboratory Supervisors are responsible for verifying if any items on their chemical inventory are subject to the requirements of the hazard communication regulation. Note that [hazardous chemical](#) is formally defined in [8 CCR §5191](#) and [8 CCR §5194](#).

The term “hazardous substance” refers to any chemical which may present an asphyxiation hazard, environmental hazard, health hazard, physical hazard, or hazard not yet classified. Hazardous substances include, but are not limited to, those chemicals listed in the following:

1. “The Hazardous Substance List”, commonly known as the Directors List of Hazardous Substances, [8 CCR §339](#)
2. “Toxic and Hazardous Substances, Air Contaminants”, [8 CCR, §5155](#)
3. “Threshold Limit Values for Chemical Substances in the Work Environment”, ACGIH, updated annually
4. “[14th Report on Carcinogens](#)”, NTP, 2016
5. “[Monographs](#)”, IARC, WHO
6. Safety Data Sheets ([SDSs](#)) for reproductive toxins and cancer causing substances

Inventory items found on the above lists are subject to the requirements outlined below in Sections 1-4.

1. Safety Data Sheets

A [SDS](#) must be available for each hazardous substance in a laboratory's or facilities chemical inventory. SDSs are available from the UC [SDS website](#). PIs/Laboratory Supervisors are responsible for keeping SDSs current and making them available to all employees throughout the work day. SDSs must be in a central location that can be accessed immediately in the event of an emergency. Electronic copies may be used, but must be accessible to all laboratory personnel.

A [SDS Quick Card](#) and more detailed information is available from [OSHA](#).

2. Labels and Other Forms of Warning

Labeling requirements for all hazardous substances are summarized as follows:

- All manufacturer containers of hazardous materials must be labeled with the identity of the hazardous substance.
- The label must contain all applicable hazard warning statements.
- The name and address of the chemical manufacturer or other responsible party must be present.
- Manufacturer's product labels must remain on all containers, and must not be defaced in any manner. Appropriate hazard warning statements must be present. If not, that information must be added.
- Labels must be legible, in English, and prominently displayed.
- Symbols or other languages are required for non-English speaking employees.
- Secondary containers (*i.e.* containers used for storing commercial chemicals that are not the original manufacturer packaging, such as spray bottles) must be labeled with the identity of the substance and appropriate hazard warnings.
- Laboratory-prepared solutions of hazardous chemicals and analytical samples containing hazardous chemicals should be labeled with the identity of the chemical(s), an appropriate hazard warning(s), and the identity of the responsible party whenever possible and practical.
- New synthesized compounds must be labeled with the appropriate hazard warnings based on the knowledge of the chemical and physical properties of that substance. If a lab-specific system of identifying synthesized compounds is developed, the system must be documented in the lab's LSP or a SOP.
- If a system of abbreviations is used within the laboratory for labeling, the abbreviations and their meanings must be posted in a conspicuous place and available to all personnel, including emergency response personnel.

Additional information on container labeling, laboratory personnel responsibilities, and potential labeling resources is provided in [Appendix C](#).

3. Employee Information and Training

Employee training on specific workplace hazards must be provided at the time of initial assignment, whenever a new hazard is introduced into the workplace, and whenever employees

may be exposed to hazards in other work areas. All training must be in the appropriate language, educational level, and vocabulary for laboratory personnel. Employees must be given the opportunity to ask questions. The training requirements and resources for laboratory and research personnel are summarized in [Training](#).

4. Laboratory Hazard Assessment Tool

The online [University of California LHAT](#) was developed to broadly identify activities involving chemical and other types of laboratory hazards, and it functions as a component of hazard communication. The LHAT captures information on hazard categories, the location of the hazard(s), the name of the PI/Laboratory Supervisor, the laboratory personnel roster, and helps to identify the minimum proper PPE that should be used by the active researcher and individuals in adjacent areas. Once the required PPE is identified, the laboratory is required to conduct and document training for laboratory personnel on the use and maintenance of PPE. It must be updated whenever hazards in the laboratory or facility change or new hazards are identified, and certified at least annually. The LHAT will not identify all the hazards within a laboratory, and serves as one tool to aid PIs/Laboratory Supervisors to assess hazards within the workplace. The American Chemical Society has prepared guidance on hazard assessment in [“Identifying and Evaluating Hazards in Research Laboratories,”](#) which should be consulted when completing workplace hazard assessments. The ACS and their Committee on Chemical Safety has further developed [tools supporting their hazard recognition and risk assessment technique methodologies](#) described on their website:

Laboratory Hazard Assessment Tool					
Activity performed		Chemical Hazards			
Yes	No	Activity in lab	Potential Hazard	Active Researcher PPE (Direct Manipulation)	Adjacent Individuals PPE
<input type="checkbox"/>	<input type="checkbox"/>	C01. Working with small volumes of concave (e.g. acids, caustics, etc.) liquid or solids.	Eye or skin damage. Low probability for a splash hazard.	✓ Safety glasses ✓ Chemical-resistant gloves ✓ Lab coat	In adjacent area within meters ✓ Safety glasses ✓ Lab coat
<input type="checkbox"/>	<input type="checkbox"/>	C02. Working with concave or concave liquid, solids or other materials which creates a splash hazard.	Increasing increased potential for eye and skin damage.	✓ Safety goggles ✓ Chemical-resistant gloves ✓ Lab coat and ✓ Chemical-resistant apron	In adjacent area within meters ✓ Safety glasses ✓ Lab coat
<input type="checkbox"/>	<input type="checkbox"/>	C03. Working with small volumes of flammable solvents/materials when no reasonable ignition sources are present.	Skin or eye damage, potential poisoning through skin contact.	✓ Safety glasses ✓ Chemical-resistant gloves ✓ Lab coat	In adjacent area within meters ✓ Safety glasses ✓ Lab coat
<input type="checkbox"/>	<input type="checkbox"/>	C04. Working with flammable materials (including solvents), when using a large quantity, or any quantity where there is a risk of ignition, or areas where flammable vapors or gases may be present.	Minor fire. Major skin or eye damage, potential poisoning through skin contact.	✓ Safety glasses ✓ Flame-resistant (FR) outer gloves ✓ Chemical-resistant inner gloves ✓ NFPA 2112 rated Flame-resistant (FR) lab coat	All personnel in laboratory room ✓ Safety glasses ✓ NFPA 2112 rated Flame-resistant (FR) lab coat
<input type="checkbox"/>	<input type="checkbox"/>	C05. Working with toxic or hazardous chemicals (solid, liquid, or gas) producing fumes related to: GHS H301, H332, H311, H312, H331, H332.	Skin or eye damage, potential poisoning through skin contact.	✓ Safety glasses ✓ Chemical-resistant gloves ✓ Lab coat	In adjacent area within meters ✓ Safety glasses ✓ Lab coat
<input type="checkbox"/>	<input type="checkbox"/>	C06. Working with Acutely Toxic Chemicals (GHS H300, H310, H330).	Spills, splashes, ingestion, emulsion, absorption. Chemicals pose a high level of immediate health risk.	✓ Safety glasses ✓ Chemical-resistant gloves ✓ Lab coat (plus chemical protective apron for H330)	All personnel in laboratory room ✓ Safety glasses ✓ Lab coat
<input type="checkbox"/>	<input type="checkbox"/>	C07. Working with an apparatus with contents under pressure or vacuum.	Eye or skin damage.	✓ Safety glasses ✓ Face shield (for high risk activities) ✓ Chemical-resistant gloves ✓ Lab coat ✓ Chemical-resistant apron (for high risk activities)	In adjacent area within meters ✓ Safety glasses ✓ Lab coat

It should be understood that laboratory hazard assessments involve all potential hazards associated with laboratory work including physical, radiological, laser, biological, as well as chemical hazards. Non-chemical hazards should not be overlooked.

5. Novel Chemicals

Unique chemical hazard identification situations exist when novel materials are prepared in research. For new materials synthesized in the laboratory, the following campus requirements will be implemented:

1. When the chemical composition is known and the material is produced only for use in the laboratory of origin the PI/Laboratory Supervisor will provide and document training on the hazards as described in this CHP.
2. If the chemical composition is not known with 100% certainty the PI/Laboratory Supervisor will assume the substance is hazardous and implement applicable elements of the CHP.
3. New chemical substances synthesized or produced in a laboratory, and used or shared outside of the laboratory of origin may require the preparation of a SDS. Contact the campus CHO at (530) 752-1493 or chem-safety@ucdavis.edu for more information on necessity for preparing new SDSs.

III. Classes of Hazardous Chemicals

Chemicals pose health and safety hazards to personnel due to inherent chemical, physical, and toxicological properties. Chemicals can be grouped into several different hazard classes. The hazard class will determine how similar materials should be stored and handled and what special equipment and procedures are needed to use them safely. Each chemical container, whether supplied by a vendor or produced in the laboratory, must include labels that clearly identify the hazards associated with that chemical. More detailed hazard information for specific chemicals can be found by referencing the SDS for that chemical.

The *Globally Harmonized System* (GHS) is an international standardized system for identifying and classifying chemical hazards. Information on identified hazards is conveyed on container labels and SDSs. GHS provides consistency in the structure and content of a SDS and applicable hazard warning information on chemical labels. The hazard pictograms are summarized in *Appendix D* for the GHS system. Written hazard ratings are structured as Hazard Codes (H-Code) and corresponding Hazard Statements. It's important to note that GHS uses an inverse scale with 0 representing the greatest hazard and subsequent higher numbers represent lower hazard. An example for oral toxicity would be the H-Code of H300 corresponds to "Fatal if swallowed", H301 corresponds to "Toxic if swallowed", and H302 corresponds to "Harmful if swallowed". Comprehensive information on GHS is provided in the *OSHA guide on GHS*, and helpful reference graphics are available from Millipore-Sigma that outline the *H-Codes* and also the Precautionary Statements (*P-Codes*).

An older hazard posting and labeling methodology is described by the National Fire Prevention Association (NFPA), *Standard 704*, for building and/or door placarding that provides an overview of the key chemical hazards contained within that building or room. NFPA postings have the familiar four color 1-4 number rating, which quickly supplies the hazard information broken down into four hazard classes. The four chemical hazard types correspond to the four color areas: red indicates a flammability hazard, yellow indicates a reactive hazard, blue indicates a health hazard and the white area is reserved for special hazards that are identified by hazard symbols or labels to indicate hazards such as radioactivity, biohazard, water reactive chemicals, etc. Each of these hazards has a different set of safety precautions associated with them. Figure III-I illustrates the NFPA rating system. It's important to note that under the NFPA system lower numbers (*e.g.* 1) represents a lower level of hazard than a higher number (*e.g.* 4). In comparing NFPA to GHS for the earlier example of oral toxicity, under the NFPA diamond an acutely toxic chemical via ingestion would be given a Health Hazard rating of "4" but under GHS it would be assigned the H300 code (Fatal if swallowed).

It is essential that all personnel be trained to understand and identify the types of chemical hazards and the associated risks, recognize the potential routes of exposure, and are familiar with the major hazard classes of chemicals. In many cases, the specific hazards associated with new compounds and mixtures will not be known, so it is recommended that all chemical compounds be treated as if they were potentially harmful and to use available engineering controls and PPE.

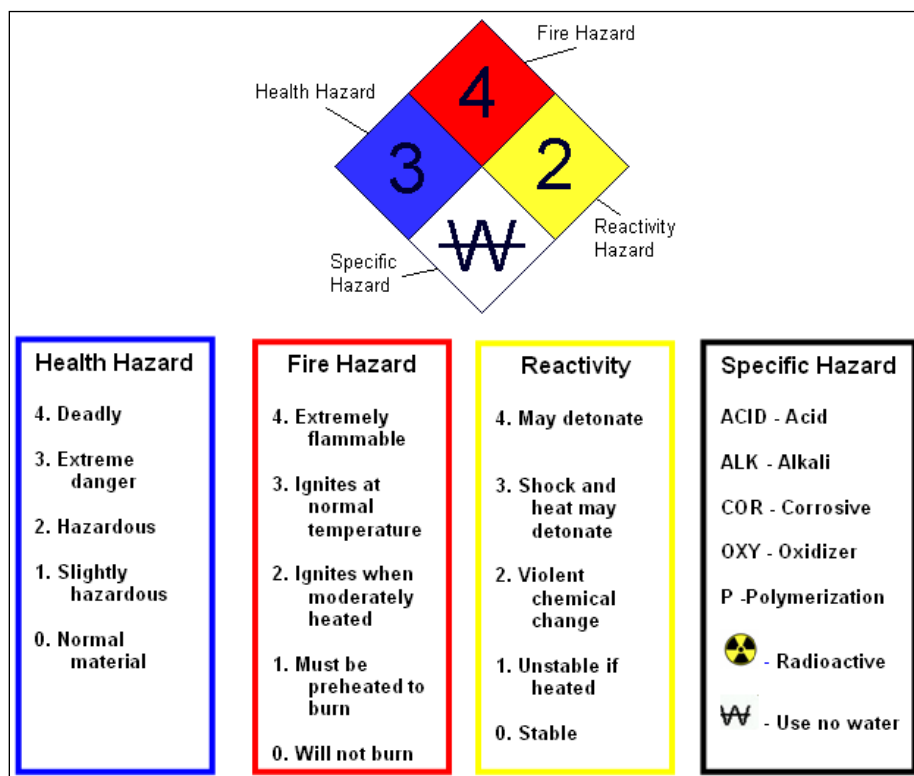


Figure III-I. NFPA Posting

1. Flammability and Combustibility Hazards

A number of highly flammable substances are in frequent use in campus laboratories. Flammable liquids include those chemicals that have a *flashpoint* of less than 100 degrees Fahrenheit (°F), and combustible liquids have a flashpoint between 100–200 °F. These materials must be stored in flammable storage cabinets if aggregate quantities of 10 gallons/room or more are stored in the lab. Guidance on proper flammable liquid storage is provided in a *SafetyNet* from UC Davis Fire Prevention. Flame-resistant laboratory coats must be worn when working with large volumes of flammable materials (>1L) and/or with procedures where a significant fire risk is present (*e.g.* when working with open flame, pyrophorics, etc.) as described in *Protective Clothing and Equipment (PPM 290-50)*. These materials pose a significant risk and should be treated with care, even though use of these materials is fairly common in the laboratory setting. Particular attention should be given to preventing static electricity and sparks when handling flammable liquids.



It is the vapors from flammable liquids that burn, rather than the liquids themselves. For a fire to occur, there must be: 1) vapor concentration between the lower and upper *flammability limits*; 2) source of oxygen (often air); and 3) an ignition source. Careful handling of chemicals and use of chemical fume hoods are typically sufficient to prevent high vapor concentrations. Do not use open flames where flammable vapors may be present. Ensure that containers are properly bonded and grounded before transferring flammable liquids between metal containers or equipment.

Pyrophoric chemicals are a special class of materials that spontaneously ignite when in contact with air and require laboratory-specific training. Flame-resistant (FR) laboratory coats and hand protection **must** be worn when handling pyrophoric chemicals. Individuals working with pyrophoric materials **must** know the appropriate method(s) to quench the chemicals being used. Additional information related to pyrophoric and water-reactive materials is provided in [SafetyNet #135 – Procedures for Safe Use of Pyrophoric/Water Reactive Reagents](#). Helpful safety videos on [reactive](#) and [pyrophoric](#) chemicals are available from the Dow Chemical Company, for [organolithium](#) chemicals from Yale University, and [handling pyrophorics](#) from Dartmouth College.

2. Reactivity and Stability Hazards

Reactive and unstable substances are materials which may violently decompose, rapidly condense, vigorously polymerize, or become self-reactive under conditions of shock, friction, temperature, pressure, light, or contact with other materials, with the release of large volumes of gas or heat. Some examples of such chemicals include explosives, peroxides, azo compounds, and azido compounds. These substances pose an immediate hazard and procedures for their use and storage must be carefully reviewed and followed. Such materials must also be stored in a manner to protect from light, heat, shock, friction, static discharge, contact with a catalyst, or other conditions to which they are sensitive. Some materials, such as peroxide formers, may not be explosive, but may form explosive substances over time or upon concentration.



3. Oxidizers

Oxidizers present a fire and explosion hazard when they come in contact with flammable, combustible materials, or other fuels. They can: 1) speed the development of a fire and increase intensity, 2) cause substances which are normally stable in air to rapidly burn, and 3) lead to spontaneous combustion of materials without an obvious ignition source. Oxidizers are classified on a [scale of 1-4 by the NFPA](#) based on their potential to initiate spontaneous combustion, with 1 being the lower hazard and 4 being a greater hazard. In addition to the flammability hazards posed by oxidizers, they can also be corrosive or toxic.



4. Health Hazards

Cal/OSHA uses the following definition for health hazard in [8 CCR §5191](#):

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



Criteria by which a specific chemical is classified as a [health hazard](#) can be found in [8 CCR §5194](#), including the definition of a “simple asphyxiant.” An overview of the major classes of “hazardous” and “particularly hazardous substances” and their related health and safety risks are detailed below.

a. Corrosive Substances

As a health hazard, corrosive substances cause destruction of, or alterations in, living tissue by chemical action at the site of contact.

Major classes of corrosive substances include:

- Strong acids – *e.g.* sulfuric, nitric, and hydrochloric acids.
- Strong bases – *e.g.* sodium hydroxide, potassium hydroxide and ammonium hydroxide.
- Dehydrating agents – *e.g.* sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide.
- Oxidizing agents – *e.g.* hydrogen peroxide, chlorine, bromine, perchloric acid, and nitric acid.



Symptoms of exposure for inhalation include a burning sensation, coughing, wheezing, laryngitis, shortness of breath, nausea, and vomiting. For eyes, symptoms include pain, blood shot eyes, tearing, and blurring of vision. For skin, symptoms may include reddening, pain, inflammation, bleeding, blistering and burns, as shown in a [video from UCSD](#). As a physical hazard, corrosive substances may corrode materials they come in contact with and may be highly reactive with other substances. It is important to review information: 1) regarding the materials they may corrode, 2) on their reactivity with other substances, and 3) on health effects. In most cases, these materials should be segregated from other chemicals and require secondary containment during storage.

b. Irritants

Irritants are 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. Consequently, eye and skin contact with all laboratory chemicals should **always** be avoided. Smoke is a common example of an irritant which can irritate the nasal passages and respiratory system. Symptoms of exposure can include reddening or discomfort of the skin and irritation to respiratory systems.



c. 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. Examples of sensitizers include diazomethane, chromium, nickel, formaldehyde, isocyanates, arylhydrazines, benzylic and allylic halides, many phenol derivatives, and latex proteins. Sensitizer exposure can lead to all of the symptoms associated with allergic reactions, or can exacerbate an individual's existing allergies.



d. Hazardous Substances with Specific Target Organ Toxicity (STOT)

Substances included in this category include:

- Hepatotoxins –substances that produce liver damage, such as nitrosamines and carbon tetrachloride.
- Nephrotoxins –agents causing damage to the kidneys, such as certain halogenated hydrocarbons.
- Neurotoxins – substances which produce their primary toxic effects on the nervous system, such as mercury, acrylamide and carbon disulfide.
- Agents which act on the hematopoietic system – *e.g.* carbon monoxide and cyanides which decrease hemoglobin function and deprive the body tissues of oxygen.
- Agents which damage lung tissue – *e.g.* asbestos and silica.

Personnel working with these materials need to review the SDS for the specific chemical being used, and take special note of the symptoms of exposure.

e. Particularly Hazardous Substances

OSHA recognizes that some classes of chemical substances pose a greater health and safety risk than others. To differentiate this risk characteristic, OSHA identifies two categories of hazardous chemicals:



1. *Hazardous chemicals*
2. **Particularly hazardous substances**

Substances that pose such significant threats to human health are classified as "particularly hazardous substances" (PHS). The Cal/OSHA "Laboratory Standard" (*8 CCR §5191*) requires that special provisions be documented in laboratory SOPs to prevent the exposure of laboratory personnel to PHSs, including:

- i. Establishment of designated areas
- ii. Use of containment devices (*e.g.* fume hoods, glove boxes)
- iii. Procedures for contaminated waste disposal
- iv. Decontamination procedures

Supplemental information on particularly hazardous substances is provided in [Appendix E](#).

Particularly hazardous substances are divided into three primary types.

1. Acute Toxins

Substances that have a high degree of acute toxicity are interpreted by OSHA as being substances that "may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration." These chemicals, their associated chemical waste, and storage containers must be handled with care to prevent cross contamination of work areas and unexpected contact. These chemicals must be labeled as "Toxic." Empty containers of these substances must be packaged and disposed of as hazardous

waste without rinsing trace amounts into the sanitary sewer system. Many of these compounds can also be classified as corrosives, irritants, sensitizers, [Select Agent Toxins](#), or Specific Target Organ Toxins.

2. Reproductive Toxins

Reproductive toxins include any chemical that may affect the reproductive capabilities, including causing chromosomal damage (mutagenesis), effects on fetuses (teratogenesis), and adverse effects on sexual function and fertility. Reproductive toxins can affect the reproductive health of both men and women if proper procedures and controls are not used. For women, exposure to reproductive toxins during pregnancy can cause adverse effects on the fetus; these effects include embryo lethality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. For men, exposure can lead to sterility.

Examples of embryo toxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryo toxins 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 personal physician, supervisor, and EH&S before working with substances that are suspected to be reproductive toxins. Additional information for laboratory personnel are available on the EH&S [Reproductive Health webpage](#) and in [SafetyNet #108 – Pregnancy and Reproductive Hazards in the Workplace: Chemical and Radiological Hazards](#).

3. Carcinogens

Carcinogens are chemical or physical agents capable of causing cancer or tumor development. Generally, they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects.

Current UC Davis requirements related to carcinogen use, originally described in the UC Davis Chemical Carcinogens Manual, are under revision. During this time and transitional period, if you have any questions regarding the campus requirements for carcinogen use contact [EH&S](#) for assistance. Laboratory use of carcinogens requires the preparation of a [carcinogen SOP](#). Additional chemical-specific guidance is available for formaldehyde and dichloromethane in [SafetyNet #139 – Guidelines for Handling Formaldehyde](#) and [SafetyNet #140 – Guidelines for Handling Dichloromethane \(Methylene Chloride\)](#) respectively.

f. Nanomaterials

The increasing use of nanomaterials in research laboratories warrants consideration of the hazards they may pose. As is the case with many new technologies, the health effects of

nanomaterials have not been thoroughly investigated. Consequently, the uncertainty surrounding the toxicity of nanomaterials merits a cautious approach when working with them.

Nanomaterials include any materials or particles that have an external dimension in the nanoscale ($\sim 1 - 100$ nanometers, 10^{-9} meter). Nanomaterials occur naturally in the environment, are products of incomplete combustion, and are produced via chemical synthesis. Synthesized nanomaterials are referred to as Engineered Nanomaterials (ENMs). Materials whose properties do not differ significantly between their nanoscale and larger forms are generally excluded from ENMs. Some examples of ENMs include fullerenes (carbon *buckyballs* C_{60}), carbon nanotubes, carbon nanofibers, quantum dots, and metal oxide nanoparticles.

Nanomaterials can be categorized by the risk of potential exposure they pose to personnel based on the physical state of the materials and the conditions in which they are used. In general, the risk of exposure is lowest when nanomaterials are bound in a solid matrix with little potential to create airborne dust or when in a non-volatile liquid suspension. The risk of exposure increases when nanomaterials are used as fine powders or are suspended in volatile solvents or gases. The parent compound of the nanomaterial should also be taken into consideration when evaluating the potential hazards associated with exposure (e.g. a highly toxic compound such as cadmium should be anticipated to be at least as toxic and possibly more toxic when used as a nanomaterial). Laboratory personnel using or preparing nanomaterials must utilize a combination of engineering controls, SOPs, and personal protective equipment to minimize potential exposure to their self and others.

The UC Davis Chemical and Laboratory Safety Committee has adopted the detailed guidance related to nanomaterials from the California Nanosafety Consortium of Higher Education's "*Nanotoolkit: Working Safely with Engineered Nanomaterials in Academic Research Settings*" and the National Institute of Occupational Safety & Health's (NIOSH) "*Safe Practices for Working with Engineered Nanomaterials in Research Laboratories*." A useful video on *nanoparticle safety* is available from the Dow Chemical Company. Given the uncertainty of the health and environmental hazards posed by nanomaterials, SOPs are required for the preparation, use, storage, and disposal of nanomaterials. All nanomaterials, including solutions containing nanomaterials, are to be disposed as hazardous waste. *SafetyNet #132 - Nanotechnology: Guidelines for Safe Research Practices* has been prepared to provide additional guidance on these materials, and a summary of available resources for nanotechnology laboratory safety is available from the *National Nanotechnology Initiative*. Contact researchsafety@ucdavis.edu for additional information if needed.

g. Compressed Gases & Cryogenic Liquids

Compressed gases and cryogenic liquids present pressure and asphyxiation hazards in the workplace. Both compressed gases and cryogenic liquids may also present additional health hazard and/or flammability concerns. Given these hazards, special handling and storage requirements must be followed to mitigate the associated risks. More detailed information on compressed gases can be found in *SafetyNet #60 - Compressed Gas Safety*, while additional information on cryogenic liquids is contained in *SafetyNet #58 - Safety Precautions for Cryogenic Liquids*.

h. Pesticides

Pesticides, as defined by the [*California Food and Agricultural Code §12753*](#), are chemicals used to control unwanted species including, but not limited to, insecticides, fungicides, herbicides, rodenticides, nematocides, plant growth regulators, fumigants, and desiccants. In many instances these chemicals present known or suspected human health hazards, and shall be managed accordingly. While pesticides may be involved in research activities, it is how these materials are being applied that determines regulatory obligations. If the chemical is being used as directed by the manufacturer its use must include one of the following:

1. Person applying the chemical (Applicator) is in possession of a Qualified Applicator Certificate (QAC) or Qualified Applicator License (QAL).
2. Applicator is under the direct supervision of an individual with a QAC or QAL.
3. Applicator with a QAC or QAL has been contracted to apply the chemical in question.

When the use of pesticide differs from the manufacturers' directions then this use of material would be considered research use. Some examples of research use of pesticides may include, but are not limited to, the following:

1. Applying different concentrations of the chemical for efficacy assessment.
2. Applying multiple chemicals at the same time to examine synergistic effects, toxicity effects, degradation timelines, etc.
3. Applying novel chemicals to examine pesticide efficacy.

Application of pesticides within enclosed spaces that are located within other enclosed spaces (e.g. growth chambers, growth rooms, etc.) may present challenges with respect to ventilation control and pesticide exposures. Please contact healthandsafety@ucdavis.edu prior to applying pesticides within such spaces to determine appropriate chemical exposure risk mitigation steps.

IV. How to Reduce Exposures to Hazardous Chemicals

A. Regulatory Requirements

The necessary work practices, procedures, and policies outlined in this chapter are required by the following:

- [8 CCR §3380](#), “Personal Protective Devices”
- [8 CCR §5141](#), “Control of Harmful Exposure to Employees”
- [8 CCR §5154.1](#), “Ventilation Requirements for Laboratory-Type Hood Operations”
- [8 CCR §5191](#), “Occupational Exposures to Hazardous Chemicals in Laboratories”
- [8 CCR Article 110](#), “Regulated Carcinogens”.

B. Introduction

Hazardous chemicals require a carefully considered, multi-tiered approach to effectively manage their associated risks. There are four primary routes of exposure for chemicals which have associated health hazards (illustrated in Figure IV-I):

1. Inhalation
2. Absorption (through the skin or eyes)
3. Ingestion
4. Injection (skin being punctured by a contaminated sharp object or uptake through an existing open wound)

Of these, the most likely route of exposure in the laboratory is via inhalation. Many hazardous chemicals may affect people through more than one of these exposure routes, so it is critical that protective measures are in place for each of these uptake mechanisms.

The methodology for controlling exposures to hazardous chemicals typically proceeds through the following hierarchy:

- Elimination
- Substitution
- Engineering Controls
- Administrative Controls
- Personal Protective Equipment

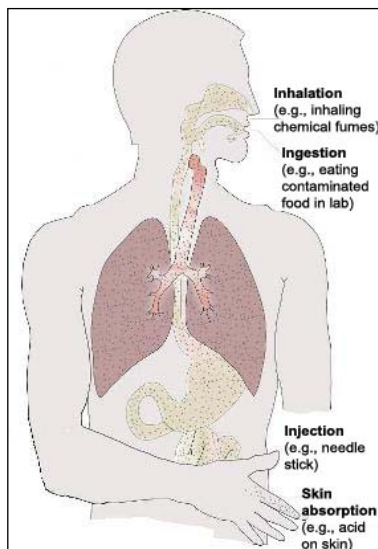


Figure IV-I. Routes of Exposure

The rationale behind this hierarchical approach is that the controls at the top, which should be considered first, are the most effective and offer a greater level of protection than those towards the bottom. Typically, Elimination or Substitution are most easily considered and implemented while processes are still under design and development. Existing processes often pose greater challenges for implementing Elimination or Substitution, and thus are typically addressed using the other Safety Controls available.

C. Safety Controls

Beyond Elimination and Substitution control approaches, Safety Controls are grouped into three main classifications:

1. Engineering Controls
2. Administrative Controls
3. Protective Apparel and Equipment

Elements of these three classes are typically applied in a layered approach to mitigate the risks associated with hazardous chemicals. The principles of each safety control group are described in the following materials.

1. Engineering Controls

The National Institute of Occupational Safety and Health ([NIOSH](#)) states that:

“Engineering Controls are used to remove a hazard or place a barrier between the worker and the hazard. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection.”

Following Elimination and Substitution these controls offer the first line of protection to prevent exposures to hazardous chemicals. Engineering controls can be very effective and are the preferred method for reducing exposures. Examples of engineering controls include, but are not limited to, general room ventilation, chemical fume hoods, glove boxes, “elephant trunks” (or “snorkels”), flammable material storage equipment, ventilated balance enclosures, and downdraft tables. Note that elements of “Isolation” and “Segregation” accompany use of various engineering controls.

a. General Laboratory Ventilation

Laboratory spaces shall have mechanically generated and conditioned supply and exhaust air. All laboratories shall exhaust 100% to the outside. Air intakes for laboratory ventilation systems shall supply outside fresh air. General laboratory room ventilation should meet a minimum of 6 air change per hour (0.1 cfm of mechanical exhaust per cubic foot of laboratory gross room volume) whenever the laboratory is occupied. Laboratories should be kept at negative pressure to adjoining low-hazard non-laboratory space to prevent the spread of hazardous chemicals. In cases where 100% exhaust and/or negative pressure are not desirable, a formal evaluation **must** be made by EH&S to determine what work can be done in the space and under what special

conditions or limitations. See the [UC Davis Campus Standards and Design Guide](#) for additional information on laboratory ventilation. Note that with isolated exceptions hazardous chemicals should not be used in enclosed spaces that have recirculated ventilation, please contact healthandsafety@ucdavis.edu if you have any questions about the suitability of the space in which you would like to use hazardous chemicals for a site- and chemical-specific evaluation.

b. Fume Hoods

Chemical fume hoods are an effective way to control exposure to hazardous chemicals. Fume hoods are the most commonly used local exhaust system on campus. Other methods include vented enclosures for large pieces of equipment or chemical storage, and portable exhaust systems for capturing contaminants near the point of release. Some systems are equipped with air cleaning devices (HEPA filters or carbon absorbers). The exhausts from fume hoods are designed to terminate at least ten feet above the roof deck or two feet above the top of any parapet wall, whichever is higher. Figure IV-II displays the key components of a fume hood. It is important to note that the correct type of fume hood to be used is dependent upon the materials involved in the activities. A helpful [fume hood overview video](#) is available from Dow Chemical; and guidance for proper use of a fume hood can be found in [SafetyNet #35 – How to Use a Chemical Fume Hood Safely](#) and augmented with the [UC Davis Fume Hood Training Course](#).

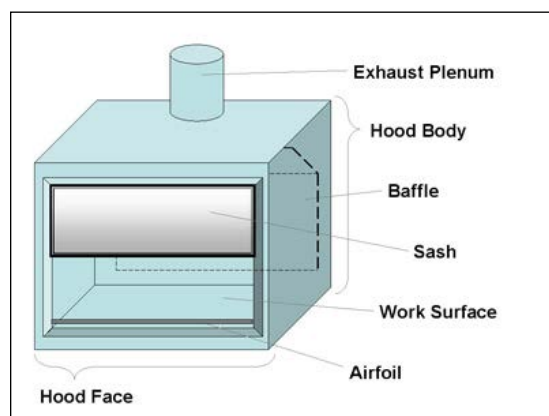


Figure IV-II. Fume Hood

Chemical fume hoods should be used for the safe handling of noxious, corrosive, or volatile chemicals whenever possible. In addition, a laboratory hood or other suitable containment device must be used for all work with [PHS](#). Note, that a fume hood should not be used as a substitute for a biosafety cabinet or a laminar flow hood. Fume hoods are evaluated and certified by Facilities Management (FM) at least once per year. Fume hoods used for the carcinogens listed in [8 CCR §5209](#) are evaluated semi-annually. These evaluations verify the proper fume hood air flow velocity to ensure that the unit will operate as designed. Data on fume hood monitoring is maintained by FM.

Each chemical fume hood should have a current calibration sticker and a marker indicating the highest sash height to be used when working with hazardous materials. Contact Facilities Management (530) 752-1655 for a hood evaluation if these labels are missing on the Davis campus, or Plant Operation & Maintenance (PO&M) at (916) 734-2763 on the Sacramento campus. Air flow for fume hood ventilation is measured at nine points. The average of the nine readings must be at least 100 feet per minute (fpm) with a minimum of 70 fpm for any measurement. The average face velocity should not exceed 120 fpm. All chemical fume hoods must have an audible and visual alarm to show proper operation. Contact Facilities Management (530) 752-1655 if the alarm is not working properly on the Davis campus, or PO&M (916) 734-2763 for any fume hood issues on the Sacramento campus.

Routine maintenance and repairs of fume hoods are conducted by FM. If any problem with chemical fume hoods occurs, discontinue use of the fume hood and **immediately** call Facilities Management at (530) 752-1655 to arrange for repairs. Make sure to indicate the urgency of the matter and indicate a health and safety deficiency.

The use of perchloric or hydrofluoric acids in chemical fume hoods necessitates additional considerations. Perchloric acid when heated above ambient temperature can form potentially explosive perchlorate salts in a fume hood and its associated duct system and hood fan. Perchloric acid can also form explosive mixtures with organic compounds. Hydrofluoric acid can dissolve glass, and is very corrosive to many metals. For these reasons, the use of perchloric and hydrofluoric acids in fume hoods must be carefully evaluated prior to use, contact EH&S at (530) 752-1493 or researchsafety@ucdavis.edu for more information. Additional information can be found in [SafetyNet #18 - Safe Use of Perchloric Acid](#) and [SafetyNet #70 - Safe Use of Hydrofluoric Acid](#).

General Rules for Fume Hood Use

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

1. Fume hoods should not be used for work involving hazardous substances unless they have a certification label that confirms certification has occurred within the past year, or six months if using one of the carcinogens listed in [8 CCR §5209](#).
2. Before beginning work in a fume hood check the fume hood flow indicator to verify proper air flow and make sure the audio alarm has not been disabled.
3. Always keep hazardous chemicals more than six inches behind the plane of the sash, see [Protective Air Barrier](#).
4. **Never** put your head inside an operating laboratory hood. The plane of the sash is the barrier between contaminated and uncontaminated air. Keep the sash clean so your vision is unobstructed.
5. Work with the hood sash in the **designated operating height range**. The maximum operating sash height for vertical sash hoods should be clearly marked. Contact FM there is no sash height indicated on your fume hood. The sash also acts as a physical barrier in the event of an accident.
6. 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. Clutter inside the hood may disrupt air flow and thus reduce capture efficiency.
7. Do not make any modifications to hoods, duct work, or the exhaust system without first contacting EH&S at (530) 752-1493.
8. 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.
9. Avoid sudden movements while working in the fume hoods. Such movements can create turbulence which may disrupt air currents and pull vapors out of the fume hood.
10. For energy efficiency, make sure to shut your sash when the hood is not in use.

Laboratory fume hoods are vital pieces of equipment for protecting personnel from exposure to hazardous chemicals. Chemical fume hoods must be inspected upon installation, renovation, when a deficiency is reported, or a change has been made to the operating characteristics of the hood. Whenever possible volatile/semi-volatile chemicals and PHSs should be handled under ventilation engineering controls (*e.g.* fume hoods). Please contact chem-safety@ucdavis.edu if you have any questions on ventilation controls for the chemicals needed in your research.

Fume Hood Inspections

Step 1–Physical Inspection (Laboratory Personnel)	Step 2–Hood Performance Inspection (Facilities Management Personnel)
<p>Evaluates the physical condition of the hood and the materials being used in the hood. This includes checking for:</p> <ul style="list-style-type: none"> • Improper storage of materials inside the fume hood • Use of proper materials • General hood cleanliness • Physical damage to the fume hood (<i>e.g.</i> broken sash) • Fully functioning lighting, fume hood indicator, airflow monitor, and alarm 	<p>Evaluates the overall hood performance to ensure that it is functioning properly. This involves checking the:</p> <ul style="list-style-type: none"> • Average face velocity and minimum face velocity, which is used to determine the rating of the hood and what the hood can be used for • Noise generated by the fume hood, to ensure that it is below 85 dB • If fume hood does not pass inspection, it will be labeled with a “DO NOT USE” sign until it can be repaired

c. Glove Boxes and Ventilated Containment Devices

In addition to chemical fume hoods, some laboratories use contained glove boxes (dry boxes) or other ventilated containment units for working with reactive chemicals under an inert atmosphere, working with very toxic substances in a completely closed system, or for creating a stable, draft-free, system for weighing hazardous or reactive materials. These units can be very effective because they offer complete containment. Personnel **must** be trained in the proper use of this equipment, and the training must be documented.

d. Other Engineering Controls

In addition to the elements listed above, consideration must be given to providing sufficient engineering controls for the storage and handling of hazardous materials. No more than 10 gallons of flammable chemicals may be stored outside of an approved flammable storage cabinet. For refrigerator or freezer reduced-temperature storage, flammable and explosive materials must be kept in units specifically designed and rated for storing these respective materials. It is common for laboratories to use a “lab-safe” refrigerator approved for the safe storage of flammable chemicals. These units should be visibly labeled with a rating from Underwriters Laboratory or other certifying organization. Lab-safe refrigerators do not contain internal electrical components that could spark and trigger an ignition, and the cooling elements are external to the unit. While lab-safe refrigerators can safely store chemicals which may emit flammable vapors, these refrigerators should not be used in locations that contain explosive vapors. If you need a refrigerator or freezer for chemical storage in a location with explosive vapors, contact EH&S for assistance with an explosion-proof refrigerator. See [SafetyNet#523](#) on Flammable Storage for additional information.

i. Biological Safety Cabinets

Biological Safety Cabinets (BSCs or biosafety cabinets) are primary containment devices used in laboratories for working safely with biological hazardous agents. There are three types of cabinets: Classes I, II, and III, each with different performance characteristics and applications. The most commonly used BSCs at UC Davis are Class II BSCs.

Class II BSCs provide protection for the user, biological agents used, and the environment. Class II BSCs use High Efficiency Particulate Air (HEPA) filters to control airborne particles and may be ventilated into the room or ducted out of the building.

Class II BSCs must be tested and certified by EH&S when first installed. On an annual basis, and whenever they are moved, the campus-contracted testing firm tests and certifies BSCs. Purchase and placement of BSCs within the laboratory must be approved by EH&S. Contact biosafety@ucdavis.edu for additional information.

ii. Laminar Flow Benches

Laminar flow benches (“clean benches”) provide a high quality, clean work surface and environment for manipulation of materials. There are three types of laminar flow benches:

- a. **Forward flow** (towards the operator): The operator sits directly downstream from the clean bench airflow. This type of clean bench must **never** be used for handling toxic, infectious or sensitizing materials. Only handling of **non-hazardous** materials is allowed in this type of laminar flow bench. While it is understood that ethanol solutions are typically used with such equipment, note that this puts the operator at an increased risk of injury should a fire ignite where the flames may be blown towards the operator.
- b. **Vertical flow** (top to bottom): These benches are designed to protect samples and processes from contamination where operator protection is not required. Only handling of **non-hazardous** materials is allowed in this work setting.
- c. **Reverse flow** (away from operator): The operator sits upstream of the clean bench airflow - the airstream blows away from the operator. These benches provide effective laboratory protection for a variety of low to moderate hazard materials - aqueous liquids, small quantities of volatile materials, etc. One common application for reverse flow laminar benches is for chemical weighing/dispensing of solid materials.

It's important to note that laminar flow benches are not the same as downdraft tables, which find application in anatomy and engineering laboratories. Also, a laminar flow bench is NOT a biosafety cabinet, and some models may recirculate the airstream back into the general laboratory space following filtration. For additional information on the correct application of laminar flow benches contact [EH&S](#).

2. Administrative Controls

Administrative controls consist of policies and procedures to reduce or prevent exposures to laboratory hazards. These controls are generally not as reliable as engineering controls in that the user has to carefully follow the appropriate procedures and must be fully trained and aware in order to do so. Note that elements of “Isolation” and “Segregation” may be contained in an administrative control.

a. Prior Approval

Several committees and programs at UC Davis are tasked with reviewing research protocols and/or approving/monitoring the use of hazardous materials. These committees or programs are as follows:

- i. Chemical and Laboratory Safety Committee (*CLSC*)
- ii. *Controlled Substances Program*
- iii. Institutional Animal Care and Use Committee (*IACUC*)
- iv. Institutional Biosafety Committee (*IBC*)
- v. Institutional Review Board (*IRB*)
- vi. Radiation Safety Committee (*RSC*)
- vii. *Select Toxin Registration*.

In addition to the identified committees and programs with their respective emphasis, the campus Chemical Hygiene Officer is available to work with investigators prior to beginning laboratory operations that involve any of the following:

- i. Working with potentially explosive chemicals, extremely reactive chemicals, acutely toxic chemicals, or large quantities of material that could potentially be released to the environment.
- ii. When it is likely that a Cal/OSHA Action Level or *Permissible Exposure Limit* (see *Chapter V*) could be exceeded.

Finally, the PI/Laboratory Supervisor is strongly encouraged to establish rules for the following activities and chemical usage in their laboratory operations that involve an increased level of risk:

- i. Working alone in the laboratory. A laboratory-specific SOP that defines laboratory activities that may not be undertaken while alone in the laboratory is strongly recommended, and a *template* has been prepared.
- ii. Unattended laboratory operations.
- iii. Modifying a procedure in such a manner that the overall hazard is increased substantially. One such example is the scale-up of a reaction. The capability of the existing protective mechanisms to accommodate the changes in the thermodynamics of the chemical system must be considered. It is strongly recommended that the PI/Laboratory Supervisor establish upper limits for quantities of material use, and require prior approval for work when these limits need to be exceeded.

b. Standard Operating Procedures

While general guidance regarding laboratory work with chemicals is contained in this Chemical Hygiene Plan, PIs/Laboratory Supervisors are required to develop and implement laboratory-specific SOPs for hazardous chemicals, including *PHS*, that are used in their laboratories. This is a Cal/OSHA requirement - *8 CCR §5191*, subpart (e)(3)(A). Development and implementation of laboratory-specific SOPs is a core component of promoting a strong safety culture at UC Davis

and helping to promote a safe work environment. The campus CHO, chem-safety@ucdavis.edu, and [DSCs](#) are available to assist PIs/Laboratory Supervisors with the development of SOPs.

Laboratory-specific SOPs must be prepared in writing by personnel who are most knowledgeable about the experimental process and approved by PI/Laboratory Supervisor prior to starting work. SOPs identify safety precautions and requirements specific to the hazardous chemicals and/or process. Laboratory personnel must be trained on all SOPs for the hazardous chemicals they will be using, and shall be trained on emergency procedures for all chemicals contained in the laboratory. Laboratory-specific SOPs should be developed on a case-by-case basis for hazardous procedures unique to the laboratory. For certain hazardous chemicals, [PHS](#), or specialized practices, consideration must be given to whether additional consultation with safety professionals is warranted or required.

The PI/Laboratory Supervisor, or their qualified designee, will train all personnel responsible for performing the procedures detailed in the SOP, and will document training on the material. Training on a SOP involves more than simply reading and signing the training documentation form. The trainer demonstrates the procedures/techniques described in the SOP, and then observes the trainees while they complete those procedures/techniques, demonstrating competence to perform the procedure/techniques.

SOPs shall be reviewed, and revised as needed, when one of the following criteria is met:

- i. Nature of the hazard changes (*e.g.* previously unknown hazard is identified, use of vacuum or pressure, increased/decreased temperature, etc.).
- ii. Chemical changes (*e.g.* quantity increase or scale-up, increase in concentration, new chemical supplier, etc.).
- iii. Equipment changes.
- iv. An unexpected outcome occurs (*e.g.* unanticipated rise or fall in temperature, increased gas production, unexpected color change or phase separation, etc.).

PI/Laboratory Supervisor review and re-approval is required following any SOP revision. Laboratory personnel must be trained on any SOP revisions, and documentation of the training must be maintained. Once laboratory personnel have been trained on the content of a SOP they may prepare an Executive Summary document for quick reference. An Executive Summary must be approved by the PI/Laboratory Supervisor to ensure that it accurately reflects the expectations for safe handling, storage, and disposal of the hazardous chemicals in the SOP. Such an Executive Summary **may not** be used for training, as training must be completed on the entire content of the SOP.

Circumstances requiring prior approval from the PI/Laboratory Supervisor or designee must also be stated in laboratory-specific SOPs. These circumstances are based on the inherent hazards of the 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 include, but are not limited to, working alone in a laboratory, unattended or overnight operations, the use of highly toxic gas of any amount, the use of large quantities of toxic or corrosive gases, the use of extremely reactive chemicals (*e.g.* pyrophoric or water reactive chemicals), reaction scale-up, or the use of carcinogens.

When preparing an SOP, consider the type and quantity of the chemical being used, along with the frequency of use. The [SDS](#) for each hazardous chemical should be referenced during SOP development. The SDS lists important information, such as hazard warnings, chemical/physical properties, type of toxicity, symptoms of exposure, and exposure limits. If a novel chemical will be produced during the experiment, an SDS will not 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.

SOPs should be maintained as hardcopy and/or electronic format in such a way as to be readily available to laboratory personnel. The SOP storage location and organizational structure is at the discretion of each PI/Laboratory Supervisor. Additional guidance on writing SOPs, including a sample template, is available on the [EH&S website](#).

Several control-banded [SOP templates](#) are currently available, and the CLSC and EH&S are developing tools and resources to further assist with the SOP development process. Details are available at [EH&S Chemical and Laboratory Safety](#), and additional information can be obtained from chem-safety@ucdavis.edu.

3. Protective Apparel and Equipment






a. Personal Protective Equipment

Personal protective equipment serves as a researcher's last line of defense against chemical exposures. Specific minimum requirements for PPE use during operations involving chemicals are contained in *Protective Clothing and Equipment* ([PPM 290-50](#)).

The PPE policy outlines the basic PPE requirements, which include but are not limited to the following:

- Full length pants and closed-toe/closed-heel shoes, or equivalent.
- Protective gloves, laboratory coats, and eye protection when working with, or adjacent to, hazardous chemicals.
- Flame resistant laboratory coats for pyrophoric and high-hazard flammable materials use. For more information, see [PPM 290-50](#).

Additionally, it is **strongly recommended** that safety eye protection be worn in the laboratory at all times. Several videos from UCSD highlight the [importance of vision protection](#), the dynamic character of the [splash zone in a laboratory](#), and a [reminder of the benefits of PPE](#).

PPE	Specific type (example)	Characteristics	Applications
Safety glasses		Polycarbonate lens, side shields for eye protection Personnel with corrective lenses will need prescription safety glasses or overglasses	Working with chemical, biological, radiation, physical hazards
Goggles		Protects eyes from impact, spray, paint, chemicals, flying, chips, dust particles	Working with chemical liquids with likely splash probability or high splash hazard
Laser Eyewear		Appropriately shaded goggles; optical density based on beam parameters	Working with Class 3 or Class 4 lasers, consult laser use authorization for specific applications.
Surgical / Procedure Mask		Protects nose and mouth from direct contact with biological and chemical fluids; prevent spread of aerosolized infectious biological agents	Anatomical, surgical, medical and clinical settings
Face Shield		Impact and chemical resistant face shield, must be combined with safety glasses or goggles	For use with potential chemical splash or projectiles, apparatus under pressure or vacuum, cryogenics handling

The primary goal of PPE is to reduce the risk associated with handling hazardous substances and performing hazardous activities. Additional more protective PPE may be needed for certain activities and chemical hazards. The CLSC has approved a [PPE Selection Guide](#) to assist in selecting the appropriate equipment for work activities and hazards. When selecting appropriate gloves consider the following:

- A. Chemical(s) being used.
- B. Anticipated chemical contact (*e.g.* immersion, incidental, etc.).
- C. Manufacturer's permeation and degradation data.
- D. Whether a combination of different gloves is needed.

Additional guidance is provided in [SafetyNet #50 – Guidelines for the Selection of Chemical-Resistant Gloves](#) which includes links to online glove permeation charts from glove manufacturers. Informative videos on PPE are available from [UCSD](#) and the [Dow Chemical Company](#).

UC Davis policy ([PPM 290-50](#)) requires a hazard assessment be completed for all personnel prior to beginning work. This hazard analysis will help identify the minimum needed PPE and equipment needed. An online [Laboratory Hazard Assessment Tool](#) is available to assist with the job hazard analysis. Note that the LHAT may not address all the potential hazards within a laboratory. Additional resources to guide hazard assessment are available from the ACS, [Identifying and Evaluating Laboratory Hazards](#), contact EH&S at (530) 752-1493 or researchsafety@ucdavis.edu for assistance.

b. How to Use and Maintain PPE

Personal protective equipment (PPE) should be kept clean and stored in an area where it will not become contaminated. PPE should be inspected prior to use to ensure it is in good condition. It should fit properly and be worn properly. If it becomes contaminated or damaged, it should be cleaned or repaired when possible, or replaced and properly discarded as hazardous waste. See the [PPE FAQs](#) or chem-safety@ucdavis.edu for additional question or help related to PPE. PPE may be reassigned to other laboratory personnel provided that it is appropriately fitting and in good condition, see the [Lab Coat Fitting Guidance and Reassignment Instructions](#) for more information.

For additional requirements and information on selection of PPE, see [PPM 290-50](#), and [SafetyNet #5 - Eye and Face Safety Protection for Laboratory Workers](#).

c. Respiratory Protection

Typically, respiratory protection is not needed in a laboratory. Under most circumstances, safe work practices, small scale usage, and engineering controls (fume hoods, biosafety cabinets, and general ventilation) adequately protect laboratory workers from chemical, radiological, and biological hazards. However, under certain circumstances respiratory protection may be needed. These can include:

- An accidental spill such as:
 - Chemical spill outside the fume hood.
 - Spill of biohazardous material outside a biosafety cabinet.

- Performance of an unusual operation that cannot be conducted under the fume hood or biosafety cabinet.
- When weighing powdered chemicals or microbiological media outside a glove box or other protective enclosure. Disposable filtering face-piece respirators are generally recommended for nuisance dusts. If the chemicals are toxic, contact EH&S for additional evaluation.
- When exposure monitoring indicates that exposures exist that cannot be controlled by engineering or administrative controls.
- As required by a specific laboratory protocol or as defined by applicable regulations.

Detailed requirements related to respiratory protection are described on the [UC Davis Respiratory Protection Program website](#) including the [UC Davis Respiratory Protection Manual](#), how to obtain a respirator, and requirements for respirator training, medical surveillance, and fit testing. **Always** contact EH&S or your DSC before proceeding with the use of a respirator, even a disposable one.

d. Safety Shields

Face shields protect the face, neck, and ears from splash or flying particles. They are worn over safety glasses or chemical splash goggles, and should be worn when major splashing may occur.

Standing shields, affixed to the countertop and of good rigidity and strength, protect the face, neck and upper torso from projectiles when over-pressurization or implosion may occur. Standing shields should be considered for:

- i. Work with potentially-explosive compounds.
- ii. Systems under high or low pressure.
- iii. Scaling up reactions

4. Safe Laboratory Habits

As detailed above, a safety program must include policies and protective equipment to promote a safe working environment, but to truly achieve effectiveness, a number of fundamental elements must become an integral part of our safety culture. According to the American Chemical Society (ACS):

“To build a strong safety culture, all faculty, staff, and students need the skills to recognize hazards, to assess the level of risk of exposure to those hazards, to minimize the risk, and to be prepared to respond to laboratory emergencies.”

ACS has prepared a report on “[Creating Safety Cultures in Academic Institutions](#)” that has been endorsed by the [CLSC](#). The CLSC highly recommends that all researchers review this report. Some of the fundamental or operational elements of an effective safety program and safety culture are detailed below:

a. Personal Protective Equipment

- Wear closed-toe/closed-heel shoes and full length pants, or equivalent, at all times when in the laboratory. Open shoes, sandals, bare feet, bare shins, bare midriffs, and bare shoulders are prohibited.

- Use appropriate PPE while in the laboratory and while performing procedures that involve the use, movement, or disposal of hazardous chemicals or materials. Perform hazard assessments to determine the necessary PPE.
- Wear appropriate eye protection in the laboratory.
- Do not manipulate contact lenses while in the laboratory. If they are used, inform the PI/Laboratory Supervisor and the other laboratory personnel that they are being worn.
- Long hair should be tied back or otherwise confined.
- Secure neckties or other articles of clothing or jewelry that might become entangled in equipment.
- Remove laboratory coats or gloves immediately on significant contamination, as well as before leaving the laboratory. Do not touch common surfaces (*e.g.* door handles, elevator button, telephone, compressed gas cylinders, etc.) with a gloved hand.

a. Chemical Handling:

- Review the SDS to better understand the hazards of any new chemical to be handled, and reexamine as needed.
- Properly label and store all chemicals.
- Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures specified in the Chemical Hygiene Plan and SOPs.
- Do not dispose of any hazardous chemicals through the sewer system.
- Do not smell or taste chemicals.
- Never use mouth suction for pipetting or starting a siphon.
- Be prepared for an accident or spill and refer to the emergency response procedures for the specific material. Procedures should be readily available to all personnel. Minor chemical spill information is described in the [CHP](#) and also in [SafetyNet #13 - Guidelines for Chemical Spill Control](#). For general guidance, the following situations should be addressed:
 - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention, as portrayed in the guidance video from [UCB](#).
 - Skin Contact: Promptly flush the affected area with water (15 minutes) and remove any contaminated clothing, after washing seek medical attention.

b. Equipment Storage and Handling:

- Use the proper safety equipment for your activities, which may include a chemical fume hood, glove box, biosafety cabinet, shields, or other equipment.
- Use certified fume hoods, glove boxes, or other ventilation devices for operations which might result in release of toxic chemical vapors or dust. Preventing the escape of these types of materials into the working atmosphere is one of the best ways to prevent exposure.
- Do not use uncertified fume hoods or glove boxes for hazardous chemical handling.
- Store laboratory glassware with care to avoid damage.
- Inspect all glassware and equipment prior to use; do not use damaged items.

- Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur.
- Handle broken glass and sharps with caution and appropriate hand protection; properly dispose of these materials.
- Keep fume hood sash closed when you are not working in the fume hood.
- Avoid storing materials in fume hoods.
- Do not allow the vents or air flow to be blocked.

c. Laboratory Operations:

- Know the location of all exits for the laboratory and the building.
- Know the location and proper operation of safety showers, eyewashes, and first-aid kits.
- Know where the fire extinguishers and alarm pull boxes are located and how they operate.
- Know the location of the nearest phone that can be used in an emergency. Critical phone numbers should be posted near the phone.
- Be prepared for laboratory accidents, chemical spills, and other emergency situations.
- Be prepared for seismic activity, including guidance provided in [SafetyNet #83 - Non-Structural Seismic Safety](#).
- Know the potential hazards of the materials, facilities, and equipment with which you will work. If you are uncertain, ask your PI/Laboratory Supervisor or contact EH&S.
- Research staff and students should never work alone on procedures involving hazardous chemicals, biological agents, or other physical hazards unless the PI/Laboratory Supervisor has:
 - A. Developed a [SOP specifically on working alone](#) in the laboratory, and
 - B. Granted formal approval for the laboratory activities being performed.
- Follow electrical safety guidance as described in [SafetyNet#512 - Electrical Safety](#) and [PPM 290-85 Electrical Safety](#).
- Keep the work area clean and uncluttered.
- Seek information and advice about hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation.
- Follow written protocols or instructions. Perform only authorized experiments. Do not create shortcuts to procedures.
- When using unfamiliar equipment complete a “dry run” of your experiment using a less hazardous chemical to familiarize yourself with the proper operation of the equipment and PPE.
- If cooling water is required for laboratory activities ensure that the chosen system is not single-pass, utilizing recirculating baths or other water-less alternatives (e.g. [Findenser™](#)), consistent with [UCOP Sustainability Policy](#).
- Vacuum lines must be protected with traps to prevent vacuum system component contamination.
- If unattended operations are unavoidable, and have been approved by the PI/Laboratory Supervisor, place an appropriate sign on the door, leave lights on, and provide for containment of toxic substances in the event of failure of a utility service (e.g. cooling water). Highly exothermic, potentially explosive reactions, or sudden polymerization reactions must never be left unattended.

- Notify other laboratory personnel when an explosion hazard is present or may be produced, through direct announcement and prominent warning signs.
- Be alert to unsafe conditions and ensure that the PI/Laboratory Supervisor is notified of such conditions and they are corrected promptly.
- Do not move or disturb equipment in use without consent of the user.
- Do not engage in distracting behavior such as practical jokes in the laboratory. This type of conduct may confuse, startle, or distract another worker.
- Use of headphones in the laboratory, for non-research purposes, is strongly discouraged, some of the risks are highlighted in a [video from Cornell](#). If headphones are used in the laboratory for non-research purposes leave one ear unobstructed to be able to hear any sounds and language of any emergency events.
- If personal electronic devices (*e.g.* laptop, cellular phone, MP3 player, etc.) are used in the laboratory, take precautions to prevent contamination with hazardous materials.
- Wash hands carefully before leaving the laboratory. Beware of contamination on clothing, doorknobs, doorframes, etc.
- Maintain good laboratory cleanliness, including:
 - Clean bench tops, work areas, and equipment regularly.
 - Prevent the accumulation of dirty glassware, unneeded samples/chemicals, and trash.
 - Keep aisles and areas around eyewashes and showers clear to allow for unobstructed exit and easy access to safety equipment in emergency situations.
 - Ensure all compressed gas cylinders are properly restrained.
 - Practice good refrigerator and freezer management by preventing overcrowding, using secondary containment, and completing periodic defrosting procedures.
- Follow guidance described in the *EH&S and Fire Prevention SafetyNets*.
- Immediately report all accidents, injuries, and near-misses, however small, to the PI/Laboratory Supervisor. Report any fires or the discharge of any fire extinguisher to the Fire Department, even if the fire is extinguished.

d. Food/Drink:

- No eating, drinking, gum chewing, tobacco chewing, handling contact lenses, and the application of cosmetics (including lip balm) where biological hazards, radioactive materials, or hazardous chemicals will be stored or used. Food must not be kept in refrigerators or cold rooms used for hazardous chemicals or other hazardous materials. Refrigerators used for food and beverage storage should not be located in the laboratory.

5. Guidance for Support Personnel Entering a Laboratory

a. Custodial Staff

- To aid proper recognition of laboratory hazards the [Lab Safety for Support Personnel](#) training has been developed. You must have completed this training before you may enter a laboratory environment.

- Rooms that have a Caution Sign or any other warning stickers on laboratory doors, may contain materials or equipment which, if used improperly, could cause harm.
- Any container (box, bottle, carton, etc.) that holds hazardous material should be clearly marked with an appropriate warning label. Do not touch, move or handle containers of any chemicals or materials in a laboratory. If items need to be moved in order to perform your duties, have the PI/Laboratory Supervisor arrange for this to be completed or contact your immediate supervisor.
- If the contents of any laboratory container are spilled, **do not touch it or attempt to clean it up**. Evacuate the area, close the laboratory door as you leave, and contact your supervisor. Call **9-1-1** for assistance with cleanup or to report a chemical spill.
- Wear appropriate laboratory coat or work uniform and eye protection.
- Do not eat, drink, apply cosmetics, handle contact lenses, or take medications in a laboratory.
- Chemical bottles should not be disposed as regular trash unless they have been completely emptied, air dried, label defaced, and the cap removed. If in doubt about the containers, leave them in the laboratory.

b. Facilities Maintenance & Information Technology

- To aid proper recognition of laboratory hazards the [*Lab Safety for Support Personnel*](#) training has been developed. This training must be completed before you may enter a laboratory environment.
- **Before** working in a laboratory or chemical fume hood, notify the PI/Laboratory Supervisor or laboratory personnel about the problem, the length of time anticipated to accomplish the corrective actions, and when the work will be performed. **Before** work starts, adequately notify lab personnel so equipment which could cause injury or be damaged is turned off or moved.
- The PI/Laboratory Supervisor is responsible for making sure your work area within the room is free from physical, chemical, and/or biological hazards. Your work area could include hoods, sinks, cabinets, benches, bench tops, floors, and/or equipment. You may be required to repair, move, remove, replace, or paint as part of your work.
- Do not handle or move chemicals in the laboratory. If you need chemicals moved in order to perform your work, have the laboratory supervisor arrange for this to be done.
- Do not move or handle equipment in the laboratory. If your work requires you to move, remove, or replace a piece of equipment, have the PI/Laboratory Supervisor assure you that the equipment is free of any physical, chemical, and/or biological hazards.
- Do not eat, drink, apply cosmetics, handle contact lenses, or take medication in the laboratory.
- In situations where the hazard cannot be totally removed, specific work procedures will be developed in conjunction with the PI/Laboratory Supervisor and EH&S.
- If there is a chance your work could bring you in contact with chemical hazards (*e.g.* working on laboratory sinks, working in areas where there is a chance of chemical contamination) or when working in rooms where chemical experiments are taking place, consult with the PI/Laboratory Supervisor on the appropriate coveralls and eyewear.
- If working on a hood, ask the room supervisor if the hood is used for perchloric acid or radioactive material. Contact EH&S before performing maintenance on any part of a

perchloric acid or radioactive material fume hood system (including: hood, base, duct, fan, and stack). Lubricate perchloric acid hood fans with fluorocarbon grease only.

- If you have any questions, contact the PI/Laboratory Supervisor first, your supervisor next, or EH&S.

V. Hazard Assessment and Chemical Exposure Monitoring (HACEM)

A. Regulatory Overview

It is University policy to comply with all applicable health, safety, and environmental protection laws, regulations and requirements. Under [Article 107 of Title 8](#) Cal/OSHA requires that all employers “*measure an employee’s exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance exceed the action level (or in the absence of an action level, the exposure limit).*” Repeated monitoring may be required if initial monitoring identifies employee exposure over the action level or exposure limit.

Cal/OSHA regulates Permissible Exposure Limits ([PELs](#)) for airborne contaminants to which “*nearly all workers may be exposed daily during a 40-hour workweek for a working lifetime (of 40 years) without adverse effect*”, and are based upon an 8-hour Time-Weighted Average (TWA) exposure. Thus, the PELs are the maximum permitted 8-hour TWA concentration of an airborne contaminant without the use of respiratory protection. Cal/OSHA has also defined Short Term Exposure Limits ([STELs](#)) as the maximum TWA exposure during any 15 minute period, provided the daily PEL is not exceeded and Ceiling (C) exposures that shall not be exceeded at any time.

Cal/OSHA has listed established PELs, STELs and Ceiling exposures for chemical contaminants identified in [8 CCR §5155 \(Airborne Contaminants\) Table AC-1](#). In the absence of a published Ceiling limit, Cal/OSHA requires employee exposure to concentrations above the PEL be controlled to prevent harmful effects. Further, Cal/OSHA has 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.

B. Exposure Assessment Overview

All University employees require protection from exposure to hazardous chemicals above PELs, STELs and Ceiling concentrations. Principal Investigators and supervisors are responsible for assessing hazards. For concerns of airborne chemical exposure, contact EH&S for consultation and further evaluation. Per Cal/OSHA, chemical exposure monitoring must be performed by or under the direction of a person competent in industrial hygiene. At UC Davis, EH&S provides this expertise and serves this role. Contact EH&S at healthandsafety@ucdavis.edu or (530) 752-1493 for general questions regarding exposure assessments or the Industrial Hygiene Program.

Minimizing an exposure may be accomplished by elimination, substitution, or using a combination of engineering controls, administrative controls and PPE, listed in order of priority. Assessing exposure to hazardous chemicals may be accomplished through a number of methods performed by EH&S, including employee interviews, evaluation of chemical properties, visual observation of chemical use, evaluation of engineering controls, use of direct-reading

instrumentation, or the collection of analytical samples from the employee's breathing zone. Personal exposure assessment may be performed under situations including the following:

1. Based on chemical inventories, review of SOPs, types of engineering controls present, laboratory inspection results and/or review of hazard assessments, EH&S determines whether an exposure assessment is warranted.
2. User of a hazardous chemical has concern or reason to believe exposure is not minimized or eliminated through use of engineering controls or administrative practices and the potential for exposure exists. The user should then inform his or her PI/Laboratory Supervisor, who will in turn contact EH&S or the University's Occupational Health Services. EH&S and Occupational Health Services will then determine the best course of action in assessing employee exposure, including visual assessment, air monitoring, medical evaluation, examination, or medical surveillance.

In the event of any serious injury or exposure, including chemical splash involving dermal or eye contact, **immediately call 9-1-1** and obtain medical treatment immediately. Do not wait for an exposure assessment to be performed before seeking medical care.

1. Exposure Assessment Protocol – Notification to employees or employee representatives and right to observe monitoring (8 CCR §340.1)

The EH&S Industrial Hygiene Program conducts exposure assessments for members of the campus community. Employees have a right to observe testing, sampling, monitoring or measuring of employee exposure. They are also allowed access to the records and reports related to the 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:

- a. Employee interviews.
- b. Visual observation of chemical usage and/or laboratory operations.
- c. Evaluation of simultaneous exposure to multiple chemicals.
- d. Evaluation of potential for absorption through the skin, mucus membranes or eyes.
- e. Evaluating existing engineering controls (such as measuring face velocity of a fume hood).
- f. Use of direct-reading instrumentation.
- g. Collection of analytical samples of concentrations of hazardous chemicals taken from the employees breathing zone, noise dosimetry collected from an employee's shirt collar, or various forms of radiation dosimetry.

If exposure monitoring determines an employee exposure to be over the Action Level (or the 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 PI/Laboratory Supervisor to ensure that any necessary medical surveillance requirements are met. When necessary, EH&S will make recommendations regarding adjustments to engineering

controls or administrative procedures to maintain exposure below any applicable PEL. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, UC Davis will provide, at no cost to the employee, the proper respiratory equipment and training.

In assessing exposure to hazardous chemicals for which Cal/OSHA has not published a PEL, STEL or Ceiling exposure, EH&S may defer to the Threshold Limit Values (*TLVs*) established by the American Conference of Governmental Industrial Hygienists (ACGIH) or the Recommended Exposure Limits (*RELs*) established by the NIOSH. OSHA has consolidated most of this information at <https://www.osha.gov/dsg/annotated-pels/index.html>. Please contact EH&S at (530) 752-1493 for more information regarding these guidelines.

2. Notification

The Industrial Hygienist will promptly notify the employee and his/her PI/Laboratory Supervisor of the results in writing (within 15 working days or less if required) after the receipt of any monitoring results. The Industrial Hygienist will establish and maintain an accurate record of any measurements taken to monitor exposures for each employee. Records, including monitoring provided by qualified vendors, will be managed in accordance with *8 CCR §3204* “Access to Employee Exposure and Medical Records”.

3. Exposure Assessment to Determine and Implement Controls

EH&S and Occupational Health Services will use any of the following criteria to determine required control measures to reduce employees’ occupational exposure:

- a. Verbal information obtained from employees regarding chemical usage.
- b. Visual observations of chemical use or laboratory operations.
- c. Evaluation of existing engineering control measures or administrative practices.
- d. Recommendations expressed in Safety Data Sheets.
- e. Regulatory requirements of Cal/OSHA.
- f. Recommendations from professional industrial hygiene organizations.
- g. Direct-reading instrumentation results.
- h. Employee exposure monitoring results.
- i. 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 “Control of Harmful Exposure to Employees” (*8 CCR §5141*), the control of harmful exposures shall be prevented by implementation of control measures in the following order:

- a. Elimination, whenever possible.
- b. Substitution, whenever possible.
- c. Engineering controls, whenever feasible.
- d. Administrative controls whenever engineering controls are not feasible or do not achieve full compliance and administrative controls are practical.
- e. Personal protective equipment, including respiratory protection:
 - a. During the time period necessary to install or implement feasible engineering controls.
 - b. When engineering and administrative controls fail to achieve full compliance.

- c. In emergencies.

a. Medical Evaluation

All employees, student workers, medical health services volunteers, or laboratory personnel who work with hazardous chemicals shall have an opportunity to receive a free medical evaluation, including supplemental examinations which the evaluating physician determines necessary, under the following circumstances:

1. Whenever an employee develops signs or symptoms possibly associated with a hazardous chemical to which an employee may have been exposed in a laboratory.
2. Where personal monitoring indicates exposure to a hazardous chemical is above a Cal/OSHA AL or PEL.
3. Whenever an uncontrolled event takes place in the work area such as a spill, leak, explosion, fire, etc., resulting in the likelihood of exposure to a hazardous chemical.
4. Upon reasonable request of the employee to discuss medical issues and health concerns regarding work-related exposure to hazardous chemicals.

All work-related medical evaluations and examinations will be performed under the direction of UC Davis campus Occupational Health Services or UC Davis Health System (UCDHS) Employee Health Services by licensed physicians or staff under the direct supervision of a licensed physician. Evaluations and examinations will be provided without cost to the employee, without loss of pay, and at a reasonable time and place.

Any laboratory employee or student worker who exhibits signs and symptoms of adverse health effects from work-related exposure to a hazardous chemicals should report to [Occupational Health Services](#) (Davis employees), [Student Health and Counseling Services](#) (Davis students), or [Employee Health Services](#) (Sacramento) immediately for a medical evaluation.

Refer to your Department's IIPP for procedures on how to obtain medical evaluation under the above-listed circumstances.

b. Information to Provide to the Clinician

At the time of the medical evaluation, the following information should be provided to Health Services:

1. Personal information such as age, weight, and University employee ID number.
2. Common, trade, and/or International Union of Pure and Applied Chemistry (IUPAC) name of the hazardous chemicals to which the individual may have been exposed.
3. A description of the conditions under which the exposure occurred.
4. Quantitative exposure data, if available.
5. A description of the signs and symptoms of exposure that the employee is experiencing, if any.
6. A copy of the SDS of the hazardous chemical or material in question.



7. History of exposure including previous employment and non-occupational (recreational) hobbies.
8. Any additional information helpful to Health Services in assessing or treating an exposure or injury such as a biological component of exposure or existence of an antitoxin.

c. Physician's Written Opinion

For evaluation or examinations required by Cal/OSHA, the employer shall receive a written opinion from the examining physician which shall include the following:

1. Recommendation for further medical follow-up.
2. Results of the medical examination and any associated tests, if requested by the employee.
3. Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace.
4. A statement that the employee 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.

d. Confidentiality & Individual's Access to Personal Medical Records

All patient medical information is protected by California and federal law and is considered strictly confidential. Health Services, both campus and UCDHS, are 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 Health Services to the employee's supervisor will be limited to information necessary in assessing an employee's return to work, including recommended restrictions in work activities, if any. Any patient information disclosed by Health Services to EH&S will be limited to information necessary to develop a course of exposure monitoring, or perform hazard assessments and incident investigations, if appropriate. Health Services will otherwise disclose patient medical information only as required by California and Federal law, such as for Worker's Compensation Insurance claims. Each employee has the right to access his/her own personal medical and exposure records. Health Services will provide an employee with a copy of his/her medical records upon written request.

e. Medical Surveillance

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 AL or PEL.

Health Services and/or 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:

- | | |
|------------------------|--|
| ○ Asbestos | ○ Dichloromethane |
| ○ Beryllium | ○ Noise (<i>Hearing Conservation Program</i>) |
| ○ Bloodborne pathogens | ○ Radioactive Materials (<i>Bioassay Program</i>) |
| ○ Formaldehyde | ○ Respirator Use (<i>Respiratory Protection Program</i>) |
| ○ Lead | ○ Other Particularly Hazardous Substances |

Individuals with questions regarding work-related medical surveillance are encouraged to contact campus *Occupational Health Services* at (530) 752-6051, *Employee Health Services (Sacramento)* at (916) 734-3572, or *EH&S* at (530) 752-1493 for more information.

f. Record Keeping

1. UC Davis Health Services maintains records for each employee included in this medical surveillance program. These records include any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions.
2. Employee exposure monitoring records are permanently maintained by EH&S. Exposure records include environmental monitoring and related collection and analytical methodologies, calculations, and other background data relevant to interpretation of the results; biological monitoring results, and specific Safety Data Sheets.
3. The UC Davis Health Services will maintain medical records for each employee in strict confidence. Medical records of employees who have worked for less than one year for the University need not be retained beyond the term of employment if they are provided to the employee upon termination of employment.

VI. Inventory, Labeling, Storage, and Transport

A. Regulatory Requirements

The necessary work practices, procedures, and policies outlined in this chapter are required by the following:

- [8 CCR §5154.1](#), “Ventilation Requirements for Laboratory-Type Hood Operations”
- [8 CCR §5164](#), “Storage of Hazardous Materials”
- [8 CCR §5191](#), “Occupational Exposures to Hazardous Chemicals in Laboratories”
- [8 CCR §5194](#), “Hazard Communication”
- [8 CCR §5209](#), “Carcinogens”

B. Chemical Inventories

Each PI/Laboratory Supervisor is required to maintain a current comprehensive chemical inventory, through the [Chemical Inventory System](#), (CIS) which lists the hazardous chemicals and compressed gases used and stored in the labs and the quantity of these chemicals. This information is managed and reported to meet obligations under the Emergency Planning and Community Right-to-Know Act (EPCRA) that is managed in California by the Certified Unified Program Agencies ([CUPA](#)). This inventory needs to be updated:

1. At least annually
2. Whenever new chemicals are introduced into the laboratory
3. Whenever a chemical is completely removed from the laboratory

Specific storage locations must be kept as part of the inventory list to ensure that chemicals are easily located. The CIS is used to aid compliance with storage limits, reporting requirements, fire and life safety regulations, and may be used in emergency situations to identify potential hazards to emergency response personnel. Additionally, an accurate chemical inventory aids the operational and financial management of laboratory activities. Active chemical inventory management can also deter chemical diversion, and quickly identify instances where diversion may have occurred. Given the multitude of advantages afforded by an accurate and current chemical inventory, efforts should be taken to actively manage the laboratory’s chemical inventory through the CIS.

Management of the laboratory chemical inventory should include the following aspects:

1. Chemical inventory reviewed prior to chemical procurement
2. Chemical purchases target the minimum quantities necessary for the research, and never exceed quantities that can be consumed within one year

3. When new chemicals are added to the laboratory, each laboratory group must confirm they have access to the SDS for that chemical, and update their CIS information to reflect the addition of the chemicals to the laboratory
4. Each chemical container is dated upon receipt so expired chemicals can be easily identified for disposal.
5. Unneeded chemicals should be culled from the inventory and properly disposed to reduce laboratory risk from storage of hazardous materials.
6. Chemicals beyond their expiration dates should be removed via proper disposal (See [Chapter IX](#)).
7. Any visible evidence of chemical or container degradation including:
 - Cloudiness in liquids
 - Color change
 - Evidence of liquids in solids, or solids in liquids
 - "Pooling" of material around outside of containers
 - Pressure build-up within containers
 - Obvious deterioration of containers (*e.g.* corrosion)

These indicators should prompt chemical disposal.

8. Chemical quantities are updated frequently, especially after large changes.
9. Chemicals are returned to their designated storage area when not in use.
10. Chemical storage locations are inspected regularly.

Access to hazardous chemicals, including toxic and corrosive substances, should be restricted at all times, as discussed in [SafetyNet #118 - Laboratory Security Tips for Hazardous Materials Users](#). These materials must be stored in laboratories or storerooms that are kept locked when laboratory personnel are not present. Locked storage cabinets or other precautions may be required in the case of acutely toxic or hazardous chemicals, tax-free alcohol (see [PPM 350-20](#)), [select toxins](#), and [controlled substances](#). Acutely toxic chemicals may include those associated with very low IDLH conditions. For guidance on locked storage requirements, please contact EH&S at (530) 752-1493 or chem-safety@ucdavis.edu.

Additional information related to storage and management of laboratory chemicals is provided in [SafetyNet #42 – General Guidelines for Storage and Management of Laboratory Chemicals](#), and guidance on the current [CIS system](#) is available on the EHS website.

Lastly, on termination or transfer of laboratory personnel, all their related hazardous materials (including chemicals and samples) shall be properly disposed of, or transferred to the PI/Laboratory Supervisor or a designee, with the chemical inventory updated appropriately.

C. Chemical Labeling

All chemicals found in the laboratory should be properly labeled. Hazardous chemicals, including dilute solutions, must be labeled properly including the associated hazards (consistent with [PPM 290-27](#), [Appendix C](#), and [SafetyNet 42 - General Guidelines for Storage and Management of Laboratory Chemicals](#)). Commercial chemicals come with a manufacturer's label which contains the necessary

information. Care should be taken to not damage or remove these labels. Commercial chemical labels should be augmented with the date of receipt and date of opening, to aid in determining if chemicals are expired and require disposal. When novel chemicals are synthesized, their containers must be labeled with the identification name, date, and hazard information; the generator or other party responsible for this chemical should be noted on the container so they may be contacted if questions arise about the contents. The Dow Chemical Company provides an excellent [video](#) highlighting the importance of chemical labeling for a safe working environment. Additional guidance and resources on the labeling of chemical containers is provided in [Appendix C](#).

Peroxide forming chemicals (*e.g.* ethers, alkenes, alkynes, etc.), see [SafetyNet #23 – Peroxide Formation in Ethers and Other Chemicals](#), must be labeled with:

- A) Date of receipt, and
- B) Date of opening; a useful label for this purpose is contained in [SafetyNet #23](#).

These chemicals can degrade to form highly reactive compounds sensitive to shock, heat and friction, and need to be stored and labeled very carefully. Chemicals which may form peroxides have varying shelf lives; consult [SafetyNet#23](#) for additional information on the types of chemicals of concern and their associated storage and disposal timelines.

[PHSs](#) have additional labeling requirements; consult [EH&S](#) for guidance. The storage area for these materials must be labeled with the appropriate hazard information. It is advised to store PHSs segregated from less hazardous chemicals to aid access restriction, inventory control, and hazard identification.

D. Chemical Storage & Segregation

Establish and follow safe chemical storage & segregation procedures for your laboratory.

Storage guidelines for flammable, oxidizing, corrosive, water reactive, explosive, and acutely toxic materials are described in the following materials. The specific SDS should **always** be consulted when doubts arise concerning chemical properties, compatibilities, associated hazards, and storage recommendations. All storage procedures must comply with Cal/OSHA, California Fire Code, and California Building Code regulations. **Always** wear appropriate PPE (*e.g.* laboratory coat, safety glasses, gloves, safety goggles, apron) when handling hazardous chemicals. Be aware of the locations of the safety showers and emergency eyewash stations. Each laboratory is required to provide appropriate laboratory-specific training on how to use this equipment **prior** to working with hazardous chemicals. **Table VI-I** lists chemical safety storage priorities.

1. General Recommendations for Safe Storage of Chemicals

Each chemical in the laboratory should be stored in a specific location and returned there after each use. Acceptable chemical storage locations may include corrosive cabinets, flammable storage cabinets, laboratory shelves/cabinets, and appropriate refrigerators or freezers, as discussed in [SafetyNet #42](#). Fume hoods should not be used as general storage areas for chemicals, as this may seriously impair the ventilating capacity of the hood and its capture efficiency. **Figure VI-I** depicts improper fume hood storage. Chemicals should not be routinely stored on bench tops or stored on the floor. Chemicals used in animal research should not be stored in the vivarium or procedural space locations, but rather returned to the laboratory for proper segregation and storage. Additionally, bulk quantities of chemicals (*i.e.* larger than 1 gallon) should be stored in a separate storage area, such as a stockroom or supply room.



Figure VI-I. Improper Fume Hood Chemical Storage

Laboratory shelves used for chemical storage must have a raised lip along the outer edge or a railing to prevent containers from falling. Hazardous chemicals should not be stored above a height of 5 feet. Chemicals which are acutely toxic or corrosive shall be stored below a height of 5 feet and shall be stored in unbreakable secondary containers.

Table VI-I. Chemical Safety Storage Priorities

Keep in mind that most chemicals have multiple hazards and a decision must be made as to which storage area would be most appropriate for each specific chemical. First you have to determine your priorities:

1. **Flammability.** When establishing a storage scheme, the number one consideration should be the flammability characteristics of the material. If the material is flammable, it should be stored in a flammable cabinet or refrigerator/freezer rated for the storage of flammable liquids.
2. **Isolate.** If the material will contribute significantly to a fire (*e.g.* oxidizers), it should be isolated from the flammables. Water-reactive material must be sufficiently segregated from flammable and combustible materials.
3. **Corrosivity.** Isolate acids from bases, and further segregate by organic vs. inorganic origin. Segregate oxidizing inorganic acids from flammable and combustible materials.
4. **Special Hazard.** Be sure to consider chemicals requiring special handling and storage (*e.g.* air/water reactive, peroxide forming chemicals, reduced temperature storage, inert atmosphere storage, etc.).
5. **Toxicity.** Finally, consider the toxicity of the material, with particular attention paid to regulated materials. In some cases, this may mean certain chemicals will be isolated within a storage area. For example, a material that is an extreme poison but is also flammable, should be locked away in the flammable storage cabinet to protect it against accidental release.

There will always be some chemicals which will not fit neatly in one category or another, but with careful consideration of the hazards involved, most of these cases can be handled in a reasonable fashion. For instances where a chemical has multiple hazardous properties (*e.g.* corrosive and oxidizer) the initial assignment would be the hazard of greatest risk. When this assignment results in chemical incompatibility, the multiple-hazard chemical will require additional segregation within its assigned hazard class. Consult [SafetyNet#42](#) or [EHS](#) for further information.

Chemicals must be stored at an appropriate temperature and humidity level and should **never** be stored in direct sunlight or near heat sources, such as laboratory ovens. Be sure to consider chemical compatibility before storing laboratory chemicals, guidance is provided in **Figure VI-II** and *Appendix F*.

Implementation of the storage approach shown in **Figure VI-II** is **strongly** recommended. Additional information to aid implementation of this segregation approach is available from the National Academies of Science, *including classification group codes for some common laboratory chemicals*. Incompatible materials should be stored in separate cabinets, whenever possible. If these chemicals must be stored in one cabinet, due to space limitations, adequate segregation and secondary containment must be ensured to prevent adverse reactions. Note that Group X materials typically require special storage considerations and may not be appropriate to store as a collective group. Please contact *EH&S* for assistance with appropriate storage guidance of these materials.

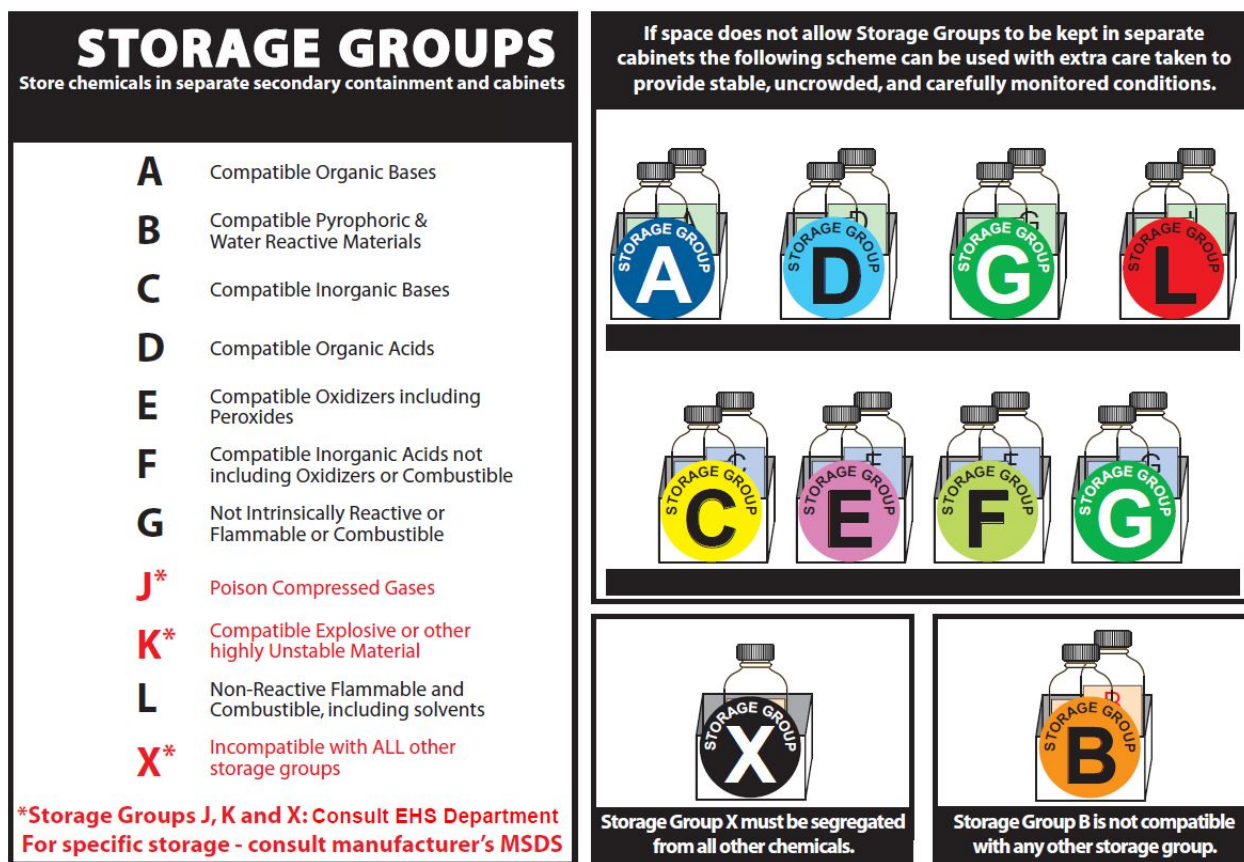


Figure VI-II. Chemical Segregation Guidance.²

All chemical containers and research samples must be appropriately labeled and tightly capped to prevent vapor interactions and to alleviate nuisance odors. Flasks with cork, rubber or glass stoppers should be avoided because of the potential for leaking.

² Provided with permission from Environmental Health & Safety, Stanford University, 2013

Laboratory refrigerators and freezers **must** be labeled appropriately with “No Food/Drink” and must **never** be used for the storage of consumables. Freezers should be defrosted periodically so chemicals do not become trapped in ice formations. Storage of peroxide formers (*e.g.* ether) in a refrigerator is not recommended.

2. Flammable and Combustible Liquids

Large quantities of *flammable* or *combustible* materials should not be stored in the laboratory. No more than **10 gallons** of flammable or combustible liquids, including flammable/combustible hazardous waste, are allowed to be kept outside a flammable storage cabinet, safety can, or approved refrigerator/freezer. The maximum total quantity of Class 1A flammable liquids must not exceed **60 gallons** within a flammable storage cabinet. Total volume of flammable and combustible liquids must not exceed 120 gallons per cabinet. Flammable materials must **never** be stored in domestic-type refrigerators/freezers and should not be stored in a refrigerator/freezer if the chemical has a flash point below the temperature of the equipment. Flammable or combustible liquids must not be stored on the floor or in any exit access. **Always** segregate flammable or combustible liquids from oxidizers, including oxidizing acids (*e.g.* nitric, perchloric, chromic, sulfuric). Only the amount of material required for the experiment or procedure should be stored in the work area. Additional guidance on flammable/combustible liquid storage is available from the UC Davis [SafetyNet#523](#).

Handle flammable and combustible materials only in areas free of ignition sources and use the chemical in a fume hood whenever possible. Ignition sources may include electrical equipment, open flames, static electricity, and hot surfaces. If heating of a flammable liquid is required, it should be limited to heating mantles, heating tapes, and water/oil/sand baths.

Always transfer flammable and combustible chemicals from glass containers to glassware or from glass container/glassware to plastic. If transferring flammable liquids between metal equipment ensure that the containers are bonded together and connected to a common ground. When transferring or dispensing highly flammable liquids with the aid of a pump, that the pump shall be constructed of metal rather than plastic due to better chemical resistivity and the ability to bond the pump/bulk container to the receiving container. Do not pour directly from metal drum into receiving flask. Failure to follow these guidelines for flammable liquid transfer may present a fire hazard due to static electricity. The transfer of flammable liquid from 5 gallon or larger metal containers should **not** be performed in the laboratory. Flammable and combustible liquids may be stored in safety cans, less than 2 gallons in volume.

3. Pyrophoric & Water Reactive Materials

Because pyrophoric substances *can* spontaneously ignite on contact with air and/or water, they must be handled under an inert atmosphere and in such a way that rigorously excludes air and moisture. Some of these chemicals are also toxic, and many are dissolved or immersed in a flammable solvent. Other common hazards include corrosivity, teratogenicity, or peroxide formation. **All** users of pyrophoric and water-reactive materials at UC Davis must know and follow the guidance provided in [SafetyNet #135 - Procedures for Safe Use of Pyrophoric/Water](#)

Reactive Reagents, know the appropriate quenching methods, and the use of these materials is never to be performed when alone in the laboratory.

Examples of pyrophoric and water-reactive chemicals include:

CHEMICAL TYPE	EXAMPLE(S)	CHEMICAL TYPE	EXAMPLE(S)
Grignard Reagent	RMgX (R=alkyl, X=halogen)	Non-metal hydrides	R ₃ B, R ₃ P, R ₃ As
Metal alkyls/ aryls	Alkyl lithium, tert-butyl lithium	White/ red phosphorous	
Metal carbonyls	Lithium carbonyl, nickel tetracarbonyl	Group I (alkali) metals	Lithium, potassium, sodium
Metal powers (finely divided)	Cobalt, iron, zinc, zirconium	Gases	Silane, dichlorosilane, diborane, phosphine, arsine
Metal Hydrides	NaH, LiAlH		

Only minimal amounts of reactive chemicals should be used in experiments or stored in the laboratory. These chemicals must be stored as recommended in the SDS, and compliant with *CCR, Title 8* and the *California Fire Code*. Reactive materials containers must be clearly labeled with the correct chemical name, in English, along with a hazard warning.

Suitable storage locations may include inert gas-filled desiccators or glove boxes; however, some pyrophoric materials must be stored in a refrigerator or freezer rated for the storage of flammable liquids. It is further recommended that an inert gas-filled desiccator also be used in conjunction with reduced temperature storage. If pyrophoric or water reactive reagents are received in a specially designed shipping, storage or dispensing container (e.g. *Aldrich Sure/Seal*™ packaging system), ensure that the integrity of that container is maintained. Ensure that sufficient protective solvent, oil, kerosene, or inert gas remains in the container while pyrophoric materials are stored. Don't store reactive chemicals with flammable materials or in a flammable storage cabinet with other flammable liquids. A flammable storage cabinet may be used but it must be dedicated to storing pyrophoric or water reactive materials only.

Storage of pyrophoric gases is described in the *California Fire Code, Chapter 64*. 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. Please contact chem-safety@ucdavis.edu for assistance with appropriate storage guidance of these materials.

Additional information on proper handling, disposal, safety equipment, emergency procedures, and excess chemical storage for these materials is contained in *UC Davis SafetyNet #135 - Procedures for Safe Use of Pyrophoric/Water Reactive Reagents*. Incredibly helpful videos are available from the *Dow Chemical Company*, from Yale University on *organolithium reagents*, and from UCSD on *preparation for pyrophoric reagents*, and *transfer of pyrophoric liquids*, and *working with reactive metals*.

4. Oxidizers

Oxidizers (e.g. hydrogen peroxide, halogens, potassium permanganate, ferric chloride, potassium dichromate, sodium nitrate, etc.) should be stored in a cool, dry place and kept away from flammable and combustible materials, such as wood, paper, Styrofoam, plastics, flammable organic chemicals, and away from reducing agents (e.g. zinc, alkaline metals, metal hydrides, formic acid).

5. Peroxide-Forming Chemicals (Time-Sensitive Materials)

Peroxide forming chemicals (e.g. ethers, alkenes, alkynes, etc.), see [SafetyNet #23 – Peroxide Formation in Ethers and Other Chemicals](#), should be stored in airtight containers in a dark, cool, and dry place and must be segregated from other classes of chemicals (e.g. acids, bases, oxidizers) that could create a serious hazard to life or property should an accident occur. The containers must be labeled with the date received and the date opened. This information, along with the chemical identity should face forward to minimize container handling during inspection. These chemicals should be periodically tested for the presence of peroxides and the results documented annually. Minimize the quantity of peroxide-forming chemicals stored in the laboratory and dispose peroxide-forming chemicals within one year of receipt or six months after opening. Refer to [SafetyNet #23 – Peroxide Formation in Ethers and Other Chemicals](#) for specific guidelines and/or contact chem-safety@ucdavis.edu with questions on peroxide forming chemicals or peroxide testing.

Keep an inventory of peroxide-forming chemicals for your workplace, and never purchase more quantity than can be consumed prior to the manufacturer's expiration date.

Do not handle the container if:

- old containers of peroxide-forming chemicals are discovered in the laboratory, (greater than five years past the expiration date or if the date of the container is unknown);
- Crystallization is present in or on the exterior of a container.

Secure the immediate area and restrict access to the container until it can be evaluated by EH&S personnel. Contact **EH&S at (530) 752-1493** or hazwaste@ucdavis.edu for inspection, pick-up, and disposal.

6. Corrosives

Store *corrosive chemicals* (e.g., acids, bases) below a height of five feet and in secondary containment that is large enough to contain at least 10% of the total volume of liquid stored or the volume of the largest container, whichever is greater.

Acids must **always** be segregated:

- from bases and from active metals (e.g. sodium, potassium, magnesium) at all times and
- Must also be segregated from chemicals which could generate toxic gases upon contact (e.g. sodium cyanide, iron sulfide, potassium ferricyanide).

Specific types of acids require additional segregation:

- Mineral acids must be kept away from organic acids, and

- Oxidizing acids must be segregated from flammable and combustible materials.

Picric acid must be stored wet with at least 30% water, in a cool, dry, well-ventilated area, away from heat sources. Picric acid is considered a flammable solid when wet >30% water. Incompatibilities for picric acid include oxidizers, metals, reducing agents, and bases. Recurring inspection and rehydration should be completed every six months to ensure it does not dry out to <10% water, at which point picric acid becomes unstable and may pose an explosion hazard. See [SafetyNet #104 - Safe Use and Management of Picric Acid](#) for additional information.

Additional guidance for handling and storage of nitric and perchloric acid is provided in [SafetyNet #14 - Safe Use of Nitric Acid](#) and [SafetyNet #18 - Safe Use of Perchloric Acid](#) respectively.

7. Acutely Toxic Chemicals

Acutely toxic chemicals should be stored based on their hazards and physical properties. Storage for acutely toxic solids and liquids includes secondary containment in a well-ventilated area. Containers should be closed with tape or other sealant. Storage areas for acutely toxic chemicals and their containers must be meticulously labeled. Acutely toxic chemicals shall be stored no higher than eye level (~5ft).

8. Special Storage Requirements

a. Compressed Gas Cylinders

Compressed gas cylinders must be secured to prevent tipping, falling, or rolling caused by contact, vibration, seismic activity, or transportation. Methods for properly securing cylinders include:

- Compressed gas cylinders must be stored with the safety cap in place when not in use and segregated by hazard class.
- Secure cylinders upright to a substantial, fixed surface with restraints made of non-combustible material such as chains.
- Do not expose cylinders to excessive dampness or temperatures >125 °F, nor corrosive chemicals or fumes.
- Secure cylinders to (or within) a rack, rail framework, or similar assembly designed for such use.
- Nesting of cylinders is allowed if a minimum of 3-points of contact can be achieved. If dislodged, cylinders must not obstruct the required means of egress.
- Secure cylinders on carts or other mobile devices designed for the moving of cylinders, when transporting cylinders.
- Cylinders must be restrained by at least one non-combustible restraint, but preferably

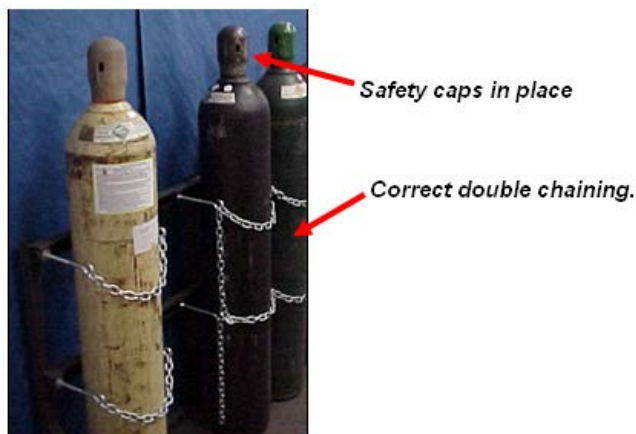


Figure VI-III. Proper Compressed Gas Cylinder Storage

two non-combustible restraints; one restraint at 1/3 from the top of the cylinder, and the other at 1/3 from the bottom of the cylinder (see **Figure VI-III**).

- Bolted “clam shells” may be used in instances where gas cylinders must be stored or used away from walls or racks.

Certain gas cylinders and chemicals require additional precautions. **Cylinders containing certain gases are prohibited from being stored in a horizontal position, including those which contain a water volume of more than 5 liters.** Compressed oxygen gas cylinders must be stored at least 20 feet away from combustible materials and flammable gases. Liquefied fuel gas cylinders must be stored securely in the upright position. Piping and tubing for flammable, corrosive and toxic gases must be made of compatible materials.

Gas cylinder connections must be inspected frequently for deterioration and must never be used without a regulator. Never use a leaking, corroded or damaged cylinder and never refill compressed gas cylinders. When stopping a leak between cylinder and regulator, **always** close the valve before tightening the union nut. The regulator should be replaced with a safety cap when the cylinder is not in use. Gas cylinders must be moved with the safety cap in place using carts designed for this purpose. Separate empty from full cylinders in storage areas, and arrange full cylinders such that the oldest materials are utilized first. Refer to the UC Davis [SafetyNet #60 - Compressed Gas Safety](#), the [gas cylinder safety video](#) from Dow Chemical Company, and [Safetygram #10](#) from Air Products for more information. **Toxic, corrosive, and pyrophoric gases have special handling and storage requirements.** Contact [Fire Prevention](mailto:FirePrevention@ucdavis.edu) and chem-safety@ucdavis.edu for additional information. [Training on toxic compressed gases](#) is available through the LMS.

b. Cryogenic Liquids

Because cryogenic liquid (*e.g.* Nitrogen, Argon, Helium, etc.) containers are at low pressure and have protective rings mounted around the regulator, they are not required to be affixed to a permanent fixture such as a wall. However, additional protection considerations should be addressed when storing cryogenic liquids in a laboratory. The primary risk to laboratory personnel from cryogenic liquids is skin or eye damage caused by contact with the material. Additionally, all cryogenic liquids have large expansion volumes, typically greater than 500:1 when transitioning from a cryogenic liquid to a room temperature gas. This volumetric increase can create high pressure hazards if confined to a closed system; pressure relief valves must **always** be functional and unobstructed. While the gases are usually not toxic, a significant risk of asphyxiation is a possibility due to oxygen displacement. Consult with EH&S prior to locating cryogenic liquids in confined spaces or areas without adequate ventilation. **Always** use appropriate thermally insulated gloves when handling cryogenic liquids. Face shields may be needed in cases where splashing can occur. Refer to the UC Davis [SafetyNet #58 - Safety Precautions for Cryogenic Liquids](#) and the [cryogen safety video](#) from the Dow Chemical Company for further information. Training on the [Cryogen Safety](#) is available through the LMS.

E. On-Campus Transport of Hazardous Chemicals

Precautions must be taken when transporting hazardous materials between laboratories and buildings. Chemicals must be transported in break-resistant, secondary containers such as commercially available bottle carriers made of rubber, metal, or plastic, that include carrying handle(s) and which are large enough to hold the contents of the chemical container in the event of breakage. Consult the UC Davis *Hazardous Chemical Use, Storage, Transportation, and Disposal* ([PPM 290-65](#)) for more information on campus policy regarding chemical transportation.

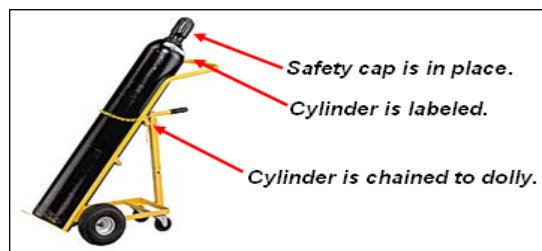


Figure VI-IV. Correct Transport of Compressed Gas Cylinder

When transporting cylinders of compressed gases, **always** secure the cylinder with straps or chains onto a suitable hand truck (dolly) and protect the valve with a safety cap. Avoid dragging, sliding, or rolling cylinders and use a freight elevator when possible. **Figure VI-IV** illustrates correct cylinder transport. **Never transport a cylinder with a regulator attached.**

F. Off-Campus Transport or Shipment of Hazardous Chemicals

The transportation of hazardous chemicals and compressed gases over public roads, or by air, is strictly governed by international, federal, and state regulatory agencies, including the U.S. Department of Transportation (DOT) and the International Air Transport Association (IATA). Any person who prepares and/or ships these types of materials must ensure compliance with pertinent regulations regarding training, quantity limits, packaging, labeling, documentation and hazard communication. **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. UC Davis campus personnel who sign hazardous materials manifests, shipping papers, or those who package hazardous material for shipment, must be properly trained and certified. Consult the UC Davis *Hazardous Chemical Use, Storage, Transportation, and Disposal* ([PPM 290-65](#)) for more information on campus policy regarding chemical transportation and shipping.

Individuals who wish to ship or transport hazardous chemicals or compressed gases off-campus, even when using UC Davis or personal vehicles, must contact EH&S at (530) 752-1493 or hazshipping@ucdavis.edu for assistance.

VII. Training

A. Regulatory Requirements

The necessary work practices, procedures, and policies outlined in this chapter are required by the following:

- [8 CCR §3380](#), “Personal Protection Devices”
- [8 CCR §5191](#), “Occupational Exposures to Hazardous Chemicals in Laboratories”
- [8 CCR §5194](#), “Hazard Communication”
- [8 CCR §5209](#), “Carcinogens”
- [19 CCR §2659](#), “Training”

B. Introduction

Effective training is critical to facilitate a safe and healthy work environment and prevent laboratory accidents. All PIs/Laboratory Supervisors must participate in formal safety training and ensure that all their employees have appropriate safety training before working in a laboratory. Comprehensive resources are available at the [EH&S website for training](#).

C. Types of Training

All laboratory personnel must complete the online [UC Laboratory Safety Fundamentals](#) training course before: beginning work in a laboratory. Additionally, before being granted unescorted access to a laboratory, personnel must complete and document site-specific safety orientation and training. Guidance on materials that need to be covered in the site-specific safety orientation and training is provided in the [Safety Orientation and Training Checklist for New Laboratory Personnel](#), which includes documentation of training on the campus CHP and any applicable [LSPs](#). Note, equivalent existing checklists and documentation are also acceptable.

Additional training may be needed when:

1. New hazards are introduced into the workplace.
2. New work activities/processes are to be implemented.
3. New equipment is introduced into the workplace.

EH&S offers [general classroom and online training](#), plus resource materials to assist laboratories in implementing laboratory-specific training. Questions regarding laboratory safety training can be directed to researchsafety@ucdavis.edu.

1. UC Laboratory Safety Fundamentals Training

The UC Laboratory Safety Fundamentals training includes:

- Review of laboratory rules and regulations, including the Chemical Hygiene Plan and the “Laboratory Standard”.
- Recognition of laboratory hazards.
- Use of engineering controls, administrative controls and PPE to mitigate hazards.
- Exposure limits for hazardous chemicals.
- Signs and symptoms associated with exposures to hazardous chemicals;
- Chemical exposure monitoring.
- Review of reference materials (*e.g.* SDS) on hazards, handling, storage and disposal of hazardous chemicals.
- Procedures for disposing of hazardous chemical waste.
- Fire safety and emergency procedures.
- Information required by [8 CCR §3204](#) regarding access to employee exposure and medical records.

All laboratory personnel must take and successfully complete the online [UC Laboratory Safety Fundamentals](#) online course prior to working in the laboratory and being granted unescorted access. Refresher training for “Fundamentals” is required every three years.

2. Laboratory-Specific Safety Orientation & Training

PIs/Laboratory Supervisors must also provide site-specific [safety orientation and training](#) before allowing unescorted access to the laboratory. The use of an existing equivalent checklist documenting training of these topics is also accepted. Topics that require specific training include:

- Location and use of the Laboratory Safety Manual, Chemical Hygiene Plan, SDS(s) and other regulatory information (*e.g.* “Laboratory Standard” [8 CCR §5191](#)).
- Review of departmental IIPP and Emergency Action Plan, including location of emergency equipment and exit routes.
- Specialized equipment, including Engineering Controls.
- Administrative Controls, including Standard Operating Procedures.
- Personal Protective Equipment.
- Chemical Spill Response (*see* [SafetyNet #13](#)).
- Specialized procedures and protocols.
- Particularly Hazardous Substances including physical and health hazards, potential exposure, medical surveillance, and emergency procedures.
- Methods and observations to detect chemical releases.
- Any applicable Laboratory Safety Plans.

General laboratory safety training requirements are summarized on the EH&S [Safety Training Matrix for Laboratory Personnel](#). A complete list of available health and safety training is provided at the [EH&S website](#). This includes classroom as well as online training. Laboratory and research targeted safety training resources are listed at the [Laboratory and Research Safety Training website](#). Additional training and informational resources are available from the [University of California EH&S Lab Safety Training webpage](#). The following provides an outline of the expected general laboratory safety training and frequency intervals:

A. **Initial:**

- i. UC Laboratory Safety Fundamentals
- ii. Site-Specific Safety Orientation and Training (includes, IIPP, EAP, CHP, SOPs, LSP, etc.)
- iii. Fume hood operation (included in Laboratory Safety Fundamentals) or biosafety cabinet operation (if necessary)
- iv. LHAT – PPE Training
- v. Lab-specific Chemical Spill Response (SafetyNet#13)
- vi. Cryogen Safety (if necessary)

B. **Annual:**

- i. IIPP, EAP, CHP updates, LSP if applicable
- ii. Chemical Spill Response (SafetyNet#13)
- iii. Lab-specific safety topics (e.g.: laser, radiation)

C. **Triennial:**

- i. UC Laboratory Safety Fundamentals refresher
- ii. SOPs (if no revision has triggered earlier training)

EH&S provides additional assistance in planning laboratory-specific training upon request.

D. Documentation of Training


Accurate recordkeeping is a critical component of health and safety training. Per OSHA regulations, departments or laboratories are responsible for documenting health and safety training, including safety meetings, one-on-one training, classroom, and online training. Documentation should be maintained with the Laboratory Safety Manual or be otherwise readily available. Additional information on recordkeeping can be found in [Chapter VIII](#).

A generic [safety training attendance form](#) is available on the UC Davis EH&S website.

**Documentation of Training
 Acutely Toxic Materials**

(signature of all users is required)

- ✓ Prior to conducting any work with (SOP Title) **Acutely Toxic Materials**, laboratory personnel must be trained on the hazards involved in working with this SOP, how to protect themselves from the hazards, and emergency procedures.
- ✓ Ready access to this SOP and to a Safety Data Sheet for each hazardous material described in the SOP must be made available.
- ✓ The Principal Investigator (PI), or the laboratory supervisor if the activity does not involve a PI, must ensure that his/her laboratory personnel have attended appropriate laboratory safety training or refresher training within the last three years.

Designated Trainer: *(signature is required)* 

I have read and acknowledge the contents, requirements, and responsibilities outlined in this SOP:

Name	Signature	Trainer Initials	Date

V1 011113

VIII. Inspections and Compliance

A. Regulatory Requirements

The necessary work practices, procedures, and policies outlined in this chapter are required by the following:

- [8 CCR §3203](#), “Injury Illness Prevention Program”
- [8 CCR §5191](#), “Occupational Exposures to Hazardous Chemicals in Laboratories”

B. Laboratory Safety Inspections – Lab Personnel

The primary goal of safety inspections is to identify both existing and potential incident-causing hazards, activities, procedures, and faulty operations that can be corrected **before** an incident occurs. Regular laboratory inspections performed by laboratory personnel have been shown to substantially improve laboratory safety conditions, reduce accidents and incidents, and should help to ensure fewer findings when inspections are performed by regulatory personnel or other campus inspectors.

PIs/Laboratory Supervisors are required to self-inspect their laboratories on a routine basis, **at least annually**. While inspections are a snapshot in time and cannot identify every accident-causing condition, they do provide important information on the overall operation of a particular laboratory. Laboratory personnel may use the EH&S [self-inspection checklist](#), or use an alternate inspection checklist at the discretion and preference of laboratory personnel that best meets the needs of the laboratory. Note, a self-inspection checklist is available within the online [Safety Inspection Tool \(SIT\)](#).

Follow-up and documentation related to any identified corrective actions is very important. Inspection documentation for recent inspections and follow-up actions should be maintained and readily available.



C. Laboratory Safety Reviews – EH&S

Under the direction of the CLSC, EH&S has instituted a comprehensive [Laboratory Safety Review Program](#) to assist laboratories and other facilities in maintaining a safe work environment. This program provides assistance to aid compliance with regulations and to fulfill UC Davis’s commitment to protecting the health and safety of the campus community. These safety reviews are meant to supplement laboratory self-inspections. The safety reviews 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. The [criteria of the Laboratory Safety Review](#) are available from the EH&S website.

Once the review is completed, a Laboratory Safety Review Report is issued via e-mail. The report will identify deficiencies in the laboratory, both serious and non-serious.

Serious deficiencies are those which have the potential to lead to serious injuries or be of critical importance. Corrective action for serious deficiencies must be initiated within 3 days.

Non-serious deficiencies must have corrective action initiated within 30 days.

If corrective action is not undertaken in the identified time period, an escalation process will be initiated. Depending on the severity of the deficiency, the EH&S Research Safety Manager, in consultation with the Chairperson for the CLSC, may temporarily suspend research activities until the deficiency is corrected. In some cases, the PI/Laboratory Supervisor may be required to provide a corrective action plan to the CLSC prior to resuming research activities.

D. Recordkeeping Requirements

Accurate recordkeeping demonstrates a commitment to the health and safety of the UC Davis community, integrity of research, and protection of the environment. EH&S is responsible for maintaining records of the safety reviews, accident investigations, monitoring equipment calibration, and training conducted by EH&S staff. Per OSHA regulations, departments or laboratories must document health and safety training, including safety meetings, one-on-one training, classroom training, and online training. A copy of recent Laboratory Safety Review Report and [self-inspection](#) documentation must also be maintained or otherwise be readily available. Additionally, the following records must be retained in accordance with the requirements of state and federal regulations:

1. Measurements taken to monitor employee exposures.
2. Inventory and use records for high-hazard substances.
3. Any medical consultation and examinations records, including tests or written opinions required by [8 CCR §5191](#).

IX. Hazardous Chemical Waste Management

A. Regulation of Hazardous Waste

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 most of our waste is 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 [Yolo County Environmental Health Services - Hazardous Materials Programs](#).

B. Hazardous Waste Program

The EH&S Hazardous Waste Program manages the shipment and disposal of all hazardous waste generated on campus. All laboratory personnel must comply with the campus Integrated Hazardous Waste program requirements and all applicable regulations. A regular pick-up service is provided to most research buildings equipped with labs, and a pick-up is available upon request to other locations where hazardous waste is generated. Laboratory personnel are responsible for identifying, labeling, and properly storing hazardous waste in the laboratory. [Laboratory clean-outs](#) and disposal of high hazard compounds must be scheduled in advance. The PI/Laboratory Supervisor is responsible for coordinating the disposal of all chemicals from his/her laboratories including prior to closing down laboratory operations. Comprehensive UC Davis requirements and guidance related to hazardous waste are provided in [UC Davis Hazardous Materials and Hazardous Waste Management](#), including a list of hazardous wastes, current definitions of hazardous waste, and related guidance.



Additional hazardous chemical waste information is available from:

- [SafetyNet #8 - Guidelines for Disposal of Chemical Waste](#)
- [SafetyNet #34 - Managing Chemical Waste Streams to Reduce Disposal Cost](#)
- [SafetyNet #43 - Identification and Segregation of Chemical Waste](#)
- [SafetyNet #110 - Guidelines for Completing the Chemical Waste Label](#)
- [SafetyNet #124 - Empty Container Management](#)

1. Definition of Hazardous Waste

EPA regulations define hazardous waste as substances having one of the following hazardous characteristics:

- Corrosive: $\text{pH} \leq 2$ or $\geq 12.5^3$
- Ignitable: liquids with flash point below 60°C or 140°F (*e.g.* Methanol, Acetone)
- Reactive: unstable, explosive or reacts violently with air or water, (*e.g.* Sodium metal) or produces a toxic gas when combined with water, or contains cyanides or sulfides that can create a toxic gas or vapor
- Toxic: Determined by toxicity testing (*e.g.* Mercury)

The EPA definition of hazardous waste also extends to the following items:

- Abandoned chemicals
- Unwanted chemicals
- Chemicals in deteriorating containers
- Empty containers that have visible residues
- Containers with conflicting labels
- Unlabeled or unknown chemicals

Chemicals not in frequent use must be carefully managed to prevent them from being considered a hazardous waste. This is especially true for certain compounds which degrade and destabilize over time and require careful management so they do not become a safety hazard (see [Wastes Which Require Special Handling](#)). **NOTE** the campus has more stringent waste restrictions as it relates to drain disposal of materials, be sure to consult the [Drain Disposal](#) section and consult [EH&S](#) prior to placing any materials into any campus drain.

2. Extremely Hazardous Waste

Certain compounds meet an additional definition known as “extremely hazardous waste”. This list of compounds includes carcinogens, pesticides, and reactive compounds, among others (*e.g.* cyanides, sodium azide, and hydrofluoric acid). The Federal EPA refers to this waste as “acutely hazardous waste,” but Cal/EPA has published a more detailed list of extremely hazardous waste. Both the State and Federal lists are included in the [EH&S List of Extremely Hazardous Waste](#). **NOTE**: While there is some overlap with the list of Particularly Hazardous Substances, such as the examples listed above, the extremely hazardous waste list is specific to the hazardous waste management program.

3. Biohazardous and Medical Waste

Please consult [SafetyNet #3 - Sharps Safety Guidelines](#) and the [Medical Waste Management](#) website for UC Davis information on biohazardous and medical waste, and contact [EH&S Biosafety](#) for handling and disposal information.

³ There are additional restrictions on the disposal of substances with a non-neutral pH; see the section on [Drain Disposal](#).

4. Radiological Waste

Activities that produce or use radioactive materials may generate radioactive waste. Waste generated by research activities at UC Davis is typically low-level radioactive waste. The UC Davis [procedures for radioactive waste disposal](#) are described on the Radiological Safety page of the EH&S website and [SafetyNet #9 - Guidelines for Disposal of Radioactive Waste](#). Please contact [EH&S](#) for additional information.

C. Proper Hazardous Waste Management

1. Training

All personnel who are responsible for handling, managing or disposing hazardous waste must attend training **prior** to working with these materials. [Hazardous Waste Minimization](#) training is available from EH&S, and includes instruction on the [container labeling program](#). Each laboratory must also complete annual training on their lab-specific spill response procedures and the [CUPA self-audit](#).



2. Waste Identification

All the chemical constituents in each hazardous waste stream must be accurately identified by laboratory personnel, even those components present at trace levels. This is a critical safety issue for both laboratory personnel and hazardous waste technicians who handle the waste once it is turned over to EH&S. Mixing of incompatible waste streams has the potential to create violent reactions and is a common cause of laboratory accidents. If there is uncertainty about the composition of a waste stream resulting from an experimental process, laboratory personnel must consult the PI/Laboratory Supervisor, the CHO, or the Hazardous Materials Manager. 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 commercial chemical products; and also the chemical, physical, and toxicological properties of the ingredients. The [UC SDS website](#) provides access to SDS for hazardous chemicals.

3. Labeling

Comprehensive [UC Davis hazardous waste labeling information](#) is provided on the EH&S website, and an [online system for generating hazardous waste labels \(WASTe\)](#) is also provided. Related information is available from [SafetyNet #110 – Guidelines for Completing the Chemical Waste Label](#). Refer to these resources as **all** hazardous waste must be appropriately labeled.

Tracking #: 0002228		
Accumulation Start Date: 2016-09-22 Must Be Given to EH&S By: 2017-03-21		
Contents: Chemical Name		Amount
Ethylene Diamine		100 %
500.0 mL Liquid Bottle, Glass		
<input checked="" type="checkbox"/> Flammable <input checked="" type="checkbox"/> Corrosive Acid (pH<2) <input type="checkbox"/> Reactive <input type="checkbox"/> Extremely Hazardous		
<input type="checkbox"/> Toxic <input type="checkbox"/> Corrosive Base (pH>12.5) <input type="checkbox"/> Oxidizer		
		
0002228		
UC-DEMO -- not available --		
-- not available -- -- not available --		
HAZARDOUS WASTE		
Generator Account Name: Cat's Test Lab		
Your Name: Natalie Portman		Phone #: (123) 456-7899
Location: Chemistry, 1234A		
Comments:		

4. Storage

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. This means the SAA should be located in an area that is supervised and is not accessible to the public. The chosen SAA within the laboratory should be properly labeled and located in such a place as to minimally impact normal laboratory activities. Other SAA requirements include the following:

1. Hazardous waste containers must be labeled at all times.
2. Waste must be collected and stored at or near the point of generation.
3. According to State law, the maximum amount of waste that can be stored in a SAA is 55 gallons of a hazardous waste or one liter of extremely hazardous waste. If you reach these volumes for a specific waste stream, you must dispose of the waste within three days.
4. The maximum amount of flammable solvents allowed to be stored in a laboratory is 60 gallons; this limit also includes waste solvents.
5. All hazardous waste containers in the laboratory must be kept closed when not in use.
6. Hazardous waste streams must have compatible constituents, and must be compatible with the containers in which they are stored.
7. Hazardous waste containers must be stored in secondary containment at all times. Primary waste containers must be in good condition with leak proof lids.
8. Containers must be less than 90% full.
9. Dry wastes must be double-bagged in clear, three-mil plastic bags.

5. Segregation

All hazardous waste must be managed in a manner that prevents spills and unexpected reactions. Additionally, proper waste segregation can help reduce disposal costs. Whenever possible, recommended segregation approaches include:

- Segregate:
 - acids from bases
 - oxidizers from organics
 - cyanides from acids
 - halogenated solvents from non-halogenated solvents
 - radioactive waste from chemical waste
- Exclude metals from solvent wastes.

Refer to *SafetyNet #43 – Identification and Segregation of Chemical Waste* for additional guidance on chemical waste segregation.

6. Incompatible Waste Streams

Mixing incompatible waste streams, or selecting a container that is not compatible with its contents, is a common cause of accidents in laboratories and waste storage facilities. Reactive mixtures can cause catastrophic container failure, 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 waste container, so personnel in the laboratory will be aware and manage the container and waste accordingly.

Some common incompatible waste streams include:

- Oxidizers added to any fuel can create an exothermic reaction and may cause catastrophic container failure. The most frequent is acids oxidizing flammable liquids. Piranha etch solution is a specific waste stream which contains sulfuric acid and hydrogen peroxide. This forms a reactive mixture often still fuming during disposal. For this waste stream, and other reactive mixtures like it, vented caps are mandatory.

US EPA has provided guidance on the compatibility of hazardous wastes, which can be obtained from [Yale University EH&S](#).

7. Accumulation Time

Hazardous waste may not accumulate anywhere on campus for more than one year. This one-year period includes the 60-90 days EH&S may need to store the waste prior to shipment. As such, hazardous wastes must be removed from laboratories no more than 270 days after the accumulation start date.

One major exception to the one year maximum accumulation period pertains to [extremely hazardous wastes](#). Extremely hazardous wastes (*e.g.* hydrofluoric acid, arsenic or bromine-containing wastes) may not be accumulated for more than 90 days if certain volume limits are exceeded. For this reason, EH&S advises removal of all hazardous waste as soon as containers are full or at least every 90 days.

8. Waste Which Require Special Handling

a. Sharps

Syringes, glass pipettes, and other sharps contaminated with hazardous materials (chemicals, radioactive, or biological) must be placed in a specially designed rigid container. Such “sharps” containers can be purchased through the [UC Davis Central Storehouse](#). Do NOT use red medical waste containers for non-medical waste sharps; unless the biohazard symbol has been defaced.

EH&S will pick up sharps waste containers on request for disposal. Autoclaved sharps containers of medical waste must be disposed through EH&S or an approved medical waste disposal company; contact [EH&S Biosafety](#) for more information. Additional guidance for disposal of sharps and broken glassware is available in [SafetyNet #3 - Sharps Safety Guidelines](#).

b. Unknowns

Unlabeled chemical containers and unknown/unlabeled wastes are considered “unknowns”, and additional fees must be paid to have these materials analyzed and identified. These containers must be labeled with the word “unknown”. Do not mix unknowns in order to minimize disposal costs.

c. Peroxide Forming Chemicals

Peroxide-forming chemicals, or PFCs, include a number of substances which 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; thereby, concentrating any peroxides that may have formed in the container.

Each container of peroxide forming chemicals should be dated with the date received and the date first opened.

There are three classes of peroxide forming chemicals:

1. Form potentially explosive peroxides without concentration,
2. Form potentially explosive peroxides on concentration, and
3. Autopolymerize; with each class having different management guidelines (see [SafetyNet #23 - Peroxide Formation in Ether and Other Chemicals](#)).

Ensure containers of PFCs are kept tightly sealed to avoid unnecessary evaporation, as this inhibits the stabilizers that are sometimes added. Visually inspect containers periodically to ensure they are free of exterior contamination or crystallization. PFC containers must be disposed prior to expiration date.

If old containers of peroxide forming chemicals are discovered in the laboratory, (greater than five 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** and contact **EH&S at (530) 752-1493 immediately**. Secure the immediate area and restrict access to the container until it can be evaluated by EH&S personnel.

d. Dry Picric Acid

Picric acid (also known as trinitrophenol) must be kept hydrated at all times, as it becomes increasingly unstable as it loses water content. When dehydrated, it 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 six months. Add distilled 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 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 **EH&S at (530) 752-1493 immediately**. Secure the immediate area and restrict access to the container until it can be evaluated by EH&S personnel.

[SafetyNet #104 - Safe Use and Management of Picric Acid](#) provides additional information related to picric acid.

e. Explosive Compounds with Shipping Restrictions

A variety of other compounds classified as explosives, or are water or air reactive are used in research laboratories. These compounds often have shipping restrictions and special packaging requirements. When disposing these compounds, employees must ensure they are stored appropriately for transport. Flammable metals must be completely submerged in oil before they are offered for waste pick-up. 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. Consult with the Chemical Hygiene Officer and the Integrated Hazardous Waste group for disposal considerations of these compounds.



f. Chemotherapy Waste

Pourable chemotherapy/oncology chemicals should be left in their original container and can be offered for hazardous waste pick-up. Complete the [hazardous waste label](#) and the [hazardous waste disposal request](#).

Medical devices and supplies associated with patient treatment, including tubes, empty containers, syringes, and sharps also contaminated with chemotherapy drugs should not be managed through the standard hazardous waste pick-up system. These are disposed via the medical waste program. Because chemotherapy drugs are potent toxins, special yellow barrels are available for these materials, which are usually located in medical waste storage areas. For more information, contact the [Biosafety Program personnel](#) or the [Medical Waste Management website](#).

g. Animals

Animal carcasses not contaminated with chemicals or radioactive materials are disposed through individual Department contracted service providers. For animal carcasses which have chemical or radioactive material contamination, contact EH&S at (530) 752-1493 or hazwaste@ucdavis.edu for guidance on the needed disposal method.

9. Managing Empty Containers

Empty containers that held [Extremely Hazardous or Acutely Hazardous Waste](#) must be managed as hazardous waste following the standard hazardous waste disposal procedures. **Do not rinse** or reuse these containers.

All other empty hazardous waste containers, if they are less than, or equal to 5 gallons in size, should either be reused for hazardous waste collection, recycled, or discarded. The labels should be completely defaced (remove it or mark it out completely) and the cap removed. Dispose or recycle empty plastic or glass containers as regular trash or in a campus recycling bin.

Empty containers greater than 5 gallons can be reused as a waste container or recycled through Environmental Stewardship and Sustainability. The container must be marked with the date it was emptied, and the container reused or recycled within one year of that date. [EH&S SafetyNet #124 - Empty Container Management](#), provides additional information related to empty container management at UC Davis.

D. Hazardous Waste Minimization

UC Davis is a large quantity generator of hazardous waste. In order to meet our permit obligations and our sustainability mission, EH&S has developed a Hazardous Waste Minimization Program, in an effort to minimize the costs, health hazards, and environmental impacts associated with the disposal of hazardous waste. Additional information and training on [Hazardous Waste Management and Minimization](#) is available.



1. Administrative Controls

In order to reduce the amount of chemicals that become waste, administrative and operational waste minimization controls can be implemented. 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.

Purchasing: When ordering chemicals, be aware of any properties precluding 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 and associated risk. Consider establishing a centralized purchasing program to monitor chemical purchases and avoid duplicate orders. Purchase the minimum quantity needed, and no more than can be consumed within a year.

Inventory: Rotate chemical stock to keep chemicals from becoming outdated, and implement the “first in, first out” approach to stock chemicals. Locate surplus/unused chemicals and attempt to redistribute these to other users, or investigate returning unused chemicals to the vendor.

Operational Controls: Review your experimental protocol to ensure chemical usage is minimized. Reduce total volumes used in experiments; employ small scale procedures when possible. Instead of wet chemical techniques, use instrumental methods, as these generally require smaller quantities of chemicals. Evaluate the costs and benefits of off-site analytical services. Avoid mixing hazardous and non-hazardous waste streams. Reuse solvents if possible. Spent solvents can also be used for initial cleaning, using fresh solvent only for final rinse. Use less hazardous or non-hazardous substitutes when feasible. Some examples include:

- Specialty detergents can be substituted for sulfuric acid/chromic acid cleaning solutions.
- SYBR Safe Gel Green and Gel Red are recommended in place of ethidium bromide.

Ideas for ways to reduce disposal costs are provided in [SafetyNet #72 – Chemical Substitutes](#), and [SafetyNet #34 – Managing Chemical Waste Streams to Reduce Disposal Cost](#).

2. Drain Disposal

UC Davis does not permit drain disposal of chemical wastes, unless a specific dilution and/or neutralization method for a consistent waste stream has been reviewed and approved by EH&S. This applies to weak acid and base solutions. As indicated in previous sections, EPA hazardous waste definitions specify that materials with a pH between 2 and 12.5 are not hazardous wastes. However, drain disposal of these materials is still not permitted, because local industrial waste water discharge requirements have more restrictive pH thresholds (pH < 5 and pH > 11 are prohibited). In addition, acid and base neutralization may be considered waste treatment, a process strictly regulated by the EPA (see “Bench Top Treatment” below). Additional information on drain disposal of materials can be found in [SafetyNet#6 - Drain Disposal Guidelines](#), [Sewer Disposal Guidelines](#), and on the [Local Limits](#) webpage. Contact [EH&S](#) for additional questions about drain disposal variances.

Drain disposal of properly disinfected infectious or bio-hazardous liquids is acceptable, if disinfection is conducted as specified by the [EH&S Biological Safety Program](#), and the liquids disposed contain no other hazardous constituents.

3. Bench Top Treatment

EPA regulations allow some limited bench top treatment of certain chemical waste streams in laboratories provided specific procedures are followed. Due to the stringent nature of these requirements, any treatment of hazardous waste in labs must be reviewed and approved by EH&S. The EPA requirements for treating hazardous waste in laboratories generally follow the [National Research Council "Prudent Practices in the Laboratory" 2011, Chapter 8](#) procedures, or other peer-reviewed scientific publications. The quantity of waste treated in one batch cannot exceed 5 gallons of liquid or 18 kilograms of solid/semi-solid waste. As treatment may result in residuals which may have to be managed as hazardous waste, all residual hazardous waste must be handled according to [UC Davis Hazardous Waste Program requirements](#).

4. Laboratory Clean-out

Laboratory clean-out typically involves the removal and disposal of excess chemicals when a laboratory is closing, moving, or when legacy chemicals have been accumulated. Chemicals should be stored in the original manufacturer container (in good condition) with the original label. Departments must establish processes to ensure laboratory clean-outs are completed when needed and determine the financially-responsible party for disposal costs. EH&S will assist with the completion of a laboratory clean-out. Please contact hazwaste@ucdavis.edu for consultation and guidance.

E. Transportation and Disposal

It is a violation of DOT regulations to transport hazardous waste in personal vehicles. As a result, EH&S provides pick-up services for all hazardous waste generators. These recurring waste pick-ups are for routinely generated research wastes. [Hazardous waste disposal requests](#) can be initiated using the online forms from the EH&S website.

Frequent disposal will ensure that waste accumulation areas in labs are managed properly, and that maximum storage volumes are not exceeded. Once a waste container is 90% full or it is near the *accumulation time* limit, it should be scheduled for pick-up by EH&S. Once an experiment or process is completed, all containers, including those that are partially filled, should be scheduled for EH&S pick-up. *SafetyNet #8 – Guidelines for Disposal of Chemical Waste* provides related information.

Prior to EH&S pick up, please inspect all containers to make sure they are safe to transport. Verify each container has an accurate waste label, and the containers are clean and free of residue and do not show any signs of bulging, fuming, or bubbling. EH&S may refuse to pick up waste that is not properly prepared.

- Hazardous waste pick-ups can be initiated at the *EH&S WASTE website*.
- Radioactive Wastes – related information is available at the *EH&S Radioactive Waste Management website*
- Biohazardous waste (medical waste, infectious materials or biohazardous agents) - contact *Biosafety Program personnel* or waste pick-up requests can be initiated from the *EH&S Biological Waste Management website*
- Controlled Substances – requests for controlled substance disposal can be initiated at the *EH&S Disposal Requests for Controlled Substances website*

X. Chemical and Laboratory Security

A. Motivation

Laboratories and university research activities can become a target of malicious actions with intent of inflicting harm to individuals or pursuant to criminal activity. Implementation of a laboratory security plan can help to mitigate risks of these malicious actions while being complementary to existing laboratory safety policies and procedures. Guidance on the elements of a laboratory security plan is available within [Prudent Practices](#) (see Chapter 10). UC Davis is presently preparing a campus policy on Laboratory Security. Following approval of the policy, this section will be revised for consistency with policy requirements and guidance for implementation. Current campus laboratory security guidance can be found in [SafetyNet #118 - Laboratory Security Tips for Hazardous Materials Users](#). ACS has developed a [security vulnerability checklist](#); it is recommended all laboratories complete this self-assessment.

B. Areas of Concern

1. Chemical Diversion

2. Chemical Release

3. Data Theft or Loss

4. Equipment Theft, Sabotage or Vandalism

5. Activist Protests & Threats

6. Rogue Activities

XI. Accidents and Chemical Spills

A. Regulatory Requirements

The necessary work practices, procedures, and policies outlined in this chapter are required by the following:

- [8 CCR §342](#), “Reporting Work-Connected Injuries”
- [8 CCR §3320](#), “Emergency Action Plan”
- [8 CCR §5162](#), “Emergency Eyewash and Shower Equipment”

B. Overview

Laboratory emergencies may result from a variety of factors, including serious injuries; fires and explosions; spills and exposures; and natural disasters. All laboratory employees should be familiar with and aware of the location of their laboratory’s or department’s emergency action plan and safety manuals. **Before beginning any laboratory task**, know what to do in the event of an emergency situation. Identify the location of safety equipment, including first aid kits, eye washes, safety showers, fire extinguishers, fire alarm pull stations, and spill kits. Plan ahead and know the location of the closest fire alarms, exits, and telephones in your laboratory. Additional information is available including:

- Campus emergency management policy ([PPM 390-10](#)).
- [UC Davis Campus Emergency Management Plan](#).
- Information on [Emergency Management & Mission Continuity](#).
- [Emergency Response Guide for the UC Davis campus](#) provides an overview of emergency response procedures. A separate [Emergency Response Guide for the UC Davis Health System](#) is available for activities at the Sacramento campus. The applicable guide should be posted in each laboratory.

For all incidents requiring emergency response, call 9-1-1.

C. Accidents

In the event of an injury or illness:

1. Seek medical attention if needed.
2. Notify the PI/Laboratory Supervisor immediately.
3. File a Worker’s Compensation claim through the [Employer’s First Report](#) (EFR) system.

Serious injuries and illnesses require an immediate notification to Environmental Health and Safety at (530) 752-1493 during normal business hours or (530) 752-1230 after hours, in accordance with [SafetyNet#121- Reporting Work-Related Fatalities and Serious Injuries or Illnesses](#). The most common examples of a serious injury is anytime an employee is hospitalized, suffers permanent disfigurement (facial burn), or amputation (bony involvement with a finger cut).

PIs/Laboratory Supervisors are responsible for ensuring that their employees receive appropriate medical attention in the event of an occupational injury or illness. All accidents and injuries requiring medical care must be reported to EH&S. At a minimum, each laboratory should have the following preparations in place:

1. Access to a first aid kit.
2. Posting of emergency telephone numbers and locations of emergency treatment facilities, including Occupational Health Services. This information should be reviewed and updated if needed at least annually.
3. Training of adequate number of staff in basic CPR and first aid.
4. Training of staff to accompany injured personnel to medical treatment site and to provide medical personnel with copies of SDS(s) for the chemical(s) involved in the incident.

ACCIDENT PREVENTION METHODS	
Do	Don't
<ul style="list-style-type: none"> • Always wear appropriate eye protection; • Always wear appropriate laboratory coat; • Always wear appropriate gloves; • Always wear closed-toe/closed-heel shoes and full length pants; • Always confine long hair and loose clothing; • Always use the appropriate safety controls (e.g. certified fume hoods); • Always label and store chemicals properly; and • Always keep the work area clean and uncluttered. 	<ul style="list-style-type: none"> • Never enter the laboratory wearing inappropriate clothing (e.g. open-toe shoes and shorts); • Never work alone on procedures involving hazardous chemicals, biological agents, or other physical hazards unless approved by the PI/Laboratory Supervisor; • Never eat, drink, chew gum or tobacco, smoke, or apply cosmetics in the laboratory; • Never manipulate contact lenses in a laboratory; and • Never use damaged glassware or other equipment.

Note the [UC Center for Laboratory Safety](#) maintains a [website of Lessons Learned](#) from previous research-related incidents and injuries. Please review this information such that a known situation that previously resulted in an injury/incident at a previous institution is not repeated at UC Davis. Researchsafety@ucdavis.edu welcomes the opportunity to discuss any previous incidents, corresponding Lessons Learned analyses, and efforts to support dissemination of anonymous Incident and Near-Miss information. By sharing this information at UC Davis, and throughout the UC system, we can aim to learn from previous events with the goal of preventing future recurrence. Efforts are underway to develop an efficient mechanism to anonymously collect and disseminate information on laboratory [Incidents](#) and [Near-Misses](#) to the UC Davis research community and UC system.

If laboratory personnel experience a severe or life threatening injury, or any other medical emergency, call **9-1-1** for emergency response. When treatment at an Emergency Room is needed (e.g. burns, large lacerations, etc.) the two most applicable locations are:

1. [Sutter Davis Hospital Emergency Room](#), (530) 756-6440, 2000 Sutter Place, Davis, CA 95616.
2. [UC Davis Medical Center \(UCDMC\) Emergency Department](#), (916) 734-2011, 2315 Stockton Boulevard, Sacramento, CA 95817.

Personnel with minor injuries should be treated with first aid kits as appropriate, and receive further evaluation and treatment when necessary at:

1. [Occupational Health Services](#), (530) 752-6051, in the Cowell Building, UC Davis campus.
2. [Student Health Services](#), (530) 752-2300, in Student Health and Wellness Center, UC Davis campus.
3. [Employee Health Services](#), (916) 734-3572, at 2221 Stockton Boulevard, Cypress Building, Suite A, UCDMC.

After normal business hours, treatment can be obtained at designated medical centers and emergency rooms. If the injury is work-related, please follow the instructions for [Worker's Compensation Injury Reporting](#).

Note, if your work environment is not in close proximity to Davis, CA (main campus) or Sacramento, CA (UCDMC), you must provide laboratory personnel with guidance on the location and contact information for the most appropriate medical treatment facility to your location. This information shall be contained in either: A) laboratory-specific [SOPs](#), or B) a laboratory-specific [LSP](#).

Serious occupational injuries, illnesses, and exposures to hazardous substances must be reported to EH&S at (530) 752-1493 within eight hours. EH&S will report the event to Cal/OSHA, investigate the accident, and complete exposure monitoring if necessary. Serious injuries include those that result in permanent impairment or disfigurement, or require hospitalization. Examples include, but are not limited to, amputations, lacerations with severe bleeding, burns, concussions, fractures, and crush injuries. As soon as PIs/Laboratory Supervisors are aware of a potentially [serious injury](#), they must contact EH&S. Serious injury posters are displayed across campus with instructions on reporting injuries to EH&S to ensure that all serious injuries are reported to Cal/OHSA within eight hours. See [SafetyNet #121 - Reporting Work-related Fatalities and Serious Injuries or Illnesses](#) for additional information. It is better to over-report injuries than it is to not report at all.

D. Laboratory Safety Equipment

New personnel must be instructed in the location of fire extinguishers, emergency eyewashes, safety showers, and other safety equipment before they begin work in the laboratory. This training is considered part of the laboratory-specific training all lab personnel must complete, and is outlined in the [Site-Specific Safety Orientation and Training Checklist for New Laboratory Personnel](#). Existing equivalent checklists are also acceptable.

1. Fire Extinguishers

All laboratories working with combustible or flammable chemicals must be outfitted with appropriate fire extinguishers. All extinguishers must be mounted on a wall in an area free of

clutter or stored in a fire extinguisher cabinet. Personnel should be familiar with the location, use, and classification of the extinguishers in their laboratory. A helpful overview video on laboratory fires and fire extinguishers is available from the [Dow Chemical Company](#) and [training on the proper operation of a fire extinguisher](#) is available from Fire Prevention.

Laboratory personnel are not required to extinguish fires that occur in their work areas and should not attempt to do so unless:

- It is a small fire (*i.e.* small trash can-sized fire).
- Appropriate training has been received.
- It is safe to do so.
- The person wishes to do so and is capable.

Any time a fire occurs or a fire extinguisher is used, no matter for how brief a period, the PI/Laboratory Supervisor, or most senior laboratory personnel present at the time of the incident, must immediately report the incident to the UC Davis Fire Department at 9-1-1.

2. Safety Showers and Eyewash Stations

Immediate access to emergency eyewash stations and safety showers is required where the risk of chemical exposure can cause:

- eye damage
- severe irritation
- permanent tissue damage
- toxicity by absorption

Access must be available in **10 seconds** or less for a potentially injured individual; and access routes must be kept clear. The installation locations of emergency eyewashes and safety showers shall follow the current version of ANSI Z358.1. Safety showers must have a minimum clearance of 16 inches from the centerline of the spray pattern in all directions at all times; this means that no objects should be stored or left within this distance of the safety shower. Sink based eyewash stations and drench hoses are not adequate to meet this requirement and can only be used to support an existing compliant system. Additionally, keg-type shower/eyewash systems are only acceptable as a temporary solution and are not intended to replace emergency safety showers/eyewash stations.



In the event of contact with a chemical or substance, immediately irrigate the eyes and/or other parts of the body for 15 minutes. Individuals using the emergency eyewash and/or safety shower should be assisted by an uninjured person to aid in decontamination and to encourage the individual to use the eyewash and/or shower for the full 15 minutes. Clothing that has been in contact with hazardous materials must be removed. Fire blankets and clean lab coats may be used to cover the injured person for warmth and modesty. Medical attention must be sought immediately, and the event reported to the PI/Laboratory Supervisor and EH&S (530) 752-1493.

Safety shower/eyewash combination units are tested according to [SafetyNet #66 – Emergency Eyewash and Shower Testing and Use](#).

3. Fire Doors

Many areas of research buildings contain critical fire doors as part of the building design. These doors are an important element of the fire containment system and shall remain closed unless they are held open by an electromagnetic releasing system integrated with the building fire detection system. See [SafetyNet - Fire Door Regulations](#) for more information.

E. Fire-Related Emergencies

Everyone working in a laboratory should know the location and correct use of fire extinguishers. It is important to use the right kind of fire extinguisher for a given fire, as not all extinguishers can be safely used on all types of fires. At UC Davis the following classes of fire extinguishers are most common:

- **A** - Ordinary combustibles including paper, wood, coal, rubber, and textiles.
- **B** - Flammable and combustible liquids including gasoline, diesel fuel, alcohol, motor oil, grease and flammable solvents.
- **C** - Electrical equipment.



If you encounter a fire, or a fire-related emergency (*e.g.* abnormal heating, smoke, burning odor), immediately follow these instructions:

1. Pull the closest fire alarm pull station **and call 9-1-1** to notify the Fire Department.
2. Evacuate and isolate the area
 - Use portable fire extinguishers to facilitate evacuation and/or control a small fire (*i.e.* size of a small trash can), if safe to do so.
 - If possible, shut off equipment before leaving.
 - Close doors.
3. Remain safely outside the affected area to provide details to emergency responders.
4. Evacuate the building when the alarm sounds. **It is against state law to remain in the building when the alarm is sounding.** If the alarm sounds due to a false alarm or drill, you will be allowed to re-enter the building as soon as the Fire Department determines that it is safe to do so. **Do not go back in the building until the alarm stops and you are cleared to reenter by Fire Department personnel.**

If your clothing catches on fire, go to the nearest emergency shower immediately and activate the water flow. If a shower is not immediately available (3-5 steps), stop, drop, and roll; then proceed the nearest safety shower to cool off. A fire extinguisher may be used to extinguish a fire on someone's person. Report any burn injuries to the supervisor immediately and seek medical treatment. Report every fire (even if extinguished), explosion, and all situations having fire or explosion potential to 9-1-1, as required by *Fire Safety (PPM 390-40)*. Contact UC Davis Fire Prevention at 530-752-4268 or 530-752-2059 immediately every time a fire extinguisher is discharged. Information on fire extinguisher training, or to request a new fire extinguisher can be obtained from [UC Davis Fire Prevention](#).

F. Chemical Spills

Chemical spills, or release of gas, chemical smoke, or vapor, can result in chemical exposures and contaminations. [SafetyNet #13 – Guidelines for Chemical Spill Control](#) provides helpful information and should be posted in all laboratories. Additional guidance related to mercury spills is provided in [SafetyNet #16 – Guidelines for Mercury Spill Control](#). These incidents become emergencies when:

- The spill results in a release to the environment (*e.g.* sink or floor drain).
- The material or its hazards are unknown.
- Laboratory personnel cannot safely manage the hazard.
- The material is too hazardous or the quantity is too large to safely manage without professional assistance.

Effective emergency response to these situations is imperative to mitigate or minimize adverse reactions when chemical incidents occur. After emergency procedures are completed, all personnel involved in the incident should follow UC Davis chemical exposure procedures as appropriate (see [Hazard Assessment and Chemical Exposure Monitoring \(HACEM\)](#)).

In the event of a significant chemical exposure or contamination, immediately try to remove or isolate the chemical if safe to do so. When skin or eye exposures occur, remove contaminated clothing and flush the affected area using an eye wash or shower for at least 15 minutes. Remember to wear appropriate PPE before helping others. For a non-emergency chemical ingestion, inhalation, or dermal exposure contact the [California Poison Control System](#) at 1-800-222-1222 immediately for assistance, and seek medical care as instructed. PIs/Laboratory Supervisors must review all exposure situations, make sure affected employees receive appropriate medical treatment and/or assessment, and arrange for containment and clean-up of the chemical as appropriate.

FACTORS TO CONSIDER BEFORE SPILL CLEAN-UP

- Spill location
- Size of spill area/chemical quantity
- Toxicity
- Volatility
- Flammability and presence of ignition sources
- Availability of spill cleanup materials, including proper PPE
- Training of responders

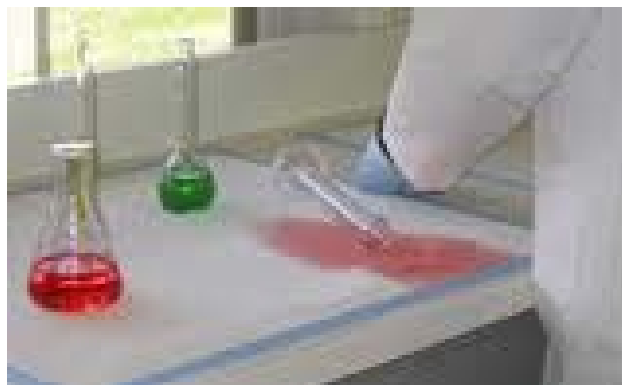
HIGHLY TOXIC CHEMICAL SPILLS

Do not try to clean up spills of any size. All spills of these materials require emergency response:

- Aromatic amines
- Bromines
- Cyanides
- Carbon disulfide
- Hydrazine
- Nitriles
- Ethers
- Nitro-compounds
- Organic halides

1. What to Do With a Small Chemical Spill (< 0.5 Liter)

- Evacuate all non-essential persons from the spill area.
- If needed, call for medical assistance by dialing 9-1-1.
- Help anyone who may have been contaminated. Use emergency eyewashes/showers by flushing the skin or eyes for *at least 15 minutes*. Seek medical attention following use of the eyewash/safety shower.
- Post someone just outside the spill area to keep people from entering. Avoid walking through contaminated areas.
- Before attempting to clean-up a spill you must have the proper protective equipment (including safety goggles, gloves and a laboratory coat or other protective garment) and appropriate clean-up materials. Check the chemical's SDS in your laboratory or [online](#) for spill clean-up procedures, or call EH&S at (530) 752-1493 for guidance.
- Turn off potential ignition sources (*e.g.* open flames, electrical heaters, and other electrical equipment), and close valves on compressed gas cylinders if the chemical is flammable.
- Confine the spill to a small area. Do not let it spread.
- Avoid breathing vapors from the spill. If the spill is in a non-ventilated area, do not attempt to clean it up. Call for emergency personnel to provide HazMat response.
- Work with another person to clean-up the spill. Do not clean-up a spill alone.
- **DO NOT ADD WATER TO THE SPILL.**
- Use an appropriate chemical spill kit to neutralize and absorb inorganic acids and bases. For other chemicals, use the appropriate spill kit or absorb the chemical with sorbent pads, paper towels, vermiculite, dry sand, or diatomaceous earth.
- Collect the residue and place it in a clear plastic bag. Double bag the waste and label the bag with a properly completed [Hazardous Waste label](#).



Note, solid spills are not typically emergencies. If the chemical is toxic, use damp paper towels to transfer it into plastic bags, **DO NOT** dry sweep.

2. What to Do With a Large Chemical Spill (> 0.5 Liter)

Large chemical spills require emergency response. Call 9-1-1. If the spill presents a situation that is IDLH or presents a significant fire risk, activate a fire alarm, evacuate the area and wait for emergency response to arrive.

- Remove the injured and/or contaminated person(s) and provide first aid.
- Call for emergency medical response.
- As you evacuate the laboratory, close the door behind you, and:
 - Post someone at a safe distance from the spill area to keep people from entering the spill area.
 - Confine the spill area if possible and safe to do so.
 - Leave on or initiate exhaust ventilation;
 - If possible, turn off all sources of flames, electrical heaters, and other electrical equipment if the spilled material is flammable.
 - Avoid walking through contaminated areas or breathing vapors of the spilled material.
 - Any employee with known contact with a particularly hazardous chemical must shower, including washing of the hair as soon as possible unless contraindicated by physical injuries.



G. Earthquake

In the event of an earthquake, please take the following precautions:

1. Take cover under a desk or strong doorframe during the shaking.
2. Remain under cover indoors until the shaking subsides. Evacuate the building only once the shaking has ceased.
3. Report any injuries or broken utility services to 9-1-1.
4. Assist any injured individuals with receiving medical attention.
5. Be prepared for these events. Know your department's Emergency Action Plan.

XII. Acknowledgements & References

UC Davis acknowledges the assistance of the UCLA Office of Environment, Health & Safety. The UCLA Laboratory Safety Manual and Chemical Hygiene Plan served as a base reference for much of the content, and was augmented and adapted for applicability to UC Davis.

Supporting and cited materials are referenced electronically via hyperlink throughout the document whenever possible. The following publications served as substantive information references.

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APPENDICES

A. Glossary

ACCIDENT - an undesired event that results in personal injury or property damage, as defined by the [National Safety Council](#).

ACGIH - The [American Conference of Governmental Industrial Hygienists](#) is a voluntary membership organization of professional industrial hygiene personnel in governmental or educational institutions. The ACGIH develops and publishes recommended occupational exposure limits each year called Threshold Limit Values (TLVs) for hundreds of chemicals, physical agents, and biological exposure indices.

ACTION LEVEL - A concentration designated in Title 8, California Code of Regulations 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.

AEROSOL - Liquid droplets or solid particles dispersed in air that are of fine enough size (less than 100 micrometers) to remain dispersed for a period of time.

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

BIOLOGICALS - Medicinal preparation made from living organisms and their products, including, but not limited to, serums, vaccines, antigens and anti-toxins.

"C" OR CEILING - A description usually seen in connection with a published exposure limit. It refers to the concentration that should not be exceeded, even for an instant. It may be written as TLV-C or Threshold Limit Value - Ceiling. (See also Threshold Limit Value).

CARCINOGEN - A cancer-producing substance or physical agent in animals or humans. A chemical is considered a carcinogen or potential carcinogen if it is so identified in any of the following:

- National Toxicology Program, "Annual Report of Carcinogens" (latest edition)
- International Agency for Research on Cancer, "Monographs" (latest edition)
- OSHA, 29 CFR §1910, Subpart Z, Toxic and Hazardous Substances

Cal/OSHA has an additional definition for [Select Carcinogens](#). Additional information is available in the UC Davis Carcinogen Manual.

CHEMICAL HYGIENE OFFICER - An EH&S employee who is qualified by training or experience to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan and Standard Operating Procedures.

CHEMICAL HYGIENE PLAN - A written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment, and work practices that (1) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (2) meets the requirements of OSHA regulation 29 CFR 1910.1450.

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

COMPRESSED GAS - A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 °F (21.1 °C), or; a gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 °F (54.4 °C) regardless of the pressure at 70 °F (21.1 °C), or; a liquid having a vapor pressure exceeding 40 psi at 100 °F (37.8 °C) as determined by ASTM D-323-72.

CORROSIVE - A substance that, according to the DOT, causes visible destruction or permanent changes in human skin tissue at the site of contact or is highly corrosive to steel.

DESIGNATED AREA - An area which has been established and posted with signage for work involving hazards (*e.g.* "select carcinogens," reproductive toxins, or substances which have a high degree of acute toxicity). A designated area may be the entire laboratory, an area of a laboratory, or a device such as a laboratory hood.

EMERGENCY - Any potential occurrence, such as, but not limited to, equipment failure, rupture of containers, or failure of control equipment which could result in an uncontrolled release of a hazardous chemical into the workplace.

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

FLAMMABILITY LIMITS - The range of concentrations where a gas or vapor (from a liquid) as a mixture in air will propagate a flame and cause an explosion. The concentration range spans the lower flammability limit (lower explosive limit) for the minimum concentration to the upper flammability limit (upper explosive limit) for the maximum concentration. Note that these limits vary according to temperature, oxygen levels, and the presence of other chemicals.

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

1. Flammable aerosol - an aerosol that, when tested by the method described in 16 CFR §1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening.
2. Flammable gas - a gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13% by volume or less; or a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12% by volume, regardless of the lower limit.
3. Flammable liquid - any liquid having a flashpoint 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% or more of the total volume of the mixture.

4. Flammable solid - a solid, other than a blasting agent or explosive as defined in 29 CFR §1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and, when ignited, burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR §1500.44, it ignites and burns with a self-sustained flame at a greater than one-tenth of an inch per second along its major axis.

FLASHPOINT - The minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite in the presence of an ignition source or when tested as follows:

1. Tagliabue Closed Tester (See American National Standard Method of Test for Flashpoint by Tag Closed Tester, Z11.24-1979 (ASTM D-56-79) for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 °F (37.8 °C) or that contain suspended solids and do not have a tendency to form a surface film under test.
2. Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7-1979 (ASTM D-73-79) for liquids with a viscosity equal to or greater than 45 SUS at 100 °F (37.8 °C), or that contain suspended solids, or that have a tendency to form a surface film under test.
3. Setaflash Closed Tester (See American National Standard Method of Test for Flashpoint of Setaflash Closed Tester (ASTM D-3278-78)). Organic peroxides, which undergo auto accelerating thermal decomposition, are excluded from any flashpoint determination methods specified above.

GENERAL VENTILATION - Also known as general exhaust ventilation, this is a system of ventilation consisting of either natural or mechanically induced fresh air movements to mix with and dilute contaminants in the workroom air. This is not the recommended type of ventilation to control contaminants that are highly toxic, when there may be corrosion problems from the contaminant, when the worker is close to where the contaminant is being generated, and where fire or explosion hazards are generated close to sources of ignition. (See Local Exhaust Ventilation)

HAZARD ASSESSMENT - A formal procedure undertaken by the Principal Investigator or designee in which occupational hazards for all employees are described per procedure or task, and by affected body part(s) or organ(s), and which is documented and posted in the workplace with all personal protective equipment requirements.

HAZARD WARNING - Any words, pictures, symbols or combination thereof appearing on a label or other appropriate form of warning which convey the hazards of the chemical(s) in the container(s).

HAZARDOUS CHEMICAL - Any chemical which is classified as a physical hazard, or a health hazard, a simple asphyxiant, combustible dust, pyrophoric gas, a hazard not otherwise classified, or is included in the List of Hazardous Substances prepared by the Director pursuant to Labor Code 6382 ([8 CCR §339](#)). A chemical is also considered hazardous if it is listed in any of the following:

1. OSHA, 29 CFR §1910, Subpart Z, Toxic and Hazardous Substances.
2. "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment," ACGIH (latest edition).

3. "The Registry of Toxic Effects of Chemical Substances," NIOSH (latest edition).

HAZARDOUS MATERIAL (DOT) - A substance or material capable of posing an unreasonable risk to health, safety, and property when transported including, but not limited to, compressed gas, combustible liquid, corrosive material, cryogenic liquid, flammable solid, irritating material, material poisonous by inhalation, magnetic material, organic peroxide, oxidizer, poisonous material, pyrophoric liquid, radioactive material, spontaneously combustible material, and water-reactive material.

HEALTH HAZARD - From [8 CCR §5194](#), a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, and neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes or mucous membranes. The criteria for determining whether a chemical is classified as a health hazard are detailed in [Appendix A](#), which incorporates by reference [29 CFR 1910.1200 Appendix A](#).

HIGHLY TOXIC - A substance falling within any of the following categories:

1. A substance that has a median lethal dose (LD₅₀) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
2. A substance that has a median lethal dose (LD₅₀) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each.
3. A substance that has a median lethal concentration (LC₅₀) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

INCIDENT - an unplanned, undesired event that adversely affects completion of a task.

IGNITABLE - A solid, liquid or compressed gas waste that has a flashpoint of less than 140 °F. Ignitable material may be regulated by the EPA as a hazardous waste as well.

INCOMPATIBLE - The term applies to two substances to indicate that one material cannot be mixed with the other without the possibility of a dangerous reaction.

IRRITANT - A substance which, by contact in sufficient concentration for a sufficient period of time, will cause an inflammatory response or reaction of the eye, skin, nose or respiratory system. The contact may be a single exposure or multiple exposures. Some primary irritants: chromic acid, nitric acid, sodium hydroxide, calcium chloride, amines, metallic salts, chlorinated hydrocarbons, ketones, and alcohols.

LABEL - Any written, printed or graphic material displayed on or affixed to containers of chemicals, both hazardous and non-hazardous.

LABORATORY TYPE HOOD - A device located in a laboratory, enclosed on five sides with a movable sash or fixed partial enclosure on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

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

LABORATORY USE OF HAZARDOUS CHEMICALS - Handling or use of such chemicals in which all of the following conditions are met:

1. Chemical manipulations are carried out on a "laboratory scale".
2. Multiple chemical procedures or chemicals are used.
3. The procedures involved are not part of a production process nor in any way simulate a production process.
4. "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

LOCAL EXHAUST VENTILATION (Also known as exhaust ventilation) – A ventilation system that captures and removes the contaminants at the point they are being produced before they escape into the workroom air. The system consists of hoods, ductwork, a fan, and possibly an air-cleaning device. Advantages of local exhaust ventilation over general ventilation include: it removes the contaminant rather than dilutes it, requires less airflow and, thus, is more economical over the long term; and the system can be used to conserve or reclaim valuable materials; however, the system must be properly designed with the correctly shaped and placed hoods, and correctly sized fans and ductwork.

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

MIXTURE - Any combination of two or more chemicals if the combination is not, in whole or in part, the result of a chemical reaction.

MUTAGEN - Anything that can cause a change (or mutation) in the genetic material of a living cell.

NEAR-MISS - As defined by [OSHA](#), refers to incidents where no property was damaged and no personal injury sustained, but where, given a slight shift in time or position, damage and/or injury easily could have occurred. General examples of near-misses include:

- Any non-compliance that could have led to an accident.
- Observation of unsafe conditions such as fire risks, faulty equipment, or failure to use appropriate PPE.

- Falling or flying objects that do not make contact with individuals nor cause any significant property damage.
- Waste going into the wrong waste stream.
- Failure of any equipment or associated systems that are in place to protect health and safety (e.g. fume hoods, glove boxes).
- Unexpected failure of building facilities systems which may compromise laboratory activities (e.g. water supply, HVAC system).

Some specific examples of near-misses that have occurred in academic research include:

- a. A vacuum pump leaking oil creates a slick floor surface where someone slips but does not fall nor is injured.
- b. A centrifuge tube breaks but not all of the broken glass is removed from the rotor. Someone reaches into the rotor and is poked by a residual piece of broken glass but no laceration occurs.
- c. Incompatible material is added to a hazardous waste container. The waste container pressurizes and ruptures while the lab is unoccupied. No equipment damage or chemical exposure occurs.

NFPA - The *National Fire Protection Association*; a voluntary membership organization whose aims are to promote and improve fire protection and prevention. NFPA has published 16 volumes of codes known as the National Fire Codes. Within these codes is Standard No. 705, "Identification of the Fire Hazards of Materials". This is a system that rates the hazard of a material during a fire. These hazards are divided into health, flammability, and reactivity hazards and appear in a well-known diamond system using from zero through four to indicate severity of the hazard. Zero indicates no special hazard and four indicates severe hazard. (Note: The GHS system uses a numerical severity rating that is opposite.)

NIOSH - The *National Institute for Occupational Safety and Health*; a federal agency that among its various responsibilities trains occupational health and safety professionals, conducts research on health and safety concerns, and tests and certifies respirators for workplace use.

ODOR THRESHOLD - The minimum concentration of a substance at which a majority of test subjects can detect and identify the substance's characteristic odor.

OXIDIZER - Is a substance that gives up oxygen easily to stimulate combustion of organic material.

PERMISSIBLE EXPOSURE LIMIT (PEL) - An exposure, inhalation or dermal permissible exposure limit specified in 8 CCR §5155. PELs may be either a time-weighted average (TWA) exposure limit (8-hour), a 15-minute short-term limit (STEL), or a ceiling (C).

PERSONAL PROTECTIVE EQUIPMENT - Any devices or clothing worn by the worker to protect against hazards in the environment. Examples are respirators, gloves, and chemical splash goggles.

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

PYROPHORIC - A chemical that will spontaneously ignite in the air at a temperature of 130°F (54.4°C) or below.

REACTIVITY - A substance's susceptibility to undergoing a chemical reaction or change that may result in dangerous side effects, such as explosion, burning, and corrosive or toxic emissions. The conditions that cause the reaction, such as heat, other chemicals, and dropping, will usually be specified as "Conditions to Avoid" when a chemical's reactivity is discussed on an SDS.

RECOMMENDED EXPOSURE LIMIT (REL) - NIOSH maximum recommended concentration to which workers can be exposed for time-weighted average (TWA) for up to a 10-hour work day during a 4-hour work week. The recommendations are proposed for adoption as PELs by OSHA.

REPRODUCTIVE TOXINS - Chemicals which negatively affect the reproductive capabilities including fertility, chromosomal damage (mutagenesis), and effects on fetuses (teratogenesis).

RESPIRATOR - A device which is designed to protect the wearer from inhaling harmful contaminants.

RESPIRATORY HAZARD - A particular concentration of an airborne contaminant that, when it enters the body by way of the respiratory system or by being breathed into the lungs, results in some body function impairment.

SAFETY DATA SHEET (SDS) - Written or printed material concerning a hazardous chemical which is prepared in accordance with paragraph (g) of [29 CFR §1910.1200](#).

SATELLITE ACCUMULATION AREA (SAA) - Places where wastes are generated in the industrial process or the laboratory and where those wastes must initially accumulate prior to removal to a central area.

SELECT CARCINOGENS - Any substance which meets one of the following:

1. It is regulated by OSHA as a carcinogen.
2. It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition).
3. It is listed under Group 1 ("carcinogen to humans") by the International Agency for Research on Cancer Monographs (IARC)(latest editions).
4. It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:
 - a. After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m³;
 - b. After repeated skin application of less than 300 mg/kg of body weight per week; or
 - c. After oral dosages of less than 50 mg/kg of body weight per day.

SENSITIZER - A substance that may cause no reaction in a person during initial exposures, but afterwards, further exposures will cause an allergic response to the substance.

SERIOUS INJURY OR ILLNESS - Any injury or illness occurring in a place of employment or in connection with any employment which requires inpatient hospitalization for a period in excess of 24 hours for other than medical observation or in which an employee suffers a loss of any member of the body or suffers any serious degree of permanent disfigurement, but does not include any injury or illness or death caused by a Penal Code violation, except the violation of Section 385 of the Penal Code, or an accident on a public street or highway.

SHORT-TERM EXPOSURE LIMIT (STEL) - Represented as STEL or TLV-STEL, this is the maximum concentration to which workers can be exposed for a short period of time (15 minutes) for only four times throughout the day with at least one hour between exposures. Also the daily TLV-TWA must not be exceeded.

SOLVENT - A substance, commonly water, but in industry often an organic compound, which dissolves another substance.

THRESHOLD LIMIT VALUE (TLV) - Airborne concentration of substances devised by the ACGIH that represents conditions under which it is believed that nearly all workers may be exposed day after day with no adverse effect. TLVs are advisory exposure guidelines (not legal standards) that are based on evidence from industrial experience, animal studies, or human studies when they exist. There are three different types of TLVs: Time-Weighted Average (TLV-TWA), Short-Term Exposure Limit (TLV-STEL), and Ceiling (TLV-C). (See also PEL).

TOXICITY - A relative property of a material to exert a poisonous effect on humans or animals and a description of the effect and the conditions or concentration under which the effect takes place.

VAPOR - The gaseous form of substances which are normally in the liquid or solid state (at normal room temperature and pressure). Vapors evaporate into the air from liquids such as solvents. Solvents with lower boiling points will evaporate faster.

B. General Rules for Laboratory Work with Chemicals

Prudent Laboratory Practices

It is prudent to minimize all chemical exposures. Few laboratory chemicals are without hazards, and general precautions for handling all laboratory chemicals should be adopted, in addition to specific guidelines for particular chemicals. Exposure should be minimized even for substances of no known significant hazard, and special precautions should be taken for work with substances that present special hazards. One should assume that any mixture will be more toxic than its most toxic component and that all substances of unknown toxicity are toxic.

Avoid inadvertent exposures to hazardous chemicals by developing and encouraging safe habits and thereby promoting a strong safety culture.

Safe Laboratory Habits

1. Personal Protective Equipment

- Wear closed-toe/closed-heel shoes and full length pants, or equivalent, at all times when in the laboratory.
- Utilize appropriate PPE while in the laboratory and while performing procedures that involve the use of hazardous chemicals or materials. These items may include laboratory coats, gloves, and safety glasses or goggles. (See [UC Davis 290-50, Protective Clothing and Equipment](#).)
- Confine long hair and loose clothing.
- Wear appropriate gloves when the potential for contact with toxic materials exists; inspect the gloves before each use, and replace them often. Remember that latex gloves provide little to no protection from solvents and strong corrosives.
- Remove laboratory coats or gloves immediately on significant contamination, as well as before leaving the laboratory.
- Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken.
- Ensure that appropriate PPE is worn by all persons, including visitors, where chemicals are stored or handled.
- Use appropriate respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls, inspecting the respirator before use. Respirator requirements are summarized in [SafetyNet #88 – The Respiratory Protection Program](#).
- Use any other protective and emergency apparel and equipment as appropriate. Be aware of the locations of first aid kits and emergency eyewash and shower stations.

2. Chemical Handling

- Before using any chemical know its characteristics (SDS are an excellent source of information) including:
 - Quantity that is toxic or hazardous
 - Route(s) of exposure
 - Type of hazard
 - Method of chemical action in the body
 - Symptoms of exposure
 - Physical properties of the chemical
 - Chemical compatibility
- Use only those chemicals for which the quality of the available ventilation system is appropriate.
- Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices.
- Properly label and store all chemicals. Use secondary containment at all times;
- Keep chemical containers tightly closed when not in use.
- Segregate chemicals in storage to keep adequate separation between incompatible materials.
- **Do not** store chemicals in alphabetic order.
- Avoid smelling chemicals.
- Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures in the campus Chemical Hygiene Plan.
- In the case of an accident or spill, refer to the emergency response procedures for the specific material. These procedures should be readily available to all personnel. Information on minor chemical spill mitigation may also be referenced in [SafetyNet #13 - Guidelines for Chemical Spill Control](#). For general guidance, the following situations should be addressed:
 - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention.
 - Skin Contact: Promptly flush the affected area with water and remove any contaminated clothing. If symptoms persist after washing, seek medical attention.
 - Clean-up: Promptly clean up spills, using appropriate protective apparel and equipment, and proper disposal.

3. Equipment Storage and Handling

- Use equipment only for its designed purpose.
- Store laboratory glassware with care to avoid damage. Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur.
- Use certified fume hoods, glove boxes, or other ventilation devices for operations which might result in release of toxic chemical vapors or dust. Preventing the escape of these types of materials into the working atmosphere is one of the best ways to prevent exposure.
- Keep hood closed at all times, except when adjustments within the hood are being made.

- Leave the fume hood "on" even when it is not in active use if toxic substances are in the fume hood or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off."

4. Laboratory Operations

- Keep the work area clean and uncluttered.
- Seek information and advice about hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation.
- If unattended operations are unavoidable, and have been approved by the PI/Laboratory Supervisor, place an appropriate sign on the door, leave lights on, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water).
- Vacuum lines must be protected with traps to prevent contamination.
- Be alert to unsafe conditions and ensure that they are corrected when detected.
- Use of headphones in the laboratory, for non-research purposes is strongly discouraged, some of the risks are highlighted in a [video from Cornell](#). If headphones are used in the laboratory for non-research purposes leave one ear unobstructed to be able to hear any sounds and language of any emergency events.
- If personal electronic devices (*e.g.* laptop, cellular phone, MP3 player, etc.) are used in the laboratory, take precautions to prevent contamination with hazardous materials
- Know the locations of fire extinguishers, alarm pull stations, eyewashes, and emergency showers, and know how they operate.
- Immediately report any fires or fire extinguisher discharge to the PI/Laboratory Supervisor.

5. Hazardous Waste

- Call EH&S with any problem concerning hazardous waste and its disposal.
- Completely fill out and attach hazardous waste labels before waste accumulation starts.
- Date containers when the first drop of waste is added to the container.
- Use only screw-top containers that can be securely closed.
- Keep containers closed except when being filled.
- Leave headspace in containers for expansion (do not fill over 90% full).
- Keep waste in secondary containers and properly labeled.
- Substitute less hazardous chemicals whenever possible.

Unsafe Laboratory Habits

1. Personal Protective Equipment

- Do not enter the laboratory without wearing appropriate clothing, including closed-toe/closed-heel shoes and full length pants, or equivalent. The area of skin between the shoe and ankle should not be exposed.
- Do not wear laboratory coats or gloves outside of the laboratory area.

2. Chemical Handling

- Do not smell or taste chemicals.
- Do not allow release of toxic substances or fumes into cold or warm rooms, as these types of areas typically involve re-circulated atmospheres.
- Never use mouth suction for pipetting or starting a siphon.
- Do not dispose any hazardous chemicals through the sewer system. These substances might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow.

3. Equipment Storage and Handling

- Do not use damaged glassware or other equipment, under any circumstances. The use of damaged glassware increases the risks of implosion, explosion, spills, and other accidents.
- Do not use uncertified fume hoods or glove boxes for hazardous chemical handling.
- Avoid storing materials in hoods and do not allow them to block vents or air flow.

4. Laboratory Operations

- Never work alone on procedures involving hazardous chemicals, biological agents, or other physical hazards unless you have received prior approval from the PI/Laboratory Supervisor.
- Avoid unattended operations, if at all possible. Unattended operations require prior approval from the PI/Laboratory Supervisor.
- Do not engage in distracting behavior such as practical joke playing in the laboratory. This type of conduct may confuse, startle, or distract another worker.

5. Hazardous Waste

- Do not mix chemical waste streams, *e.g.* halogens, metals, solvents, etc.
- Never put chemical hazardous waste in red or biohazard bags.
- Do not place sharps, pipettes or broken glass in plastic bags (use an appropriate sharps container).
- Do not leave waste containers open.
- Never guess at the contents of an unknown container.

6. Food/Drink

- Do not eat, drink, smoke, chew gum, or apply cosmetics in areas where hazardous chemicals are present; wash hands before conducting these activities.
- Do not store, handle, or consume food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations involving hazardous chemicals.
- Wash areas of exposed skin well before leaving the laboratory.

C. Chemical and Workspace Labeling

Primary Container Labeling

Most manufacturer labels provide safety information to inform about chemical hazards and to help workers protect themselves. This information may include protective measures and/or protective clothing to be used, first aid instructions, storage information and emergency procedures.

On original manufacturer containers the label must not be removed or defaced in any way until the container is emptied of its original contents. Incoming containers must be inspected to make sure the label is in good condition. Date new chemicals when they are received in the laboratory, as well as the initials of the responsible person. Time-sensitive peroxide forming chemicals should be labeled with the date received and date opened.

Secondary Container Labeling

The appropriate labeling of secondary chemical containers (*i.e.* containers used for storing commercial chemicals that are not the original manufacturer packaging) or laboratory-prepared solutions/dilutions is important to laboratory safety. With the exception of transient containers that will contain chemicals for immediate use and will not be left unattended, all containers of chemicals being used or generated in UC Davis research laboratories should be labeled sufficiently to indicate the contents of the container. Many chemicals lack a unique identification property (e.g. color, odor, etc.), and are thus impossible to distinguish based on sensory assessment. Following a consistent and comprehensive chemical labeling approach in the laboratory has many advantages including, but not limited to the following:

- To help prevent hazardous reactions resulting from the accidental combination of incompatible chemicals.
- To give workers the “right to know” regarding hazardous chemical exposure.
- To minimize the high costs associated with the disposal of unknown chemicals.
- To facilitate the proper storage and segregation of chemicals.
- To enable a quick response in the event of a chemical spill or other emergency.

Appropriate labeling impacts the safety of various stakeholders in the laboratory, including laboratory personnel, safety personnel, and support personnel. Although experienced laboratory personnel may have learned and adapted to a prescribed labeling convention, new or inexperienced personnel may have difficulties understanding the labeling conventions used in a new laboratory setting. Additionally, improperly-labeled or unlabeled chemicals can be dangerous for safety and support personnel including, but not limited to:

- Laboratory personnel
- Laboratory Safety Officers/Laboratory Managers
- Custodial personnel
- Hazardous waste disposal personnel

- Facilities and Maintenance and Design and Construction Management personnel
- School/College/Departmental Safety Coordinators/Safety Officers
- Laboratory Safety Professionals
- Contractors
- Emergency Responders
- Regulatory Officials (e.g. California Safety and Health Administrations (Cal/OSHA), California Department of Public Health Representatives (CDPH), Department of Toxic Substances and Control (DTSC), California Unified Program Agency (CUPA), etc.

Standardized laboratory chemical labeling conventions are important to avoid confusion. Labels containing the proper chemical name, in English, can eliminate the confusion that may be caused when acronyms are used. Some examples of potentially confusing acronyms/abbreviations are:

- ABS: Acrylonitrile Butadiene Styrene *or* Alkyl Benzene Sulfonate
- ACN: Acetonitrile *or* Acrylonitrile
- BHA: Beta Hydroxy Acid *or* Butylated Hydroxyanisole
- DBA: 4-(Dimethylamino)azobenzene *or* 3,3'-Diaminobenzidine *or* 1,4-Diaminobutane
- IPA: Isopropyl Alcohol *or* India Pale Ale (☺)
- PAN: Phosphorus, Acetic and Nitric Acids *or* Peroxyacetyl Nitrate
- PGA: PhosphoGliseric Acid *or* PhosphoGlyceric Acid *or* PolyGlycolic Acid
- TEA: Triethylamine *or* Triethanolamine

At a **minimum**, the following information must be provided on a hazardous chemical container:

1. The name of the chemical written in legible English:
 - a. Acronyms or abbreviations may be used so long as the corresponding definitions are posted in a prominent location and available to all laboratory occupants. Any acronyms/abbreviations being used in the laboratory must be legible, located on a conspicuous area of the container, and included in the definitions posting;
2. The hazard(s) associated with the chemical. Any of the following hazard-labeling systems may be used:
 - a. Word(s) that explain the hazard
 - i. The use of acronyms or abbreviations for the hazard statement is strongly discouraged
 - ii. The warning may be a single word (e.g. “Danger”, “Caution”, “Warning”) or preferably identifies the hazard(s), including both physical (e.g. “Water Reactive”, “Flammable” or “Explosive”) and health (e.g. “Carcinogen”, “Corrosive”, “Irritant”, etc.), such as what is found on the NFPA diamond and in hazard warnings on the manufacturer label or SDS
 - b. Globally Harmonized System (GHS) hazard *pictograms*
 - c. National Fire Prevention Association *diamond*
3. *Chemicals prone to peroxide formation* must have:
 - a. Date Received
 - b. Date Opened

Additionally, the following information should be provided on a hazardous chemical container:

4. The name of the person responsible for the chemical.
5. The date the chemical was synthesized or transferred from the original container.

Containers of non-toxic and normally harmless chemicals should also be labeled with content information, including containers such as squirt bottles containing water or containers of buffer solutions. This helps to minimize the inadvertent combination of incompatible materials.

There are a few other laboratory labeling situations that occur frequently:

- A. Small vials can be grouped into one secondary container which is labeled with the above listed information.
- B. Novel chemicals need to be labeled based upon knowledge of the chemical and physical properties. If these properties are unknown, the materials should be treated similarly to *Particularly Hazardous Substances* and labeled as “Toxic”.
- C. Temporary flasks must be labeled following the above requirements whenever they are left unattended.

Chemical Labeling – What are Laboratory Personnel Responsible for?

- Inspecting incoming containers to be sure that labels are attached and are in good condition and contain the information outlined above;
- Reading the container label each time a newly purchased chemical is used. It is possible that the manufacturer may have added new hazard information or reformulated the product since the last purchase;
- Ensuring that chemical container labels are not removed or defaced, except when containers are empty;
- Labeling any secondary containers used in the laboratory, to prevent unknown chemicals or inadvertent reaction; and
- Verifying that chemical waste containers have complete and accurate chemical waste labels

Labeling Resources and Options

Labels should be durable and water, solvent and fade-resistant.

Inexpensive commercially-manufactured squeeze bottles printed with NFPA triangle and/or GHS hazard labels are available for commonly used solvents. These are optimal because solvents tend to erode labels over time. [Fisher Scientific](#), [Thermo Scientific](#), and other laboratory equipment vendors offer a wide variety of options.



Pre-Printed Solvent Squeeze Bottles¹

Label Makers

Commercial label makers are available starting at prices as low as \$20 and can be used to make simple text labels. [Brother](#) manufactures many options, which can be used in conjunction with [Brother TZe tape](#) that adheres to glass, metal and plastic and resists fading, water and solvents.

Labels pre-printed with the applicable GHS hazard pictograms can be used to identify hazards. [Fisher Scientific](#), [Labelmaster](#), and other vendors offer options for hazard symbol labels, and some (e.g. [LabelMaster](#)) even offer a [variety pack of hazard labels](#). Additionally, EH&S has a Cobra Systems printer capable of printing labels on vinyl adhesive tape for a variety of unique safety situations, including the GHS pictograms.



Pre-printed Labels/Pictograms

Ink-Jet/Laser-Jet Printer Labels

[Avery](#) and other manufacturers offer a multitude of adhesive labels and document templates to assist the creation of laboratory labels. By using printed text, a large amount of information can be placed legibly into a smaller area than would be possible by hand-written ink. One great application of this type of label is for ampules. Once the printed label has been adhered to the container surface it can be further covered by clear tape to improve the label's durability.


















Workspace Labeling

It is good laboratory practice to label one's workspace to convey information regarding the activities and hazards to other laboratory occupants. Workspaces **must** be labeled under the following conditions:

1. In areas where radioactive materials are used or stored;
2. In areas where *Particularly Hazardous Substances* are used or stored, including:
 - a. Acutely Toxic Materials;
 - b. Carcinogens; and
 - c. Reproductive Toxins;
3. When a reaction is left unattended; and
4. When a reaction is left overnight.

Vet Med Central Storehouse on campus sells a variety of materials that aid chemical labeling in the laboratory. For more information on labeling, see *Chapter 6: Inventory, Labeling, Storage, and Transport* and *SafetyNet #42 - General Guidelines for Storage and Management of Laboratory Chemicals*.

D. Globally Harmonized System (GHS) – Old vs. New GHS System

OLD			NEW		
Symbols	Description		GHS-Symbols	Description	Hazard statement examples
	E	Explosive		GHS01 Exploding bomb	Explodes due to fire, shock, friction or heat; danger due to fire, blast and projectiles.
	F+ F	Extremely flammable Highly flammable		GHS02 Flame	Flammable; catches fire spontaneously if exposed to air; in contact with water releases flammable gases which may ignite spontaneously.
	O	Oxidizing		GHS03 Flame over circle	May cause fire or explosion; strong oxidizer.
No equivalent				GHS04 Gas cylinder	Contains gas under pressure; may explode if heated; contains refrigerated gas; may cause cryogenic burns or injury.
	C	Corrosive		GHS05 Corrosion	May be corrosive to metals; causes severe skin burns and eye damage.
	T+ T	Very toxic Toxic		GHS06 Skull and crossbones	Small quantities are harmful or fatal.
	Xn	Harmful	No direct equivalent		
	Xi	Irritant			
No equivalent				GHS07 Exclamation mark	Harmful, irritates eyes, skin or respiratory system; large quantities are fatal.
No direct equivalent				GHS08 Health hazard	Causes allergic reactions; may cause cancer, may cause genetic defects; may damage fertility or the unborn child; causes damage to organs.
	N	Dangerous for the environment		GHS09 Environment	Harmful, toxic or very toxic to aquatic life with long lasting effects.

E. Particularly Hazardous Substances – Supplemental Information

Particularly Hazardous Substances Definitions

Particularly hazardous substances fall into the following three major categories: acute toxins, reproductive toxins, and carcinogens.

Acute Toxins

Substances that have a high degree of acute toxicity are substances that may be fatal or cause damage to target organs as the result of a single exposure or exposures of short duration. They can be defined as:

1. A chemical with a median lethal dose (LD₅₀) of 50 mg or less per Kg of body weight when administered orally to albino rats weighing between 200 and 300 grams each;
2. A chemical with a median lethal dose (LD₅₀) of 200 mg or less per Kg of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 Kg each; and
3. A chemical that has a median lethal concentration (LC₅₀) in air of 5000 ppm by volume or less of gas or vapor, or 50 mg per liter or less of mist, fume, or dust, when administered by continuous inhalation for 1 hour (or less if death occurs within 1 hour) to albino rats weighing between 200 and 300 grams each.

Reproductive Toxins

Reproductive toxins include any chemical which may affect the reproductive health of men and women including fertility, chromosomal damage (mutagenesis), and developmental effects on embryos or fetuses (teratogenesis). A list of reproductive toxins is maintained online at http://oehha.ca.gov/prop65/prop65_list/Newlist.html.

Carcinogens

Carcinogens are chemical or physical agents that are capable of causing cancer. Generally, they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure and their effects may only become evident after a long latency period. Comprehensive UC Davis requirements related to carcinogens originally provided in the UC Davis Chemical Carcinogens Manual are under revision during the 2017-2018 Academic Year. Please contact [EH&S](#) with any questions you may have on the safety expectations for carcinogen use during this transitional period.

F. Segregation of Incompatible Chemicals

Table F.1 contains a list of incompatible chemicals. The following chemicals, listed in the left column, should not be used with chemicals listed in the right column, except under specially controlled conditions. Chemicals in the left column should not be stored in the immediate area with chemicals in the right column. Incompatible chemicals should **always** be handled, stored or packed so that they cannot accidentally come into contact with one another. This list is representative of chemical incompatibilities and is not complete, nor are all incompatibilities shown.

Table F.1 – Incompatible Chemicals

Chemical	Keep Out of Contact with:
Alkaline metals, (powdered aluminum, magnesium, sodium, potassium, etc.)	Carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide and water
Acetic Acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides and permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver and mercury
Ammonia	Mercury, chlorine, calcium hypochlorite, iodine, bromine and hydrofluoric acid
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organic or combustible materials
Carbon, activated	Calcium hypochlorite
Copper	Acetylene and hydrogen peroxide
Chromic acid	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol and flammable liquids
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane, hydrogen, sodium carbide, turpentine, benzene and finely divided metals
Cyanides	Acids - organic or inorganic
Hydrogen peroxide	Copper, chromium, iron, most metals, alcohols, acetone, organic materials, aniline, nitromethane, flammable liquids and combustible materials
Hydrogen sulfide	Fuming nitric acid and oxidizing gases
Hydrocarbons (butane, propane, benzene, gasoline, turpentine etc.)	Fluorine, chlorine, bromine, chromic acid and sodium peroxide
Iodine	Acetylene, ammonia and hydrogen
Nitric acid	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass and any heavy metals
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, ether, oils and grease
Phosphorous	Oxidizing agents, oxygen, strong bases
Potassium chlorate	Sulfuric and other acids
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde and sulfuric acid
Sodium	Carbon tetrachloride, carbon dioxide and water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate and furfural
Sulfides, inorganic	Acids Sulfuric acid Potassium chlorate, potassium perchlorate and potassium permanganate

Special Segregation of Incompatible Chemicals

In addition to the segregation noted in Table M.1, dangerously incompatible substances, even in small quantities, should not be stored next to each other on shelves or in such a position that accidental rupture of containers may allow mixing. Table M.2 contains examples of dangerously incompatible substances. Table M.3 contains examples of incompatible oxidizing agents and reducing agents.

Table F.2 – 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

Table F.3 – Incompatible Oxidizing Agents and Reducing Agents

Oxidizing Agents	Reducing Agents
Chlorates	Ammonia
Chromates	Carbon
Dichromates	Metals
Chromium trioxide	Metal hydrides
Halogens	Nitrates
Halogenating agents	Organic Compounds
Hydrogen peroxide	Phosphorus
Nitric acid	Silicon
Nitrates	Sulfur
Perchlorates	
Peroxides	
Permanganates	
Persulfates	

EH&S *provides additional information on incompatible materials..*

G. Summary of Revisions

The following are brief descriptions of revisions to v1.0 of the UC Davis Laboratory Safety Manual that were approved by the CLSC:

1. Revised Appendix C on Chemical and Workspace Labeling;
2. Added guidance language regarding headphones in laboratories (for non-research purposes);
3. Added guidance language regarding personal electronic devices and contamination prevention;
4. Added GHS Hazard Code discussion;
5. Added Controlled Substances, Tax-free Alcohol, and Electrical Safety PPM;
6. Added language regarding eyewash installation expectations (following current version of ANSI Z358.1);
7. Moved “Laboratory Safety Equipment” (IV.C.3.d) to Chapter XI, and added reference to Title 8 Eyewash regulation.
8. Added language regarding review/revision frequency for emergency contact information;
9. Added revised UC Davis Principles of Safety;
10. Added UCSD corrosive video and eye protection video links;
11. Added language regarding Fire Prevention’s virtual fire extinguisher training;
12. Added reference to 8 CCR 5139 as it relates to HACEM and engineering controls for exposure protection;
13. Updated all SDS references to remove language on Chemwatch and added language and hyperlink for ucsds.com;
14. Added Responsibility to applicable personnel groups with respect to notification of fire extinguisher discharge and/or fire event;
15. Added hyperlink to Yale pyrophoric training, removed UCLA video hyperlink/reference;
16. Updated manual cover image;
17. Added language regarding SOP training expectations;
18. Added SOP Executive Summary description;
19. Added hyperlink to SIT;
20. Added self-inspection SIT language;
21. Updated injury/illness language to reflect Employer’s First Report application and notification/reporting expectations;
22. Added guidance for Laboratory Safety Plan and hyperlink to LSP template. LSP development is required for:
 - a. Unique hazards, engineering controls, and/or PPE policy (e.g. clean room);
 - b. PI/Lab Supervisor formally delegates any assigned CHP Responsibility; and
 - c. Lab has received an approved exception to the PPE bare minimum attire.
23. Added language regarding revisions/updates to campus Carcinogen Program;
24. Added training frequency guidance language;
25. Moved pyrophorics from Reactivity hazard to Flammability hazard section;
26. Added storage guidance clarification for Group X materials;
27. Removed language regarding new CIS release/deployment/reporting thresholds;
28. Added language regarding no hazardous chemical storage in vivarium/procedure rooms;

29. Updated CA Fire Code Pyrophoric Chapter reference;
30. Updated hazardous shipping contact to hazshipping@ucdavis.edu; and
31. Added additional Drain Disposal language by the hazardous waste definitions section.

The following are brief descriptions of revisions to v1.1 of the UC Davis Laboratory Safety Manual that were approved by the CLSC:

1. Added signed letter of expectation for laboratory safety from campus leadership.
2. Added Principles of Safety updated graphic.
3. Added Responsibilities Section for Fire Marshal/Fire Prevention.
4. Added Section on Pesticides and reference to PPM 290-95.
5. Added Section for Shop Safety and reference to PPM 290-58.
6. Added separate links to campus ERG and UCDHS ERG.
7. Added PI Responsibility to consult Fire Prevention for activities with inherent fire or explosion potential.
8. Added Lab Personnel responsibility to obtain PI/Lab Sup approval for new chemical purchase/use.
9. Added APLU and NAS Safety Culture reports hyperlinks and references. Added ACS Guidelines for Chemical Laboratory Safety in Academic Institutions reference, hyperlinks, and graphic image.
10. Added materials from APLU task force report
 - a. <http://www.aplu.org/projects-and-initiatives/research-science-and-technology/task-force-laboratory-safety/>
 - b. Core Safety Culture values <http://www.aplu.org/projects-and-initiatives/research-science-and-technology/task-force-laboratory-safety/Core-Values.html>
 - c. Role-specific actions that support Culture of Safety <http://www.aplu.org/projects-and-initiatives/research-science-and-technology/task-force-laboratory-safety/Roles.html>
11. Added “Table of Contents” into the document bookmarks.
12. Added link to CLS Lessons Learned materials.
13. Added language on protecting house vacuum lines.
14. Added language regarding shields for PECs and vacuum work (see old CLSM). Added details regarding face and fixed safety shields.
15. Added link to Nano.gov Resources for Lab Safety (<http://www.nano.gov/node/1606>).
16. Added language regarding acceptable locations for hazardous chemical usage.
17. Added language regarding restrictions on single-pass cooling H₂O, and citation to UCOP sustainability policy.
18. Added hyperlink for “Table of Contents” to improve navigability of pdf file Bookmarks.
19. Added emphasis to elements related to bare minimum attire (and prohibited clothing items) and prohibited eating/drinking/chewing gum and food/beverage storage where hazardous materials are used/stored.
20. Added additional CCR references into the Introduction 8 CCR 3203, 8 CCR 3380, and 8 CCR 5194.
21. Added language related to SafetyNet#131 revisions and PI Responsibilities for Safety Program requirements.
22. Changed emphasis language of Prudent Practices Appendices regarding chemical segregation.

- 23. Moved GHS hazard classification discussion before description of NFPA 704 Standard.
- 24. Updated broken hyperlinks after Safety Services website migration.
- 25. Updated hazardous waste disposal language regarding WASTE.

The following are brief descriptions of revisions to v1.2 of the UC Davis Laboratory Safety Manual that were approved by the CLSC:

1. Added updated Safety Expectations Letter signed by Chancellor May and Provost Hexter.
2. Updated URL links for supporting documentation.
3. Updated emails from researchsafety@ucdavis.edu to chem-safety@ucdavis.edu where appropriate.
4. Added link to 8 CCR §342 regarding reporting of work-related injuries.
5. Added version notation to manual cover.
6. Added reference to LOTO PPM.
7. Added verbiage of recommendation to assign responsible person for safety, and empower them to implement/oversee day-to-day safety in laboratory.
8. Added link/language regarding reassignment of PPE.
9. Added information on EPCRA and CUPA for chemical inventory obligations.
10. Added reference/URL to 8th edition of Safety in Academic Chemistry Laboratories.
11. Revised language on door signage update frequency.
12. Moved the “How to Use...” section earlier in the document.
13. Added language regarding reassignment of lab coats.
14. Added language regarding chemical storage height, below 5 feet for Corrosives and Acutely Toxic materials.
15. Added language regarding transfer pump materials of construction.
16. Changed references to any FireNets to SafetyNets.
17. Added contact information to Plant Operation & Maintenance (PO&M) for fume hood certification and maintenance at the Sacramento campus.
18. Added language regarding annual training on CHP updates.

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