

Laboratory and Research Safety Manual

Revision Date – October 2018

Purpose

The purpose of this manual is to support safe and productive research activities at University of California Agriculture and Natural Resources (UC ANR) facilities and in all projects that are conducted on behalf of UC ANR.

Scope and Applicability

This manual has been prepared by the UC ANR Environmental Health and Safety (EH&S) Department for use by research staff at UC ANR Research and Extension Centers (RECs) and UC Cooperative Extension (CE) offices. This manual also applies to many aspects of UC ANR-sponsored research projects at non-UC sites. Research conducted on a UC campus (or facilities owned and operated by that campus) should be conducted as specified by local campus authorities with this manual serving as a secondary reference applicable primarily in UC ANR facilities.

The typical UC ANR work location reflects the resources and missions of cooperative extension and is diverse in personnel as well as research venues. The regulations in this manual apply primarily to university employees and other employed persons conducting research on behalf of the university. The *principles and guidelines* presented in this manual are intended to apply to the broader UC ANR workforce and outreach network that is involved in UC ANR-sponsored research investigations and operations. The broader UC ANR workforce may include: university employees, county employees, federal employees, temporary employees, students, volunteers, and emeritus retirees.

Specific policies apply to minors (people under 18 years of age) working on research projects or in laboratories. Those policies are not covered in depth in this manual. If minors are employed or volunteering in research projects outside of established UC ANR youth programs (e.g., 4H) contact EH&S for advising before including minors in research activities or inviting them to work in laboratory or animal research projects. See Appendix 1d for UC policy on minors in labs and shops.

Research activities may be conducted in laboratories or other technical work locations such as greenhouses, post-harvest facilities, barns, and other animal housing or husbandry facilities. Research activities may also occur in temporary non-lab locations such as offices or conference rooms, at field sites, or in technical work locations such as post-harvest grading and storage facilities or grain/soil/plant processing and storage facilities.

This manual is meant to be modular, some sections may or may not apply to individual research projects and some sections may be more emphasized and developed based on the specific research operations.

The preface and each section of the manual are to be applied as follows:

- Preface (pages i – xi) – This section provides background on the intended purpose, use, and implementation of this manual as well as key rights and responsibilities as they apply to research safety at UC ANR.
- Section One – Site Safety and Employee Training Records applies to all employees who routinely enter and work in laboratories or on non-lab research projects that require use of personal protective equipment (PPE) for protection from hazardous exposures covered under specific regulations or the location Injury Illness Prevention Plan.
- Section two – Biosafety and Containment applies to employees who work with, or may be exposed to, biological hazards or regulated biological materials (GMOs, plant pests).
- Section Three – Chemical Hygiene Plan is a chemical safety manual and repository for chemical safety standard operating procedures (SOPs). Information in this section applies to any research or location staff who may have hazardous chemical exposures in labs or research projects.
- Section Four – Radiation, Physical Hazards, and Technical Work Locations applies to employees who have hazardous exposures to physical forces in the course of research. This section of the manual can be used by research staff to document safety information for physical hazards such as radiation sources, hazardous equipment, heat illness, or outdoor field work sites. This section applies to research uses of potentially hazardous industrial/agricultural machinery and vehicles used in research such as tractors, forklift/industrial truck, harvester, shop equipment (grinders, saws), all-terrain vehicles, orchard/picking ladders, pesticide application equipment, pack lines, stills, gins, mechanical threshing operations, and any another pressurized, motorized, or noise-generating equipment used in research. This section can also be used as primary section for safety information for outdoor research activities, field work, and non-lab locations.
- Section Five – Occupational Exposure Assessment and Medical Services applies to all employees who have potential for hazardous exposures in the workplace, that is, all employees covered under the Hazard Communication Standard (8CCR5194), the Chemical Hygiene Standard (8CCR5191), the Aerosol Transmissible Disease Standard (8CCR5199), the Zoonotic Disease Standard (8CCR5199.1), the Illness and Injury Prevention Plan (IIPP), and other state and federal occupational exposure regulations and standards, as applicable.

Required elements of a laboratory/research biological safety plan (8CCR5199)

ELEMENT	SEE PAGE(S)
1. Standard operating procedures designed to address safety and health concerns associated with aerosol-transmissible and zoonotic disease hazards	2-8
2. Criteria to be used to identify and implement control measures to reduce exposure (e.g. engineering controls, personal protective equipment)	2-6, 2-12
3. Provisions for employee information and training	1-7, 2-9
4. Protocol for employer pre-approval for certain laboratory operations, procedures, or activities	2-2, 2-8
5. Provisions for medical consultation and examinations	5-5
6. The designation of personnel responsible for performing biological risk assessments	iv – vii, 5-7
7. Provisions for respiratory protection	2-6

Required elements of a chemical hygiene plan (8CCR 5191)

ELEMENT	SEE PAGE(S)
1. Standard operating procedures designed to address safety and health concerns associated with the use of hazardous chemicals in laboratories	3-12
2. Criteria to be used to identify and implement control measures to reduce exposure (e.g. engineering controls, personal protective equipment)	3-9
3. A requirement to ensure that fume hoods and other protective equipment are functioning properly	3-10
4. Provisions for employee information and training	1-7, 3-13
5. Protocol for employer pre-approval for certain laboratory operations, procedures, or activities	3-12
6. Provisions for medical consultation and examinations	5-5
7. The designation of personnel responsible for implementing the chemical hygiene plan, including the assignment of a chemical hygiene officer	iv - vii
8. Provisions for additional employee protection for work with particularly hazardous substances(e.g. select carcinogens, reproductive toxins, acutely toxic substances)	3-7

Rights and Responsibilities

Employee rights

Employees and other personnel who work in laboratories have the right to be informed about the potential health hazards in their work areas and to be properly trained to work safely with those hazards. This includes custodial staff and other personnel who work to clean and maintain laboratories.

Employees have the right to file a complaint with Cal/OSHA if they feel they are being exposed to unsafe or unhealthy work conditions. An employee cannot be discharged, suspended, or otherwise disciplined by their employer for filing a complaint or exercising these rights. All personnel working with hazardous materials are encouraged to report (anonymously, if preferred) any concerns about unsafe work conditions to the UC ANR Environmental Health and Safety (EH&S) Department online at:

<http://ucanr.edu/survey/survey.cfm?surveynumber=1480>

or by contacting Brian Oatman, UC ANR Director or Risk and Safety Services (baoatman@ucanr.edu).

Responsibilities of the UC ANR Vice President

- Implementing the university's environmental health and safety policies at all facilities under UC ANR control. This task has been delegated to UC ANR Risk and Safety Services through the Associate Vice President for Business Operations and the Office of the Controller.

Responsibilities of UC ANR Vice Provost, REC Directors, and County Directors

- Ensuring that *operations and maintenance of ANR facilities* are in keeping with applicable regulations, UC policy, and published standards for laboratory safety.

Responsibilities of UC Campus Departmental Leadership, Deans, REC Directors, and County Directors

- Ensuring that *principal investigators (PIs) under their supervision* adhere to applicable regulations, UC policy, and published standards for laboratory safety.

Responsibilities of the UC ANR Environmental Health and Safety (EH&S) Department

- Updating the ANR laboratory and research safety manual template;
- Assisting in the development and annual review of location-specific Chemical Hygiene Plan(CHP);
- Acting as the liaison and coordinator to the laboratory or location safety representative;
- Acting as the liaison and coordinator for access to UC Campus EH&S and safety representatives;
- Providing biosafety expertise for preparation of biological risk assessments and biosafety plans;
- Providing technical guidance in the development and implementation of the Chemical Hygiene Plan;
- Providing technical guidance in selection of PPE and documenting hazard assessments for PPE;
- Providing periodic safety reviews of labs and research facilities and reporting findings to REC Directors, County Directors, and UC Campus EH&S departments as appropriate;
- Providing funding for initial or routine worksite exposure monitoring (in collaboration with PIs).

Responsibilities of Principal Investigator (PI)

For the purposes of this manual, a principal investigator is defined as the individual (or individual co-investigators) who is (are) responsible to the university (and funding agencies) for delivery of research outcomes. The principal investigator or “PI”, as the director of the research project, has responsibility for the health and safety of all personnel working in his or her research project who handle hazardous chemicals, biological materials, or physical hazards. The PI may delegate safety duties, but remains responsible for ensuring that delegated safety duties are adequately performed.

The principal investigator is responsible for:

- Knowing all applicable health and safety rules and regulations, training and reporting requirements and standard operating procedures associated with laboratory safety for regulated substances (chemicals, biologicals, radiation, and physical hazards);
- Identifying hazardous conditions or operations in the laboratory or other facility containing hazardous materials, determining safe procedures and controls, and implementing and enforcing standard safety procedures;
- Conducting a formal hazard assessment in order to mitigate the hazards found;
- Establishing standard safety operating procedures (general and protocol specific) and performing literature searches relevant to health and safety for laboratory-specific work;
- Ensuring that standard operating procedures (SOPs) and biosafety plans (when required) are written and maintained in the laboratory safety manual.
- Providing prior-approval for the use of hazardous chemicals in the PI’s laboratory;
- Providing prior-approval for the use of infectious substances (human, animal, or plant pathogens) in the PI’s laboratory;
- Consulting with EH&S on the use of higher risk materials, such as use of particularly hazardous substances or potentially infectious research materials;
- Maintaining updated inventory of biological materials and chemicals for the laboratory or facility;
- Ensuring laboratory or other personnel under his/her supervision have access to and are familiar with the appropriate lab safety plans;
- Training all laboratory or other personnel he/she supervises to work safely with hazardous materials and maintain written records of laboratory-specific or other specialized training in the appropriate Lab Safety Plans and documentation.
- Promptly notifying EH&S and/or facilities management should he/she become aware that workplace engineering controls (e.g., fume hoods) and safety equipment (e.g., emergency showers/eyewashes, fire extinguishers, etc.) become bypassed, disabled or non-operational;
- Ensuring the availability of all appropriate personal protective equipment (PPE) which properly fits the wearer (e.g., laboratory coats, gloves, eye protection, etc.), training on the selection, care, use and proper storage, ensuring the PPE is maintained in working order;
- Promptly reporting accidents and injuries to EH&S. Fatalities and serious injuries MUST be reported to EH&S immediately. Any doubt as to whether an injury is serious should favor reporting;
- Providing funding for exposure monitoring and medical surveillance and/or medical consultation and examination for laboratory and other personnel, as required;
- Identifying and minimizing potential hazards to provide a safe environment for repairs and renovations;
- Informing facilities personnel, other non-laboratory personnel and any outside contractors of potential laboratory-related hazards when they are required to work in the laboratory environment;

Responsibilities of All Personnel Who Handle Hazardous Materials in Research

All personnel who use, handle, or store hazardous materials as part of a research project are responsible for:

- Annual review of the chemical safety information and requirements including: Chemical Hygiene Plan or Hazard communication plan), as well as review of the appropriate SOPs, safety plans, and policies (as applicable);
- Annual review of biosafety information and requirements including: Biological Use Authorization, biosafety/containment plan, permit conditions for regulated materials, as well as review of the appropriate SOPs, safety plans, and policies (as applicable);
- Completing all required health, safety and environmental training and providing written documentation to their supervisor;
- Following all verbal and written laboratory safety rules, regulations, and standard operating procedures required for the tasks assigned;
- Following the [UCLA Procedures for Safe use of Pyrophoric Liquid Reagents](#) when applicable;
- Developing good lab hygiene habits, including but not limited to, keeping the work areas safe and uncluttered and not storing or consuming food and drink in research areas where hazardous materials are present;
- Planning, reviewing, and understanding the hazards of materials and processes in their laboratory research or other work procedures prior to conducting work;
- Utilizing appropriate measures to control identified hazards, including consistent and proper use of engineering controls, administrative controls, and personal protective equipment;
- Understanding the capabilities and limitations of personal protective equipment (PPE) issued to them;
- Consulting with and gaining prior approval from the PI before using biological materials that can cause disease in healthy adults, particularly hazardous substances (PHS), explosives, and other highly hazardous materials or equipment;
- Immediately reporting all accidents and unsafe conditions to the PI;
- Participating in the medical surveillance program, when required;
- Informing the PI of any work modifications ordered by a physician as a result of medical surveillance, occupational injury, or exposure;
- When working autonomously or performing independent research or work:
 - Reviewing the plan or scope of work for their proposed research with the PI;
 - Notifying in writing and consulting with the PI, in advance, if they intend to significantly deviate from previously reviewed procedures (Note: Significant change may include, but is not limited to, change in the objectives, change in PI, change in the duration, quantity, frequency, temperature or location, increase or change in PPE, change in scale, and reduction or elimination of engineering controls.);
 - Preparing SOPs and performing literature searches relevant to safety and health that are appropriate for their work;
 - Providing appropriate oversight, training and safety information to laboratory or other personnel they supervise or direct.

Responsibilities of the Location or Laboratory Safety Representative*

*Please note that the location or laboratory safety representative functions as the default Chemical Hygiene Officer

- Preparing and reviewing (at least annually) the site-specific Chemical Hygiene Plan and other site-specific documents in the laboratory and research safety manual;
- Providing guidance and support to the location safety committees;
- Attending and participating in laboratory safety committee meetings;
- Providing technical assistance to laboratory workers;
- Facilitating the implementation of the Chemical Hygiene Plan and assisting in establishing a safe work environment by collaborating with EH&S, faculty, other researchers and lab personnel;
- Providing guidance on laboratory safety compliance and technical subjects;
- Coordinating or providing training on occupational health and safety requirements;
- Serving as a liaison between laboratories and EH&S in helping maintain safety and regulatory information, including Safety Data Sheets (SDS) formerly known as Material Safety Data Sheets (MSDS);
- Requesting information and clarification on regulatory requirements from EH&S;
- Assisting EH&S in evaluating program effectiveness;
- Assisting in responding to any regulatory actions or investigations;
- Communicating with the director, business officer and faculty on laboratory safety and injury/illness prevention efforts and activity;
- Participating in the development of the site-specific emergency operations plan;
- Assisting with emergency management planning and response as needed;

Instructions for Adapting this Manual for your Project or Location.

The manual has five sections covering the primary risk and hazards of concern for research safety and regulatory compliance. Basic information is provided to guide research activities that do not involve any special or unique hazards. Appendices and hyperlinks are provided for template documents and forms that can be used to customize this manual.

Users of this manual are expected to make the following changes and additions to this manual to ensure that it is detailed and accurate enough to serve as a lab-specific or project-specific safety resource:

Section 1 (Site Safety Information and Employee Training Records):

- Add information about how to access site-specific safety plans.
- Create a roster of lab users and revise it whenever employees join and leave the lab.
- Document and retain hazard assessment for each employee who must use PPE in a lab.
- Document or retain copies of training records for employees.

Section 2 (Biosafety and Containment):

- Create and implement project-specific biosafety SOPs and associated training records, as needed.
- Retain copies of current Biological Use Authorizations (BUAs), regulatory permits, and IACUC protocols that apply to the work.
- Maintain a complete and accurate inventory of cultures and other biological materials (viable samples, animal carcasses) stored for long term use.

Section 3 (Chemical Hygiene Plan):

- Create and implement project-specific chemical SOPs and associated training records, as needed.
- Maintain a complete and accurate inventory of chemicals used or stored in research locations.

Section 4 (Physical Hazards, Radiation Safety, and Technical Work Locations):

- Document and retain any job safety analysis and PPE certifications for physical hazards and technical work locations (may also be kept in Section 1).
- Retain copies of any critical equipment information or manufacturer instructions, as needed.

Section 5 (Occupational Exposure Assessment and Medical Services):

- Retain contact information and required service request forms for local occupational health providers.
- Retain information regarding mandatory and recommended occupational medical services.

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Section 1 - Site Safety Information and Employee Training Records

Review and training on site-specific safety plans is required before commencing work in the lab or research spaces. Refresher reviews should be conducted annually or with any significant changes to plans.

Site-Specific Safety Information

**The location or laboratory safety representative for the _____
lab/facility is:**

Name:
Office
Phone:

Illness and Injury Prevention Plan (IIPP)

Lab users are responsible for knowing and adhering to the location Injury and Illness Prevention Plan (IIPP) including the Heat Illness Protection Plan.

Written copies of the Heat Illness Protection Plan must be available to employees at all outdoor worksites including field work sites. A copy of the plan can be included in section four of this manual. Copies should be maintained in frequently used vehicles to assure that they will be available for field crews. Employees who work in high heat (over 80F) indoor or semi-confined locations such as greenhouses, animal housing areas, or other work areas lacking air conditioning must also receive heat illness training and observe all safety precautions.

The IIPP and Heat Illness Plan for my location can be accessed in the following location(s):

Emergency Action and Fire Prevention Plan

Lab users are responsible for knowing and adhering to the location Emergency Action and Fire Prevention Plan including evacuation routes and procedures for all work locations.

The emergency action and fire prevention plan be accessed in the following location(s):

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Roster of active lab and research facility users

A roster of current lab users is maintained by the principal investigator or their delegate. The roster should be available upon request for emergency evacuation, hazard/exposure assessment, or training verification purposes. Lab user rosters should include employee names, supervisor, and the worksites the employees are authorized to routinely work in or access. Training records or any other well-maintained current list of employees that contains equivalent information can be considered the lab user roster.

See appendices 1a and 1b for templates and examples of lab user rosters.

DRAFT

Signage and postings

Requirements for entry door and facility hazard signage are based on who will need to read the sign. External entrances to buildings must have the NFPA placard to communicate hazards to emergency firefighting personnel. The general public may also need to know that there are chemicals in the facility that require posting under proposition 65. Employees entering work areas or buildings need to know about the hazards within so they can use the correct protective equipment when working in the building or room.

National Fire Protection Association (NFPA) hazard placard

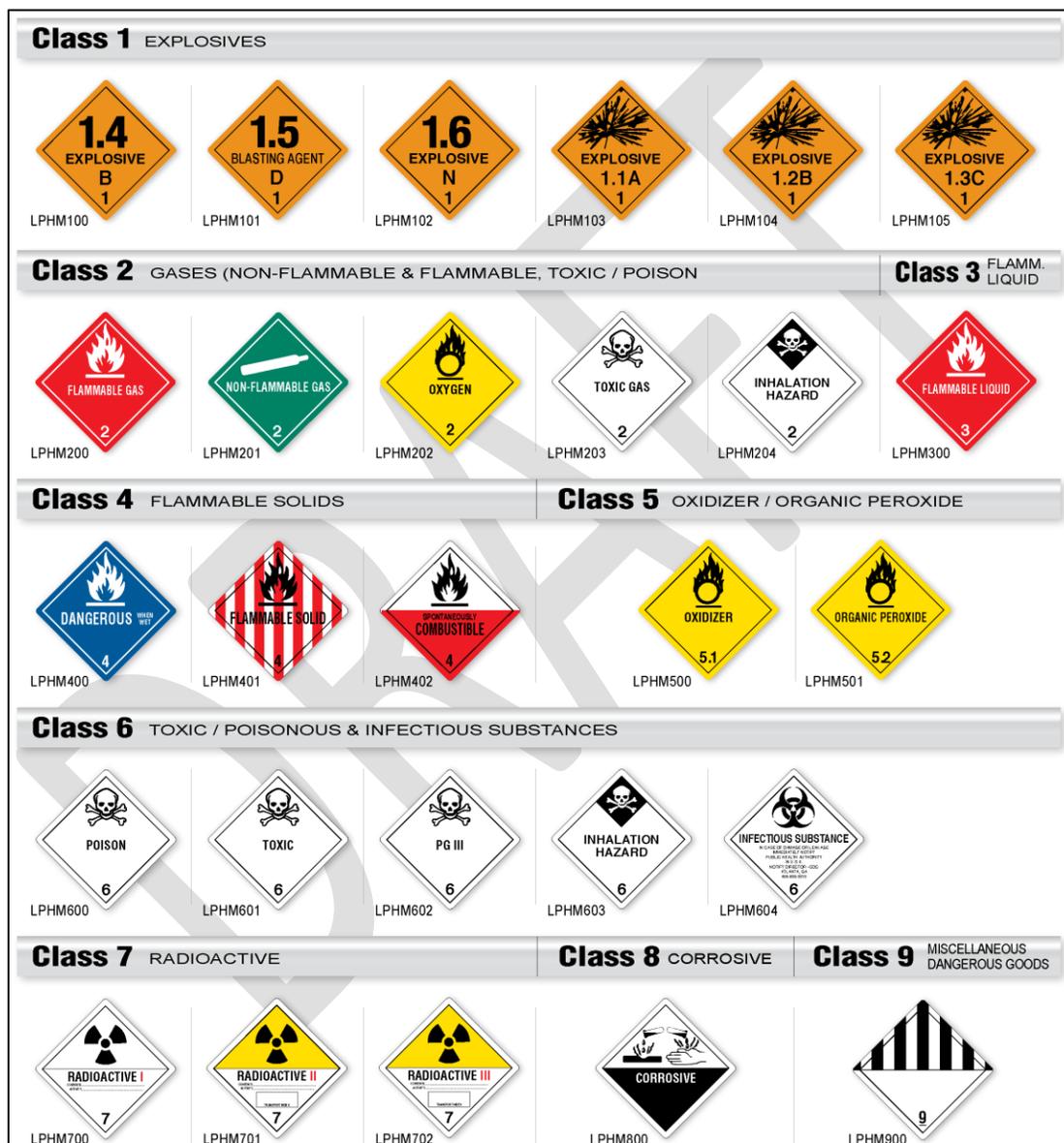
Based on the hazards, the placard may contain the familiar NFPA four color, 1-4 number rating symbol that quickly supplies the hazard information broken down into four hazard classes, with 1 indicating a low level of hazard and 4 indicating a high hazard level. The four chemical hazard types correspond 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.



The NFPA hazard warning placard is most important for fire fighters and emergency personnel to see. This placard is required on large outdoor gas storage tanks and on exterior entrances to buildings where hazardous materials are stored and used. This signage is very important for fire fighters, but might not be clearly understood by employees.

Department of Transportation (DOT) hazard labels

Hazardous materials labels are required by the Department of Transportation (DOT) for hazardous materials that are shipped via road, air, or rail. The DOT hazard label should be left affixed to the hazardous materials while in storage to notify others of hazards that are present. A DOT label with warning language fulfills hazard communication requirements for chemical stored outside of labs.



Examples of DOT hazard labels

Globally Harmonized System (GHS) hazard pictograms

The GHS was developed to identify to the user of a material both the hazards and the risks associated with chemicals. The EPA, OSHA, and U.S. Department of Transportation have adopted the GHS for use in the United States. Lab users are expected to understand and use the GHS signal word, symbol, hazard statement, and precautionary statement. These items are appropriately placed on commercial labels found on chemical containers and in Safety Data Sheets (SDSs). The prudent practice would be to transfer the signal word and symbol to the labels on secondary containers.

GHS language includes:

- A signal word (such as “danger” or “warning”)
- A symbol or pictogram (such as a flame within a red-bordered diamond)
- A hazard statement (such as “causes serious eye damage”)
- Precautionary statements for safely using the chemical

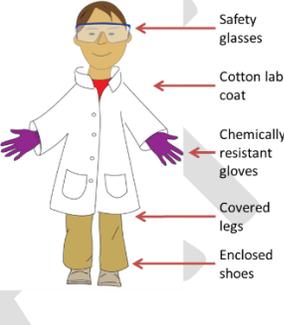
An important part of this hazard classification system is the set of criteria that describe a given class of hazard (e.g., flammable liquids) and the ratings (categories) of the hazards within each hazard class.

The hazard categories are numbered from 1 to 5. The LOWER the number, the GREATER the severity of the hazard. So, category 1 hazards are the most dangerous. Note: This GHS numbering system is the opposite of the NFPA rating system under the NFPA system, the most dangerous rating is 4 while 0 would pose a minimal hazard.

GHS PICTOGRAMS		
<p>Health Hazard Carcinogens, respiratory sensitisers, reproductive toxicity, target organ toxicity, germ cell mutagens</p> 	<p>Flame Flammable gases, liquids, & solids; self-reactives; pyrophorics;</p> 	<p>Exclamation Mark Irritant, dermal sensitiser, acute toxicity (harmful)</p> 
<p>Gas Cylinder Compressed gases; liquefied gases; dissolved gases</p> 	<p>Corrosion Skin corrosion; serious eye damage</p> 	<p>Exploding Bomb Explosives, self-reactives, organic peroxides</p> 
<p>Flame Over Circle Oxidisers gases, liquids and solids</p> 	<p>Environment Aquatic toxicity</p> 	<p>Skull & Crossbones Acute toxicity (severe)</p> 

Entry door signage

When the external door is also the entry door to the lab room, or inside of buildings that contain multiple lab rooms, door signage must be more descriptive to provide instructions for all who may enter or need to contact room owners in case of emergency. Entry door signage should include signal words and symbols that are clearly understood by all who work in that area. Whenever applicable, the Global Harmonized System (GHS) hazard pictograms should be used on entry door signage to designate hazards within the lab. If words are used, multiple languages may be needed for wording on signage.

Hazard Notification Information		
Building 115 Room 10 Dr. Jones Lab		
Principal Researcher Dr. Spock Office: Bldg 115, rm 4 Phone: 123-4567	Alternate Mr. Lab Manager Office: Bldg 115, rm 11 Phone: 123-1234	Location safety Coordinator Office: _____ Phone: _____
NO FOOD OR DRINK PERMITTED IN LAB		
HAZARDS PRESENT		REQUIRED LAB PPE
Biological Hazards  CAUTION Biosafety Level 1 (BSL-1) Plant Pest Containment Facility Authorized Personnel Only Appropriate PPE required. Wash hands before exiting.		
Radiological Hazards  Enclosed Laser. Avoid direct exposure to beam.		
Chemical Hazards  Flammable Liquid  Irritant  Corrosive		
Physical Hazards  Vacuum/Pressurized  Unshielded UV  Cryogen		
Emergency - 911 safety.ucanr.edu ehs@ucanr.edu		
University of California Agriculture and Natural Resources <small>Sept 2018</small>		

Entry door sign templates are available for download at http://safety.ucanr.edu/Training/Lab_Safety_Training/

Lab door signage should communicate the following information, at a minimum:

- The name of the PI, lab director, or other party responsible for the lab.
- Building and room number
- Emergency contact information
- Personal protective equipment (PPE) requirements
- Hazard warning information for any physical chemical, biological, radiological hazards that require PPE (GHS symbol and/or words)
- Lab-specific restrictions and prohibitions (no food or drink, plant materials, insects, soil)
- Any other special requirements for entry or exit (e.g., permit requirements, use of foot bath, clothes change)

Training

Effective training is critical to facilitate a safe and healthy work environment and prevent laboratory accidents. Principal investigators must participate in formal safety training and ensure that all their employees have appropriate safety training before working in a laboratory. Training must be in the appropriate language, educational level, and vocabulary for the personnel. Employees must be given the opportunity to ask questions. Any questions can be directed to UC ANR EH&S department (ehs@ucanr.edu; 530-750-1264).

All employees (including Faculty (PI's) and other Supervisors) must take the Laboratory Safety Orientation on-line training class prior to starting work in the laboratory.

Types of training

All laboratory personnel must complete general laboratory safety training before:

1. Beginning work in the laboratory;
2. Prior to new exposure situations; and
3. As work conditions change.

Annual refresher training is also required for all laboratory personnel. EH&S offers online training, plus resource materials to assist laboratories in implementing laboratory-specific training.

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, and classroom and online training. Documentation should be maintained in the laboratory safety manual. Additional information on recordkeeping can be found in Compliance and Enforcement section

A summary of trainings which have been completed online is available for all laboratory employees is available to supervisors upon request from the UC Learning Center Administrator. This document can serve as an official record of laboratory safety training conducted by EH&S and others. Contact UC ANR EH&S to request documentation from UC-sponsored online training systems.

A record safety training and PPE hazard assessments for lab users must be available for review in the lab. A summary spreadsheet of training dates can be maintained in the lab with individual training records on file and available for review upon request. Employee training records should be maintained for at least the past year of work in the lab. Training record older than one year or for employee who have separated employment need not be available in the lab and may be retained in archive files as part of employee exposure records.

Hazard assessment and personal protective equipment (PPE) training

It is essential that all laboratory workers understand the types of hazards, recognize the routes of exposure, and are familiar with the major hazard classes of chemical and biological hazards that can affect one's health. In many cases, the specific hazards associated with new compounds and mixtures or unidentified microorganisms will not be known, so it is recommended that all chemical compounds and biological materials be treated as if they may be potentially harmful and to use appropriate eye, inhalation, and skin protection equipment.

California regulation and UC policy require that supervisors document and certify a hazard assessment for each lab user who is required to use personal protective equipment. If employees who enter the lab to perform housekeeping and maintenance duties must also use PPE, they must be included the hazard assessment. Each employee who is required to use PPE in their job must also review train in the use of that PPE including limitations and potential hazards posed by misuse of the PPE.

Attire when occupying a Laboratory/Technical Area: Full length pants (or equivalent) and closed toe/heel shoe attire must be worn at all times by all workers who are occupying or entering a laboratory/technical area. The area of skin between the pants and shoe should not be exposed.

PPE when working with, or adjacent to, hazardous material use areas within a Laboratory/Technical Area: Laboratory coats (or equivalent protective garments) and protective eyewear are required to be worn by all workers working with hazardous materials. In addition, laboratory personnel occupying the adjacent area, who have the potential to be exposed to chemical splashes or other hazards as determined by SOP requirements and/or the laboratory hazard assessment, are required to wear laboratory coats (or equivalent protective garments) and protective eyewear.

General laboratory safety training

All lab users are required to complete UC Laboratory safety fundamentals course prior to starting work in a lab. This course can be accessed through UC campus EH&S Departments and on the UC ANR EH&S department website here: http://safety.ucanr.edu/Training/Lab_Safety_Training/

General laboratory safety training topics

Anyone working in a laboratory is required to complete General Laboratory Safety training, which includes:

- Review of laboratory rules and regulations, including the Chemical Hygiene Plan
- Recognition of laboratory hazards
- Use of engineering controls, administrative controls and personal protective equipment 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 8CCR3204 regarding access to employee exposure and medical records (annually required) (www.dir.ca.gov/Title8/3204.html).

General lab safety training resources

A summary matrix of UC ANR training requirements is available on the UC ANR EH&S website:

<http://safety.ucanr.edu/files/2860.pdf>

A new employee safety checklist is also available on the UC ANR EH&S website:

<http://safety.ucanr.edu/files/235594.pdf>

UC ANR EH&S lab safety training: http://safety.ucanr.edu/Training/Lab_Safety_Training/

Each UC campus also has lab safety and chemical safety training available online through the respective EH&S department:

- UC Berkeley EH&S lab safety training: <https://rac.berkeley.edu/training.html>
- UC Davis EH&S chemical safety training: http://safetyservices.ucdavis.edu/training?f%5B0%5D=field_categories%3A5
- UC Riverside EH&S lab safety training: www.ehs.ucr.edu/training/index.html
- UC Merced EH&S chemical safety training: <https://ehs.ucmerced.edu/researchers-labs/chemical-safety/training>

UC Riverside has published a helpful training needs assessment form which may be helpful in determining which trainings are necessary for individual employees based upon hazard exposures and job tasks. This needs assessment can be found on the EH&S website at: <http://ehs.ucr.edu/training/assessment.html>

UC ANR Laboratory Safety Rules (Safety Note #127 General Lab Safety)

Pre-laboratory activities

- Employees must be familiar with safety information including the Injury and Illness Prevention Program (IIPP), Building Evacuation Plan, the Chemical Hygiene Plan (CHP), and Biosafety & Containment Plans.
- Employees must be trained to use and know the location of emergency equipment including, spill equipment, fire extinguishers, emergency eyewash/shower units, first aid kits and fire alarms. Employees must be trained to use all personal protective equipment (PPE) including eye/face protection, protective gloves, protective clothing, respiratory protection and any other PPE required in the laboratory. All required PPE must be provided to the laboratory employees by the employer. Employees must be trained about proper chemical storage and compatibility and use, including waste and container labeling, and Safety Data Sheets (SDS). Training must also include the hazards of flammable, corrosive and oxidizing chemicals, carcinogens, water reactive chemicals, and peroxide forming chemicals.
- Employees must be trained in the proper use of lab equipment including fume hoods, ultraviolet sources, compressed gas cylinders, ovens, centrifuges, and all other equipment which has a potential for injury.
- Employees who will be working with bio-hazardous materials, radiation, lasers, and x-ray equipment must be properly trained and authorized. Safety programs must be implemented prior to such activities being performed in the laboratory. Contact EH&S to assure appropriate protocols, permits, or licenses are in place prior to starting this type of work.

Operating precautions

- Dress properly during laboratory activities. Long hair, jewelry, and loose or baggy clothing can be a hazard. Shoes must completely cover the foot. No open toed shoes are allowed in the laboratory.
- Report any accident (spill, breakage, etc.) or injury (cut, burn, etc.) to the principal investigator or immediate supervisor immediately, no matter how trivial it may appear.
- Food and drink are not allowed in areas where hazardous chemicals or biological materials are present. Refrigerators and microwave ovens must be labeled either “Food Only”, or “Lab Use Only”. Only explosion proof refrigerators and freezers can be used for flammable or explosive chemicals. Laboratory sinks cannot be used for washing of both lab glassware and food utensils.
- Practice good housekeeping. Keep work areas uncluttered and walkways and exits clear. Do not obstruct emergency equipment including fire extinguishers, eyewash/shower units, and fire alarms.
- Follow all Standard Operating Procedures (SOPs) and recommended work practices.
- Perform activities in a sanitary manner. Do not eat or drink while working. Wash hands after performing work. Clean, rinse and dry all work surfaces and equipment, including glassware.
- All electrical systems must be installed according to building codes and Cal-OSHA regulations. Extension cords are not to be used as substitutes for permanent wiring. Unplug hot plates before leaving the laboratory.

If you are in doubt about directions for an experiment, or about use or disposal of materials, ask your supervisor first before acting.

Laboratory-specific training

In addition to basic laboratory safety training, training may be required for specific subject areas such as biosafety, chemical safety, hazards such as chemicals or biological agents or task such as animal handling, sharps handling, culture of microorganisms, or use of autoclaves.

Principal investigators must also provide laboratory-specific training. Topics that require specific training include:

- Location and use of the Chemical Hygiene Plan, IIPP, SDS(s) and other regulatory information
- Review of IIPP and Emergency Management Plan, including location of emergency equipment and exit routes
- Specialized equipment
- Standard Operating Procedures
- Personal Protective Equipment
- Specialized procedures and protocols
- Particularly Hazardous Substances including physical and health hazards, potential exposure, medical surveillance, and emergency procedures
- Requirements for regulated or quarantined biological materials (use of disinfectant chemicals, biocides, and chemical preservatives)

Accidents and emergencies

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 emergency response plans 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.

Serious occupational injuries, illnesses, and exposures to hazardous substances must be reported to the EH&S Director, Brian Oatman, within 8 hours (office: 530-750-1264, cell phone: 530-304-2054). 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 amputations, lacerations with severe bleeding, burns, concussions, fractures and crush injuries. Instructions on reporting injuries to EH&S should be posted at all work sites to ensure that all serious injuries are reported to Cal/OHSA within 8 hours. For all incidents requiring emergency response, call 911 and follow your site specific emergency action plan.

Accidents

Supervisors are responsible for ensuring that their employees receive appropriate medical attention in the event of an occupational injury or illness. All accidents and near misses must be reported to UC ANR EH&S. EH&S will conduct an accident investigation and develop recommendations and corrective actions to prevent future accidents.

At a minimum, each laboratory must have the following preparations in place:

- Fully stocked first aid kit
- Posting of emergency telephone numbers and locations of emergency treatment facilities
- 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

Reporting an injury or incident in a UC ANR lab:

- Ensure that the employee gets first aid or professional medical care as needed.
- Within 24 hours, report the injury using one of the following methods:
 - Online Report: Preferred Reporting Method. Injuries may be reported using the Online Employer First Report form. The employee or other staff member may access the form at: <http://ehs.ucop.edu/efr>. Note: a UC Davis kerberos login is required to access the form. Once the report is submitted, the supervisor will be prompted to complete additional information. Notification of the report will also go to Staff Personnel Unit.
 - Paper form: Injuries may be reported to the Staff Personnel Unit (including Academic personnel). Use the UC Davis Employers Report of Occupational Injury or Illness form to report injuries (Link to download paper form: <http://safety.ucanr.edu/files/204622.doc>). E-mail the completed form to: anrstaffpersonnel@ucanr.edu or fax to: (530) 756-1180.
- Additional information on reporting injuries and incidents is available on the UC ANR EH&S website here: http://safety.ucanr.edu/Guidelines/Reporting_an_Injury/

Fire-related emergencies

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

1. Pull the fire alarm pull station and call 911 to notify the Fire Department and close the fume hood sash
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
3. Close doors;
4. Remain safely outside the affected area to provide details to emergency responders; and
5. 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.
6. If your clothing catches on fire, go to the nearest emergency shower immediately. If a shower is not immediately available, then stop, drop, and roll. 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 to your local safety coordinator within 8 hours every time a fire extinguisher is discharged.

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Audits and Compliance

Laboratory safety audits

Laboratory safety audits provide an opportunity for departments, faculty, students, and staff to reemphasize safety by focusing on safety topics specific to each research laboratory. Annual audits are conducted at each Research and Extension Center (REC) by EH&S specialists. The audit assesses the overall safety of the laboratory. This program evaluates the labs conformance to UC ANR's Chemical Hygiene Plan, federal and state regulations, standards, and codes. They are also vital to identifying and addressing potential hazards and unsafe conditions in the laboratory.

While audits are a snapshot in time and cannot identify every accident-causing mistake, they do provide important information on the overall operation of a particular laboratory. They can also help to identify weaknesses that may require more systematic action across a broader spectrum of laboratories, and strengths that should be fostered in other laboratories.

Inspection audit categories include:

- Documentation and Training;
- Emergency and Safety Information;
- Fire Safety;
- General Safety;
- Use of personal protective equipment (PPE);
- Housekeeping;
- Chemical Storage;
- Fume Hoods;
- Chemical Waste Disposal and Transport;
- Seismic Safety; and
- Mechanical and Electrical Safety.

Inspection results are communicated to the location safety coordinator, with a requirement that any deficiencies be corrected within a specific time frame (30 days, 60 days, or optional recommendation). A follow-up inspection might also be done after receipt of the inspection results.

In addition to lab safety audits conducted by EH&S specialists, lab supervisors and safety contacts are encouraged to perform periodic self-audits of their lab operations and may be required to do so by their home campus (e.g., UC Riverside). Checklists for use in self-audits are available for download from UC ANR and UC campus EH&S websites.

- UC ANR lab safety self-audit checklist: <http://safety.ucanr.edu/files/276367.doc>
- UC Riverside lab safety self-audit checklist: <http://www.ehs.ucr.edu/laboratory/audits/self-audit%20checklist.pdf>
- UC Davis lab safety audit checklist: <http://safetyservices.ucdavis.edu/sites/default/files/documents/LaboratorySafetyReviewChecklist.pdf>

Notification and accountability

The audit program requires that principal investigators and other responsible parties take appropriate and effective corrective action upon receipt of inspection findings. Failure to take corrective actions within the required timeframe will result in an escalation of the notification to the Department Chair, Dean and Provost. Depending on the severity of the deficiency, the EH&S Director, in consultation with the Department Chair, Dean, and Provost, may temporarily suspend research activities until the violation is corrected. In some cases, the PI may be required to provide a corrective action plan to the EH&S Director prior to resumption of research activities.

Recordkeeping requirements

Accurate recordkeeping demonstrates a commitment to the safety and health of the UC ANR community, integrity of research, and protection of the environment. EH&S is responsible for maintaining records of inspections, accident investigations, equipment calibration. Documentation of completion of online training can be accessed via the Learning Management System (LMS). Per OSHA regulations, departments or laboratories must document health and safety training, including safety meetings, one-on-one training, and classroom and online training. Additionally, the following records must be retained in accordance with the requirements of state and federal regulations:

- Accident records; (Department, Location)
- Measurements taken to monitor employee exposures; (Department, Location)
- Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations; (Laboratory)
- Inventory and usage records for high-risk substances should be kept; (Laboratory)
- Any medical consultation and examinations, including tests or written opinions required by CCR, Title 8, Section 5191; and
- Medical records must be retained in accordance with the requirements of state and federal regulations. (Department, Location)
- Personal Protective Equipment(PPE) used in the lab(Laboratory)

Appendices and SOPs

Appendices

Appendix 1a – Lab User Training / Lab User Roster

Appendix 1b – Laboratory Hazard Assessment for PPE use (paper form)

Appendix 1c – PPE Selection Guide (UC Davis resource)

Appendix 1d – UC Policy for Minors in labs (October 2013)

Appendix 1e – UC Policy for Personal Protective Equipment (PPE) (March 2014)

Appendix 1f – UC Policy on Laboratory Safety Training (October 2013)

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Section 2 - Biosafety and Containment

Background and Introduction

Purpose and scope

This section of the Laboratory and Research Safety Manual serves as a general biosafety and containment manual for UC ANR research operations. This section of the manual is based on best practices identified in, among others sources, the CDC publication *Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Edition*, guidelines published by the U.S. Department of Agriculture - Animal Plant Health Inspection Service (USDA-APHIS), and guidelines published by National Institutes of Health - Office of Biotechnology Activities (NIH OBA). In addition to guidelines published by federal agencies, guidance in this manual is intended to support compliance with the California Medical Waste Management Act, the California Aerosol-Transmissible Disease Standard (8CCR5199), Zoonotic Disease Standard (8CCR5199.1), and Bloodborne Pathogen Standard (8CCR5193)

Biosafety is defined as, “The discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials” (CDC, BMBL 5th ed.)

The term “biological materials” refers to living organisms or biologically active molecules, and may include any of the following:

- Recombinant or synthetic DNA/RNA (plasmids, cloned materials, siRNA, and experimentally-produced viral vectors)
- Genetically-modified organisms (animals, microorganisms, plants, insects, cells/cell lines)
- Human products, including blood, tissues, bodily fluids, clinical specimens
- Live animals, carcasses, or animal products including tissues, cells, blood, or other bodily fluids
- Pathogenic microorganisms (including human, animal, or plant pathogens)
- Arthropod plant pests and disease vectors
- Plants, animals, insects, microorganisms, or cells that produce toxic compounds
- Select Agent organisms (including the toxins they produce)

These biological materials may pose health risks to animals or plants. When the risk posed to animals or plants is high enough to warrant human health protection measures or other containment precautions to prevent release, then these biological materials may be considered hazardous biological agents or biohazards.

“Biosafety programs reduce or eliminate exposure of individuals and the environment to potentially hazardous biological agents. Biosafety is achieved by implementing various degrees of laboratory control and containment, through laboratory design and access restrictions, personnel expertise and training, use of containment equipment, and safe methods of managing infectious materials in a laboratory setting.” (CDC, BMBL 5th ed.)

Biological Risk Assessment

The foundation of biological safety practice is the biological risk assessment. Due to the variety of practices, pathogens, and species that may be involved in biological research operations, the process for assessing risk is usually a case-by-case determination based upon established standards in biological safety. In general the factors to be considered in a biological risk assessment are:

- The inherent risk posed by the biological materials or agent
- Any additional risks posed by the experimental procedures, handling, or storage
- Containment or confinement features of the facilities where the work is conducted
- Competency and level of training in employees who handle the materials

A biosafety plan template is included as an appendix to this safety manual. The biosafety plan is designed to guide the user in conducting and documenting a biological risk assessment for hazardous or regulated biological materials. Once a risk assessment has been documented for the work, then safety controls can be applied to the risk that have been identified. The safety controls which are selected for use should also be captured in the biosafety plan

Classes of biological hazards and regulated materials

Microorganisms such as viruses, bacteria and fungi biological hazards are classified into four categories called Risk Groups, according to their level of relative risk to human health. ***Important compliance requirements and restrictions associated with specific materials or research activities are presented in bold red italics.***

Risk group one (RG1) organisms are those which are not known to cause disease in health adult humans. Risk group one agents may still cause serious disease in immunocompromised people, children, elderly adults, non-human animals, or plants.

Risk group two (RG2) organisms are known to cause disease in humans, but the disease is usually not severe or is treatable or preventable with medical interventions. Examples of this type of microorganism are pathogenic *E. coli* strains, *Salmonella* species, *Aspergillus* species, and *Francisella tularensis*. ***Any storage, use, or research on risk group two agents or biological materials that require Biosafety Level 2 or higher level of protection is prohibited at ANR facilities unless the principal investigator first obtains approval from a campus Institutional Biosafety Committee (IBC).*** If campus IBC review does not appear to be appropriate, contact UC ANR office of Environmental Health & Safety for further instruction before use of biological materials requiring protection of Biosafety Level 2 or higher.

Risk group three (RG3) organisms are those known to cause serious or lethal disease in humans. The disease may have some treatment or prevention options. Many risk group three agents are also infectious via aerosol, causing disease if they become airborne and employees are exposed to the contaminated air. Examples of risk group three agents are *Brucella abortus*, *Burkholderia mallei*, and *Coxiella burnettii*. Risk group four (RG4) organisms cause serious or lethal disease and medical interventions are usually not available or effective. An example of this type of organism is Ebola virus. ***Possession or deliberate culture of risk group three and risk group four agents is prohibited in ANR facilities. If any risk group three and risk group four agents are ever found or identified at an ANR facility, the party in possession of the materials must secure them from any possible access by others and immediately contact EH&S for further instructions.***

Select Agent pathogens and toxins – certain biological agents and toxins produced by biological agents have been identified by the U.S. government as having great potential for deliberate or malicious misuse. Any possession of these materials (even accidental or unintentional) is highly regulated and controlled by U.S. government agencies. A list of Select Agents and Toxins is included as an appendix to this manual. ***Any storage or use of Select Agents or Toxins at ANR facilities is prohibited (see appendices for list of Select Agent Pathogens and Toxins). If any Select Agents or Toxins are ever found or identified at an ANR facility, the party***

in possession of the materials must secure them from any possible access by others and immediately contact EH&S for further instructions. Contact EH&S for any questions or concerns related to Select Agent Pathogens.

Plants and animals are not assigned to risk groups. However, sometimes materials are considered to have the same risk as a specific pathogen if the pathogen may be present in the materials. These materials may be called “other potentially infectious materials” or OPIM. Some examples of OPIM are: mammalian cells used in tissue culture, animal tissue samples, carcasses of animal species that are known to harbor zoonotic disease, and bedding and waste from animal housing or husbandry operations. Plant materials and soils may also harbor pathogenic microorganisms that could present exposure hazards if aerosolized. In addition to infectious diseases, microorganisms and airborne debris from plants or animals research can cause hazardous allergic or asthmatic conditions in healthy adults. These serious health conditions are a result of the human immune system reacting to exposures to airborne materials which are not generally considered pathogens (grain dusts, soils, ground up plant materials).

Bloodborne pathogens in the broadest sense can refer to pathogenic organisms that reside in blood or are transmitted through contact with blood. However, Cal/OSHA bloodborne pathogen regulations (8CCR5193) and mandated safety controls are primarily applicable to work-related exposures to human blood, human tissues, and other potentially infectious materials commonly encountered in medical settings. Pathogen exposures that occur due to exposure to animals or their waste materials are considered zoonotic pathogen exposures. These pathogens (described below) are covered under different regulations. ***Research activities that involve collection or handling of human blood, tissues, or body fluids must be reviewed and approved by (or receive written confirmation of exemption from) an Institutional Biosafety Committee (IBC) and Institutional Review Board (IRB) at a UC campus.***

Zoonotic pathogens are pathogenic agents which can cause disease in humans and come from animal sources. The infected animals may show no signs of disease, but the disease they harbor may cause serious illness in human who are exposed. Exposure to zoonotic disease is a significant occupational hazard for employees who work with or around animals (alive or dead), their housing/bedding, or untreated waste from animal operations. Water and airborne dust coming from animal operations may also pose threat to human health. ***A written safety plan as specific in the Cal/OSHA zoonotic disease standard (8CCR5199.1), is required for any research involving potential exposure to zoonotic disease agents. This requirement may be fulfilled by an IBC-approved BUA or other project-specific documentation (IACUC protocol)***

Pathogens affecting only non-human animals – some pathogens may affect animals only and may not cause disease in humans. Protective measures are important in work with animals so that infectious diseases are not transferred in and among research or wild animal populations by human activities. Research involving potential for exposure to, or transmission of, animal diseases may require specific permits from California Department of Fish and Game (CDFG), California Department of Food and Agriculture (CDFA), and/or US Department of Agriculture Animal Plant Health Inspection Service (USDA-APHIS). ***Research activities involving any organisms regulated under CDFG, CDFA, or USDA-APHIS permits should be reported to EH&S, ideally with a copy of the permit provided for compliance review and recordkeeping. Research activities involving animal pathogens that are regulated by CDFA or USDA-APHIS may require review and approval from a campus Institutional Biosafety Committee (IBC).***

Quarantined and regulated pests (QARP) is a term applied to plant pests that may cause serious or detrimental effects to local ecology, agriculture, or the environment. Quarantined and regulated pests, can be microorganisms, invertebrates, or other plants. These pests are identified at a local level by the county agricultural commissioner (CAC), at the state level by California Department of Food and Agriculture (CDFA), and at the federal level by US Department of Agriculture Animal Plant Health Inspection Service (USDA-APHIS). Movement of plant-associated invertebrates, plant materials, soils, or OPIM across county lines, into or out of quarantine zones, across state lines inside the U.S., importation into U.S., or exportation to other countries may require specific authorization from local, state, or federal regulatory authorities. ***Research activities involving any organisms regulated under CDFG, CDFA or USDA-APHIS permits should be reported to EH&S, ideally with a copy of the permit provided for compliance review and recordkeeping. Research activities involving microbial plant pathogens that are regulated by CDFA or USDA-APHIS may require review and approval from a campus Institutional Biosafety Committee (IBC).***

Routes of exposure

Each pathogen has one or more ways to infect and cause disease in the desired host. These are called routes of exposure. If we understand a pathogen's route of exposure, then we have a better chance of preventing a disease-causing exposure event.

In protecting human health, we focus on the routes that a human worker may be exposed to a pathogen. That is, we look for the route by which the pathogenic organism may gain access to the human body in order to cause disease. Those routes, in order of importance are:

- Inhalation (of airborne contaminants)
- Ingestion (including direct contact with mouth/eyes/nose)
- Wound/blood contact

A key exposure control for biological hazards is to minimize aerosol-generating activities and to be mindful of the airborne contamination that such activities can generate. Beyond the immediate danger of inhalation, settled aerosols can lead to surface contamination of workspaces and establishment of a reservoir of contamination in a lab or work area. Whenever energy is added to a biological sample, the production of aerosols and resulting contamination must be considered and mitigated with proper use of protective equipment and sanitation of work areas. Examples of aerosol-generating activities are: mixing, grinding, cutting, sweeping, and applying pressurized air or water to a sample. The actions of natural wind or ventilation can increase risk of exposures to airborne contaminants. In cases of live animal operations, the respiration, bodily functions, and movement of the animals are all considered aerosol-generating activities that increase exposure risks for workers. Because all aerosols will eventually settle, housekeeping and sanitation of work areas where aerosol-generating activities occur is very important for minimization of exposures risks.

Wound exposure is a prominent and common route of entry for infectious microorganisms in lab and research operations. Open wounds should always be covered and protected from exposure to animals or microbiological cultures. Wounds that become red and hot to the touch, that do not heal normally, or that do not show signs of improvement within 7 day time period should be seen by a doctor at earliest sign of concern. All employees who work in agricultural operations, particularly those involving animals, are strongly encouraged to obtain vaccination for tetanus.

Allergens and opportunistic pathogens - Some organisms are not specifically pathogenic, but they may cause dangerous allergic reactions or obstructions in human systems if they gain access to and colonize certain parts of the body. These organisms which may only be hazardous in some people may be referred to as allergens or opportunistic pathogens. Allergic reactions may appear suddenly and severely in the cases of some allergens. Whenever working around flowering plants, live cultures of non-pathogenic microorganisms, invertebrate insects, live animals, or animal wastes employees should take measures to minimize creation of aerosols and avoid breathing dusts and mists of biological materials.

Quarantined and regulated pests - When working with organisms that are not harmful to human health, but pose a threat to the health or plants, animals, or the enforcement, one must consider the route of exposure as well. In these cases, the route of exposure is the route by which the pathogen, pest, or regulated organism, may gain access its desired host or habitat. This route may be via water flow from a research plot, via transfer from the bottom of one's shoe in the greenhouse, via transfer from one's wet truck tire in the field, or via escape of

invertebrate pests on one's clothing. Additionally, one's behavior inside labs and greenhouses also matters. Sloppy work leads to invertebrate infestations of stored materials and contamination of floors and common spaces until eventually the pest is causing trouble with other experiments and in danger of spreading to the local area. In many cases, the same safety measures that are used to protect human health will also assure that plant pests and animal pathogens stay within the confinement of one's research operation. Even when biological materials aren't a threat to human health, the principals and practices of biosafety and containment are important to assure the safety of local agricultural commodities, the trust of industry cooperators, and the continued ability to conduct critical research.

Safety Controls for Biological Materials

Safety controls may be used to protect employees from exposure to biohazards in the course of their work. In cases where the biological materials pose little threat to human health, safety controls may be required to prevent unintentional release of biological materials to the environment where they can make contact with susceptible or receptive hosts. Safety controls are prioritized according to the hierarchy of controls. The most effective control for biohazard risk is to avoid or eliminate the biohazards or regulated materials from the work. If pathogenic or regulated biological materials must be used, or are the subject of the research itself, other controls must then be considered to reduce the risk. Engineering controls are the next line of defense followed by administrative controls. If the exposure or release risk cannot be sufficiently lowered by use of engineering and administrative controls, then use of personal protective equipment may be required.

Elimination, substitution, or biological inactivation as a safety control

The most effective control for biohazards is to not use them in the first place. Examples of this method of risk management may include limiting work to locally endemic pests inside of a single county, using attenuated strains of pathogens which have been modified to not cause disease, collecting non-viable samples for analysis, or using a validated method to biological inactivate the viable biological materials before use or storage.

Whenever non-pathogenic or attenuated microorganisms are substituted for closely related pathogenic strains and all organisms are stored and used in the same lab or project, careful attention must be placed on labeling and identification of cultures in storage and in use. Experiments should include routine measures for confirming the identity of the biological agents to verify that they are non-pathogenic.

Biological inactivation refers to eliminating the ability of the organism to persist in the environment or pass on its genes. Biological inactivation procedures must be established for any hazardous or regulated biological materials used in research in order to safely dispose of material at the conclusion of the project. Whenever viable materials are biologically inactivated, a standard method must be used or the method in use must be tested and validated to inactivate the targeted biological materials. Standard methods of biological inactivation are autoclave treatment, heating to specific temperature for specific amount of time, freezing at -80C, and use of disinfectant chemicals (must use correct concentration and contact time). Disinfectant chemicals or physical methods are most often used to kill microorganisms. Some arthropods may be frozen. Plants and plant parts may be composted or ground up, but seeds and pollen might also require control or higher level of destruction such as autoclave or incineration. Imported or contaminated soils may require biological inactivation via heat to destroy any living organisms or specific experimental organisms before storage or disposal. It is important to consider that all methods do not work on all materials. If published literature verifying the inactivation method

does not exist, the method must be tested and validated by the PI's lab before it can be accepted as effective for biological inactivation of viable materials.

Engineering controls

Engineering controls are the next line of defense if the hazardous or regulated materials cannot be eliminated or substituted. Engineering controls are equipment and physical facility features that ensure control of biological materials and can be externally tested and validated for effectiveness. Engineering controls commonly used to contain or isolate biological materials are often minimal or unnoticeable at lower hazard levels, but can be very complex and expensive to implement for high hazard work. Examples of engineering controls used for biohazard protection include the primary laboratory room with a closed door and inward airflow from areas of least hazard towards areas of highest hazard work, use of HEPA-filtered enclosures such as biosafety cabinets or glove boxes to isolate work that may generate aerosols, safety eyewashes for irrigation of the eye, and use of autoclaves to sterilize materials. Use of secondary leak-proof containers and locked freezers for storage of biological materials may also be considered engineering controls.

Biosafety level (BSL) is a term that refers to the suite of facilities, equipment, and practices that may be applied to control exposure to biological hazards. Biosafety levels have been established to identify laboratory safety controls for protection of human or animal health. However, BSL designations do not always take threats to crop health posed by plant pests into consideration. There are four biosafety levels and these roughly correspond to the risk group classification of organisms. Biosafety level one (BSL1) facilities are appropriate for work with risk group of organisms. Most plants, plant pathogens, and plant-associated invertebrates can be used safely at BSL1, but additional controls may be required to prevent environmental release of pests. Biosafety two level (BSL2) facilities have more equipment and practices in place to protect human health because risk group two agents are in use. UC ANR does not have any facilities that meet biosafety level three (BSL3) or biosafety level four (BSL4) requirements. This level of high hazard work must be conducted on a UC campus in an appropriate facility.

Facility guidelines for applying engineering controls to biosafety or containment needs at ANR facilities are summarized in Appendix 2c.

Administrative controls

Administrative controls are the next line of defense if engineering controls are not feasible or cost effective based upon the level of risk posed by the materials. Administrative controls are practices and procedures that people must perform in order to assure protection or containment of biological materials. For biological research involving low hazard materials (that do not cause human disease), administrative controls are commonly applied and may be quite extensive. Training, creating and using standard operating procedures, medical surveillance programs, signage, regulatory permits, internal and external inspections, handwashing practices, and maintaining accurate inventories of biological materials in storage are all examples of administrative controls. Some forms of administrative controls such as regulatory permits for use of pathogens or GMOs are enforceable as law with fines and imprisonment. Administrative controls also vary widely depending upon the risk posed by the agents.

Laboratory signage

Entry door signage is a valuable and often overlooked administrative control. Each lab and research location controlled See section 1 for information on entry door signage and requirements for door signs. Entry door signage for research areas that contain regulated or hazardous biological materials should communicate requirements for people to safely enter and exit the space without exposing themselves or others to biological hazards; these requirements may include use of lab coats and protective outerwear while in the lab or use of a disinfectant footbath upon exit from an area. Entry signage should also communicate any restrictions or prohibitions on use of personal electronics or storage of personal items such as backpacks and purses in research areas.

Inventory of biological materials

An inventory of cultures retained for long term storage (archived cultures at 4C, -20C or -80C) must be maintained for each lab that handles or stores pathogenic or genetically modified organisms. This inventory should include pathogens of humans, animals, and plants as well as closely related organisms that may be confused with or used in conjunction with pathogens (such as insect vectors). A complete list of genetically-modified organisms used or stored in labs or other research facilities (greenhouses growth rooms, post-harvest storage facilities). In addition to pathogens and GMOs, any biological materials such as plant samples or microbial cultures that may be subject to spoilage or infestation by pests must be labeled to indicate contents and responsible party.

Biological Use Authorizations (BUA), standard operating procedures, and containment plans

This manual is intended to serve as a safety manual for laboratories which do not use any biological materials of concern such as pathogens, GMOs, or quarantined and regulated pests. If hazardous or regulated biological materials are in use, specific SOPs must be developed to describe the safety and containment features that are required to control the hazards posed by the biological materials. When required for the work, a current Biological Use Authorization that has been reviewed and approved by an IBC, fulfills the requirement for a biosafety/containment plan. If a BUA is not required for work with quarantine or regulated biological materials, an SOP or containment plan may still be required under state or federal regulations if those materials pose a threat to living organisms or the environment.

A template for a biosafety and containment plan is provided as Appendix 2a in this section lab safety manual. A biosafety SOP is required for work with animals or animal materials that poses disease hazard to employees (see requirements for work with live vertebrate animals). A containment SOP is required for any USDA plant pest permit application (see Guidelines for Plant Health Protection). Whenever containment of plant pests is required to prevent serious detrimental effects upon susceptible hosts in the local environment, a containment SOP is advised.

Biosafety training resources

General biosafety courses available through UC Davis learning management system (requires UCD log-in ID)

UC Davis has two online biosafety training modules available for BSL1 lab users. The content is tailored to UC Davis campus, but the basic principles and practices of biosafety are described.

Go to: lms.ucdavis.edu and search for:

- Proper Handling of Materials at Biosafety Level 1 (DACS-L-112713-SAFSVC) This course is required for those whose work in research and related projects involve microbiological materials and recombinant or synthetic nucleic acids that can be safely handled at BSL1.
- Biological Safety for Plant Research (DACS-L-PLANTBIO-SAFSVC) This course provide basic background for those who work with plant pathogens and GMOs in BSL1 labs and greenhouses.

Greenhouse sanitation

Purdue University has published useful guidance on greenhouse sanitation which is available free online here:

Greenhouse Sanitation for Disease and Pest Management (Purdue University extension publication):
<https://www.extension.purdue.edu/extmedia/ho/ho-250-w.pdf>

USDA-APHIS permit acquisition for plant pests

USDA-APHIS-Plant Pest Quarantine (PPQ) division has published online learning modules to assist researchers in acquisition of USDA-APHIS-PPQ permits for regulated items such as microbes, insects, soil, and plants:

https://www.aphis.usda.gov/aphis/ourfocus/planthealth/import-information/permits/regulated-organism-and-soil-permits/ct_modules

Personal protective equipment

Personal protective equipment is considered after all other levels of controls have been assessed and applied. PPE may be used for human health protection or to prevent cross-contamination or release of biological materials used and stored in labs and research facilities.

University of California policy states that minimum lab attire for anyone entering a lab is: closed toed shoes and full length pants.

Gloves, lab coat, and eye protection for splash hazards are standard protective equipment for use in BSL1 labs. Lab coats may be cotton or cotton-polyester blends. Use of human pathogens or blood may necessitate use of liquid impermeable lab coat. Use of highly flammable chemicals in conjunction with biological materials requires use of flame retardant lab coat. Standard nitrile disposable gloves protect skin from biohazard exposures in labs. In situations where extra protection is desirable thicker gauge gloves can be used or employees can wear a second pair of gloves on top of the other (double-gloving). Eye protection such as splash goggles is required if there is chance of splash to the eyes. Respirators can provide protection from inhalation of airborne biohazards.

Respiratory protection

Any use of respirators for protection from biohazards requires full participation in the respiratory protection program including a medical evaluation for use of respirator and annual fit test and training. 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 and biological hazards.

Under certain circumstances, however, respiratory protection may be needed. These can include:

- An accidental spill such as:
 - a chemical spill outside the fume hood
 - a spill of bio-hazardous 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.

Because there are numerous types of respirators available, and each has specific limitations and applications, respirator selection and use requires pre-approval by EH&S. Any use of respirators for protection from biohazards requires full participation in the respiratory protection program including a medical evaluation for use of respirator and annual fit test and training. Use of filtering face masks under voluntary use provisions for protection from nuisance dusts and non-hazardous materials should be registered with EH&S.

Because wearing respiratory equipment places a physical burden on the user, laboratory workers must be medically evaluated prior to wearing respiratory equipment. Certain individuals (e.g., persons with severe asthma, heart conditions, or claustrophobia) may not be medically qualified to wear a respirator. Upon enrollment in Respirator Training and Fit Testing, the employee will be sent the appropriate medical questionnaire. The completed medical questionnaire will be evaluated before the employee proceeds with the training. NOTE: This medical questionnaire is confidential. The employee will be provided additional information on who to contact for follow up questions.

After successful completion of the medical evaluation, the employee will be trained and fit tested by EH&S. Training topics include:

- Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator;
- What the limitations and capabilities of the respirator are;
- How to use the respirator effectively in emergency situations, including situations in which the respirator malfunctions;
- How to inspect, put on and remove, use, and check the seals of the respirator;
- What the procedures are for maintenance and storage of the respirator;

- How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators; and
- The general requirements of the respiratory program.

Finally, a qualitative or quantitative fit test is conducted by EH&S for each respirator user. The fit test ensures a proper face to face piece seal for each individual and his/her mask. Fit testing is done in accordance with Cal/OSHA regulations (8CCR5144) (<http://www.dir.ca.gov/title8/5144.html>).

An annual refresher is required for the medical evaluation, respirator training, and fit testing. In addition to the annual training refresher, a more frequent re-training, fit testing or medical evaluation must be performed when any of the following occur:

- Changes in the workplace or the type of respirator render previous training obsolete;
- Inadequacies in the employee's knowledge or use of the respirator indicate that the employee has not retained the requisite understanding or skill;
- Any other situation arises in which reevaluation appears necessary to ensure safe respirator use;
- Facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight; or
- An employee reports medical signs or symptoms related to their ability to use a respirator.

Storage, maintenance, and cleaning of PPE

Contaminated PPE can pose an exposure hazard to the wearer as well as a risk for release of pests to the environment. Protective equipment used in labs should be kept in the lab space or other research location unless there is a safety need to wear it outside of the lab.

Gloves used in labs should be discarded inside of the lab into the appropriate waste container. If gloves may be contaminated with microbial agents or plant pests, measures must be taken to decontaminate the waste prior to disposal outside the lab.

Safety eyewear and face shields should be periodically cleaned with disinfectant cleaning wipes and maintained in a clean and useable condition. Eyewear and face shields should never be stored with the viewing lens/panel down, as this can cause scratching on the lens surface.

Used lab coats must be stored in labs or research areas and never inside of offices or food storage areas. Lab coats must never be taken home for cleaning. Lab coats must be collected and laundered at the worksite (in a designated washing machine) or picked up for routine laundering by a vendor. Heavily contaminated clothing may need to be disinfected before transfer to dirty laundry. In such cases, lab coats can be pre-treated in 10% bleach, autoclaved, or frozen to eliminate the pests or microbes of concern.

Guidelines for Human and Animal Health Protection

Guidelines for human health protection in laboratory research are published by the U.S. Centers for Disease Control (CDC) in *Biosafety in Microbiological and Biomedical Laboratories* (BMBL, 5th Edition, 2009). This publication is available free online (<https://www.cdc.gov/biosafety/publications/bmbl5/>) and is considered the reference text for biosafety practices.

Section IV of the publication describes the suite of control measures and facilities appropriate for various levels of lab research involving microorganisms, animals, and other potentially biohazardous materials.

Laboratories are classified into 4 “biosafety levels” based on the protective measures applied to the work. Biosafety level one laboratories are designed for use of lowest hazard biological materials, or materials which are not known to cause disease in healthy adults. Microorganisms are also classified in a similar manner into four risk groups according to their relative level of ability to cause disease in humans. Risk group one organisms are those organisms which are not known to cause disease in healthy adults. Some risk group one organisms may cause disease in plants, non-human animals, or in humans with compromised immune systems. Therefore standard precautions are always observed in all work with viable microorganisms in laboratories.

Any significant deviations from standard practices described below, work with pathogens, or work with genetically modified organisms must be described in a biosafety plan/SOP, regulatory permit, or Biological Use Authorization (BUA) that has been reviewed and approved by a UC Campus Institutional Biosafety Committee. This additional project-specific or agent-specific safety information should be included in the lab safety manual and must be available to lab users for review and training purposes.

The following standard practices, safety equipment, and facility requirements apply to biosafety level one labs and research spaces.

Standard Microbiological Practices for Biosafety Level One (BSL-1) Labs (from BMBL 5th ed.)

1. The laboratory supervisor (PI) must enforce the institutional policies that control access to the laboratory.
2. Persons must wash their hands after working with potentially hazardous materials and before leaving the laboratory.
3. Eating, drinking, smoking, handling contact lenses, applying cosmetics, and storing food for human consumption must not be permitted in laboratory areas. Food must be stored outside the laboratory area in cabinets or refrigerators designated and used for this purpose.
4. Mouth pipetting is prohibited; mechanical pipetting devices must be used.
5. Policies for the safe handling of sharps, such as needles, scalpels, pipettes, and broken glassware must be developed and implemented. Whenever practical, laboratory supervisors (PIs) should adopt improved engineering and work practice controls that reduce risk of sharps injuries. Precautions, including those listed below, must always be taken with sharp items. These include:
 - a. Careful management of needles and other sharps are of primary importance. Needles must not be bent, sheared, broken, recapped, removed from disposable syringes, or otherwise manipulated by hand before disposal.
 - b. Used disposable needles and syringes must be carefully placed in conveniently located puncture-resistant containers used for sharps disposal.
 - c. Non-disposable sharps must be placed in a hard walled container for transport to a processing area for decontamination, preferably by autoclaving.
 - d. Broken glassware must not be handled directly. Instead, it must be removed using a brush and dustpan, tongs, or forceps. Plastic ware should be substituted for glassware whenever possible.
6. Perform all procedures to minimize the creation of splashes and/or aerosols.
7. Decontaminate work surfaces after completion of work and after any spill or splash of potentially infectious material with appropriate disinfectant.
8. Decontaminate all cultures, stocks, and other potentially infectious materials before disposal using an effective method. Depending on where the decontamination will be performed, the following methods should be used prior to transport.
 - a. Materials to be decontaminated outside of the immediate laboratory must be placed in a durable, leak proof container and secured for transport.
 - b. Materials to be removed from the facility for decontamination must be packed in accordance with applicable local, state, and federal regulations.
9. A sign incorporating the universal biohazard symbol must be posted at the entrance to the laboratory when infectious agents (that cause disease in healthy humans) are present. The sign may include the name of the agent(s) in use, and the name and phone number of the laboratory supervisor (PI) or other responsible personnel. Labs working with plant pathogens, GMOs, or other regulated plant materials must post research spaces with signage to indicate restricted access areas that require prior authorization for entry and any special requirements for entry and exit to the work space. Agent information should be posted in accordance with the institutional policy.
10. An effective integrated pest management program is required.
11. The laboratory supervisor (PI) must ensure that laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposures, and exposure evaluation procedures. Personnel must receive annual updates or additional training when procedural or policy changes occur.

Personal health status may impact an individual's susceptibility to infection, ability to receive immunizations or prophylactic interventions. Therefore, all laboratory personnel and particularly women of childbearing age should be provided with information regarding immune competence and conditions that may predispose them to infection. Individuals having these conditions should be encouraged to self-identify to the institution's healthcare provider for appropriate counseling and guidance.

Safety Equipment for BSL – 1 Labs (Primary Barriers and Personal Protective Equipment)

1. Special containment devices or equipment, such as biosafety cabinets (BSCs), are not generally required.*
2. Protective laboratory coats, gowns, or uniforms are recommended to prevent contamination of personal clothing.
3. Wear protective eyewear when conducting procedures that have the potential to create splashes of microorganisms or other hazardous materials. Persons who wear contact lenses in laboratories should also wear eye protection.
4. Gloves must be worn to protect hands from exposure to hazardous materials. Glove selection should be based on an appropriate risk assessment. Alternatives to latex gloves should be available. Wash hands prior to leaving the laboratory. In addition, BSL-1 workers should:
 - a. Change gloves when contaminated, glove integrity is compromised, or when otherwise necessary.
 - b. Remove gloves and wash hands when work with hazardous materials has been completed and before leaving the laboratory.
 - c. Do not wash or reuse disposable gloves. Dispose of used gloves with other contaminated laboratory waste. Hand washing protocols must be rigorously followed.

Laboratory Facilities (Secondary Barriers for BSL – 1 Labs)

1. Laboratories should have doors for access control.
2. Laboratories must have a sink for hand washing.
3. The laboratory should be designed so that it can be easily cleaned. Carpets and rugs in laboratories are not appropriate.
4. Laboratory furniture must be capable of supporting anticipated loads and uses. Spaces between benches, cabinets, and equipment should be accessible for cleaning.
 - a. Bench tops must be impervious to water and resistant to heat, organic solvents, acids, alkalis, and other chemicals.
 - b. Chairs used in laboratory work must be covered with a non-porous material that can be easily cleaned and decontaminated with appropriate disinfectant.
5. Laboratories windows that open to the exterior should be fitted with screens.

****Note: Mandatory requirements for special handling/disposal of personal protective equipment, special facilities (secondary barriers), and use of primary barriers such as biosafety cabinets may be set by regulatory agencies (USDA, CDFA) or by UC campus Institutional Biosafety Committees (IBCs) that review work with plant or animal pathogens.***

Requirements for work with live vertebrate animals, carcasses and tissues, or untreated waste Research involving live animals may require additional review by an Institutional Animal Care and Use Committee (IACUC) that examines risk posed to animal health and welfare. Any animal operations that include employee exposure to animals, animal tissues and body fluids, or untreated waste from animal housing operations may also fall under the purview of the CalOSHA aerosol-transmissible disease standard which requires a site-specific safety plan to address the disease hazards.

Institutional review

In keeping with USDA regulations and UC standards for ethical care and use of animals in research, teaching, and demonstration most uses of live vertebrate animals in lab research require review and approval by an Institutional Animal Care and Use Committee (IACUC). Other uses of live animals outside of laboratory research may also require institutional review. If review is required, an Animal Use Protocol (AUP) must be submitted for review and be approved by the IACUC before work with live animals can commence.

Guidelines for animal health and ethical treatment of animals are published by the Federation for Animal Sciences and available free online for most species. Two guides are available: One for agricultural animals and one for lab animals used on research.

Guide for the Care and Use of Laboratory Animals (8th ed., 2011) is available here:

https://www.aaalac.org/resources/Guide_2011.pdf

Guide for the Care and Use of Agricultural Animals in Research and Teaching or the “The Ag Guide” (3rd ed. 2010) is available here: https://www.aaalac.org/about/Ag_Guide_3rd_ed.pdf

The local UC ANR Research Advisory Committee (RAC) and UC ANR EH&S must be notified of initial application and kept apprised of the ongoing status of any active IACUC-approved research conducted at UC ANR facilities or through UC Cooperative Extension (UCCE) Offices. Principal investigators who are based at a UC campus and conducting research with live animals at an ANR location (or through UCCE) must request review (or exemption from review) from the IACUC at their home campus. UC ANR researchers who do not have an affiliation or appointment with a UC campus must have their work reviewed by the UC Merced IACUC.

If a principal investigator is unsure whether their work requires IACUC review, they should complete the “Determination of Need for Animal Use Protocol” (Appendix 2b) from the Institutional Animal Care and Use Committee University of California, Merced (UC Merced). For help in preparing an AUP, or for advice about the laws, regulations, and policies that may affect your proposed use of animals, please contact the IACUC office at rci@ucmerced.edu or 209-383-8655. For assistance in planning specific animal care or use procedures (e.g., use of anesthetics or analgesics, surgical procedures, special animal care requirements, transportation, etc.), please contact the UC Merced Attending Veterinarian at 209-228-4040.

Zoonotic disease exposure awareness

In addition to institutional review for the safe and ethical use of animals, the potential for exposure to zoonotic disease agents must be assessed and addressed. Zoonotic diseases are diseases which can be passed from animal species to humans. The infectious animals may or may not have symptoms of illness, with some diseases only causing serious illness in humans. Working with live animals, or handling and storage of animal carcasses, tissues, and bodily fluids may pose risks for exposure to zoonotic disease agents, especially when aerosol-

generating processes are applied to viable biological materials. Storage of animal carcasses can also pose risks for exposure to disease through parasitic vectors such as fleas, mites, and ticks.

When employees are exposed to animal materials that pose zoonotic disease risk, supervisors and employees must follow the requirements of the Aerosol Transmissible Disease Standard (8CCR5199-Laboratory, 8CCR5199.1-Zoonotic). This California regulation sets forth requirements for work in laboratories and as well as work with potentially infectious animal samples outside of lab settings. If research activities fall under the scope of the regulatory standard, a formal written safety plan is required and must be available to employees for reference and training purposes. This safety plan should include a description of the nature of the biological hazards and routes of exposure, the work classifications or employees who may be exposed, safety practices to prevent disease exposures, information on medical services, and medical surveillance requirements. This manual, along with documentation of site-specific hazard assessment, PPE requirements, and SOPs, should fulfill requirements of the aerosol-transmissible disease standard (see page iii - "Required Elements of a laboratory/research biological safety plan (8CCR5199)").

Human health and safety guidelines for use of animals in research are included in the BMBL, see above section regarding protection of human health. In addition to the BMBL, the National Association of State Public Health Veterinarians Veterinary Infection Control Committee has published a compendium of standard precautions for zoonotic disease exposures in 2015. This document may serve well for non-lab settings, animal husbandry, and field work involving wild animals. Relevant portions of this document can be used to inform site-specific work practices and added to this manual as appendices in order to fulfill requirements for zoonotic disease information and training.

Compendium of Veterinary Standard Precautions for Zoonotic Disease Prevention in Veterinary Personnel
<http://nasphv.org/Documents/VeterinaryStandardPrecautions.pdf>

Laboratory work (involving animals or animal-source materials)

In general laboratory work involving animals at UC ANR is limited to studies of health animal populations.

Intentional culture or manipulation of pathogenic organisms requires specific approval from a UC campus Institutional Biosafety Committee (IBC). Intentional culture of microorganisms from animal samples may pose zoonotic disease exposure risk and should only be conducted in a Biosafety Level Two (BSL-2) facility. If a BSL-2 facility is not available, a biosafety cabinet may be used along with enhanced biosafety (BSL-2) practices in a controlled access lab facility.

Disposal of animal carcasses and waste products must be conducted in accord with local public health and agricultural codes. Disposal of potentially infectious waste or animal carcass waste requires a specific waste management plan and may require a contract with a waste vendor. Such plans and vendor agreements must be set up by principal investigators prior to commencing work with any animal materials.

Lab safety guidance and precautionary practices for handling of animal samples that may contain pathogens can be found in the two CDC resources linked below:

- *Biosafety in Microbiological and Biomedical Laboratories* (BMBL, 5th Edition, 2009) is available free online here: <https://www.cdc.gov/biosafety/publications/bmb15/>

- *Guidelines for Safe Work Practices in Human and Animal Medical Diagnostic Laboratories (MMWR Supplements, January 6, 2012 / 61(01);1-101)* is available for download here:
<https://www.cdc.gov/mmwr/preview/mmwrhtml/su6101a1.htm>

Handling and storage of environmental samples and plant materials (human health hazards)

The environment is rich in microbial diversity. Soil, water or plant samples may contain microbial species that can affect human health either as opportunistic pathogens or as chronic irritants and allergens. Exposure risk potential is higher when aerosol-generating activities are applied to materials or when microorganisms are cultured from the crude materials. Inhalation of aerosolized plant samples, soils, and water samples should be avoided. Airborne plant materials and soils may contain bacteria and fungi or they may raise the likelihood and risk of allergies in employees. Ventilation and sample handling controls should be used wherever feasible to limit exposure to aerosols. If engineering and administrative controls do not sufficiently reduce exposure hazards, employees may be advised or required to use respiratory protection (N95 filtering facemask). Pure cultures of isolates from plant, soil or other environmental samples should always be handled with caution, until they are verified as non-pathogenic.

Storage of unprocessed samples may also pose human health hazards if fungi or bacteria are allowed to grow in the sample materials. Any stored samples should be labeled with owners contact information and date. Materials must always be stored in sift-proof leak-proof containers.

Guidelines for Plant (Crop) Health Protection

Regulations and enforcement - Plant health protection regulations are established by the California Department of Food and Agriculture and the US Department of Agriculture – Animal Plant Health Inspection Service (USDA – APHIS). USDA APHIS regulates importation, exportation, and interstate movement of plant materials, soils and other items that may pose a threat to plant health. CDFA sets regulations for movement of these materials into the state and between the counties within the state. CDFA regulations are enforced by agricultural commissioners in each county.

Penalties for violation of agricultural regulations can be severe, impacting viability of research operations for decades following an incident. Penalties may include seizure or destruction of research materials, crop destruct orders issued to local farmers, monetary fines, and imprisonment.

The principles of plant pest containment – The goal of plant pest containment is to prevent the plant pest from coming in contact with susceptible hosts. While some airborne fungi and bacteria may pose risks for infection, most plant pests do not pose serious disease risk for humans. The goal of containment is to prevent release of pests from the lab location. Plant pests may be microbial agents such as bacteria fungi and viruses, water-borne invertebrates such as nematodes, or insects that crawl or fly; pests may escape labs on personal items such as back backpacks, on clothes, on the soles of shoes, in one's hair, on one's hands, on plant materials, in soil, in water effluent, or they may walk or fly out open windows and doors. For these reasons, personal items should not be brought into or stored in research areas where quarantined or regulated materials are used. Proper use of personal protective equipment such as lab coats and gloves is essential to avoid accidental release of pests and contamination of materials. Storage of personal food items in the same location as plant samples that are used for research purposes poses a risk for accidental exposures or for pest release.

A Practical Guide for Containment: Plant Biosafety in Research Greenhouses (2008), published by Virginia Tech University, provides guidance appropriate for containment of all level of plant pathogens and GMOs used in plant research. Of particular utility is a summary table of greenhouse containment features that is provided in section VI of the manual linked below.

A Practical Guide for Containment: Plant Biosafety in Research Greenhouses (2008):

<https://vtechworks.lib.vt.edu/bitstream/handle/10919/78423/ISBPracticalGuidePlantContain.pdf?sequence=1&isAllowed=y>

Plant pest standard operating procedures and containment plans

USDA-APHIS-PPQ has published containment guidelines for various types of plant pests. Whenever containment of plant pests is required to prevent serious detrimental effects upon susceptible hosts in the local environment, a containment SOP is advised. A containment SOP is required for any USDA plant pest permit application. A template for a containment or biosafety plan is provided as an appendix to the lab safety manual. Containment facility SOPs that describe the practice, equipment, and facilities used to control plant pests should be based upon the principles outlined in the following USDA containment manuals:

USDA - APHIS - PPQ Containment Guidelines for Viral Plant Pathogens and their Vectors

https://www.aphis.usda.gov/plant_health/permits/downloads/plant_viral_pathogens_containment_guidelines.pdf

USDA - APHIS - PPQ Containment Guidelines for Plant Pathogenic Bacteria

https://www.aphis.usda.gov/plant_health/permits/downloads/bacteria_containment_guidelines.pdf

USDA - APHIS - PPQ Containment Guidelines for Fungal and Oomycete Plant Pathogens

https://www.aphis.usda.gov/plant_health/permits/downloads/plant_fungal_pathogens_containment_guidelines.pdf

USDA - APHIS - PPQ Containment Guidelines for Plant Pathogenic Nematodes

https://www.aphis.usda.gov/plant_health/permits/downloads/nematodes_containment_guidelines.pdf

USDA - APHIS - PPQ Containment Guidelines for Non-indigenous biocontrol arthropods

https://www.aphis.usda.gov/plant_health/permits/downloads/arthropod_biocontrol_containment_guidelines.pdf

USDA - APHIS - PPQ Containment Guidelines for Noxious weeds and parasitic plants

https://www.aphis.usda.gov/plant_health/permits/downloads/noxiousweeds_containment_guidelines.pdf

Genetically-modified Organisms (GMOs)

Research materials that have been subject to genetic modification through experimental means must be assessed for risk posed to health and the environment. Public institutions such as the University of California must adhere to state and federal regulations and guidelines in production, use, and transfer of GMOs.

Experimental production of genetically-modified organisms (by addition or use of synthetic nucleic acid tools) requires specific review and authorization from UC ANR EH&S. Most work with recombinant or synthetic nucleic acids requires review and approval of a UC Campus IBC. Specific requirements for the work may be set by the

campus committee. Principal investigators are responsible for fulfilling the containment requirements set forth by the IBC and for immediately notifying UC ANR EH&S and the UC Campus IBC if containment requirements cannot be met or there has been an accidental release of regulated research materials.

All genetically-modified organisms must be rendered biologically inactive prior to disposal into the land fill. Edible materials produced by experimental GMOs must be destroyed and prevented from ever entering the food chain. Any accidental release of GMOs or possible contamination of the food chain with experimental materials must be reported immediately to EH&S. Reporting to federal or state agencies may be required as well.

Indoor research (labs, greenhouses, growth rooms, post-harvest facilities, storage, insectaries, etc)

“As a condition for NIH funding of recombinant or synthetic nucleic acid molecule research, institutions shall ensure that such research conducted at or sponsored by the institution, irrespective of the source of funding, shall comply with the *NIH Guidelines*.”

Laboratory production, use and storage of Genetically Modified Organisms in labs and plant growth areas must be conducted according to guidelines set for the National Institutes of Health Office of Biotechnology Activities (NIH OBA).

The NIH Guidelines for Research Involving Recombinant or Synthetic Nucleic Acids or “the NIH Guidelines” provide specific guidance for containment and biosafety for **indoor research locations**. This document is available here: https://osp.od.nih.gov/wp-content/uploads/2013/06/NIH_Guidelines.pdf

Guidelines for containment of GMOs in research involving whole plants is found in appendix P of the NIH guidelines: https://osp.od.nih.gov/wp-content/uploads/NIH_Guidelines.html#_Toc446948504

Outdoor research and shipping via commercial carrier

Importation, interstate movement, or Intentional outdoor release of regulated GMOs (GMOs that have not gone through the process to become commercially available products) requires specific approval from the Biotechnology Regulatory Service of USDA-APHIS (USDA-APHIS-BRS). See also: Transportation and shipment of biological materials below.

USDA-APHIS-BRS Guidance for Permit Applications (March 2017) is available here: https://www.aphis.usda.gov/biotechnology/downloads/permit_guidance.pdf

USDA-APHIS-BRS Guidance for Notifications (March 2011) is available here: https://www.aphis.usda.gov/biotechnology/downloads/notification_guidance_0311.pdf

In order to support compliance with federal regulations in the event of an emergency or natural disaster, UC ANR EH&S should be notified of any USDA-permitted outdoor plantings or significant storage of regulated GMOs at ANR facilities.

Standard Procedure for Biological Spill Clean-up

Prior to work with any biological materials, it is essential that employees know how to clean up and report any hazardous spills or accidental release outdoors.

Before you decide to clean up the spill, ask yourself...

- Is the spill indoors and small enough that you can clean it up without assistance?
- Have you checked yourself and others nearby the spill for spatter or shoe contamination?
- Have you alerted the lab personnel and passersby (for spills in corridors)?
- Have you located the spill kit and verified that you have everything you need?
- Are you trained to clean-up the material that has spilled?

If you answered “yes” to the questions above and it is appropriate for you to clean up the spill, you may proceed as outlined below:

1. Wear appropriate PPE to clean spills – gloves, eye protection for splash or spray hazards, and a lab coat are minimum for cleaning up a hazardous spill. Remember that you may need protection from the disinfectants as well as the biological materials.
2. If the spill involved broken glass, pick up the large pieces with the forceps or egg tongs and dispose in a hard-walled sharps container. Handle with care!
3. Distribute paper towels around the periphery of the spill, then towards the center. Use a gloved hand (or the forceps or egg tongs) to push paper towels into recesses where spilled material may have flowed.
4. Apply appropriate liquid disinfectant (10% bleach, greenhouse disinfectant, virkon, etc)
5. When the spill is fully covered with paper towels, spray or very carefully pour 10% bleach or other approved disinfectant on the paper towels.
6. Allow the spill to have the appropriate amount of contact time for disinfectant to inactivate biological agents (30 minutes for 10% bleach).
7. Pick up the paper towels with gloved hands (or large forceps or egg tongs) and put them in the appropriate waste bag. Change gloves and put used gloves in bag as well.
8. Spray or carefully pour 10% bleach or other approved disinfectant on the surface residue.
9. Wipe up the residue with paper towels and place in appropriate bag. Small bits and pieces of broken glass should be entrained in the wet paper towels and discarded into the waste bag. Pieces too large or heavy to entrain must be discarded in a sharps container.
10. Repeat steps 8-9 at least once to assure that residual contamination from the spill is eliminated.
11. Seal and transport the waste collection bag to the appropriate autoclave or waste accumulation site.
12. If broken glass was disposed in a sharps container, seal the container permanently, decontaminate the exterior with the sprayed liquid disinfectant, and transport the sealed container to dumpster or request a sharps waste pickup from hazardous waste vendor (e.g., Stericycle).
13. Clean and disinfect the forceps or egg tongs and any other non-disposable items before returning them to the spill kit. If possible, autoclave the forceps or egg tongs before returning them to the kit.
14. Report the spill to your supervisor and location safety coordinator. Some biological materials such as GMOs or infectious agents, if spilled outdoors, may require notification of UC campus IBC or local agricultural authorities.

Transportation and Shipment of Biological Materials

Movement within the state of California

Transportation and shipment of human or animal pathogens requires specific training and is regulated under federal transportation regulations. Contact EH&S if shipment or transportation of known or suspected animal or human pathogens is necessary.

GMO's that are produced within the state of California may be transported within the state of California following standard precautions to prevent release or establishment in the outdoor environment (see 7CFR340 package requirements below).

Interstate movement and international importation

Importation or movement of GMOs and USDA-regulated plant pests across state lines requires authorization from USDA-APHIS.

Shipment of potentially hazardous plant materials or regulated GMOs must follow requirements set forth in 7CFR 340.7 and 7CFR 340.8 below.

Marking and identity (7 CFR § 340.7)

(a) Any regulated article to be imported other than by mail, shall, at the time of importation into the United States, plainly and correctly bear on the outer container the following information:

- (1) General nature and quantity of the contents;
- (2) Country and locality where collected, developed, manufactured, reared, cultivated or cultured;
- (3) Name and address of shipper, owner, or person shipping or forwarding the organism;
- (4) Name, address, and telephone number of consignee;
- (5) Identifying shipper's mark and number; and
- (6) Number of written permit authorizing the importation.

(b) Any regulated article imported by mail, shall be plainly and correctly addressed and mailed to APHIS through any USDA plant inspection station listed in § 319.37-14 of this chapter and shall be accompanied by a separate sheet of paper within the package plainly and correctly bearing the name, address, and telephone number of the intended recipient, and shall plainly and correctly bear on the outer container the following information:

- (1) General nature and quantity of the contents;
- (2) Country and locality where collected, developed, manufactured, reared, cultivated, or cured;
- (3) Name and address of shipper, owner, or person shipping or forwarding the regulated article; and
- (4) Number of permit authorizing the importation;

(c) Any regulated article imported into the United States by mail or otherwise shall, at the time of importation or offer for importation into the United States, be accompanied by an invoice or packing list indicating the contents of the shipment.

Container requirements for the movement of regulated articles (7 CFR § 340.8)

(a) General requirements. A regulated article shall not be moved unless it complies with the provisions of paragraph (b) of this section, unless a variance has been granted in accordance with the provisions of paragraph (c) of this section.

The requirements of this section are in addition to and not in lieu of any other packing requirements such as those for the transportation of etiologic agents prescribed by the Department of Transportation in Title 49 CFR or any other agency of the Federal government.

(b) Container requirements -

(1) Plants and plant parts. All plants or plant parts, except seeds, cells, and subcellular elements, shall be packed in a sealed plastic bag of at least 5 mil thickness, inside a sturdy, sealed, leak-proof, outer shipping container constructed of corrugated fiberboard, corrugated cardboard, wood, or other material of equivalent strength.

(2) Seeds. All seeds shall be transported in a sealed plastic bag of at least 5 mil thickness, inside a sealed metal container, which shall be placed inside a second sealed metal container. Shock absorbing cushioning material shall be placed between the inner and outer metal containers. Each metal container shall be independently capable of protecting the seeds and preventing spillage or escape. Each set of metal containers shall then be enclosed in a sturdy outer shipping container constructed of corrugated fiberboard, corrugated cardboard, wood, or other material of equivalent strength.

(3) Live microorganisms and/or etiologic agents, cells, or subcellular elements. All regulated articles which are live (non-inactivated) microorganisms, or etiologic agents, cells, or subcellular elements shall be packed as specified below:

(i) Volume not exceeding 50 ml. Regulated articles not exceeding 50 ml shall be placed in a securely closed, watertight container (primary container, test tube, vial, etc.) which shall be enclosed in a second, durable watertight container (secondary container). Several primary containers may be enclosed in a single secondary container, if the total volume of all the primary containers so enclosed does not exceed 50 ml. The space at the top, bottom, and sides between the primary and secondary containers shall contain sufficient nonparticulate absorbent material (e.g., paper towel) to absorb the entire contents of the primary container(s) in case of breakage or leakage. Each set of primary and secondary containers shall then be enclosed in an outer shipping container constructed of corrugated fiberboard, corrugated cardboard, wood, or other material of equivalent strength.

(ii) Volume greater than 50 ml. Regulated articles which exceed a volume of 50 ml. shall comply with requirements specified in paragraph (b)(3)(i) of this section. In addition, a shock absorbing material, in volume at least equal to that of the absorbent material between the primary and secondary containers, shall be placed at the top, bottom, and sides between the secondary container and the outer shipping container. Single primary containers shall not contain more than 1,000 ml. of material. However, two or more primary containers whose combined volumes do not exceed 1,000 ml. may be placed in a single, secondary container. The maximum amount

of micro-organisms or etiologic agents, cells, or subcellular elements which may be enclosed within a single outer shipping container shall not exceed 4,000 ml.

(iii) Dry ice. If dry ice is used as a refrigerant, it shall be placed outside the secondary container(s). If dry ice is used between the secondary container and the outer shipping container, the shock absorbing material shall be placed so that the secondary container does not become loose inside the outer shipping container as the dry ice sublimates.

(4) Insects, mites, and related organisms. Insects, mites, and other small arthropods shall be packed for shipment as specified in this paragraph or in paragraph (b)(3) of this section. Insects (any life stage) shall be placed in an escape-proof primary shipping container (insulated vacuum container, glass, metal, plastic, etc.) and sealed to prevent escape. Such primary container shall be placed securely within a secondary shipping container of crushproof styrofoam or other material of equivalent strength; one or more rigid ice packs may also be placed within the secondary shipping container; and sufficient packing material shall be added around the primary container to prevent movement of the primary shipping container. The secondary (styrofoam or other) container shall be placed securely within an outer shipping container constructed of corrugated fiberboard, corrugated cardboard, wood, or other material of equivalent strength.

(5) Other macroscopic organisms. Other macroscopic organisms not covered in paragraphs (b) (1), (2), and (4) of this section which do not require continuous access to atmospheric oxygen shall be packaged as specified in paragraph (b)(3) or (b)(4) of this section. All macroscopic organisms which are not plants and which require continuous access to atmospheric oxygen shall be placed in primary shipping containers constructed of a sturdy, crush-proof frame of wood, metal, or equivalent strength material, surrounded by escape-proof mesh or netting of a strength and mesh size sufficient to prevent the escape of the smallest organism in the shipment, with edges and seams of the mesh or netting sealed to prevent escape of organisms. Each primary shipping container shall be securely placed within a larger secondary shipping container constructed of wood, metal, or equivalent strength material. The primary and secondary shipping containers shall then be placed securely within an outer shipping container constructed of corrugated fiberboard, corrugated cardboard, wood, or other material of equivalent strength, which outer container may have air holes or spaces in the sides and/or ends of the container, provided that the outer shipping container must retain sufficient strength to prevent crushing of the primary and secondary shipping containers.

(c) Request for a variance from container requirements. A responsible person who believes the container requirements normally applicable to the movement of the person's regulated article(s) are inappropriate due to unique circumstances (such as the nature, volume, or life stage of the regulated article) may submit in an application for a permit, a request for a variance from the container requirements. The request for a variance under this section shall consist of a short statement describing why the normally applicable container requirements are inappropriate for the regulated article which the person proposes to move and what container requirements the person would use in lieu of the normally prescribed container requirements. USDA shall advise the responsible person in writing at the time a permit is granted on the person's request for a variance.

Safe Use and Disposal of Sharps (needles, scalpels, glass pipettes, disposable blades)

Sharps may include needles, scalpels and other sharp pointed objects used in research that may readily puncture the skin. Use of sharps in research requires specific hands-on training and knowledge of disposal practices. Needles should never be re-capped. Needles and disposal blades must be thrown into the waste container once they are no longer of use. Needles and razor blades should never be left stored in common areas where others may accidentally come in contact with them.

Sharps must be collected in a hard-walled spill-proof container that prevents easy access and removal of waste once it is deposited within – whether or not they are contaminated with human blood or human pathogens. Needles, blades, scalpels, and glass pipettes used in non-hazardous lab operations and research cannot be thrown in the regular trash because they pose a puncture risk for others who may handle the trash during or after it is removed from the lab. Needles and similar devices used to puncture skin are also banned from many municipal landfill disposal sites and must be disposed as “home generated sharps waste” through the local sanitation agency or landfill. Sharps used for human blood or contaminated with human pathogens is considered Regulated Medical Waste. Sharps with regulated plant pests, animal pathogens, or sharps resulting from animal care (veterinary) activities may require special treatment such as autoclave sterilization or disposal through a waste vendor.

Biological Waste Handling and Treatment

Biological waste includes any material that once contained or now contains living organisms, or that is a product, portion, or waste of a living or once-living organism. Examples of biological waste may include, but is not limited to: untreated animal carcasses, soiled bedding from animal housing or husbandry operations, untreated animal tissues or body fluids, discarded cultures from labs, dead insects, discarded plant material, or soil. Biological waste may or may not be inherently hazardous. Even non-hazardous biological waste from experiments can become a sanitation concern or can provide a reservoir for establishment of hazardous pathogens or pests if it is not collected and disposed properly.

Regulated biological waste

Disposal of biological wastes that pose a threat to local human health, animal health, plant health, or ecology may be regulated by state and federal agencies. Strict regulations govern handling and treatment of waste that may contain human pathogens or USDA-regulated plant pests. Those wastes are managed under permits issued by the local department of public health (human pathogens) or USDA (animal and plant pathogens). Biological waste that contains GMOs or quarantined and regulated pests (QARP) should never be released to the environment without treatment (or specific authorization for release). This waste must be managed and disposed of as specified by USDA, CDFR, and local agricultural authority.

Regulated Medical Waste and carcass waste

Biological waste that is infectious to humans must be managed and disposed of as medical waste. Regulated Medical Waste is waste which contains human pathogens, human blood or OPIM. This type of biological waste is required to have the biohazard symbol on it and must be handled according to US Department of Transportation (US DOT) Guidelines and the California Medical Waste Management Act. If medical waste is generated as part of the research project, a medical waste management plan is required and all infectious waste must be sealed in bags and transferred to the waste vendor on a weekly basis. Service agreements and contracts must be

established with a medical waste vendor prior to commencing any research that may require or result in generation of medical waste. **The biohazard symbol, the word biohazard, and red waste bags MUST be reserved ONLY FOR MEDICAL WASTE.**

Animal carcasses, tissues, and bodily fluids from animals not known or suspected to harbor diseases must be handled and disposed as carcass waste through an authorized waste vendor. Samples or large volumes of carcass waste that have resulted from a significant animal disease event must be handled as infectious. In cases of animal disease outbreak response, local authorities may enact specific requirements for disposal of animal waste. Service agreements and contracts should be established with waste vendors prior to commencing any research that may require or result in storage of animal carcasses.

Mixed wastes

Mixed wastes are wastes that have radioactive or chemical hazard in addition to biological hazard. Whenever possible, it is best to anticipate and avoid generating mixed wastes. Unless human pathogens, biological waste containing hazardous chemicals or radioactive materials is classified as and considered to be chemical or radioactive waste respectively. Autoclaving or adding bleach to biological waste that also has other hazardous chemicals or radiation present may increase the overall hazard of the waste greatly. Deliberate culture or use of human pathogens is prohibited at UC ANR without specific authorization, thus most uses of radiation or hazardous chemicals in conjunction with human biohazards are also similarly prohibited.

Sharps waste

Sharps waste is managed according to what type of materials may be on the sharps that are discarded. Sharps waste that is generated in research involving human pathogens or human blood and tissue must be managed and disposed of as medical waste sharps. This waste is collected in a sharps container with a biohazard symbol.

Sharps waste that does not contain any human pathogens or body fluids, should be collected in a puncture proof container that prevents access and spillage of waste that is deposited within. A traditional sharps container can be used for collection of non-medical waste sharps, but the container must NOT have a biohazard symbol or the biohazard symbol and word "Biohazard" must be defaced and rendered illegible. Sharps waste containers must be disposed through a licensed waste vendor or through local waste authority that accepts sharps waste.

Unregulated biological waste

Other biological wastes such as daily lab trash containing spent media, plants, and relatively low hazard organisms should be evaluated and treated according to the level of risk posed by the waste. Any type of biological waste may still pose local contamination, disease, or sanitation concerns if not contained and managed properly. Biological waste that does not contain known human pathogens may be treated onsite to biologically inactivate resident microorganisms. Large volumes of pure cultures of locally endemic microbial agents that do not pose a serious detrimental impact to local ecology or agriculture should also be biologically inactivated prior to disposal to the land fill to avoid creating or worsening any local reservoirs of plant pests.

Waste treatment and disposal methods

Any waste treatment methods or procedures in use must be based on established practices or previously published references, and should provide for an objective means to verify efficacy of the treatment.

Sterilization refers to the complete elimination or destruction of all forms of life by a chemical or physical means. This is an absolute, not a relative term. Disinfection or decontamination refers to reduction in the number of target microorganisms, usually by at least a factor of 10^6 . Disinfection is expected to eliminate almost all disease causing microorganisms, but might not eliminate all living organisms. Some disinfectants are not effective against bacterial spores and certain types of viruses.

Physical waste treatment

Autoclave treatment (121C 15 psi for minimum 30 minutes) is the preferred method for sterilizing biological waste that is not infectious to humans. Some plant pests and pathogens may be inactivated by dry heat of ovens, by freezing or by passive desiccation.

Whenever autoclaves are relied upon to inactivate plant pests and treat waste, the function of the autoclaves should be verified twice annually by use of biological indicator tests (*Geobacillus sterothermophilus*). This is a requirement for waste that is regulated under USDA permits. Tests must be conducted as specified by manufacturer, with documentation of results and any associated repairs or maintenance on the autoclave preserved as record of compliance.

Biological waste that does not contain human pathogens or body fluids must be autoclaved in autoclave bags that DO NOT have any biohazard symbols or the word Biohazard on them. The biohazard symbol, the word biohazard, and red waste bags MUST be reserved ONLY FOR REGULATED MEDICAL WASTE that poses a threat to human health.

Chemical treatment

Chemical disinfectants commonly used in biological lab facilities include aldehydes, halogen-based disinfectants, quaternary ammonium, phenolic compounds, and alcohols.

Whenever a chemical disinfectant is used, it is critical to mix the solution gently but thoroughly (avoiding splash and pressure build up), and follow the manufacturers instruction for contact time and concentration of disinfectant needed to provide at least a 6-log reduction in viable microorganisms. Use of any chemical disinfectants must include full consideration and assessment for chemical incompatibilities in the waste, as well as disposal or liquid effluent outflow of the used disinfectant mixture to the environment. Many disinfectants listed for horticultural use cannot be released to the environment because they will cause damage to aquatic and amphibious animals. Large volume or highly concentrated bleach solutions may impact local septic or water treatment operations.

Aldehydes (formaldehyde, formalin solution, glutaraldehyde) – Aldehyde chemicals are used to disinfect surfaces and equipment. However, these chemicals are also hazardous to human health. Formaldehyde and formaldehyde solutions (such as formalin) are carcinogens that are hazardous by inhalation. Use of formaldehyde in research requires a written SOP describing the hazards of the chemical, the uses of the chemical, and steps to take to protect one's health from exposures to formaldehyde. Use of a properly functioning and annually certified fume hood is required for use formaldehyde and formalin. Formaldehyde

solutions are sometimes used for long term storage of biological specimens due to the excellent bacteriostatic properties of the chemical. Storage of plant specimens and arthropods in formaldehyde solutions should be avoided unless no other options exist. Alcohol or other less toxic chemicals should be used for archival storage of specimens

Bleach - Household bleach may be used to inactivate small to moderate volumes (1L or less) of liquid culture and suspensions of microorganisms. In general, adding bleach to achieve a 10% final concentration, mixing well and allowing to sit for 30 minutes will inactivate most microorganisms. Local ventilation (a fume hood) may be needed to remove irritant and foul odors during the contact time isolation period. Presence of organic materials, such as soil or bodily fluid, may reduce the efficacy of some chemical disinfectants such as bleach. In such instances, longer contact time or higher concentration may be required for effective disinfection.

Diluted bleach solutions should always be made up fresh. Diluted bleach solutions will lose their disinfectant activity after approximately one week of storage. Chemical test strips can be used to assess the free chlorine left in bleach solutions over time. Bleach can have hazardous chemical reactions if mixed with formaldehyde or with acids or ammonia-based chemicals. Bleach solutions should not be autoclaved.

Iodophors – Iodophor disinfectants include chemicals sold under the names Westodyne, Betadyne, and Povodine-iodine. Iodophors consist of iodine and a solubilizing agent. Iodophor antiseptics are widely used for treatment of wounds. Iodophors provide more sustained release disinfectant power than bleach solutions and are popular in animal husbandry applications. Iodophors can be used in water supplies and foot baths. Iodophor solutions may stain porous plastics.

Quaternary ammonium compounds (Simple Green, Phisan 20, Green-Shield) - Quaternary ammonium disinfectants or “quats” include popular greenhouse disinfectants like phisan and greenshield. These chemicals are more stable and effective than bleach in the presence of organic material such as soil and plant debris. Quats may leave residue that requires rinsing. If Quats are applied via spray in area of inadequate ventilation, respiratory protection may be required to avoid irritation. Written SOPs should be prepared for any large scale uses of quaternary ammonium products for disinfection.

Phenolics (Lysol, Pine-sol) – These disinfectant chemicals retain high activity in presence of organic materials. They are often used for routine cleaning in areas where virus elimination is important (bathroom, kitchen).

Alcohols (70% ethanol, 70% isopropanol) – Alcohols have been shown to be effective against a wide variety of microorganisms. However, alcohol solutions are not registered with EPA as disinfectants. Alcohol sprays and wipes can be used for quick surface disinfection. The main drawbacks of alcohol are that it is flammable and it evaporates too fast to provide disinfectant action against many microorganisms. A 70% solution in water is most effective for elimination of bacteria, fungi, and viruses.

In some cases 95% ethanol is used to facilitate flame sterilization of instruments used in aseptic tissue culture or microbiology work. In this case, heat is the primary sterilization technique and alcohol is a secondary feature. Extreme caution must be employed whenever high concentration alcohol solutions are used in conjunction with open flame. The container of 95% alcohol used as part of flame sterilization must be the smallest volume needed, have a lid that can be quickly placed atop the container (to extinguish any accidental fire and prevent

evaporation/spill hazard when not in use), and the container must be stable enough to avoid easily tipping over in use. Note: A fire retardant (FR) lab coat should be worn if there is danger of igniting one's clothes when using alcohol for flame sterilization of materials.

Destructive processing or analysis methods

Chemicals and extreme temperatures used in processing of samples may also result in biological inactivation of microorganisms such as when plant materials are ground in chemical solvents, frozen in liquid nitrogen, stored frozen at -80C, subjected to boiling temperatures (100C), or subjected to bulk nucleic acid extraction methods.

Disposal through certified hazardous waste vendor

The majority of solid Regulated Medical Waste (human infectious waste), unknown potentially infectious waste, waste containing hazardous pesticides, and sharps waste must be disposed through authorized hazardous waste vendors. Contracts with vendors must be established and implemented prior to generation of any waste that requires disposal through commercial vendors.

[Biosafety Definitions \(8CCR5199, 8CCR 5199.1, 7CFR340\)](#)

AEROSOL. A suspension of liquid or solid particles in the air, including droplets, droplet nuclei, fomites, and dusts.

AEROSOL TRANSMISSIBLE PATHOGEN (ATP). A pathogen that is transmitted by liquid or solid particles in the air, including droplets, droplet nuclei, fomites and dusts.

AEROSOL TRANSMISSIBLE PATHOGEN - LABORATORY (ATP-L). A pathogen that meets one of the following criteria: (1) the pathogen appears on the list in Appendix D, (2) the Biosafety in Microbiological and Biomedical Laboratories (BMBL) recommends biosafety level 3 or above for the pathogen, (3) the biological safety officer recommends biosafety level 3 or above for the pathogen, or (4) the pathogen is a novel or unknown pathogen.

ANIMAL WASTE. Animal carcasses, excrement, contaminated litter, or debris from the bodies of animals, such as feathers or dander.

ANIMALS INFECTED WITH ZONOTIC ATPs. Animals that (1) have been diagnosed with a zoonotic ATP through recognized testing methods or (2) meet the clinical definition of a suspect case of infection with a zoonotic ATP or (3) have been identified by the CDFA, CDFG, USDA, or USDO as requiring isolation, quarantine, or destruction due to suspected or confirmed infection.

BIOLOGICAL SAFETY OFFICER(S). A person who is qualified by training and/or experience to evaluate hazards associated with laboratory procedures involving ATPs-L, who is knowledgeable about the facility biosafety plan, and who is authorized by the employer to establish and implement effective control measures for laboratory biological hazards.

BIO SAFETY IN MICROBIOLOGICAL AND BIOMEDICAL LABORATORIES (BMBL). Biosafety in Microbiological and Biomedical Laboratories, Fifth Edition, CDC and National Institutes for Health, 2007, which is hereby incorporated by reference for the purpose of establishing requirements for risk assessments and control measures in vertebrate animal research facilities.

BIO SAFETY LEVEL 3. Compliance with the criteria for laboratory practices, safety equipment, and facility design and construction recommended by the CDC in Biosafety in Microbiological and Biomedical Laboratories for laboratories in which work is done with indigenous or exotic agents with a potential for aerosol transmission and which may cause serious or potentially lethal infection.

BIOSECURITY PROCEDURES. Control measures, such as traffic control, disinfection, and isolation, that are implemented to reduce the risk of transmission of infection into, from, or within an establishment. The purpose of biosecurity measures is to prevent direct or indirect animal-to-animal transmission of zoonotic ATPs, release of pathogens into the environment, and infection of people who may come into contact with animals or areas where animals are housed, or with debris from those areas. The specific biosecurity measures necessary depend on the type of operation conducted by the employer. Typically, no provision for biosecurity other than the use of common sanitation measures is required for incidental removal of animal carcasses or other wastes, unless the activity may result in the introduction of pathogens into areas where animals are kept or housed, or unless the animal is the subject of an applicable alert or disease control order.

CDFA. California Department of Food and Agriculture.

CDFG. California Department of Fish and Game.

CDC. United States Centers for Disease Control and Prevention.

CDPH. California Department of Public Health and its predecessor the California Department of Health Services.

CDC. United States Centers for Disease Control and Prevention.

CONTAINMENT. Enclosure of viable materials within containers or buildings such as bug dorms, greenhouses, or growth chambers.

CONFINEMENT. Control of viable materials within a designated area such as a greenhouse bench or an outdoor field plot.

DECONTAMINATION. The removal of hazardous substances from employees and their equipment to the extent necessary to preclude the occurrence of foreseeable adverse health effects.

DISINFECTANT. A chemical or physical agent that is applied to inanimate objects to kill microorganisms. Disinfectants may vary in their ability to kill various types of microorganisms or be ineffective against some type of spore-forming microorganisms.

DROPLET PRECAUTIONS. Infection control procedures as described in Guideline for Isolation Precautions designed to reduce the risk of transmission of infectious agents through contact of the conjunctivae or the mucous membranes of the nose or mouth of a susceptible person with large-particle droplets (larger than 5 m m in size) containing microorganisms generated from a person who has a clinical disease or who is a carrier of the microorganism.

EXPOSURE INCIDENT. An event in which all of the following have occurred: (1) An employee has been exposed to an individual who is a case or suspected case of a reportable ATD, or to a work area or to equipment that is reasonably expected to contain ATPs associated with a reportable ATD; and (2) The exposure occurred without the benefit of applicable exposure controls required by this section, and (3) It reasonably appears from the circumstances of the exposure that transmission of disease is sufficiently likely to require medical evaluation.

GENETICALLY MODIFIED ORGANISM (GMO). A organism which has been artificially (experimentally) altered via use of synthetic or recombinant nucleic acid molecules so as to produce a desired characteristic.

HIGH HAZARD PROCEDURES. Procedures performed on a patient that is a case or suspected case of an aerosol transmissible disease or on a specimen suspected of containing an ATP-L, in which the potential for being exposed to aerosol transmissible pathogens is increased due to the reasonably anticipated generation of aerosolized pathogens. High Hazard Procedures also include, but are not limited to, autopsy, clinical, surgical and laboratory procedures that may aerosolize pathogens.

IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH). An atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape.

INTERSTATE. From any State into or through any other State.

INTRODUCE OR INTRODUCTION (USDA-APHIS). To move into or through the United States, to release into the environment, to move interstate, or any attempt thereat.

LABORATORY. A facility or operation in a facility where the manipulation of specimens or microorganisms is performed for the purpose of diagnosing disease or identifying disease agents, conducting research or experimentation on microorganisms, replicating microorganisms for distribution or related support activities for these processes.

LOCAL HEALTH OFFICER. The health officer for the local jurisdiction responsible for receiving and/or sending reports of communicable diseases, as defined in Title 17, CCR.

MOVE (MOVING, MOVEMENT). To ship, offer for shipment, offer for entry, import, receive for transportation, carry, or otherwise transport or move, or allow to be moved into, through, or within the United States.

NOVEL OR UNKNOWN ATP. A pathogen capable of causing serious human disease meeting the following criteria:

- (1) There is credible evidence that the pathogen is transmissible to humans by aerosols; and
- (2) The disease agent is (a) A newly recognized pathogen, or (b) A newly recognized variant of a known pathogen and there is reason to believe that the variant differs significantly from the known pathogen in virulence or transmissibility, or (c) A recognized pathogen that has been recently introduced into the human population, or (d) A not yet identified pathogen.

OCCUPATIONAL EXPOSURE (ATP-L). Exposure from work activity or working conditions that is reasonably anticipated to create an elevated risk of contracting any disease caused by ATPs or ATPs-L if protective measures are not in place. In this context, “elevated” means higher than what is considered ordinary for employees having direct contact with the general public.

OCCUPATIONAL EXPOSURE (ZOO NOTIC). Reasonably anticipated work exposure to a source of zoonotic ATPs under conditions that, without the use of protective measures, create a significant risk of contracting the disease caused by the pathogen. Examples of such conditions include: conducting diagnostic sampling of animals reasonably suspected of infection, performing animal husbandry activities with flocks quarantined due to an increased risk of infection with zoonotic ATPs, and disposing of infected animal carcasses or their wastes.

ORGANISM. Any active, infective, or dormant stage or life form of an entity characterized as living, including vertebrate and invertebrate animals, plants, bacteria, fungi, mycoplasmas, mycoplasma-like organisms, as well as entities such as viroids, viruses, or any entity characterized as living, related to the foregoing.

OXYGEN DEFICIENT ATMOSPHERE. An atmosphere with an oxygen content below 19.5% by volume.

PERMIT. A written permit issued by a regulatory agency such as USDA APHIS or CDFA. The permit serves as an enforceable contract between responsible party and government agency. Under the authority of the Plant Protection Act of 2000, USDA standard permit conditions apply to all work with suspected plant pests.

PLANT. Any living stage or form of any member of the plant kingdom including, but not limited to, eukaryotic algae, mosses, club mosses, ferns, angiosperms, gymnosperms, and lichens (which contain algae) including any

parts (e.g. pollen, seeds, cells, tubers, stems) thereof, and any cellular components (e.g. plasmids, ribosomes, etc.) thereof.

PLANT PEST. Any living stage (including active and dormant forms) of insects, mites, nematodes, slugs, snails, protozoa, or other invertebrate animals, bacteria, fungi, other parasitic plants or reproductive parts thereof; viruses; or any organisms similar to or allied with any of the foregoing; or any infectious agents or substances, which can directly or indirectly injure or cause disease or damage in or to any plants or parts thereof, or any processed, manufactured, or other products of plants.

PHYSICIAN OR OTHER LICENSED HEALTHCARE PROFESSIONAL (PLHCP). An individual whose legally permitted scope of practice in California allows him or her to provide independently or be delegated the responsibility to provide some or all of the health care services required by regulation.

UNTREATED ANIMAL PRODUCTS, BYPRODUCTS, OR WASTES. Materials derived from animals that have not been processed in a manner that will deactivate zoonotic ATPs the materials may contain. "Untreated animal products, byproducts, or wastes" do not include animal carcasses or portions thereof that have passed an inspection in accordance with the standards of the USDA or CDFA and have been determined to be fit for human consumption.

VECTOR OR VECTOR AGENT.

Molecular biology/biotechnology - Organisms or objects such as DNA/RNA used to transfer genetic material from the donor organism to the recipient organism.

Infectious disease – An organism which transmits disease to other organisms.

REGULATED ARTICLE (USDA APHIS). Any organism which has been altered or produced through genetic engineering, if the donor organism, recipient organism, or vector or vector agent belongs to any genera or taxa designated in 7CFR §340.2 and meets the definition of plant pest, or is an unclassified organism and/or an organism whose classification is unknown, or any product which contains such an organism, or any other organism or product altered or produced through genetic engineering which the Administrator, determines is a plant pest or has reason to believe is a plant pest. Excluded are recipient microorganisms which are not plant pests and which have resulted from the addition of genetic material from a donor organism where the material is well characterized and contains only non-coding regulatory regions.

RELEASE INTO THE ENVIRONMENT. The use of a regulated article outside the constraints of physical confinement that are found in a laboratory, contained greenhouse, or a fermenter or other contained structure.

RESPONSIBLE PERSON (USDA APHIS PERMIT). The person who has control and will maintain control over the introduction of the regulated article and assure that all conditions contained in the permit and requirements in this part are complied with. A responsible person shall be a resident of the United States or designate an agent who is a resident of the United States.

REPORTABLE AEROSOL TRANSMISSIBLE DISEASE (RATD). A disease or condition which a health care provider is required to report to the local health officer, in accordance with Title 17 CCR, Division 1, Chapter 4, and which meets the definition of an aerosol transmissible disease (ATD).

RESPIRATOR. A device which has met the requirements of 42 CFR Part 84, has been designed to protect the wearer from inhalation of harmful atmospheres, and has been approved by NIOSH. for the purpose for which it is used.

RESPIRATOR USER. An employee who in the scope of their current job may be assigned to tasks which may require the use of a respirator, in accordance with subsection (g).

STERILIZATION. Complete elimination or destruction of all forms of life by a chemical or physical means.

SIGNIFICANT EXPOSURE. An exposure to a source of ATPs or ATPs-L in which the circumstances of the exposure make the transmission of a disease sufficiently likely that the employee requires further evaluation by a PLHCP.

SOURCE CONTROL MEASURES. The use of procedures, engineering controls, and other devices or materials to minimize the spread of airborne particles and droplets from an individual who has or exhibits signs or symptoms of having an ATD, such as persistent coughing.

USDA. United States Department of Agriculture.

USDOI. United States Department of the Interior, or any of its agencies, including the United States Fish and Wildlife Service and the United States Geological Survey.

WILDLIFE. Wild birds and other animals that are not domesticated, including their remains and wastes.

ZOONOTIC AEROSOL TRANSMISSIBLE PATHOGEN (ZOONOTIC ATP). A disease agent that is transmissible from animals to humans by aerosol, and is capable of causing human disease. Zoonotic ATPs include pathogens that are classified as transmissible either by droplets or by an airborne route.

ZOONOTIC ATP INCIDENT RESPONSE. Operations conducted to control an outbreak of an animal disease involving the destruction and/or disposal of animals infected with zoonotic ATPs and the clean up, decontamination and disinfection of areas and equipment associated with the infected animals or their remains

Appendices and SOPs

Appendices

Appendix 2a – Biosafety Plan / Containment SOP template

Appendix 2b – Determination of Need for Institutional Animal Care and Use Committee

Appendix 2c – Biosafety lab facility design matrix (engineering controls)

Appendix 2d – List of Select Agents and Toxins

Appendix 2e – List Aerosol-Transmissible Disease Agents

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Section 3 - Chemical Hygiene Plan

Background and Introduction

Purpose

The University of California Agriculture and Natural Resources (UC ANR) Chemical Hygiene Plan (CHP) establishes a formal written program for protecting laboratory personnel against adverse health and safety hazards associated with exposure to potentially hazardous chemicals and must be made available to all employees working with hazardous chemicals. The CHP describes the proper use and handling practices and procedures to be followed by faculty, staff, students, visiting scholars, and all other personnel working with potentially hazardous chemicals in laboratory settings. 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 “Safety in Academic Chemistry Laboratories” (www.acs.org).

UC ANR has developed and is implementing this Chemical Hygiene Plan. Each principal investigator is responsible for modifying this plan by adding SOPs and documentation to address lab-specific hazards. Each principal investigator is responsible for working with lab users, location safety coordinators, and EH&S specialist as needed to assure implementation, oversight, and annual review of this CHP

Scope

The CHP applies to laboratories that use, store, or handle potentially hazardous chemicals and all personnel who work in these facilities. This document is be part of the Injury Illness and Prevention Plan (IIPP) for each ANR location where employees handle hazardous chemicals in laboratory settings. The CHP does not apply to research involving exclusively radiological materials, radiation producing machines, lasers, or biological materials, as these safety procedures and regulatory requirements are outlined in the UC Davis [Radiation Safety Manual](#), [Hydroprobe Safety Manual](#), [Laser Safety Manual](#), and project-specific Biosafety Plan or [Biological Use Authorization \(BUA\)](#) 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. Laboratory personnel in compliance with the Chemical Hygiene Plan are not required to comply with the Hazard Communication component of the IIPP.

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 potentially hazardous chemicals. It is not intended to be all inclusive. Departments, divisions or other work units engaged in work with potentially hazardous chemicals that have unusual characteristics, or are otherwise not sufficiently covered in the written CHP, must customize the document by adding additional SOPs addressing the hazards and how to mitigate their risks, as appropriate. SOPs that are added to the CHP must receive prior approval from the PI and/or the UC ANR Office of Environmental Health and Safety (EH&S). For information on specific chemical safety topics not covered in the CHP, please contact the EH&S department via email ehs@ucanr.edu or phone (530) 530-1264.

Identification & Classification of Hazardous Chemicals

Chemical hazard communication

Subsequent to the passage of the Federal Occupational Safety and Health Act in 1971, the California Hazard Communication Standard [8CCR5194](#), was established in December of 1981. UC ANR has an established Hazard Communication Program that complies with the Cal/OSHA Hazard Communication Standard (<http://safety.ucanr.edu/files/2858.pdf>). The purpose of UC ANR's Hazard Communication Program is to ensure that all employees and, upon request, their personal physicians, have the right to receive information regarding the hazardous substances to which they may have been exposed at work. The requirements of the hazard communication program apply to those locations and activities specifically excluded from the Cal/OSHA laboratory standard environments such as greenhouse facilities, shops, pesticide storage facilities, and some technical work rooms.

Following adoption of the Hazard Communication Standard in California, the laboratory community successfully campaigned for a more performance-based standard. In March 1991, after federal adoption of a similar standard, California adopted the laboratory standard ([8CCR5191](#)) which sets requirements for chemical safety in laboratories, including the establishment of a Chemical Hygiene Plan to guide chemical safety in lab settings. The lab standard (and requirement for a chemical hygiene plan) applies in laboratory work areas.

The Cal/OSHA lab standard definitions:

Laboratory. A facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

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; and
4. "Protective laboratory practices and equipment" are available and in common use industry-wide to minimize the potential for employee exposure to hazardous chemicals.

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.

Many projects span both lab and non-lab areas. Due to the above definitions, it is also possible for some operations with what would otherwise seem like a lab, to be required to comply with the Hazard Communication Standard. In both cases, UC ANR is responsible for providing information about the hazardous substances in our workplace, the associated hazards, and the control of these hazards, through a comprehensive hazard communication program. Proper hazard communication involves the active participation of the PI, the Location or Laboratory Safety Representative, and Environmental Health and Safety, who are each responsible for providing consultation and safety information to employees working with hazardous chemicals.

Chemical inventory (list of hazardous substances)

All labs and work sites are required to maintain a current and accurate chemical inventory that includes each hazardous substance on their possession, specific information on any associated health or safety hazards must be made readily available to all laboratory personnel, typically through Safety Data Sheets.

Hazard determination

Principal investigators are responsible for verifying if any items on their chemical inventory are health hazards or hazardous substances.

The term “hazardous substance” refers to any 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 individuals. Hazardous substances may include, but are not limited to, those chemicals listed in the following:

1. “The Hazardous Substance List”, prepared by the Cal/OSHA Director 8CCR339 (www.dir.ca.gov/title8/339.html);
2. “Toxic and Hazardous Substances, Air Contaminants”, 8CCR5155 (www.dir.ca.gov/title8/5155.html)
3. “Threshold Limit Values for Chemical Substances in the Work Environment”, ACGIH, 2004;
4. Most Recent “Annual Report on Carcinogens”, NTP
<http://ntp.niehs.nih.gov/ntp/roc/twelfth/roc12.pdf>
5. “Monographs”, IARC, WHO (www.iarc.fr/en/publications/list/monographs)
6. SDSs for reproductive toxins and cancer causing substances (www.ehs.ucr.edu/services/msds.html).

Safety Data Sheets (SDS)

An SDS must be available for each hazardous substance in a laboratory’s chemical inventory. SDSs are available from the UC online SDS library, available through: www.ehs.ucr.edu/services/msds.html

New chemical substances synthesized or produced in a laboratory, and used or shared for commercial purposes outside of the lab where it is created, require the preparation of an SDS for each synthesized substance. The UC-system wide SDS library has the capability of developing new SDSs based on the known chemical and physical properties of that substance. SDS for a proprietary or experimental chemical which is not yet commercially available should be provided by the chemical manufacturer. If such documentation is not available, the primary exposure hazards of the chemical must be verified and documented in some form. For assistance, contact UC ANR EH&S (ehs@ucanr.edu; 530-750-1264)

Labels, signs and other forms of warning

Labeling requirements for all hazardous substances are summarized as follows:

- Labels on incoming containers of hazardous chemicals shall not be removed or defaced until the container is completely empty.
- All containers of hazardous materials must be labeled with the identity of the hazardous substance and all applicable hazard warning statements. If abbreviations are used, each room should have a posting listing the abbreviations used, along with the full chemical names an example of such an abbreviation list can be found at www.ehs.ucr.edu/laboratory/Chemical%20Abbreviation%20Example.pdf.

- Newly synthesized compounds and experimental/proprietary chemicals must be labeled with the appropriate hazard warnings based on the knowledge of the chemical and physical properties of that substance.
- Labels must be legible, in English, and clearly displayed; Lewis structures alone are inadequate.
- Non-original (secondary) containers (e.g., smaller or temporary containers into which a material is transferred for use) must be labeled with the identity of the substance and appropriate hazard warnings. Containers which are typically used for food and drink or which could be mistaken for food or drink containers should never be used to store hazardous chemicals.
- Symbols and/or other languages may be provided for non-English speaking employees.
- Use the symbols in the Globally Harmonized System of classification and labeling of chemicals (www.osha.gov/dsg/hazcom/ghs.html – see section 1 signage and postings)

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Classes of Hazardous Chemicals

Chemicals can be divided into several different hazard classes. The hazard class will determine how these 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. In addition to specific chemical labels, hazard information for specific chemicals can be found by referencing the Safety Data Sheet (SDS) for that chemical.

Flammability hazards

Flammable substances are in common use in UC ANR laboratories. Flammable liquids include those chemicals that have a flashpoint of less than 100 degrees Fahrenheit (37.78 degrees Celsius). No more than 10 gallons in aggregate of flammable liquids shall be stored outside of an approved and labeled storage cabinet. No more than 60 gallons of flammable liquids may be stored inside of an approved flammable liquid storage cabinet. Flame-resistant laboratory coats must be worn when working with large quantities (4 liters or more) of flammable materials and/or with procedures where a significant fire risk is present (e.g., when working with open flame or near ignition sources). These materials can constitute a significant immediate threat and should be treated with particular care, even though the 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 by using electrical grounding and bonding techniques whenever possible.

Reactivity hazards

Reactive and explosive substances are materials that decompose under conditions of mechanical shock, elevated temperature, or chemical action, and release large volumes of gases and heat. Some materials, such as peroxide formers, may not be explosive, but may form explosive substances over time. These substances pose an immediate potential hazard and procedures for their use must be carefully reviewed. These materials must also be stored in a separate storage cabinet or in a separate laboratory grade refrigerator or freezer that is designed for flammable/reactive chemicals. Pyrophoric chemicals are a special classification of reactive materials that spontaneously combust when in contact with air and require laboratory-specific training. Flame-resistant laboratory coats or other appropriate flame resistant protection must always be worn when working with pyrophoric chemicals.

Health hazards

Cal/OSHA uses the following definition for health hazards:

The term 'health hazard' includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

The major classes of "hazardous" and "particularly hazardous substances" and their related health and safety risks are detailed below:

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, 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 and bromine.

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 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 regarding the materials they may corrode, and their reactivity with other substances, as well as information on health effects. In most cases, these materials should be segregated from other chemicals and require secondary containment when in storage.

Irritants

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

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, and many phenol derivatives. Sensitizer exposure can lead to all of the symptoms associated with allergic reactions, or can increase an individual's existing allergies.

Hazardous substances with toxic effects on specific organs

Substances included in this category include:

- Hepatotoxins – i.e., substances that produce liver damage, such as nitrosamines and carbon tetrachloride;
- Nephrotoxins – i.e., agents causing damage to the kidneys, such as certain halogenated hydrocarbons;
- Neurotoxins – i.e., substances which produce their primary toxic effects on the nervous system, such as mercury, acrylamide and carbon disulfide;

- Ototoxic chemicals – i.e., substances which can cause or worsen hearing loss when coupled with noise exposures, such as toluene, styrene, trichloroethylene, acetonitrile, and metal fumes;
- Agents which act on the hematopoietic (blood cell production) 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.

Symptoms of exposure to these materials vary. People working with these materials should review the SDS for the specific material being used, take special note of the associated symptoms of exposure and contact EH&S for assistance in selection of PPE.

Particularly hazardous substances

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

Substances that pose such significant threats to human health are classified as "particularly hazardous substances" (PHSs). The OSHA laboratory standard and Cal/OSHA regulations require that special provisions be established to prevent the harmful exposure of researchers to PHSs, including:

1. Establishment of a designated area;
2. Use of containment devices such as fume hoods or glove boxes;
3. Procedures for safe removal of contaminated waste; and
4. Decontamination procedures.

In addition to the above requirements, a chemical-specific or procedure-specific SOP should be created for each PHS in regular use in a laboratory. Refer to the appendices in this section for more information on SOPs.

Particularly hazardous substances are divided into three primary types:

1. Acute Toxins;
2. Reproductive Toxins; and
3. Carcinogens.

A list can be found through www.ehs.ucr.edu/hazardousmaterials/AppendixAList+PHS.xlsx

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, 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.

Reproductive toxins

Reproductive toxins (<http://web.princeton.edu/sites/ehs/labsafetymanual/appa.htm>) include any chemical that may affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

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 embryoletality (death of the fertilized egg, embryo or fetus), malformations (teratogenic effects), and postnatal functional defects. For men, exposure can lead to sterility.

Examples of embryotoxins include thalidomide and certain antibiotics such as tetracycline. Women of childbearing potential should note that embryotoxins have the greatest impact during the first trimester of pregnancy. Because a woman often does not know that she is pregnant during this period of high susceptibility, special caution is advised when working with all chemicals, especially those rapidly absorbed through the skin (e.g., formamide). Pregnant women and women intending to become pregnant should consult with occupational health professional or EH&S before working with substances that are suspected to be reproductive toxins.

Carcinogens

Carcinogens are chemical or physical agents that cause cancer. Generally they are chronically toxic substances; that is, they cause damage after repeated or long-duration exposure, and their effects may only become evident after a long latency period. It is also important to recognize that some substances involved in research laboratories are new compounds and have not been subjected to testing for carcinogenicity.

Chronic toxins are particularly insidious because they may have no immediately apparent harmful effects. These materials are separated into two classes: Select Carcinogens and Regulated Carcinogens.

Select Carcinogens are materials which have met certain criteria established by the National Toxicology Program or the International Agency for Research on Cancer regarding the risk of cancer via certain exposure routes. (See definition of Select Carcinogen).

The following references (links provided) are used to determine which substances are select carcinogens by Cal/OSHA's classification:

U.S. OSHA carcinogen list (<http://web.princeton.edu/sites/ehs/labsafetymanual/sec7j.htm>):

- Annual Report on Carcinogens published by the National Toxicology Program (NTP), including all of the substances listed as "known to be carcinogens" and some substances listed as "reasonably anticipated to be carcinogens"
<http://ntp.niehs.nih.gov/index.cfm?objectid=32BA9724-F1F6-975E7FCE50709CB4C932>
- International Agency for Research on Cancer (IARC), including all of Group 1 "carcinogen to humans" by the International Agency for Research on Cancer Monographs (IARC) (Volumes 1-48 and Supplements 1-8); and some in Group 2A or 2B, "reasonably anticipated to be carcinogens" by the National Toxicology Program (NTP), and causes statistically significant tumor incidence in

experimental animals in accordance with any of the following criteria: (i) 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; (ii) after repeated skin application of less than 300 mg/kg of body weight per week; or (iii) after oral dosages of less than 50 mg/kg of body weight per day
<http://monographs.iarc.fr/ENG/Classification/crthgr01.php>

Regulated carcinogens fall into a higher hazard class and have extensive additional requirements associated with them. The use of these agents may require personal exposure sampling based on usage. When working with regulated carcinogens, it is particularly important to review and effectively apply engineering and administrative safety controls as the regulatory requirements for use of these chemicals are very extensive.

How to Reduce Exposures to Hazardous Chemicals

Hazardous chemicals require a carefully considered, multi-tiered approach to ensure safety. There are four primary routes of exposure for chemicals which have associated health hazards:

- Inhalation;
- Absorption (through the skin or eyes);
- Ingestion; and
- 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 by inhalation. Many hazardous chemicals may affect people through more than one of these exposure modes, so it is critical that protective measures are in place for each of these uptake mechanisms.

Safety controls

Safety controls are divided into three main classifications:

- Engineering Controls;
- Administrative Controls; and
- Personal Protective Equipment.

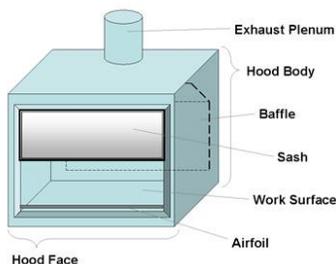
Elements of these three classes are used in a layered approach to create a safe working environment. The principles of each of these elements are detailed below.

Engineering controls

Engineering controls include all “built in” safety systems. These controls offer the first line of protection and are highly effective in that they generally require minimal special procedures or actions on the part of the user except in emergency situations. A fundamental and very common example is the laboratory fume hood which is very effective at containing chemical hazards and protecting users from inhalation hazards. Other examples of engineering controls include general room ventilation, flammable material storage units, and secondary containment.

General laboratory ventilation

All laboratory rooms in which hazardous materials are used must have fresh air ventilation with 100% of the exhaust venting to the outside; laboratory rooms should not be part of recycled air systems. In cases where this is not feasible, a formal hazard evaluation will be made by EH&S to determine what work can be done in the space and under what special conditions or limitations. Laboratory rooms should be kept at negative pressure compared to public areas to prevent the spread of hazardous vapors. See Appendix 3a for guidelines on laboratory ventilation.



Fume hoods

Fume hoods are the most commonly used local exhaust system in laboratories. 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). Exhaust 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.

It is advisable to use a fume hood when working with all hazardous substances. In addition, a fume hood or other suitable containment device must be used for all work with "particularly hazardous substances." A properly operating and correctly used hood can reduce or eliminate volatile liquids, dusts, and mists. Fume hoods must be evaluated for operation and certified by EH&S or other qualified facilities staff on an annual basis. These annual evaluations check the fume hood air flow patterns and velocity to ensure that the unit will contain hazardous vapors. Data on annual fume hood monitoring is maintained by EH&S.

Each 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 EH&S for a fume hood evaluation if these labels are missing.

Each fume hood must be equipped with at least one type of continuous quantitative monitoring device designed to provide the user with current information on the operational status of the hood. When hazardous materials are in a fume hood, but it is not under active use (e.g., during an unattended reaction or experiment), the sash should be closed. Fume hoods are not designed for long term storage of hazardous materials.

Routine maintenance and repairs of fume hoods must be conducted by qualified service contractor or equivalently-qualified ANR staff. Great care must be taken with fume hoods and associated ducting as many hoods include some amount of asbestos-containing materials which must not be handled or disturbed without proper safety controls in place. EH&S or the user may initiate maintenance as well as coordinate with location safety coordinator to ensure that any repair or maintenance work is completed safely. EH&S or other qualified HVAC professional must re-inspect the fume hood following maintenance or repairs.

General rules for fume hood use

The following general rules should be followed when using 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.
2. Always keep hazardous chemicals >6 inches behind the plane of the sash.
3. **Never** put your head inside a fume hood containing hazardous materials. The plane of the sash is the barrier between contaminated and uncontaminated air.
4. Work with the hood sash in the **lowest practical position**. The sash acts as a physical barrier in the event of an accident. Keep the sash closed when not conducting work in the hood.
5. Do not clutter your hood with unnecessary bottles or equipment. Keep it clean and clear. Only materials actively in use should be in the hood.
6. Do not make any modifications to hoods, duct work, or the exhaust system without first contacting EH&S.
7. Do not use large equipment in laboratory hoods unless the hood is dedicated for this purpose, as large obstructions can change the airflow patterns and render the hood unsafe.
8. Shut your sash! For energy efficiency, make sure to shut your sash when the hood is not in use.
9. Shut the sash if the fire alarm sounds.

Laboratory fume hoods are one of the most important pieces of equipment used to protect laboratory and other workers from exposure to hazardous chemicals. Chemical fume hoods should be inspected upon installation, renovation, when a deficiency is reported, or a when change has been made to the operating characteristics of the hood. Since fume hoods used for regulated carcinogens have additional requirements, such as increased face velocity, contact the EH&S if the intended use changes.

Glove boxes and ventilation devices

In addition to fume hoods, some laboratories use contained glove box units for working with reactive chemicals under an inert environment, working with very toxic substances in a completely closed system, or for creating a stable, breeze free, system for weighing hazardous or reactive materials. These units can be very effective because they offer complete containment. Another type of ventilation device is the elephant trunk, or snorkel, which is connected to the exhaust system. This device is effective for capturing discharges from instruments such as gas chromatographs. The intake of the snorkel must be placed very close to the source to be effective. There are newer designs that are mounted on articulating arms, which make the systems more convenient to use.

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 refrigerated or frozen storage, flammable and explosive materials must be kept in refrigeration units specifically designed for storing these materials. Generally these units do not have internal lights or electronic systems that could spark and trigger an ignition; additionally, the cooling

elements are external to the unit. These units should be labeled with a rating from Underwriters Laboratory or other certifying organization.

Secondary containment must be provided for corrosive and reactive chemicals and is recommended for all other hazardous chemicals. Secondary containment should be made of chemically resistant materials and should be sufficient to hold at least 110% the volume of at least the largest single bottle stored in the container.

Laboratories where hazardous materials are in use must contain a sink, kept clear for hand washing to remove any final residual contamination. Hand washing is required whenever a staff member who has been working with hazardous materials plans to exit the laboratory or work on a project that does not involve hazardous materials.

Administrative controls

The next layer of safety controls are Administrative Controls. These controls consist of policies and procedures; they are not generally 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.

Laboratory groups should also review their operations to minimize the amounts of hazardous substances in use or to replace them with less hazardous alternatives. Attention must also be paid to the appropriate segregation of incompatible materials.

Standard operating procedures (SOPs)

Standard operating procedures that are relevant to safety and health considerations must be developed and followed when laboratory work involves the use of hazardous chemicals (CCR, Title 8, Section 5191 (e)(3)(A)), especially for “particularly hazardous substances” (PHS). SOPs are written instructions that detail the steps that will be performed during a given experimental procedure and include information about potential hazards and how these hazards will be mitigated. SOPs should be written by laboratory personnel who are most knowledgeable and involved with the experimental process. The development and implementation of SOPs is a core component of promoting a strong safety culture in the laboratory and helps ensure a safe work environment.

While general guidance regarding laboratory work with chemicals is contained in this plan, PIs are required to develop and implement laboratory-specific SOPs for certain hazardous chemicals and PHS that are used in their laboratories. These SOPs must be submitted and reviewed by the location safety committee and/or lab safety coordinator prior to implementation. For certain hazardous chemicals, PHS, or specialized practices, consideration must be given to whether additional consultation with EH&S is warranted or required.

Circumstances requiring prior approval from the PI must also be addressed 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 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., pyrophorics, water reactive chemicals), or the use of carcinogens.

UC Davis and UC Riverside EH&S websites have downloadable templates for SOPs.

UC Davis Chemical SOPs templates:

[file:///C:/Users/malendia/Downloads/UC%20Davis%20Safety%20Services%20-%20Standard%20Operating%20Procedure%20\(SOP\)%20Templates%20-%202017-05-10.pdf](file:///C:/Users/malendia/Downloads/UC%20Davis%20Safety%20Services%20-%20Standard%20Operating%20Procedure%20(SOP)%20Templates%20-%202017-05-10.pdf)

UC Riverside Chemical SOP templates: <http://ehs.ucr.edu/laboratory/SOP/library.html>

UC Davis and UC Riverside EH&S departments maintain websites with tools and resources that may be referenced while developing SOPs, including fact sheets for the use of certain hazardous chemicals, online safety videos and an SOP Library. UC ANR EH&S is also available to assist with the development of SOPs. SOPs must be developed prior to initiating any experiments with hazardous chemicals or particularly hazardous substances and are to be filed and maintained in the Laboratory and Research Safety Manual where they are available to all laboratory personnel.

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

Chemical safety training resources

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.

Safety Note #48 Hazard Communication Awareness is available on the UC ANR EH&S website (<http://safety.ucanr.edu/files/1441.pdf>) and can be used for employee training.

UC Davis has published a helpful training handout (http://safetyservices.ucdavis.edu/sites/default/files/documents/Training_Course_Handout.pdf). UC Davis and UC Riverside have also made training available online.

Links to UC campus hazard communication training online:

UC Davis: <http://safetyservices.ucdavis.edu/training/hazard-communication>

UC Riverside: <http://www.ehs.ucr.edu/training/online/hazardcommunication/indexlms.html>

Additional Resources

- “Occupational Exposure to Hazardous Chemicals in Laboratories.” California Code of Regulations Title 8, Section 5191 [8CCR5191](#)
- Standard Operating Procedures (SOPs) for handling toxic chemicals (Laboratory Specific)
- General information on the signs and symptoms associated with exposure to hazardous substances used in the laboratory or facility (Laboratory-specific SOPs or [SDS](#))
- Identity labels, showing contents of containers and associated hazards
- Warnings at areas or equipment where special or unusual hazards exist
- Procedures to follow in case of an emergency:
 - Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers;
 - Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits and areas where food and beverage consumption and storage are permitted; and
 - Information for designated medical providers where employees may go for emergency care.

Personal protective equipment

Personal protective equipment (PPE) serves as a researcher’s last line of defense against chemical exposures and is required for everyone entering a laboratory containing hazardous chemicals.

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

- Full length pants and close-toed shoes, or equivalent.
- Protective gloves, laboratory coats, & eye protection when working with, or adjacent to, hazardous chemicals.
- Flame resistant laboratory coats for high hazard materials, pyrophorics, and ≥ 4 liters of flammables.

The primary goal of basic PPE is to mitigate, at a minimum, the hazard associated with exposure to hazardous substances. In some cases, additional, or more protective, equipment must be used. If a project involves a chemical splash hazard, chemical goggles are required; face shields may also be required when working with chemicals that may cause immediate skin damage. Safety goggles differ from safety glasses in that they form a seal with the face, which completely isolates the eyes from the hazard. If a significant splash hazard exists, heavy gloves, protective aprons and sleeves may also be needed. Gloves should only be used under the specific condition for which they are designed, as no glove is impervious to all chemicals. It is also important to note that gloves degrade over time, so they should be replaced as necessary to ensure adequate protection. The UC Riverside EH&S website (<http://ehs.ucr.edu/safety/ppeselection.html>) provides PPE Selection Guide to assist in selecting the appropriate glove type for the type of potential hazard.

EH&S requires each laboratory to complete and document a hazard assessment prior to beginning work and to provide annual updates thereafter. PPE can be selected based on this hazard assessment.

UC laboratory hazard assessment tool (LHAT)

The UC Laboratory Hazard Assessment Tool (LHAT) was developed to broadly identify activities involving chemical and other types of hazards and is an effective method of hazard communication. The online Hazard Assessment Tool can be accessed at: <https://ehs.ucop.edu/lhat/>

The UC LHAT captures information on the specific type of hazard, the location of the hazards, the name of the Faculty or other Supervisor who oversees the facility and provides guidance for the proper exposure controls (Engineering, Administrative and Personal Protective Equipment (PPE), that should be used by the people working with and around the hazards to protect themselves. Once the PPE selection is made, the laboratory is required to conduct and document training for laboratory personnel on the use of PPE.

If completion of the online tool is not feasible, an equivalent paper form is available for download on the UC ANR EH&S website (<http://safety.ucanr.edu/files/274338.pdf>) and included as an Appendix 1b. The paper form or a printed copy of the current hazard assessment and training record should be retained with other lab safety documentation.

How to use and maintain PPE

Personal protective equipment should be kept clean and stored in an area where it will not become contaminated. Personal protective equipment 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 discarded and replaced.

Contaminated clothing/PPE

In cases where spills or splashes of hazardous chemicals on clothing or PPE occur, the clothing/PPE should immediately be removed and placed in a closed container that prevents release of the chemical. Heavily contaminated clothing/PPE resulting from an accidental spill should be disposed of as hazardous waste. Lightly contaminated laboratory coats should be cleaned and properly laundered, as appropriate. Laboratory personnel should never take contaminated items home for cleaning or laundering. Persons or companies hired to clean contaminated items should be provided with hazard communication and personal protective equipment.

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 and biological hazards. Under certain circumstances, however, respiratory protection may be needed. These can include:

- An accidental spill such as:
 - a chemical spill outside the fume hood
 - a spill of bio-hazardous 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.

Because there are numerous types of respirators available, and each has specific limitations and applications, respirator selection and use requires pre-approval by EH&S. For either required or voluntary use of a respirator, the employee must contact UC ANR EH&S to request consultation with an Industrial Hygienist, who will contact the employee to evaluate the potential exposure.

The Industrial Hygiene review will include an evaluation of the work area and activities for the following:

- Provision of additional ventilation controls or enclosure of the airborne hazard;
- Substitution with a less hazardous substance;
- Qualitative or quantitative exposure assessment; and
- Respirator usage.

Processes with potential airborne hazards that cannot be eliminated by engineering or administrative controls will not be authorized by EH&S until affected employees can be incorporated into UC ANR's Respiratory Protection Program.

Because wearing respiratory equipment places a physical burden on the user, laboratory workers must be medically evaluated prior to wearing respiratory equipment. Certain individuals (e.g., persons with severe asthma, heart conditions, or claustrophobia) may not be medically qualified to wear a respirator. Upon enrollment in Respirator Training and Fit Testing, the employee will be sent the appropriate medical questionnaire. The completed medical questionnaire will be evaluated before the employee proceeds with the training. NOTE: This medical questionnaire is confidential. The employee will be provided additional information on who to contact for follow up questions.

After successful completion of the medical evaluation, the employee will be trained and fit tested by EH&S. Training topics include:

- Why the respirator is necessary and how improper fit, usage, or maintenance can compromise the protective effect of the respirator;
- What the limitations and capabilities of the respirator are;
- How to use the respirator effectively in emergency situations, including situations in which the respirator malfunctions;
- How to inspect, put on and remove, use, and check the seals of the respirator;
- What the procedures are for maintenance and storage of the respirator;
- How to recognize medical signs and symptoms that may limit or prevent the effective use of respirators; and
- The general requirements of the respiratory program.

Finally, a qualitative or quantitative fit test is conducted by EH&S for each respirator user. The fit test ensures a proper face to face piece seal for each individual and his/her mask. Fit testing is done in accordance with Cal/OSHA regulations (8CCR5144) (<http://www.dir.ca.gov/title8/5144.html>).

An annual refresher is required for the medical evaluation, respirator training, and fit testing. In addition to the annual training refresher, a more frequent re-training, fit testing or medical evaluation must be performed when any of the following occur:

- Changes in the workplace or the type of respirator render previous training obsolete;
- Inadequacies in the employee's knowledge or use of the respirator indicate that the employee has not retained the requisite understanding or skill;
- Any other situation arises in which reevaluation appears necessary to ensure safe respirator use;
- Facial scarring, dental changes, cosmetic surgery, or an obvious change in body weight; or
- An employee reports medical signs or symptoms related to their ability to use a respirator.

Laboratory safety and emergency response equipment

New personnel must be instructed in the location of fire extinguishers, safety showers, and other safety equipment before they begin work in the laboratory. This training is considered part of the laboratory specific training that all staff members must attend.

Fire extinguishers

All laboratories working with combustible chemicals, flammable chemicals, or other potential ignition sources (e.g. lasers) must be outfitted with appropriate fire extinguishers. All extinguishers should be mounted on a wall in an area free of clutter or stored in a fire extinguisher cabinet. Research personnel should be familiar with the location, use, and classification of the extinguishers in their laboratory.

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); and
- Appropriate training has been received; and
- It is safe to do so.

Any time a fire extinguisher is used, no matter for how brief a period, the PI, or most senior laboratory personnel present at the time of the incident, must immediately report the incident to the EH&S (ehs@ucanr.edu; 530-750-1264).

The UC ANR EH&S website contains a Fire Extinguisher training video which provides information on fire extinguisher use (http://safety.ucanr.edu/Training/Fire_Extinguisher_Video/).

Safety Showers and Eyewash Stations

All laboratories using hazardous chemicals must have immediate access to safety showers with eye wash stations. Access must be available in an unlocked location within 10 seconds or less for a potentially injured individual and access routes must be kept clear. This requirement applies to all areas where, during routine operations or emergencies, the eyes or body of an employee may come in contact with a substance that could cause corrosion, severe irritation, permanent tissue damage, or is toxic by absorption. 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.



In the event of an emergency, individuals using the safety shower should be assisted by an uninjured person to aid in decontamination and should be encouraged to stay in the safety shower for 15 minutes to remove all hazardous material.

Principal investigators are responsible for assuring that safety shower/eyewash stations are tested on a monthly basis. Tests may be performed by the location safety coordinator or physical plant staff. If an eyewash or safety shower needs repair, the location safety coordinator must be notified immediately and unit must be repaired before work with hazardous chemicals commences in the area served by the shower. Safety Notes #34 outlines requirements for safety eyewash and shower stations at UC ANR (<http://safety.ucanr.edu/files/1426.pdf>). Any questions regarding requirements for safety eyewashes or showers should be directed to UC ANR EH&S (ehs@ucanr.edu, 530-750-1264).

Fire doors

Many areas of research buildings may contain critical fire doors as part of the building design. These doors are an important element of the fire containment system and should remain closed unless they are on a magnetic self-closing or other automated self-closing system.

Safe laboratory habits

As detailed above, a safety program must include layers of policies and protective equipment to allow for a safe working environment, but to ensure effectiveness of the program, a number of fundamental elements must become basic working habits for the research community. Some of these elements are detailed below:

Personal protective equipment:

- Wear closed-toe 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.
- Confine long hair and loose clothing.
- 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.
- 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 station.

Chemical handling:

- Properly label and store all chemicals. Use secondary containment when required or advised.
- Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan.
- Do not smell or taste chemicals.
- Never use mouth suction for pipetting or starting a siphon.
- Do not dispose of any hazardous chemicals through the sewer system.
- 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. 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.

Equipment storage and handling:

- 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 fume hood sash closed when you are not working in the hood.
- Do not use damaged glassware or other equipment.
- Do not use uncertified fume hoods or glove boxes for hazardous chemical handling.
- Avoid storing materials in hoods.
- Do not allow the vents or air flow to be blocked.

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, 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).
- Be alert to unsafe conditions and ensure that they are corrected when detected.
- Research staff and students should never work alone on procedures involving hazardous chemicals, biological agents, or other physical hazards.
- Do not engage in distracting behavior such as practical jokes in the laboratory. This type of conduct may confuse, startle, or distract another worker.

Food/Drink:

- Do not eat, drink, smoke, chew gum, or apply cosmetics in areas where laboratory 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.
- Wash areas of exposed skin well before leaving the laboratory.

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Chemical Inventory, Labeling, Storage, and Transportation

Chemical inventories

Principal investigators must maintain a current, accurate and complete chemical inventory that includes the hazardous materials, solids, liquids gases and gels used and the locations to which they are assigned or allowed to be used. The information maintained in the inventory includes the name of the chemical, the concentration, the chemical abstracts number, the size of the container, the number of identical containers, the amount on hand, the physical state, the type of the container, whether it is pure or a mixture and both the storage pressure and temperature. Chemical inventories are used to provide the required information to the fire department, to ensure compliance with fire code storage limits, and to comply with homeland security reporting thresholds. The chemical inventory can also be used in an emergency to identify potential hazards for emergency response operations and more.

The chemical inventory list should be reviewed prior to ordering new chemicals and only the minimum quantities of chemicals necessary for the research should be purchased. As new chemicals are added to the inventory, each laboratory group can confirm that they have access to the Safety Data Sheet (SDS) for that chemical through www.ehs.ucr.edu/services/msds.html. Where practical, each chemical should be dated so that expired chemicals can be easily identified for disposal. Each PI or their delegate must review the inventory of chemicals in the laboratory at least annually for accuracy and completeness. Items that should be replaced, have deteriorated, or show container deterioration should be flagged for action or disposal. This will assure that chemical storage areas are not overcrowded with materials that are no longer useful. The Department of Homeland Security (DHS) requires a report to be submitted within 60 days of specific chemicals that exceed set threshold aggregate amounts. As a result, everyone who has chemicals at UC ANR must update their chemical inventory for each of the Department of Homeland Security (DHS) "chemicals of interest" within 60 days of when they are received or consumed/disposed. A list of these chemicals is included as an appendix to this chemical hygiene plan and also published online (<https://www.dhs.gov/sites/default/files/publications/appendix-a-to-part-27-508.pdf>). Unneeded items should be transferred to a colleague who has a legitimate business use for the chemical or they should be discarded as chemical waste through an authorized chemical waste vendor.

Attributes that may indicate the materials need to be disposed are: cloudiness in liquids, a change in color, evidence of liquids in solids, or solids in liquids, "puddling" of material around outside of containers, pressure build-up within containers and obvious deterioration of containers in addition to exceeding a manufacturer's expiration date.

Access to hazardous chemicals, including toxic and corrosive substances, should be restricted at all times. 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 are always recommended, and may be required in the case of unusually toxic or hazardous chemicals. Unusually toxic chemicals may include those that are immediately dangerous to life or health (IDLH). For guidance on storage requirements, please contact EH&S at 530-750-1264.

On termination or transfer of laboratory personnel, all related hazardous materials should be properly disposed of, or transferred to the PI or a designee.

Chemical labeling

All containers (including those with abbreviations) of hazardous materials must be labeled with the identity of the hazardous substance and all applicable hazard warning statements or abbreviations. If abbreviations are used, a list of the abbreviations used, the full chemical names and the hazards warning statement associated with each, must be prominently displayed in each room. An example of such an abbreviation list can be found at www.ehs.ucr.edu/laboratory/Chemical%20Abbreviation%20Example.pdf. In either case, all containers not actively being used in transfer or a reaction must be labeled.

New synthesized compounds must be labeled with the appropriate hazard warnings based on the knowledge of the chemical and physical properties of that substance.

Labels must be legible, in English, and clearly displayed; Lewis structures alone are inadequate.

Secondary containers (such as spray bottles) must be labeled with the identity of the substance and appropriate hazard warnings. Symbols and/or other languages may be provided for non-English speaking employees. Use the hazard symbols in the Globally Harmonized System of Classification and Labeling of Chemicals (www.osha.gov/dsg/hazcom/ghs.html).

Peroxide-forming chemicals (e.g., ethers) must be labeled with a date of receipt and the date when the bottle is first opened. For the containers without a manufacturer supplied expiration date, these chemicals are only allowed a one year shelf life and must be disposed of as waste within one year of receipt or six months of opening. These chemicals can degrade to form shock sensitive, highly reactive compounds and should be stored and labeled very carefully.

Particularly Hazardous Substances such as Regulated Carcinogens (<https://www.dir.ca.gov/title8/sb7g16a110.html>), highly hazardous chemicals (https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9761&p_table=standards), and highly toxic chemicals should be segregated from less hazardous chemicals to help with proper access control and hazard identification.

Chemical storage & segregation

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

Storage guidelines are included for materials that are flammable, oxidizers, corrosive, and water reactive, explosive and highly toxic. The specific Safety Data Sheet (SDS) should always be consulted when doubts arise concerning chemical properties and associated hazards. All procedures employed must comply with Cal/OSHA, Fire Code and building code regulations. Always wear appropriate personal protective equipment (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.

Safe chemical 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.
2. **Isolate.** If the material will contribute significantly to a fire (e.g., oxidizers), it should be isolated from the flammables. If there were a fire in the laboratory and response to the fire with water would exaggerate the situation, isolate the water reactive material away from contact with water.
3. **Corrosivity.** Next look at the corrosivity of the material, and store accordingly. Acids and bases should be segregated and contained to prevent mixture of materials in case of spill.
4. **Toxicity.** Finally, consider the toxicity of the material, with particular attention paid to regulated materials. In some cases, this may mean that certain chemicals will be isolated within a storage area. For example, a material that is an extreme poison but is also flammable, should be locked away in the flammable storage cabinet to protect it against accidental release.
5. There will always be some chemicals that 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.

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 cabinets, laboratory shelves, or appropriate refrigerators or freezers. Fume hoods should not be used as general storage areas for chemicals, as this may seriously impair the ventilating capacity of the hood.

The image to the right depicts improper fume hood storage. Chemicals should not be routinely stored on bench tops or stored on the floor. Additionally, bulk quantities of chemicals (i.e., larger than one-gallon) should be stored in a separate storage area, such as a stockroom or supply room.

Laboratory shelves should have a raised lip along the outer edge to prevent containers from falling. Hazardous liquids, toxic or corrosive chemicals should not be stored on shelves above eye-level and chemicals which are highly toxic or corrosive should be in unbreakable secondary containers.



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

Laboratory refrigerators and freezers must be labeled appropriately with “No Food/Drink” and must never be used for the storage of food or drinks intended for human consumption. Freezers should be defrosted periodically so that chemicals do not become trapped in ice formations. Never store peroxide formers (e.g., ether) in a refrigerator not specifically designed for storage of flammable liquids.

Flammable and combustible liquids

Large quantities of flammable or combustible materials should be stored in locations outside of most laboratories. The actual fire code limits on the specific volume of flammable materials or other classes of hazardous chemicals depends on the original design and construction of the facility and can vary from building to building at ANR facilities. In most B occupancy labs the maximum total quantity of class 1A, 1B and 1C flammable liquids is limited to no more than 60 gallons which must all be stored in a flammable storage cabinet.

Hazard classification for flammable liquids			
Class	Flash point	Boiling point	Examples
I-A	below 73°F (23°C)	below 100°F (38°C)	diethyl ether, pentane, ligroin, petroleum ether
I-B	below 73°F (23°C)	at or above 100°F (38°C)	acetone, benzene, cyclohexane, ethanol
I-C	73-100°F (24-38°C)	----	p-xylene
Hazard classification for combustible liquids			
II	101-140°F (39-60°C)	----	diesel fuel, motor oil, kerosene, cleaning solvents
III-A	141-199°F (61-93°C)	----	paints (oil base), linseed oil, mineral oil
III-B	200°F (93°C) or above	----	paints (oil base), neatsfoot oil

Storage Volume: No more than 10 gallons in total of flammable liquids shall be stored outside of an approved and labeled storage cabinet. Class 1A solvents, such as ethyl ether, should be purchased only in one gallon (4 liter) or smaller containers. Because of the extreme flammability of the Class 1 liquids, only quantities needed for immediate use should be stored. Examples of equipment that can be used for storage include: flammable storage cabinets, flammable storage refrigerators or freezers that are designed and UL approved for the storage of flammable substances, or approved safety cans or drums that are grounded. Always segregate flammable or combustible liquids from oxidizing acids and oxidizers. 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.

Handle flammable and combustible substances only in areas free of ignition sources and use the chemical in a fume hood whenever practical. Only the amount of material required for the experiment or procedure should be stored in the work area. Always transfer flammable and combustible chemicals from glass containers to glassware or from glass container/glassware to plastic. Transferring these types of chemicals between plastic containers may lead to a fire hazard due to static electricity. The transfer of flammable liquid from 5 gallon or larger metal containers should not be done in the laboratory.

Pyrophoric & water reactive substances

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 pyrophoric materials are also toxic and many are dissolved or immersed in a flammable solvent. Other common hazards include corrosivity, teratogenicity, or peroxide formation.

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. 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 flammable substance approved freezer. If pyrophoric or water reactive reagents are received in a specially designed shipping, storage or dispensing container (such as the 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. Never store reactive chemicals with flammable materials or in a flammable liquids storage cabinet.

Storage of pyrophoric gases is described in the California Fire Code, Chapter 41. 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.

Never return excess reactive chemical to the original container. Small amounts of impurities introduced into the container may cause a fire or explosion. For storage of excess chemical, prepare a storage vessel in the following manner:

- Dry any new empty containers thoroughly;
- Insert the septum into the neck in a way that prevents atmosphere from entering the clean dry (or reagent filled) flask;
- Insert a needle to vent the flask and quickly inject inert gas through a second needle to maintain a blanket of dry inert gas above the reagent;
- Once the vessel is fully purged with inert gas, remove the vent needle then the gas line. To introduce the excess chemical, use the procedure described in the handling section of the SOP;

- For long-term storage, the septum should be secured with a copper wire or hose clamp
- For extra protection a second same-sized septa (sans holes) can be placed over the first; and
- Use “Parafilm M®” or equivalent around the outer septa and remove the Parafilm M® and outer septum before accessing the reagent through the primary septum.

Pyrophoric Liquid Safety SOPs and videos for the safe handling of pyrophoric chemicals and can be viewed through www.ehs.ucr.edu/resources/SOPs/standard_operating_procedures_list.html.

Oxidizers

Oxidizers (e.g., oxygen, ozone, hydrogen peroxide, and other inorganic peroxides; fluorine, chlorine, and other halogens; nitric acid and nitrate compounds; persulfuric acids; chlorite, chlorate, perchlorate, and other analogous halogen compounds; hypochlorite and other hypohalite compounds, including household bleach; hexavalent chromium compounds such as chromic and dichromic acids and chromium trioxide, pyridinium chlorochromate, and chromate/dichromate compounds; permanganate compounds; sodium perborate; nitrous oxide; silver oxide; osmium tetroxide; Tollens' reagent; 2,2'-dipyridyldisulfide) should be stored in a cool, dry place and kept away from flammable and combustible materials, such as wood, paper, Styrofoam™, most plastics, flammable organic chemicals, and away from reducing agents, such as zinc, alkaline metals, and formic acid.

Peroxide-forming chemicals

Peroxide forming chemicals (e.g., acetaldehyde diethyl acetal (acetal); cumene (isopropyl benzene); cyclohexene; cyclopentene; decalin (decahydronaphthalene); diacetylene (butadiene); diethyl ether (ether); diethylene glycol dimethyl ether (diglyme); diisopropyl ether (isopropyl ether); dioxane; divinylacetylene (DVA); ethylene glycol dimethyl ether (glyme); ethylene glycol ether acetates; ethylene glycol monoethers (cellosolves); furan; inylidene chloride (1, 1-di-chloroethylene); methylacetylene; methylcyclopentane; potassium amide; potassium metal; sodium amide (sodamide); tetrahydrofuran (THF); tetralin (tetrahydronaphthalene); vinyl ethers) should be stored in airtight containers in a dark, cool, and dry place and must be segregated from other classes of chemicals that could create a serious hazard to life or property should an accident occur (e.g., acids, bases, oxidizers). The containers should 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 must also be tested and documented for the presence of peroxides periodically. Minimize the quantity of peroxide forming chemicals stored in the laboratory and dispose of peroxide forming chemicals before peroxide formation.

Carefully review all cautionary material supplied by the manufacturer prior to use. Avoid evaporation or distillation, as distillation defeats the stabilizer added to the solvents. Ensure that containers are tightly sealed to avoid evaporation and that they are free of exterior contamination or crystallization. Never return unused quantities back to the original container and clean all spills immediately.

If old containers of peroxide forming chemicals are discovered in the laboratory, (greater than two years past the expiration date or if the date of the container is unknown), do not handle the container. If crystallization is present in or on the exterior of a container, do not handle the container. Secure the container and contact a qualified hazardous waste vendor to arrange for disposal.

Corrosives

Store corrosive chemicals (i.e., acids, bases) below eye level and in secondary containers that are 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).

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 substances. Perchloric acid should be stored by itself, away from other chemicals. Picric acid is reactive with metals or metal salts and explosive when dry and must contain at least 10% water to inhibit explosion.

Special storage requirements

Compressed gas cylinders



Safety caps in place

Correct double chaining.

Compressed gas cylinders that are stored in the laboratory must be secured to prevent tipping, dropping, and damage to the regulator. Large cylinders must be chained or strapped to the wall or other stable building member, with the safety cap in place. The cylinders must be restrained by two chains or straps; one chain must be placed at one third from the top of the cylinder, and the other placed at one third from the bottom of the cylinder. If this is not practical, contact EH&S for guidance.

Bolted “clam shells” may be used in instances where

gas cylinders must be stored or used away from the wall. Store liquefied fuel-gas cylinders securely in the upright position. Smaller cylinders of non-hazardous gas may be secured in a frame or rack that holds cylinders securely in an upright position. **Cylinders are not to be stored in a horizontal position.** Do not expose cylinders to excessive dampness, corrosive chemicals or fumes.

Certain gas cylinders require additional precautions. Flammable gas cylinders must use only flame-resistant gas lines and hoses which carry flammable or toxic gases from cylinders and must have all connections wired. Compressed oxygen gas cylinders must be stored at least 20 feet away from combustible materials and flammable gases.

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. Move gas cylinders with the safety cap in place using carts designed for this purpose.

Liquid nitrogen

Because liquid nitrogen containers are at low pressure and have protective rings mounted around the regulator, they need to be affixed to a permanent fixture such as a wall to prevent them from walking or rolling into the egress path in an earthquake. However, additional protection considerations should be addressed when storing liquid nitrogen in a laboratory. The primary risk to laboratory personnel from liquid nitrogen is skin or eye thermal damage caused by contact with the material. In addition, nitrogen expands 696:1 when changing from a cryogenic liquid to a room temperature gas. The gases usually are not toxic, but if too much oxygen is displaced, asphyxiation is a possibility. Always use appropriate thermally insulated gloves when handling liquid nitrogen. Face shields may be needed in cases where splashing can occur.

Transportation of hazardous chemicals

Precautions must be taken when transporting hazardous substances between laboratories. 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. When transporting cylinders of compressed gases, always secure the cylinder with straps or chains onto a suitable hand truck and protect the valve with a cover cap. Avoid dragging, sliding, or rolling cylinders and use a freight elevator when possible. The figure below illustrates correct cylinder transport.



Correct Cylinder Transport

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, packaging, and labeling. Without proper training and packaging, it is illegal to ship hazardous materials. Those who violate the hazardous materials shipment regulations are subject to criminal investigation and penalties. Any questions regarding requirements for shipment or transport of hazardous materials should be directed to UC ANR EH&S (530-750-1264).

Chemical spills

Chemical spills can result in chemical exposures and contaminations. Chemical spills 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 staff cannot safely manage the hazard because the material is too hazardous or the quantity is too large

Effective emergency response to these situations is imperative to mitigate or minimize adverse reactions when chemical incidents occur.

Factors to consider before spill clean-up

1. Size of spill area
2. Quantity of chemical
3. Toxicity
4. Volatility
5. Clean up materials available
6. Training of responders

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. If a chemical is ingested, drink plenty of water. Obtain medical assistance as indicated. Remember to wear appropriate PPE before helping others. PIs 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.

Small chemical spills can be cleaned up by laboratory personnel who have been trained in spill clean-up and with the appropriate materials. A small spill is generally defined as < 1 liter of chemical that is not highly toxic, does not present a significant fire or environmental hazard, and is not in a public area such as a common hallway. Large chemical spills include spills of larger quantities, spills of any quantity of highly toxic chemicals, or chemicals in public areas or adjacent to drains. Large spills require emergency response. Call 911, evacuate to a safe area, and remain available in the evacuation area to communicate details of the incident to first responders.

What to do with a small chemical spill

- Evacuate all non-essential persons from the spill area;
- If needed, call for medical assistance by dialing 911;
- Help anyone who may have been contaminated. Use emergency eyewashes/showers by flushing the skin or eyes for at least 15 minutes;
- Post someone just outside the spill area to keep people from entering. Avoid walking through contaminated areas;
- You must have the proper protective equipment and clean-up materials to clean-up spills. Check the chemical's Material Safety Data Sheet (MSDS) in your laboratory for spill clean-up procedures, or call EH&S at 530-750-1264;
- Turn off sources of flames, electrical heaters, and other electrical apparatus, and close valves on 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 respond and clean up the spill;
- Wear personal protective equipment, including safety goggles, gloves, and a laboratory coat or other protective garment to clean-up the spill;
- Work with another person to clean-up the spill. Do not clean-up a spill alone;



DO NOT TRY TO DILUTE OR NEUTRALIZE THE SPILLED CHEMICAL BY ADDING WATER

Use an appropriate kit to neutralize and absorb inorganic acids and bases. For other chemicals, use the appropriate kit or absorb the spill with sorbent pads, paper towels, vermiculite, dry sand, or diatomaceous earth. For mercury spills and specific procedures for all other spills contact EH&S. Collect the residue and place it in a clear plastic bag. Double bag the waste and label the bag with the contents and label it to be picked up a chemical waste.

What to do with a large chemical spill

Large chemical spills require emergency response. Call 911 and evacuate to a safe area. If the spill presents a situation that is immediately dangerous to life or health (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 safely outside and away from the spill area to keep people from entering
- Confine the spill area if possible and safe to do so
- Leave on or establish 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

Highly toxic chemical spills

All spills of these chemicals require emergency response, do not clean up by yourself

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

Hazardous Chemical Waste Management

Hazardous waste program

Each laboratory employee must comply with the Hazardous Waste Management Program requirements at their respective location and all applicable regulations. Laboratory personnel are responsible for identifying waste, labeling it, and storing it properly in the laboratory. The PI is responsible for coordinating the disposal of all chemicals from his/her laboratories prior to closing down laboratory operations. Laboratory clean-outs and disposal of high hazard compounds should be coordinated through the location safety coordinator.

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, or RCRA.

Definition of hazardous waste

Federal and State regulations define hazardous wastes as a substance which poses a hazard to human health or the environment when improperly managed. A chemical waste is considered hazardous if it is either listed on one of the lists found in Federal or State regulations or if it exhibits one or more of the four following characteristics:

1. **Ignitable** - Ignitable wastes generally are liquids with a flash point below 60°C or 140°F (however, just because a material has a higher flash point, it still cannot be drain disposed).
2. **Corrosive** - Corrosive wastes are generally aqueous wastes with a pH less than or equal to two (2) or greater than or equal to 12.5
3. **Reactive** - Reactive wastes are those wastes that are unstable, explosive, and capable of detonation or react violently with water.
4. **Toxic** - A chemical that poses a hazard to health or the environment (this can be a gray area).

To assist in waste determination, review the Hazardous Chemicals List (www.ehs.ucr.edu/waste/hazardouschemicals.xls).

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

- Abandoned chemicals
- Unused or 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 that degrade and destabilize over time and require careful management so that they do not become a safety hazard (review “Wastes that Require Special Handling”).

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., formaldehyde, chloroform, 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 the Federal lists are included in the EH&S list of extremely hazardous waste, through www.ehs.ucr.edu/waste. NOTE: While there is some overlap with the list of Particularly Hazardous Substances, the extremely hazardous waste list is specific to hazardous waste management.

Proper hazardous waste management

Training

On-line training presentations on Hazardous Waste Management and Waste Minimization are available through UC campus EH&S websites.

UC Davis hazardous waste training: <http://safetyervices.ucdavis.edu/training/hazardous-waste-management-and-minimization>

UC Riverside hazardous waste training: <http://ehs.ucr.edu/training/index.html>

Note: campus- based training modules are for information only and may not reflect local hazardous waste program requirements. Always confirm any waste management practices with your local safety coordinator or with UC ANR EH&S (530-750-1264).

Waste identification

All the chemical constituents in each hazardous waste stream must be accurately identified by knowledgeable laboratory personnel. This is a critical safety issue for both laboratory employees and those 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 workers must consult the PI, location safety coordinator, or UC ANR EH&S. In most cases, careful documentation and review of all chemical products used in the experimental protocol will result in accurate waste stream characterization.

The manufacturer's SDS provides detailed information on each hazardous ingredient in laboratory reagents and other chemical products, and also the chemical, physical, and toxicological properties of that ingredient. The UC SDS library (www.ehs.ucr.edu/services/msds.html) provides an extensive library of research chemicals. Waste streams that have a large percentage of ingredients listed as proprietary information should be discussed with the location safety coordinator and UC ANR EH&S.

Labeling of waste

All waste must be labeled to identify the generator of the waste, the specific composition of the waste, hazardous properties of the waste, and the accumulation state date when waste was first added to the container. A generic waste label may be downloaded from the UC ANR EH&S website:

<http://safety.ucanr.edu/files/2908.pdf>.

Storage of waste

The hazardous waste storage area in each laboratory is considered a satellite accumulation area (SAA). According to EPA requirements, this area must remain under the control of the persons producing the waste. This means that it should be located in an area that is supervised and is not accessible to the public. Requirements for laboratory accumulation of hazardous waste at ANR Research and Extension Center are specified in UC ANR RECS policy (<http://safety.ucanr.edu/files/2865.pdf>).

SAA requirements include:

- Hazardous waste containers must be labeled with a waste tag at all times
- Waste must be collected and stored at or near the point of generation
- The maximum amount of waste that can be stored in a SAA is 55 gallons of a hazardous waste or 1 quart of extremely hazardous waste. If you reach these volumes for extremely hazardous waste, you must have the waste removed within 3 days
- The maximum amount of flammable solvents allowed to be stored in a laboratory includes flammable waste solvents
- All hazardous waste containers in the laboratory must be kept closed when not in use
- Hazardous waste streams must have compatible constituents, and must be compatible with the containers in which they are stored
- Hazardous waste containers must be stored in secondary containment at all times.
- Containers must be in good condition with leak proof lids
- Containers must be less than 80% full
- Dry wastes must be double-bagged in clear, 3-mil plastic bags

Segregation of waste

All hazardous materials must be managed in a manner that prevents spills and uncontrolled reactions. Stored chemicals and waste should be segregated by hazard class. Examples of proper segregation are:

- Segregate acids from bases
- Segregate oxidizers from organics
- Segregate cyanides from acids

Segregation of waste streams should be conducted in a similar manner to segregation of chemical products. Refer www.ehs.ucr.edu/hazardousmaterials for chemical segregation guidelines.

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 rupture containers and explode, resulting in serious injury and property damage. All chemical constituents and their waste byproducts must be compatible for each waste container generated. Waste tags must be immediately updated when a new constituent is added to a mixed waste container, so that others in the laboratory will be aware and manage it accordingly.

Some common incompatible waste streams include:

- Oxidizers added to any fuel can create an exothermic reaction and explode. The most frequent is acids oxidizing flammable liquids. For this reason, all flammable liquids are pH tested before they are consolidated
- Piranha etch solution is a specific waste stream that contains sulfuric acid and hydrogen peroxide, which form a reactive mixture that is often still fuming during disposal. For this waste stream, and other reactive mixtures like it, vented caps are mandatory

Wastes that require special handling

Unknowns

Unlabeled 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”.

Peroxide-forming chemicals

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

Each container of peroxide forming chemicals should be dated with the date received and the date first opened. There are three classes of peroxide forming chemicals, with each class having different management guidelines. A review of the safety information provided by the manufacturer can be used as a guide to managing PFCs.

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 that they are free of exterior contamination or crystallization. PFC containers must be disposed of prior to expiration date. If old containers of peroxide forming chemicals are discovered in the laboratory, (greater than two years past the expiration date or if the date of the container is unknown), do not handle the container. If crystallization is present in or on the exterior of a container, do not handle the container. Secure it and contact UC ANR EH&S at 530-750-1264.

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 6 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 EH&S immediately. Secure the area and restrict access to the container until it can be evaluated by qualified personnel.

Explosives and compounds with shipping restrictions

A variety of other compounds that are 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 of these compounds, employees must ensure that they are stored appropriately for transport. Flammable metals must be completely submerged in oil before they are brought to a 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 EH&S for disposal considerations of these compounds.

Managing empty containers

Empty containers that held Extremely Hazardous waste must be managed as hazardous waste. Do not rinse or reuse these containers.

All other hazardous waste containers, if they are less than 5 gallons in size, should either be reused for hazardous waste collection, or should be cleaned and discarded or recycled. Proper cleaning involves triple rinsing the container, with the first rinse collected as hazardous waste. Then the labels should be completely defaced (remove it or mark it out completely).

Transportation

It is a violation of DOT regulations to transport hazardous waste in personal vehicles, or to carry hazardous waste across campus streets that are open to the public. Contact your site safety coordinator or UC ANR EH&S for guidance.

Accumulation and disposal

Frequent disposal will ensure that hazardous waste accumulation areas in labs are managed properly, and that accumulation limits are not exceeded. Hazardous chemical waste may be stored on site for up to one year – inclusive of the time spent in the laboratory and any other 90-day waste accumulation area. Lab personnel are encouraged to minimize the amount of waste held in the lab and should strive to limit accumulation times to 180 days in order to allow for ample time to arrange for disposal within proper time limits. Once a waste container is 80% full or it is near the time limit, it should be transferred to the local safety coordinator or an authorized waste vendor for disposal.

Drain disposal

Drain disposal of chemical wastes is not allowed at UC ANR facilities 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, hazardous waste regulations specify that materials with a pH between 2.0 and 12.5 are not hazardous wastes. However, drain disposal of these materials is still not permitted, because local waste water discharge requirements have more restrictive pH thresholds. In addition, acid and base neutralization is considered waste treatment, a process that is strictly regulated by the Cal/EPA (see “Bench Top Treatment” below). Contact EH&S for specific questions about drain disposal options.

Benchtop treatment

Cal/EPA regulations allow some limited bench top treatment of certain chemical waste streams in laboratories provided that 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.

Hazardous waste minimization

In an effort to minimize the costs, health hazards, and environmental impacts associated with the disposal of hazardous waste, below are some guidelines regarding waste minimization:

ADMINISTRATIVE CONTROLS: When ordering chemicals, be aware of any properties that may preclude long term storage, and order only minimum volumes to be used. Using suppliers who can provide quick delivery of small quantities can assist with reducing surplus chemical inventory.

Inventory Control: Rotate chemical stock to keep chemicals from becoming outdated. Identify surplus/unused chemicals and attempt to redistribute these to other users.

Operational Controls: Review your experimental protocol to ensure that chemical usage is minimized. Reduce total volumes used in experiments and employ small scale procedures when possible. 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. Use less hazardous or non-hazardous substitutes when feasible. Some examples include:

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

Chemical Hygiene Plan Definitions (8 CCR 5191)

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.

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

"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

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-32372.

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.

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 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 Tagliabue 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; or,
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 supervisor 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 MATERIAL - Any material which is a potential/actual physical or health hazard to humans.

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, an water-reactive material.

HAZARDOUS CHEMICAL - A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, and neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes or mucous membranes. 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)

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; or
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.

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 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; and
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.

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.

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 8CCR5155. PELs may be either a time-weighted average (TWA) exposure limit (8hour), 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 lab coats, 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 MSDS.

REPRODUCTIVE TOXINS - Chemicals which affect the reproductive capabilities including chromosomal damage (mutations) 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. (Formerly material safety data sheet, MSDS)

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

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

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.

SHORT-TERM EXPOSURE LIMIT - 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 or the laboratory 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, which 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.

Appendices and SOPs

Appendices

Appendix 3a – Facility guidelines for chemical safety (ventilation controls)

Appendix 3b – Chemical Safety SOP template (UC Davis)

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Section 4 - Physical Hazards and Technical Work Locations

Background and Introduction

Purpose and scope

This section of the manual can be used by research staff to document safety information for physical hazards such as radiation sources, heat illness, equipment, or outdoor field work sites. This section applies to research uses of potentially hazardous equipment in research such as tractors, forklift/industrial truck, harvester, shop equipment (grinders, saws), all-terrain vehicles, orchard/picking ladders, pesticide application equipment, pack lines, stills, gins, mechanical threshing operations, and any another pressurized, motorized, or noise-generating equipment used in research.

This section can also be used as primary section for safety information for outdoor research activities, field work, and non-lab locations.

Physical Hazards

Employees who operate equipment or participate in processes that pose significant physical hazard must be trained to recognize the physical hazard and to use protective controls whenever required or recommended for the work. Significant hazards include but are not limited to hydraulic presses and equipment with high-pressure hydraulic fluid, autoclaves, drying ovens, sonicators, microtomes, grinders, vehicles, and packline operations. Operating manuals for any hazardous equipment must be maintained for reference by users and used in training. SOPs for safe use of equipment and vehicles should be included in this section of the manual. See appendices 4b – 4e at the end of this section for template forms to document general research SOPs, job safety analyses, PPE hazard assessment, and shop safety plans.

Radiation Safety

Any use of radiation or radiation producing equipment requires specific authorization and approval from UC ANR EH&S. Any use of regulated radiation-producing equipment or radioactive materials must be conducted under specific authorization from the U.S. Nuclear Regulatory Commission that is maintained by a UC campus.

Currently, all radiation producing equipment at ANR is authorized through UC Davis Radiological Safety Program. UC ANR researchers who have active Radiological Use Authorizations (RUA) are responsible for maintaining compliance with all campus RUA requirements, including conducting or facilitating semi-annual leak test for hydroprobes and other sealed sources.

Contact UC ANR EH&S prior to any planned purchase of radiation producing equipment or radioactive materials.

Heat Illness

Principal investigators are responsible for identifying work processes which may pose a risk for heat stress and providing training and support as required under regulations. Employees are responsible for adhering to the location heat illness plan and IIPP, including maintaining a copy of the heat illness plan that is relevant to the research project/site at each outdoor work location where heat illness provisions may be required. If research involves exposure to temperatures above 80F, a copy of the current heat illness plan should be printed and added as an appendix in this section of the manual. See appendix 4a for a template which can be used to create a project-specific heat illness plan.

Heat illness prevention training resources

Access to UC heat illness prevention training online UC training course is available on the UC ANR safety website here: http://safety.ucanr.edu/Programs/Heat_Illness_Prevention/ (UC login required to access to UC Learning Center)

Outdoor, Remote, and Other Temporary Research Locations

The University of California has published a field research safety manual to provide guidance to research staff who work in outdoor and remote locations. If this manual is being implemented for projects that involve a significant amount of field work, relevant sections of the manual (or the entire manual) may be printed and added to this section as an appendix. Field research projects must have documented safety plans and procedures to cover emergency response, heat illness prevention, exposure to zoonotic disease and other hazards encountered in the work. Locations of nearby medical providers and plans for access to medical care are also required. See the UC Field Research Safety Manual for more guidance.

<https://www.ucop.edu/environment-health-safety/files/uc-field-research-safety-manual-2017-18-final-082318.pdf>

Job Safety Analysis & Personal Protective Equipment Certification

Similar to biosafety and chemical safety SOPs that are used in labs, hazard assessments and safety information must be documented for any physical hazards unique to the lab environment. Additionally, physically hazardous research activities may occur in locations outside of the lab such as greenhouses and technical work rooms.

The Cal/OSHA Injury and Illness Prevention Program (IIPP) regulation (8 CCR §3203) and Personal Protective Equipment (PPE) regulation (8 CCR §3380) require employers to:

- 1) List the tasks and activities employees perform, assess the hazards and establish the required controls, and;
- 2) Establish and train employees on hazard assessment findings and required personal protective equipment (PPE), if any, for each task or activity.

Engineering and/or administrative controls should be the first choices for controlling hazards. PPE is the last resort. NOTE: Laboratory workers should use the Laboratory Hazard Assessment Tool (LHAT) for PPE hazard assessment.

Instructions for Completing Job Safety Analysis & Personal Protective Equipment Certifications
Forms for documenting a job safety analysis and PPE certification for physical hazards and technical work locations are included in appendices to this safety manual. Copies of completed JSA and PPE certifications should be retained in this section of the safety manual for easy access and reference by employees at the worksite.

Step 1: Select assessment category - Hazard assessments are conducted for areas (worksite), job activities/categories, tools, equipment or for individuals. For ease of assessment, grouping similar tasks, activities, tools and equipment into categories is highly recommended. The hazard evaluator must record the location, employee's name or position title that is being assessed, and sign and date the assessment form.

Step 2: Inform affected employees of the process - Involve affected employees in the assessment, if possible. Discuss the reasons for the assessment and the procedures being used to review the job procedures (tasks), potential hazards, and the PPE currently in use or needed.

Step 3: Part I - Job Safety Analysis

- A. Identify activities (i.e. tasks, procedures, equipment/tool use) by interviewing supervisors, principal investigator, and other experienced employees. Activities can be general (i.e. "general office work") or specific (i.e. operating a table saw).
- B. Consider and list the potential employee injury hazards of each activity, task, tool or equipment, such as:
 - Asphyxiation (i.e. confined spaces, oxygen deficient environments)
 - Chemical or biological exposure (i.e. inhalation, ingestion, skin contact, eye contact or injection – may be documented in LHAT of other assessments)
 - Compression (i.e. roll-over or pinching objects, caught in between objects)
 - Cuts/Penetration (i.e. sharp objects piercing foot/hand, needle sticks)
 - Dust/flying debris (i.e. grinding, chipping, sanding)
 - Electrical (i.e. shock, short circuit, arcing, static)
 - Fall (i.e. slip/trip, scaffolds, elevated heights, unprotected elevated edges)
 - Impact (i.e. falling/flying objects, struck by or against an object)
 - Noise (i.e. mechanical rooms, machines, cage washing, jackhammers)
 - Radiation (ionizing: i.e. X-rays, radio-isotopes)
 - Radiation (non-ionizing: i.e. UV/IR/light, lasers, welding, brazing, cutting, furnaces)
 - Temperature extremes (i.e. heat/cold)
- C. Describe controls (training, SOPs, machine guarding, safe work practices, or administrative controls) to eliminate or minimize the potential risk of the hazard
- D. Identify the need for PPE. If needed, complete Part II
- E. Evaluator signs and dates the hazard assessment
- F. Train employees on assessment findings and make assessment accessible
- G. Update assessment when new hazards are introduced or identified

Step 4: Part II - PPE Hazard Assessment/Certification (If Needed)

After completing the Job Safety Analysis (Part I), if PPE is required for a certain activity, task, tool, or equipment, complete Part II.

Select the PPE per body part protected (i.e. safety glasses for eyes). Document the required PPE. For help with proper PPE selection, contact EHS@ucanr.edu or consult the UC Davis Safety Services PPE Selection guide (Appendix 1d).

The PPE Hazard Assessment/Certification procedure is as follows:

- A. List activities identified in Part I as needing PPE
- B. Identify the body part needing protection
- C. Describe the required PPE (i.e. nitrile gloves, safety goggles)
- D. Evaluator sign and date the certification statement
- E. Review the PPE Hazard Assessment/Certification with affected employees
- F. Provide PPE and train employees on the required PPE, proper use and maintenance
- G. Document the training date and employee's printed name and signature
- H. Make this document accessible to employees

Step 5: Revise and re-assess - Update departmental protocols with new or modified PPE requirements, when applicable. Conduct periodic reassessments to identify and evaluate:

- New equipment and processes
- Injury and illness reports
- Near-miss reports
- Accident records
- Suitability of previously selected PPE

Appendices and SOPs

Appendices

Appendix 4a - Heat Illness plan template

Appendix 4b - General Research Safety SOP template

Appendix 4c - Job Safety Analysis (JSA) form

Appendix 4d - PPE Hazard Assessment and Certification form

Appendix 4e - Shop Safety Plan Template

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Section 5 - Occupational Exposure Assessment and Medical Services

Exposure Assessment Overview

It is University of California policy to comply with all applicable health, safety and environmental protection laws, regulations and requirements. 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.

Minimizing an exposure may be accomplished using a combination of engineering controls, administrative controls and personal protective equipment, listed in order of priority. Assessing exposure to hazardous chemicals may be accomplished through a number of methods performed by EH&S, including employee interviews, 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 will be performed under either of the following situations:

- When EH&S determines an exposure assessment is warranted based on chemical inventories, review of standard operating procedures (SOPs), types of engineering controls present, laboratory inspection results and/or review of the annual Laboratory Hazard Assessment Tool, or;
- When a user of a hazardous chemical has concern or reason to believe their exposure is not minimized or eliminated through use of engineering controls or administrative practices and the potential for exposure exists. In this case, the user should inform his or her PI, who will in turn contact the EH&S at 530-750-1264. EH&S will then determine the best course of action in assessing employee exposure, including visual assessment, air monitoring, medical evaluation, examination, or medical surveillance.

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

Biological exposure assessment

In keeping with requirements of CCR Title 8 Section 5199, UC ANR EH&S is responsible for providing biosafety expertise to perform and document biological risk assessments when required under code to mitigate the hazards of aerosol-transmissible diseases. Biological exposure assessments are based upon case-by-case review of lab procedures and practices; such exposure assessments must be conducted by an individual with the knowledge and ability to identify and recommend effective biological safety controls. A biological safety professional or biosafety officer is the title of EHS specialists with specific expertise in biological risk assessment. If such expertise is not available in UC ANR EH&S, UC campus Biological Safety Officers (or their delegates) may perform this function at the behest of UC ANR EH&S department.

Unlike chemical hazards, exposure limits do not exist for most biological agents. In many cases, protective equipment or practices may be required as precautionary measures. Whenever possible, prioritization and implementation of safety controls should be a collaborative effort between EH&S and research staff. In the event that a pathogen may be present. Unless prescriptive requirements apply to the work, performance-based criteria will be favored in establishing biosafety controls. Principal investigators proposing to deviate from standard biosafety practices may be required to provide evidence or data to support deviations from standard practices.

Chemical exposure assessment

All University employees require protection from exposure to hazardous chemicals above established exposure limits. The profession with expertise in chemical exposure assessment monitoring is industrial hygiene. At UC ANR, the person supervising, directing or evaluating the exposure assessment monitoring must be competent in the practice of industrial hygiene. UC ANR EH&S employs personnel with this expertise and relies on UC Davis, UC Riverside, and UC Berkeley EH&S departments for additional industrial hygiene program support. General questions regarding exposure assessment or the industrial hygiene program can be directed to the UC ANR EHS at ehs@ucanr.edu or (530)750-1264.

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”, 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 [CCR Title 8 Section 5155](#) (Airborne Contaminants) Table AC-1 (www.dir.ca.gov/Title8/ac1.pdf). 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.

Other hazardous exposures

Cal/OSHA has established exposure limits for numerous physical hazards including radiation, noise, vibration, dust (not otherwise specified), and heat. Similar to chemical exposure monitoring, someone skilled in the practice of industrial hygiene should direct and supervise any exposure monitoring activities to assure that the exposure monitoring activities are conducted and documented according to established procedures. Concerns for hazardous exposures in labs should be raised to the lab supervisor or location safety coordinator for communication to EH&S and initiation of a hard assessment.

Exposure Assessment Protocol

Assessment

UC ANR EH&S conducts exposure assessments for UC employees who work in UC ANR facilities and who conduct UC ANR business or research outside of UC facilities. Exposure assessments for projects occurring at UC campuses are conducted by the respective campus EH&S department. 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. The costs of exposure monitoring are the responsibility of the lab, department, and organization in which the personnel is employed. General protocol in conducting an exposure assessment may include any of the following:

- Employee interviews;
- Visual observation of chemical usage and/or laboratory operations;
- Evaluation of simultaneous exposure to multiple chemicals;
- Evaluation of potential for absorption through the skin, mucus membranes or eyes;
- Evaluating existing engineering controls (such as measuring face velocity of a fume hood);
- Use of direct reading instrumentation; and
- Collection of analytical samples of concentrations of hazardous chemicals taken from the employees breathing zone, or 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 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 ANR will provide, at no cost to the employee, the proper respiratory equipment and training. Respirators will be selected and used in accordance with the requirements of CCR Title 8 Section 5144 (www.dir.ca.gov/Title8/5144.html) and the UC ANR's Respiratory Protection Program.

In assessing exposure to hazardous chemicals for which Cal/OSHA has not published a PEL, STEL or Ceiling exposure, EH&S defers 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 National Institute of Occupational Safety & Health (NIOSH). Please contact EH&S at 530-750-1264 for more information regarding these chemicals.

Notification

UC ANR EH&S will promptly notify the employee and his/her PI of the results in writing) after the receipt of any monitoring results. EH&S 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 CCR Title 8 Section 3204 “Access to Employee Exposure and Medical Records” (www.dir.ca.gov/Title8/3204.html).

Determine and implement controls

EH&S will use any of the following criteria to determine required control measures to reduce employee’s occupational exposure:

- Verbal information obtained from employees regarding chemical usage;
- Visual observations of chemical use or laboratory operations;
- Evaluation of existing engineering control measures or administrative practices;
- Recommendations expressed in Safety Data Sheets;
- Regulatory requirements of Cal/OSHA;
- Recommendations from professional industrial hygiene organizations;
- Direct reading instrumentation results;
- Employee exposure monitoring results; and/or
- Medical evaluation, examination and/or surveillance findings.

Particular attention shall be given to the selection of safety control measures for chemicals that are known to be extremely hazardous. Per Cal/OSHA CCR Title 8 Section 5141 “Control of Harmful Exposure to Employees” (www.dir.ca.gov/Title8/5141.html), the control of harmful exposures shall be prevented by implementation of control measures in the following order:

- Engineering controls, whenever feasible;
- Administrative controls whenever engineering controls are not feasible or do not achieve full compliance and administrative controls are practical; and
- Personal protective equipment, including respiratory protection, during:
 1. The time period necessary to install or implement feasible engineering controls
 2. When engineering and administrative controls fail to achieve full compliance in emergencies.

Medical Evaluation

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

1. When an employee is required to use a respirator for their work (evaluation required prior to use of respirator);
2. Whenever an employee develops signs or symptoms associated with a hazardous chemical or biological agent to which an employee may have been exposed in a laboratory;
3. Where personal monitoring indicates exposure to a hazardous chemical is above a Cal/OSHA Action Level (AL) or Permissible Exposure Limit (PEL) or recommended exposure levels established by the National Institute for Occupational Safety & Health (NIOSH) or the American Conference of Governmental Industrial Hygienists (ACGIH) in the event Cal/OSHA has not established an AL or PEL for a particular hazardous chemical;
4. 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; or
5. 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 by a medical facility. 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 should report the incident following UC ANR injury reporting procedures (http://safety.ucanr.edu/Guidelines/Reporting_an_Injury/). Safety Note # 123 describes procedures for reporting employee injuries or illnesses (<http://safety.ucanr.edu/files/1369.pdf>) and Safety Note #76 describes procedures for reporting a serious work-related injury (<http://safety.ucanr.edu/files/1472.pdf>).

Serious injury or illness is defined as any injury or illness occurring in a place of 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 the commission of a Penal Code violation, or an accident on a public road or highway (CCR Title 8, Section 330 [h]).

Information to provide to the clinician

At the time of the medical evaluation, the following information shall be provided:

1. Personal information such as age, weight and University employee ID number;
2. Common and/or 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 Safety Data Sheet (SDS) of the hazardous chemical in question;
7. History of exposure including previous employment and non-occupational (recreational) hobbies;
8. Any additional information helpful in assessing or treating an exposure or injury such as a biological component of exposure or existence of an antitoxin; and
9. Employment/pay status at time of exposure/injury.

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; and
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.

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 Action Level or PEL.

UC ANR medical surveillance and services are provided by the UC Davis Occupational Medical Clinic in coordination with designated local medical providers. 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, Beryllium, Formaldehyde, Lead, Methylene Chloride, Cholinesterase-inhibiting Pesticides, Noise (Hearing Conservation Program), Radioactive Chemicals (Bioassay Program), Respirator Use (Respirator Protection Program), and other particularly hazardous substances. Individuals with questions regarding work-related medical surveillance are encouraged to contact EH&S at 530-750-1264 for more information.

Confidentiality & Individual's Access to Personal Medical Records

All patient medical information is protected by California and federal law and is considered strictly confidential. The medical facility is prohibited from disclosing any patient medical information that is not directly related to the work-related exposure under evaluation and should not reveal any diagnosis unrelated to exposure. Any patient information disclosed by the medical facility 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 the medical facility 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, the medical facility 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. The medical facility will provide an employee with a copy of his/her medical records upon written request.

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Appendices and SOPs

Appendices

Appendix 5a - List of Occupational Health Providers

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