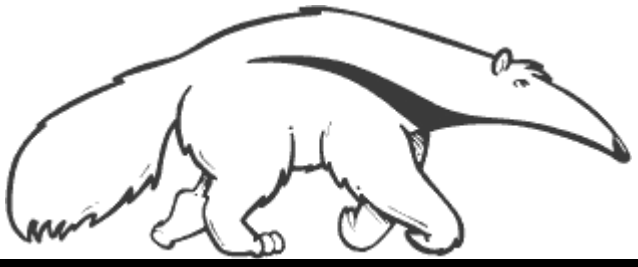

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Environmental Health and Safety
www.ehs.uci.edu

Laboratory Safety Manual
&
Chemical Hygiene Plan
(CHP)

January, 2013

_____ LABORATORY SPECIFIC SAFETY TRAINING

(print lab name)

In addition to completing Safety Training Self-Assessment and required EH&S safety courses, students and researchers must attend a laboratory specific training performed by the laboratory Safety on Site Representative (SR). Topics of this training include:

- location and proper use of safety equipment;
- emergency procedures including steps for personal injury, hazardous spills, and evacuations;
- basic laboratory safety rules (see CHP- A1)
- location, selection, and when to wear Personal Protective Equipment (PPE) based on PPE Assessment;
- location and methods for hazardous waste disposal;
- access and maintenance of hazardous material inventories;
- provisions for working alone in lab;
- Laboratory Safety Guidelines contents;
- this lab's SOS Hazard Identification Checklist (HIC);
- identified written lab-specific SOPs for highly hazardous materials and operations;
- Other: _____;
- Other: _____.

We have reviewed the above lab specific training elements and will provide information, training, and supervision to students and researchers in this laboratory.

_____

Principal Investigator Date

_____

SR Signature Print Name Date

I (researcher and students) have read and understand the Laboratory Specific Safety Requirements, and I have completed the Safety Training Self-Assessment, EHS required and work unit specific safety training.

Print Name	Signature	Training Date	SR Signature

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Health and Safety In the Research Laboratory

Section 1

I. INTRODUCTION

As a lab supervisor or researcher, you should be aware of a variety of potential hazards in the lab that you and your students may encounter. These hazards include:

- Chemicals
- Biohazards
- Machinery
- Emergencies (spills, fire, earthquakes, injuries)
- Electricity
- Radiation
- Animals

Responsibilities have been assigned to specific persons within departments and labs (See **Appendix A - Responsibilities**). Contact your school's **EH&S Coordinator** to report hazards (Reports can be made anonymously at 824-6200.)

A. EH&S Programs

Safety policies have been established to protect against hazards in laboratories. Everyone is expected to follow safe work practices and all university policies. Contact EH&S, ext. 4-6200, for assistance in any of these programs.

1. Safety on Site, SOS (*Injury and Illness Prevention Program)*

S.O.S. is an overall safety plan for the campus. Each laboratory or work area should have a plan tailored to their area. S.O.S. outlines basic safety requirements and incorporates other components appropriate to the different hazards present in an individual lab. The plan includes general safety training, and training in specific topics depending on work activities. (See **APPENDIX A - Responsibilities** for more specifics on SOS).

The following programs may apply to specific work sites.

2. *Hazard Communication Program*

The Hazard Communication program ensures workers become aware of hazards associated with the materials they use and understand how to protect themselves. Employees must be trained. Manufacturers must provide a **safety data sheet (SDS)** for each hazardous chemical purchase. Lab workers must maintain warning labels on all hazardous chemical containers.

3. ***Chemical Hygiene Plan (Lab Standard)***

Cal-OSHA requires the implementation of a Chemical Hygiene Plan (CHP). The CHP outlines the specific work practices and procedures associated with chemicals used to ensure employee protection from exposure. Standard Operating Procedures must be written for particularly hazardous chemical use and hazardous operations (See Chemical Hygiene Plan for more information)

4. ***Radiation Safety Program***

The Radiation Safety program controls all users of ionizing radiation and operators of radiation producing materials. Specific procedures for purchasing, storing, using, and disposing of radioactive materials are included. New workers must attend radiation safety training prior to using radioactive materials. Each lab using radiation is individually authorized by Radiation Safety. These authorizations are maintained through periodic inspections and careful recordkeeping.

5. ***Biosafety Program***

The Biosafety program controls all uses of biological agents (bacteria, viruses, etc.). Specific practices and procedures established by CDC (Center for Disease Control) and NIH (National Institute of Health) must be followed when handling biohazardous materials. The Institutional Biosafety Committee must authorize the use of biological agents.

A. ***Bloodborne Pathogen Program***

The Bloodborne Pathogen program educates workers to protect themselves from blood products and other potentially infectious materials. Anyone who comes in contact with human blood, tissues or human derived products (established and primary human cell lines, plasma, purified proteins, etc.), must attend Bloodborne Pathogen training annually.

B. ***The Aerosol Transmissible Disease (ATD) Program***

The ATD Program minimizes employee exposure to aerosolized transmissible diseases. Where applicable, investigators complete an Exposure Control Plan Template to help create an effective unit-specific ATD exposure control plan.

6. ***Occupational Health***

Occupational Health Program ensure that appropriate precautions are taken to protect our faculty, staff and students by providing health risk assessments for identified lab safety programs and other university programs that involve higher risk work activities; coordination for medical counseling for allergies; ergonomics; reproductive and immune status issues that may impact your job functions; medical clearance and fit testing for job required respiratory protection; and job specific vaccinations and titers. Researchers working with

animals must also enroll in the **Laboratory Animal Occupational Health Program (LAOHP)**.

7. **Controlled Substance Program**

Controlled Substance Program policies pertain to all researchers who use controlled substances and precursor chemicals in the course of research, instruction, or chemical analysis on the UCI campus, UCI-affiliated sites, and UCI Medical Center.

8. *Other Programs*

Other programs in place include **Fire Safety**, **Emergency Action Plan**, and Respiratory Protection Program. Contact EH&S for more information.

B. **Training Resources**

Visit UC Learning Center site at **www.uclc.uci.edu** to:

- Complete and update your individualized Safety Training Self-Assessment (STSA);
- Identify and maintain your required and recommended safety training;
- Enroll in courses;
- Take online training;
- View your Required Activities;
- Bio199 and Chem180, H180 students 1) gain access to UCLC and 2) update their UCLC supervisor designation using the "Student & Affiliate Access Request" form.

NOTE: UCLC does not support Chrome browser.

C. Lab Postings

- UC Irvine Injuries & Medical Treatment
- Emergency Procedures (Blue Flipchart)
- How to Access Required Safety Information
- Hazard Emergency Information Notification (HEN), lab door posting, UCINet ID required.
- Hazardous Waste Guidelines
- Biomedical Waste Guidelines
- Sharps Waste Guidelines
- Pharmaceutical Waste Guidelines
- Chemotherapy Waste Guidelines

Section 2

Chemical Hazards - Recognition, Evaluation and Control

I. RECOGNITION OF CHEMICAL HAZARDS

Working with chemicals always involves the risk of exposure. It is important to review and understand any information about hazards and special precautions regarding the handling and use of a chemical. Hazardous chemicals can be classified into the following types of hazards:

- Flammable
- Reactive
- Oxidizers
- Corrosive
- Toxics (poisons, carcinogens, mutagens, teratogens, etc.)

Chemicals should be stored with other chemicals of the same type. All liquid chemicals should be stored in secondary containment. Chemical exposure should be minimized as much as possible through the use of engineering controls, like chemical fume hoods, through work practices that minimize volume and substitute less hazardous materials, and through personal protective equipment (PPE) like gloves, splash goggles, and lab coats. **APPENDIX E - Classes of Hazards Materials**, outlines precautions for various classes of chemical hazards.

II. EVALUATION OF CHEMICAL HAZARDS

A. Material Safety Data Sheets (SDS's)

1. An SDS outlines a substance's physical and chemical hazards that include but are not limited to:

   - Identity Information
   - Hazardous Ingredients
   - Physical/Chemical Characteristics
   - Fire and Explosion Hazard data
   - Reactivity Data
   - Health Hazard Data
   - Precautions for Safe Handling & Use
   - Control Measures

   (For definitions of commonly used SDS terms see **APPENDIX T - Glossary**)

2. In accordance with the UCI Hazard Communication Program, companies that sell hazardous substances to UCI are required to provide an SDS on each substance and mixture of hazardous substances.

3. *Accessing SDS's*

a. *Internet Resources*

Campus EH&S maintains internet resources for accessing SDSs as well as access to the Thomson Micromedex system called TOMES which comprises three extensively referenced modules - the MEDITEXT®, HAZARDTEXT®, and INFOTEXT® databases.

The EH&S SDS and TOMES resources can be found at: **http://www.ehs.uci.edu/msds.html.**
-Set your browser to allow pop-ups from this url.
-Cookies must be allowed from this site.

b. *From the EH&S office:*

Contact EH&S to request an SDS or for technical assistance.

B. Health Effects of Chemicals

Working with chemicals always involves the risk of chemical exposure. The health risk is dependent upon the toxicity of the chemical, the types of effects and the various routes of entry.

1. *Toxicity vs. Hazard*

Toxicity
Ability of a chemical to act as a poison or cause injury to tissues. (See **Appendix H - Target Organ Categorization** for examples of toxic effects of chemicals on various target organs in the human body)

Hazard
Likelihood that a chemical will cause injury in a given environment or situation; degree of hazard depends on how toxic the substance is, how it is absorbed, etc.

2. *Acute vs. Chronic Exposures*
Acute Exposures
Exposure of short duration, usually to relatively high concentrations or amounts of material.

Chronic Exposures

Continuous or intermittent exposure extending over a long period, usually to relatively low material amounts or concentrations.

3. *Local vs. Systemic Effects*

Local Effects
Effects of the chemical may be localized on a specific area of the body such as nose or throat.

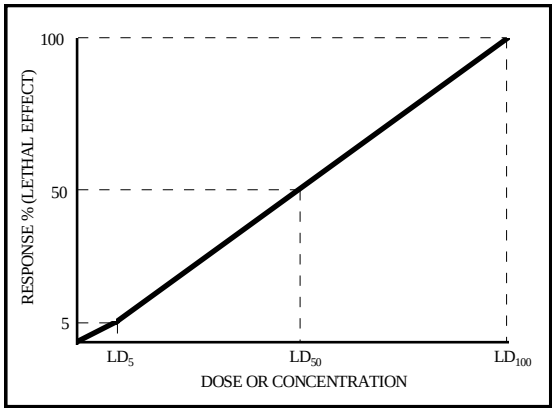
Systemic Effects
Entire body system and organs are all affected by exposure to the chemical.

C. **Threshold Limits Values - TLV-TWA**

Most health effects are dependent on the level of concentration of the exposures. The TLV-TWA is the allowable time-weighted average (TWA) airborne concentration of a material to which most workers can be exposed, during a normal 8-hr workday or 40-hr week, without adverse effects.

D. **Dose - Response Relationship**

Toxicological studies show that there is a relationship between the chemical dose and the response that is produced in the body. For example, a small amount of formaldehyde will effect minutely on the biologic tissue while large amounts of the same chemical will cause severe effect in a biologic system. This dose-response relationship can be plotted out.



E. **Routes of Entry**

There are various routes of entry whereby chemicals can gain entrance into the physical body. These routes are:

1. Inhalation
2. Skin Absorption
3. Ingestion
3. Injection

F. **Target Organ Effects**

These are chemically caused effects from exposure to a material on a specific listed organ or system such as liver, kidneys, nervous system, lungs, skin, and eyes. **APPENDIX H - Target Organ Categorization,** lists effects that may occur including examples of signs and symptoms and substances, which have been found to cause such effects.

III. CONTROL METHODS FOR CHEMICAL HAZARDS

A. **Designated Area**

To minimize contamination, **Designated Areas** are assigned for the usage of either a particularly hazardous substance or purpose. For example, if carcinogens are being used in the lab, a Designated Area should be assigned, and a warning label should be posted.

B. Engineering Controls

This is the most effective and desirable method for minimizing risk of exposure either to toxic chemicals or to mechanical equipment. Examples of engineering controls: guards, remote controls, or interlock systems.

For toxic fumes, mists, and vapors; good ventilation is the best approach to help reduce personal exposures. Generally, the two types of ventilation systems are dilution and local.

1. *Dilution Ventilation*

In most buildings, a certain percentage of the building air is recirculated periodically through the building ventilation systems.
In laboratories, all air is exhausted directly to the outside.

2. *Local Exhaust Ventilation*

Used for moderate to high-risk contaminants. Local exhaust systems, such as chemical fume hoods, capture the airborne contaminants much more effectively than dilution systems.

3. Fume Hoods

A fume hood does not provide absolute containment or protection from the materials in the hoods, however, a properly designed hood in a properly designed room can provide adequate protection. When using a fume hood, apply the acronym **MOPS**:

M = Monitor

Ensure that the hood is working before each use by inspecting the airflow monitors/alarms, gauges or inclined manometers on the front of the hood. These items indicate if the fume hood is operating correctly. Report "dry" inclined manometers to Facilities Management. **Do not ignore alarm systems. If a fume hood alarms, shut down your operation inside the hood, close the sash, and contact Facilities at extension 4.5444.**

O = Operational

Inspect the sash, lights, articulating baffles, and any other fume hood features and ensure that they are operational.

P = Placement

Place all equipment and experiments at least 6 inches back from the face of the fume hood. Remove unnecessary chemicals and equipment.

S = Sash

Position the sash no higher than the approved working height designated by an inspection decal. Maintain an 18" sash or smaller opening to provide upper body protection from splashing or explosions. Completely close the sash when not in use.

Use a perchloric acid hood when evaporating or distilling perchloric acid.

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Visit **Appendix P** for a complete coverage of Laboratory Fume Hoods.

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C. Personal Protective Equipment (PPE) Assessment & Selection

PPE includes clothing or equipment that is used to isolate a worker from direct exposure to workplace hazards. Examples of PPE include the following:

- Protective clothing
- Gloves
- Eye Protection
- Respirators

PPE is used with engineering and administrative controls for worker protection. PPE may provide adequate protection if it is properly worn and appropriately used. The lab must assess the hazards, select appropriate PPE where to control harmful exposure, and workers needed must wear the selected PPE. For questions, consult EH&S (824-6200) to ensure proper PPE selection.

1. *Guidelines for PPE Usage*

a. **PPE** does not provide protection against all hazards. Choose appropriate PPE depending on the hazard and task you are performing.

b. **PPE does not eliminate the hazard**
Know the limitations of PPE. Follow SAFETY PRECAUTIONS while working.

c. **Use and maintain PPE properly to ensure its performance**
Having safety goggles does no good if it's resting on your head.

d. **Be aware that there may be hazards with using PPE**
Talk to your supervisor or EH&S before using PPE.

e. **PPE does not protect workers the same way!**
PPE should be properly sized and fitted to ensure its adequacy

f. **Wear more than the minimum PPE!**

g. **Leave your lab coat or uniform at work**
If you take your lab coat home, wash it separately to avoid contaminating other clothes.

h. **Take off your jewelry (i.e. rings and watches).**
This reduces chemical seepage.

(See **APPENDIX I - Personal Protective Equipment** for more information)

2. *Protective Clothing*

- Lab clothing (i.e. coats and aprons) should be worn in the laboratories in order to keep contaminants from getting onto street clothes.

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- Open-toed shoes, sandals or shoes made of woven material must not be worn in the laboratory. Leather shoes provide additional protection from acid splashes and chemical burns.
- Shorts, cut-offs and miniskirts are inappropriate; skin below the waist shall be covered.
- Long hair and loose clothing should be constrained.
- Jewelry (i.e. rings, bracelets, and watches) should not be worn in order to prevent chemical seepage under the jewelry, contact with electrical sources, catching on equipment and damage to jewelry itself.

3. *Gloves*

Appropriate gloves should always be used when working in the lab**.** **APPENDIX J - Gloves - Chemical Resistance & Selection** outlines the compatibility of glove materials with particular chemicals. Disposable gloves should be discarded after each use and immediately after overt contact with chemical.

4. *Eye Protection*

Chemical splash goggles are most appropriate when working with liquid chemicals that pose eye hazards. Always use eye protection when working in the laboratory.

5. *Respiratory Protection*

At times, masks or respirators may be required for some procedures where operations may cause a potential for inhalation exposure. However, respirator users must meet the requirements of the UCI Respiratory Protection Program. Contact 824-6200 for specifics.

D. **Chemical Hygiene Plan (CHP)**

The CHP is designed to protect you from the health hazards associated with hazardous chemicals in your lab. The CHP outlines standard operating procedures for all work involving hazardous chemicals in your lab. The CHP must be available to employees in the lab at all times. It is available at **Chemical Hygiene Plan**.

E. **Standard Operating Procedures (SOP)**

Standard Operating Procedures address the safe handling, use, storage and disposal of hazardous chemicals.

- All labs using carcinogens, reproductive toxins, acutely poisonous/toxic agents, explosives, pyrophoric materials and select agents are required to have an SOP.
- An SOP must be prepared prior to beginning any new hazardous operation

- SOPs are lab specific and serve as a training tool for new workers.

EH&S maintains an SOP Library at **http://www.ehs.uci.edu/programs/sop_library/.**
(See **APPENDIX D - Standard Operating Procedure (SOP)** for additional information)

F. Work Practice Controls

A well-designed and well-understood set of work practices is the best safety insurance.

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1. *Chemical Transportation*

Assure that an unbreakable secondary container is being used, and that transport carts are designed for this purpose.

- Use carts with sufficient containment to capture the amount of liquid being transported.
- Make sure incompatibles are transported separately.
- If multiple glass bottles are transported in a secondary container, make sure they are secured to minimize rattling and avoid breakage.
- Do not transport top-heavy items on lab carts.
- Balance the load.
- Avoid small-wheeled lab carts to transport chemicals between buildings.

2. *Eating, Drinking and Smoking*

No eating, drinking, chewing of gum or tobacco, application of cosmetics, storage of utensils, food, or food containers is allowed in the laboratories, except in designated Clean Areas. This area is designed to be free of chemical, biological and radioactive hazards and MUST be posted as such.

Each lab should decide where the Clean Area will be. All lab people must buy-in to this concept, or cross contamination too easily can occur. See Clean Area Procedure at **http://www.ehs.uci.edu/programs/labres/Clean_Area_Procedures.doc** for more information.

Smoking is prohibited at many locations on campus including within 25 feet of laboratory buildings entry points. See campus smoking policy for more information.

3. *Pipetting*

Mechanical pipetting aids must always be used for all pipetting procedures. Mouth pipetting is prohibited.

4. *Personal Hygiene*

All personnel should wash their hands immediately after the completion of any procedure in which chemicals have been used and when they leave the laboratory. If a hazardous

chemical exposure occurs, immediately wash affected areas or use the emergency safety shower.

5. *Housekeeping*

Keeping the working area clean and orderly reduces the frequency and severity of accidents.

- Keep aisles, exits, stairs and hallways free of obstructions.
- Avoid slip hazards by keeping the floor clean of ice, stoppers, glass beads or rods, other small items and spilled liquids.
- Keep drawers and cabinet doors closed.
- Never store chemicals on the floor.

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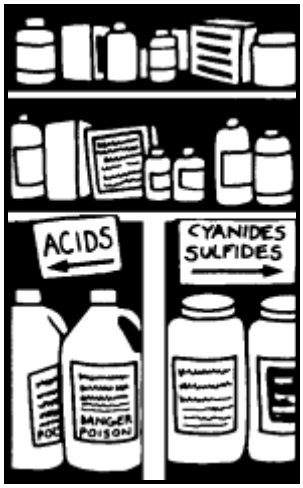
- Workspaces and storage areas should be kept clear of broken glassware, leftover chemicals and scraps of paper.
- Place all non-contaminated broken glass, pipet tips and other pointed plastic items, in rigid containers clearly marked "Broken Glass".
- Maintain a 3-foot diameter area in front of the safety shower, emergency eyewash units, fire extinguishers, fire pull boxes and electrical panels.

G. Chemical Storage

1. *Chemical Storage*



- If you work at **School of Physical Sciences**, maintain an accurate chemical inventory in **ChemInnovation** at: **http://cheminnovation.ps.uci.edu/Cbis/Login.aspx?ReturnUrl=%2fCbis%2fUci%2fCbisHome.aspx**.
-
- **All other schools** maintain an accurate chemical inventory and update the information on **CiBR-Trac** at:

  http://ucirvine.ecompliance.net/index.jsp.

- Keep incompatible chemicals separate. (See **APPENDIX G - Chemical Incompatibility Chart**) and container compatibility: **www.coleparmer.com/techinfo/ChemComp.asp.**

- Check the shelf life of your chemical inventory periodically, such as peroxide forming chemicals (see **APPENDIX E - Classes of Hazardous Materials** for additional information.)

- Inspect condition of chemical containers (e.g., crystal formation, label falling off, corroded or bulging walls) periodically.

- Store chemicals properly in the cabinets or on the shelves provided below four feet off the ground.

- Do not overcrowd or overload shelves and minimize storage of chemicals in fume hoods.
-
- Keep chemical storage facilities locked to prevent entry of unauthorized personnel.
- Keep aisles clutter-free and unobstructed.

(See **APPENDIX M – Chemical Compatibility & Storage of Hazardous Materials** for more information)

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2. *Labeling*

Container labels must indicate the chemical's identity and its health and physical hazards. Obtain blank labels at:
http://www.ehs.uci.edu/programs/enviro/HazardousMaterialInteractiveLabel.xls

(See **APPENDIX L – Labeling of Hazardous Materials**)

3. *Flammable Storage*

- Minimize the amount of flammable solvents stored in the laboratory. Consult with your EH&S School Coordinator on the allowable amounts of chemicals that may be used in your area.
- Use no more than five gallons on a workbench outside of an approved storage cabinet such as flammables storage cabinet, non-combustible exhausted cabinet, or gas cabinet.
- Storage cabinets should be posted "FLAMMABLES".
- Do not store oxidizers or inorganic acids in flammable storage cabinets.

4. *Lab Refrigerators*

- Only Flammable Materials Storage Refrigerators and Freezers are approved for the storage of flammable or reactive reagents.
- General-Purpose Lab Refrigerators or Freezers, Chromatography or Pharmacy Refrigerators and Ultra Low freezers are approved for the storage of non - flammable reagents and non-flammable biological specimens. These units **MUST** be labeled "Caution - Unsafe For Storage Of Flammable Solvents".
  - Prior approval from EH&S is required.
  - Flammable liquids will not be used or stored within 8 feet of the unit since the compressor is not vapor-proof and poses a potential safety hazard
- Domestic refrigerators or freezers are approved for food storage within the "**Clean Area**" in the lab environment. A "**Clean Area**" sign must be affixed to the front door of the refrigerator .

For further information, please review the Refrigerator and Freezer Purchasing Procedure for UCI Laboratories at: **http://www.ehs.uci.edu/programs/sanitation/refrigfreezerpurchase.html.**

5. *Special Considerations*

· When potential for violent reaction exists such as distilling peroxide formers, use firmly stabilized safety shields on all sides to protect from explosions. For

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examples of chemicals prone to rapid or violent polymerization and explosion, see Appendix E Section XII.

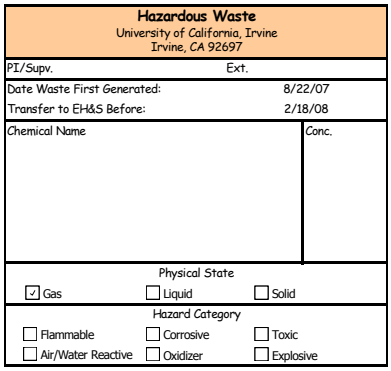
· Radioactive materials must be stored in areas designated with the radioactive trefoil hazard label.

· See **Appendix E of the Lab Safety Manual** for additional information on chemical handling and always review the SDS.

H. Chemical Waste

1. *Hazardous Waste Storage and Labeling*

- All waste must be **segregated** into categories and stored to prevent incompatible mixtures within or among individual containers.
- Waste must be kept in leak-free **containers** with adequate secondary containment in case of breakage or spillage.
- Waste storage area out of plain sight, must be inspected at least weekly.
- All waste containers must be **labeled** as required by UC Irvine - Hazardous Waste Management Program (See **APPENDIX L – Labeling of Hazardous Materials**).
- Verify the information on the Hazardous waste label each time waste is added to a container.



2. *Disposal of Hazardous Waste*

Hazardous waste, whether chemical, radioactive or biohazardous, should be labeled and disposed of in accordance with UCI - Hazardous Waste Management Program. Call EH&S for further information and assistance at extension 4-6200.

Chemical Safety: Ten Basic Rules

1. Know the hazards of chemicals in use.
2. Label all chemicals containers properly with identity and hazards.
3. Use PPE while handling hazardous chemicals.
4. Work with volatile and hazardous chemicals in a fume hood.
5. Store flammables in flammable storage cabinets.
6. Do not work alone with hazardous chemicals.
7. Maintain clear access to exits, showers and eyewashes.
8. Keep work areas free off clutter and chemicals off the floor.
9. Wash skin promptly if chemical comes in contact with skin.
10. Do not eat, drink or apply cosmetics in lab, except in the

I. Laboratory Moves and Equipment Clearances

EH&S has developed the "Laboratory Relocation Guidelines" **http://www.ehs.uci.edu/labmove.pdf**

to minimize hazards to University personnel and maintain compliance with all applicable Federal and State regulations during a lab relocation.

These procedures apply to a Principal Investigator (PI) or other laboratory owner when:

- Leaving the University and closing a laboratory.
- Retiring and closing his/her laboratory.
- Relocating the laboratory to a different location on campus.
- Leaving the University but transferring responsibility of the laboratory to another researcher.
- Laboratory equipment needs repair.
- Laboratory equipment is being relocated to salvage or another room.

In all of these situations, the PI must follow the procedures outlined in the document to either arrange for the safe disposal of hazardous materials in his/her laboratory or transfer the responsibility for those materials to another responsible party. Equipment clearances may be initiated by completing the online form: https://www.ehs.uci.edu/apps/pimoves/index.jsp

Contact your **School EH&S Coordinator** for additional questions.

Sources:

Handbook of Laboratory Safety (5th Edition), CRC Press, 2000.

Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, 1981.

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, National Academy Press, 1995.

Safety in Academic Chemistry Laboratories, 7th Edition, American Chemical Society, Washington DC, 2003.

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Section 3

Physical Hazards - Recognition, Evaluation and Controls

I. RECOGNITION OF PHYSICAL HAZARDS

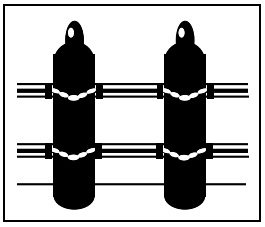
Laboratory safety means more than protecting yourself from chemical hazards. Physical hazards are the most common hazard in any work place.

Physical hazards include but are not limited to:

- Compressed gases
- Ergonomics
- Electricity
- Glassware
- Machinery and Equipment
- Noise
- Research animals
- Temperature extremes
- Vacuum operations

II. EVALUATION OF PHYSICAL HAZARDS

A. **Compressed Gases**:
(See **APPENDIX E - Classes of Hazardous Materials** for additional information on asphyxiant, flammable, and toxic gases. Consider adding "Compressed Gas Cylinder Handling" to your Safety Training Self-Assessment and take the "Compressed Gas Safety" training.)



The following safety precautions should be taken for all compressed gas cylinder usage.

1. Identify Cylinder & Chemical Contents

- Read shoulder label and tags to identify chemical.
- Review the Material Safety Data Sheet and other Gas Data Sheets.
- Do not use unknown gases.
- Determine maximum possible pressure from tank markings.
- Know your gas supplier's phone number and technical service representative.

2. Engineering Practices

- Secure cylinder firmly using two sets of chains positioned one-third from each end of the cylinder.
- Leave valve protection cap in place until cylinder is in use.
- Use compatible regulator and support equipment (check with the gas supplier if you have any questions about the compatibility of your equipment).
- Only use materials that are compatible with the gas.
- Do not use oil or grease on any gas handling fittings or equipment.

- Determine if there are special temperature, pressure, moisture, or air sensitivity requirements and engineer the system to control these requirements.
- Place explosive barriers around all glass or plastic components in your gas handling set up.
- Use correct Compressed Gas Association (CGA) fittings.
- Minimize adaptor use.
- Provide electrical grounding for all flammable gas systems. Test the ground before using the gas cylinder.
- Position gas cylinder systems so that routes of escape from work areas are clear and unobstructed.
- Use fixed point and portable monitors with toxic gases. Contact the Chemical Hygiene Officer at X45730 for assistance in selecting toxic gas monitors.

3. *Proper Gas Handling Practices*

- Flush corrosive gas systems with inert gas after each use.
- Coat or treat surfaces to reduce chemical reactivity (passivate) those systems carrying reactive or corrosive gases.
- Develop written Standard Operating Procedures for compressed gas systems.
- Establish written emergency response procedures.

4. *Storage*

- Only store the quantity of gases you will need for one week.
- Store all gases in a cool, secure location.
- Provide appropriate leak detection systems.
- Control cylinder inventory. Return empty and unneeded cylinders in a timely manner.
- Follow standard chemical management practices when handling all compressed gases.

5. *Cryogenic Liquids*

- Avoid skin contact. Cloth-like knitted mitts can trap spilled liquid. Use only oversized, well insulated gloves designed for the handling of super cold materials.
- Use in a well-ventilated area. Some liquids and solids will condense and displace oxygen from the air creating an oxygen deficient environment. Liquefied gases expand to hundreds of times their liquid volumes and can asphyxiate people in low lying or confined areas.
- Use eye protection.
- Do not use standard "thermos" bottles. Use high quality Dewars wrapped with cloth-backed tape (i.e. duct tape) to contain flying pieces if an implosion occurs.

6. Toxic Gases

- Always work with toxic gases in a well-ventilated area, such as inside a chemical fume hood or **gas cabinet**.
- If a leak is detected, evacuate the area immediately, and contact the emergency 911 system. Do not attempt to move a leaking cylinder of toxic gas.
- Leak test all toxic gas cylinders prior to acceptance from vendors.

7. *Corrosive gases*
   - Store corrosive gases for the shortest possible periods before use, preferably for fewer than 6 months.
   - The storage area should be as dry as possible.
   - Do not store near instruments, chemicals or devices sensitive to corrosive atmospheres.

8. *Acetylene*

   - Acetylene forms explosive compounds with copper, silver, and mercury. Avoid contact with these metals or their salts.
   - Never exceed the pressure limit indicated by the warning red line of an acetylene pressure gauge.
   - Ensure the outlet line of the cylinder is protected with a flash arrestor.
   - Do not use a cylinder that has been stored in a non-upright position until it has remained in an upright position for at least 30 minutes.

B. Vacuum Operations

An operation involving an evacuated system where there is higher pressure on the outside of the system than on the inside is called a vacuum operation. Vacuum operations must be assessed for an implosion hazard, which may result in flying glass, spattered chemicals and/or fire.

- Always wear eye and/or face protection (i.e. face shields, safety goggles).
- Check all glass vessels and equipment for visible defects and ensure that they are designed for vacuum operations.
- Use heavy walled glassware.
- Use High Efficiency Particulate Air (HEPA) filters or high efficiency scrubber systems to protect the vacuum line and pump. Use these filters with both local vacuum pumps and on house vacuum systems.

1. *Vacuum Desiccators*

   - Should be enclosed in a shield or wrapped with friction tape (i.e. vinyl electrical tape).
   - Whenever possible, use plastic desiccators (i.e. polycarbonate).

2. *Vacuum Pumps*

   - Use a cold trap to protect the pump oil from getting contaminated with volatile substances.
   - The output of each pump should be vented to an exhaust hood.

C. Cryogenic Vials

Cryovials can explode due to internal pressure buildup. Pressure build up is caused when liquid nitrogen, which expands significantly when vials warm, enters the vial during cryostorage. Researchers can minimize liquid nitrogen intrusion by following two important steps.

1. Avoid over tightening the cap. When over tightened, the seal crinkles, which allows liquid and cold nitrogen vapors to enter the vial.

2. Second, adjust the storage levels inside the Dewar to keep the vials in the vapor phase above the liquid phase.

The following is an excerpt from the Corning manufacturer regarding the safe use of cryogenic vials:

> To avoid injury, DO NOT immerse plastic or glass cryogenic vials in liquefied nitrogen gas. Vials immersed in liquefied gases can develop leaks. When they are eventually returned to room temperature, pressure can rapidly buildup and shatter the vials and cap seals. Harmful or biohazardous materials contained in the vials may be released. Always store vials above liquid nitrogen to reduce these potential hazards.

When cryovials explode, staff can be injured from projectiles and suffer exposure to whatever was in the vial. Open cryovials in a biosafety cabinet to protect yourself from exposure to biohazards. Wearing eye protection protects against projectiles.

D. Electrical Safety

Shock injuries are caused by the flow of electric current (amperage), not the voltage. 60/100 of an ampere is just enough to light an ordinary Christmas tree light and may kill a person if it passes through the chest.

- Grounding should be provided for all electrical equipment, machinery, portable tools, extension cords and other electrical systems. Grounding provides a safe path for electricity to the ground, preventing leakage of current in circuits or equipment.
- Maintain a three-foot clearance around electrical switches.
- All electrical equipment must be UL approved and possess an UL-approved sticker.
- Inspect all equipment periodically for defects or damage.
- Maintain all equipment in proper operating condition and ensure that all necessary repairs are completed.
- Ensure that all electrical equipment is de-energized before inspecting or making repairs. (Call EH&S at extension x46200 for assistance with **Lockout/Tagout** procedures).
- Do not overload circuits and wiring.
- All cords that are worn, frayed, abraded, corroded or otherwise damaged must be replaced.
- Do not yank cords to disconnect them.
- Keep all cords away from heat, oil and sharp edges.
- Ensure live parts of electrical equipment operating at 50 volts or more is guarded against accidental contact.
- Ensure that ground-fault circuit interrupters (GFCI) are used in high-risk areas such as wet locations. GFCI's are designed to shut off electrical power within 1/40 of a second.

How to Prevent Electrical Injuries
Practice the following safety measures to protect yourself from becoming part of the electrical circuit, and becoming vulnerable to shocks or burns:

1. Use extension cords only as temporary power sources.
2. Check all wall outlets to be sure they're tight fitting and not loose in the wall.
3. Check electrical cords and plugs to ensure that they are not damaged.
4. Use only three (3) prong plugs when possible. Do not use plug if ground prong is missing.
5. Wear appropriate clothing when working with machinery. Do not wear loose fitting clothing or jewelry.
6. Use safety caps on plugs whenever children are in the area.
7. Keep combustibles (i.e. clothes) away from lamp bulbs and heating devices.
8. Turn off any appliances that spark, stall or overheat.
9. Disconnect an appliance or equipment if it gives even the slightest "tingle" of leaking current. Place a "DO NOT USE" sign on it and notify your supervisor immediately.
10. Report all damaged equipment to your supervisor and immediately label the equipment as damaged.

Do not touch anyone experiencing a severe electrical shock. Switch off power if possible. If this is not possible, use non-conducting material (i.e. dry wood, rope, etc.) to free the person and to avoid becoming part of the electrical circuit.

E. Ergonomics

Ergonomics is the interaction of people with their workstations and work areas. Evaluations of work areas assist people to interact more comfortably and efficiently with their work environment and to prevent repetitive motion injuries (RMIs) and cumulative trauma disorders (CTDs).

1. Safe Use of Video Display Terminals (VDTs/Computers)

a. Adapt your work environment to fit you:

- Adjust light to reduce glare.
- Tilt screen angle between 10° and 20° back from vertical.
- Position height of the monitor so that the top is just below eye level.
- Use a wrist rest to keep wrists straight.
- Keep feet flat on floor or use a footrest so knees are level with hips.
- Use an adjustable chair. An ideal chair has the following qualities:
    - Adjustable height
    - Adjustable backrest
    - Firm lower back support
    - A deep seat

- A seat curved downward at knees

b. Maintain a proper posture:

- Make sure your back is straight.
- Keep your head up; eyes are level with the top of the screen.
- Let your upper arms hang relaxed at your sides.
- Keep your elbows close to your sides.
- Keep your upper and lower arms at approximately right angles.

c. Provide a variety of work tasks to prevent prolonged postures. For approximately every two (2) hours of work at the computer, integrate a different physical task away from the computer for 15 minutes.

d. Take the time to stretch and change postures while working at the computer.

Possible causes, work conditions, or risk factors that may be associated with repetitive motion injuries include:

- Repetition of the same task over a period of time
- Exerting extreme force and placing excess strain on a particular part of the body
- Holding the body in an awkward posture and unnatural position
- Working with vibrating tools
- Working in a cold environment

Symptoms indicating that you are not using your computer equipment properly or not including enough variation in your workday include:

- Sore hands and wrists
- Sore back, neck, and shoulders
- Tired and sore eyes or eyestrain
- Tingling
- Pale, cold skin
- Numbness
- Circulation problems

The effects and symptoms of RMIs are varied and mainly related to the body's extremities.

There are several ways to help reduce the pain, but it is recommended that you contact your supervisor if you experience any symptoms of discomfort.

Prevent the injury before it occurs:

- Use ergonomic equipment
- Reduce repetition by integrating different work tasks into your work day.
- Stretch and change positions throughout the day.
- Decrease the work pace and don't rush.
- Exercise and strengthen your muscles.

The following guidelines apply to safely **lifting loads**:

1. Size up the load before you lift. If it's heavy, use a mechanical aid or ask for assistance.
2. Bend the knees. (Note: This is the single, most important aspect of lifting.)
3. Place your feet close to the object and center yourself over the load.
4. Get a good grip on the load, lift smoothly and straight up, and let your legs do the work, not your back!
5. Do not twist or turn your body once you have made the lift.
6. Before you attempt to lift the load, ensure that there is a clear path to carry the load, and a place to set it down.
7. Set the load down in the same manner in which you lifted the load.
8. If it's a long or extra large load, obtain assistance.
9. Split the load into several smaller ones when you can.

Preventing accidents and injuries is everyone's responsibility!

F. Machinery Equipment

When using equipment that contains rotating parts or apparatus that can trap clothing, hair, or body parts, follow these guidelines below:

- Do not use a piece of equipment until you are instructed in its proper use.
- Do not remove guards or safety interlocks devices.
- Use the appropriate personal protective devices: glasses, gloves, goggles or face shield.

Examples of equipment that you may encounter in the lab include vacuum pumps, centrifuges, mechanical stirrers and rotary evaporators, hazardous grinding, drilling, and cutting equipment.

G. Centrifuges

Centrifuges present the possibility of two serious hazards:

- Creation of aerosols
- Mechanical failure (i.e., broken drive shaft, faulty bearing, **disintegrated rotor**).

See a manufacturer's presentation on Centrifuge Safety at:
http://www.piramoon.com/show2.htm.

1. *General Safety Procedures*

   - Before using a centrifuge, inspect tubes for cracks, inspect the inside of the trunnion cup for rough walls caused by erosion of adhering matter, and carefully remove bits of glass from the rubber cushion.
   - Screw caps or a cap that fits over the rim outside the centrifuge tube is safer than plug-in closures. Fluid collects between the plug-in closure and tube rim.
   - Aluminum foil should not be used to cap centrifuge tubes containing infectious materials because they often become detached or rupture during the centrifuging process.
   - When centrifuging is done in a ventilated glove box, the glove panel should be in place with the glove ports covered. A centrifuge in operation creates reverse air currents that may cause the escape of an agent from an open cabinet.
   - For flammable/highly hazardous materials, the centrifuge should be used under negative pressure and exhausted to a suitable system.

2. *Centrifuge and Biohazardous Material*

   - When used with biohazardous materials, centrifuge tubes, rotors, and accessories should be filled and opened in a biological safety cabinet (BSC).
   - If centrifuging of biohazardous material is to be performed outside a containment cabinet, a sealed safety bucket/tube should be used.
   - After safety bucket/tube is filled and sealed, it should be considered contaminated and wiped with cloth soaked in disinfectant. Because some disinfectants are corrosive to centrifuge rotors/buckets, rinse with water after the appropriate contact time has elapsed.
   - Minimize the amount of aerosol created by using a swirling, rotary motion rather than shaking the tube to re-suspend sediment after centrifuging.
   - Avoid decanting centrifuge tubes. If you must do so, wipe outer rim with a disinfectant; otherwise, the infectious fluid will spin off as an aerosol.
   - Avoid filling the tube to the point that the rim outside becomes wet with culture.

3. *Low Speed/Small Portable Centrifuges*
   (Centrifuges that do not have aerosol-tight chambers)

   - Outside of bucket should be decontaminated before bucket is removed for centrifuging.
   - Bucket should be returned or opened in a BSC.
   - Small centrifuge could be placed in BSC.

4. *High Speed Centrifuges*
(Chamber is connected to a vacuum pump)

- Filter should be placed between chamber and pump.
- Prone to metal fatigue; Keep a record of use that should consist of one record for each rotor and an instrument log.
- To prevent corrosion or other damage, conduct frequent inspections, proper cleaning, and timely drying of rotors.
- Rubber "O" rings and tube closures must be examined for deterioration and coated with a lubricant recommended by manufacturer.

5. *Continuous Flow Centrifuges* (allow continuous harvesting of product while centrifuge operates at full speed) *and Zonal Centrifuges* (separates product according to its density or buoyancy under centrifugal force.)

- Enclose in especially designed ventilated safety cabinet
- Conditions that can lead to production of aerosols during zonal centrifuging:
  - Leaky rotor seals due to nicks, damage to seals, improper assembly and over-pressurization
  - Drops of culture in chamber or on rotor
  - Snagging tubing or tubing connections
  - Disassembly or decontamination

H. Autoclaves

Autoclaves are pressure vessels, which can result in damage to the apparatus or injury to the personnel if used improperly. You must be trained on the job to operate an autoclave properly and safely. The physical hazards involve heat, steam and pressure. The biological hazards involve potential exposure to viable human pathogens. Review the operational and safety instructions found in the manufacturer's operating manual. Follow these important safety practices:

- Load the autoclave properly as per the manufacturer recommendations.
- Be sure to clean the drain strainer before loading the autoclave.
- Before loading containers of liquids into the autoclave, the caps must be loosened to avoid having the bottles shatter during pressurization.
- Use a tray with a solid bottom and walls to contain the bottles and catch any spills. Add a quarter to a half - inch of water so the bottles will heat more evenly.
- Don't load non-autoclavable plastic materials.
- Place individual glassware pieces inside a heat resistant plastic tray that sits on a shelf or rack. Never place glassware directly on the bottom or floor of the autoclave.
- Make sure the door of the autoclave is fully closed and the correct cycle has been selected before starting the cycle.
- Wear heat-resistant gloves when first opening the door after a run.
- After the completion of a run slightly crack open the door. Wait a full five minutes if the autoclave load contains only dry glassware, and no less than ten minutes when you are autoclaving liquids before removing the items.
- When removing items from the autoclave, always wear a rubber apron in addition to rubber sleeve protectors, heat resistant mitts and a face shield.
- Remove the load and let the glassware cool for 15 minutes before touching it with ungloved hands.
- With liquid loads, be alert for bottles continuing to bubble. Let liquid loads stand away from other activities place for a full hour before touching with ungloved hands. Scalding liquids can cause serious harm.

I. Research Animals

Research animals pose hazard in the form of bites and scratches. Generally, these result from inexperienced handling, but even seasoned animal handlers will suffer an occasional bite or scratch. A thorough cleansing of the wound with soap and water helps prevent infection. Good hygiene practices will help minimize the development of animal allergies. Below are highlights for working safely with research animals:

- Follow UC Irvine's **Animal Care and Use Program** procedures.
- Researchers inexperienced in animal handling need to obtain training. See: **http://www.research.uci.edu/ora/trainingeducation.htm**
- Follow posted vivaria entry and exiting procedures in support of controlling the intrusion and spread of animal contagions.
- Wear lab coat and gloves to avoid allergies, diseases, and to protect against bites.
- Maintain a high standard of personal hygiene, including hand-washing after handling animals.
- Develop written Standard Operating Procedures (SOPs) for animal protocols involving highly hazardous substances to standardize handling and waste management to protect people and the environment. Template available at: **http://www.ehs.uci.edu/programs/sop_library/Animal_SOP.doc.** Examples:
  - **acutely** or **extremely** hazardous materials
  - carcinogens
  - infectious microorganisms
  - **Select Agents**
- Dispose of animal research waste (bedding, carcasses) that meets the **definition of California hazardous waste** through **Environmental Health & Safety**.
- Complete and annually update the **Animal Research Health Surveillance Questionnaire**.
- Report housekeeping and cage maintenance concerns to University **Laboratory Animal Resources (ULAR)** staff.

J. Glassware Safety

- Inspect glassware for cracks and defects before using.
- For heating and pressurized operations, ensure that the appropriate glassware is used. Borosilicate glassware is recommended for all laboratory glassware except for special experiments that use UV or other light sources.

1. *Cutting glass*

- Place tubing on a hard surface and nick glass surface with a triangular file.
- Always wrap the glass tubing in a cloth before attempting to break it.
- If the tubing doesn't easily break, the nick is too shallow. Try creating a deeper nick on the glass surface.

2. *Broken glass*

- Clean all broken glass using a broom and pan. Avoid picking up broken glass with your hands.
- Dispose of broken glass properly and label the waste container as "Broken Glass".
- Contaminated glass must be placed in an appropriate durable chemical waste container.

K. Temperature Extremes

1. *Oil and Sand Baths*

- Avoid spilling water and other volatile substances.
- Silicone oil should be used for high temperatures.
- Oil baths left unattended should be fitted with thermal sensing devices that will turn off the electric power if the bath overheats.
- Care must be taken to keep salt baths dry because they are hygroscopic.
- Inspect glassware for minute cracks prior to placing in hot salt baths.

2. *Distillations and Extractions*

a. *Distillations*

- Do not distill or evaporate organic solvents to dryness unless they are known to be free of peroxides.

b. *Extractions*

- Do not attempt any extraction until the solution is cooler than the boiling point of the extractant.
- Do not vent the separatory funnel near a flame or other ignition source.

3. *Cryogenic liquids*

(See **APPENDIX E - Classes of Hazardous Materials** for additional information on hazards of cryogenic liquids.)

- Transport cryogenic liquids only in Dewars.
- Face shields, goggles, insulated gloves, and aprons should be worn while working around piping systems containing cryogens.
- Use tongs to lift objects in and out of cryogenic liquids.
- Do not use liquid helium Dewars for liquid nitrogen and vice versa
- Never allow physical contact with non-insulated pipes containing cryogenic fluids.
- Do not empty cryostats in pedestrian areas or confined spaces.

- Do not use cryogenic liquids in poorly ventilated areas such as environmental chambers or walk-in refrigerators. Vapors are colorless, odorless, and tasteless and can cause asphyxiation.
- Contact EH&S for assistance in purchasing oxygen sensors when necessary.

L. **Pressure Vessels**

All pressure vessels and systems should be checked by a professional familiar with American Standards Testing Materials (ASTM) standards. Pressure testing must be conducted a certified pressure installer. Contact EH&S for assistance.

III. CONTROL METHODS FOR PHYSICAL HAZARDS

Many control methods outlined for chemical hazards can also be applied for physical hazards. These methods include performing activities in designated areas, designing and implementing engineering controls (i.e. gas cabinets, fume hoods), developing work practice controls, wearing **PPE**, and developing **SOP's (Standard Operating Procedures) for highly hazardous operations.**

Sources:
Handbook of Compressed Gases, Compressed Gas Association, Inc. 2nd Ed., Van Nostrand Reinhold Company, 1981

Prudent Practices in the Laboratory: Handling and Disposal of Chemicals, National Academy Press, 1995.

Safety in Academic Chemistry Laboratories, 7th Edition, American Chemical Society, Washington DC, 2003.

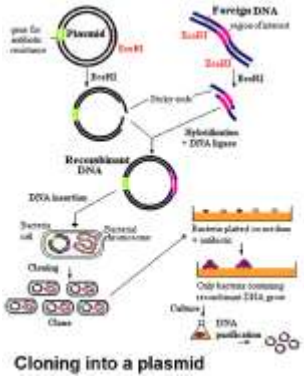
Section 4

Biological Hazards - Recognition, Evaluation and Control
(excerpts from UCI Biosafety Manual)

I. RECOGNITION OF BIOLOGICAL HAZARDS

A. Biohazard

- Biohazardous materials and organisms include all infectious organisms (bacteria, chlamydia, fungi, parasites, rickettsias, viruses, etc.), which can cause disease in humans, animals or plants, or cause significant environmental or agricultural impact.



Cloning into a plasmid

- Other biohazards include work with human or primate tissues, biologic toxins or select agents, fluids, cells or cell culture; recombinant DNA; transgenic plants or animals; human gene therapy transfer; releases of recombinant DNA to the environment; and work with animals known to be reservoirs of zoonotic diseases.

- Select Agents The United States Department of Health and Human Services (HHS), Centers for Disease Control and Prevention (CDC), the United States Department of Agriculture (USDA), and the Animal and Plant Health Inspection Service (APHIS) have identified bacteria, viruses, toxins, rickettsia, and fungi that pose a potential threat to public health or welfare. These organisms, called Select Agents and High Consequence Livestock Pathogens and Toxins, are strictly regulated.

- The campus **Institutional Biosafety Committee (IBC)** is responsible for oversight through the **IBC Protocol Application** of all research involving infectious organisms which can cause disease in humans or cause significant environmental or agricultural impact. This includes work with human or primate tissues, fluids, or cell culture; recombinant DNA; transgenic plants or animals; human gene therapy; releases of recombinant DNA to the environment; and work with animals known to be vectors of zoonotic diseases.

II. EVALUATION OF BIOLOGICAL HAZARDS

A. Biosafety Level (BSL)

The laboratory conditions under which the biohazardous agent can be safely handled

1. *Biosafety Levels*

- There are four biosafety levels. Biosafety levels are based on normal immune system status. If personnel are immune compromised low risk agents may make them ill. These levels have been summarized on the following table, which consist of combinations of laboratory practices and techniques, safety equipment, engineering controls, and facility requirements.

SAFETY LEVEL*	AGENTS	PRACTICES	SAFETY EQUIPMENT (Primary Barriers)	FACILITIES (Secondary Barriers)
1	Not known to consistently cause disease in healthy adults.	Standard microbiological practices.	None required PPE: Laboratory coats and gloves; eye, face protection, as needed.	Open bench top and sink required
2	-Associated with human disease; hazard = percutaneous injury, ingestion, mucous membrane exposure	BSL-1 practices plus: - Limited access - Biohazard warning signs - "Sharps" precautions - Biosafety manual defining any needed waste decontamination or medical surveillance policies -Waste is managed as **Medical Waste**	Primary Barriers = Class I or II BSCs or other physical containment devices used for all manipulations of agents that cause splashes or aerosols of infectious materials; Minimum PPE: lab coats, gloves, eye and face protection, as needed.	BSL-1 plus: Autoclave available.
3	Indigenous or exotic agents with potential for aerosol transmission; disease may have serious or lethal consequences.	BSL-2 practices plus: - Controlled access - Decontamination of all waste prior to leaving facility - Baseline serum maybe required -Waste is managed as **Medical Waste**	Primary Barriers = Class I or II BSCs or other physical containment devices used for all open manipulations of agents; PPE: protective lab clothing, gloves, eye, face and respiratory protection as needed	BSL-2 plus: - Physical separation from access corridors - Self-closing double door access - Exhaust air not recirculated - Negative airflow into laboratory

SAFETY LEVEL*	AGENTS	PRACTICES	SAFETY EQUIPMENT (Primary Barriers)	FACILITIES (Secondary Barriers)
4	Dangerous/exotic agents that pose high risk of life-threatening disease, aerosol-transmitted lab infections; or related agents with unknown risk of transmission.	BSL-3 practices plus: - Clothing change before entering -Shower on exit - All material decontaminated on exit from facility - Medical surveillance - Waste is managed as **Medical Waste**	Primary Barriers = All procedures conducted in Class III BS's or Class I or II BSCs in combination with full-body, air-supplied, positive pressure personnel suit	BSL-3 plus: - Separate building or isolated zone - Dedicated supply/exhaust vacuum and decon systems

*Biosafety in Microbiological and Biomedical Laboratories, CDC/NIH, 5h Edition, December 2009.
(See **APPENDIX N - Recommended Biosafety Levels**, for details on practices and procedures for each biosafety level.)

2. *Selection*

- The selection of an appropriate biosafety level is dependent upon a number of factors, most importantly the virulence, pathogenicity, biological stability and communicability of the agent, nature or function of the laboratory, quantity and concentration of the agent, communicability of the agent, and availability of effective vaccines or therapeutic measures.

  - The principal investigator is primarily responsible for assessing risks and for implementing the recommended biosafety levels with the assistance of the Biosafety Officer.

  - The biosafety level should be commensurate with that required for the agent of highest virulence known or likely to be encountered in the course of contemplated work. For example, all diagnostic sera of human origin (i.e., blood, body fluids, etc.) should be considered potentially infected with hepatitis B virus, hepatitis C virus, and the human immunodeficiency virus (HIV).

  - If, in the course of diagnostic or other laboratory examinations there is evidence that the materials being studied contains an agent of higher than expected risk, the biosafety level should be raised accordingly and the Biosafety Officer should be notified at (949) 824-6200.

B. **Waste**

1. ***Biohazardous Waste***

Biohazardous waste means any of the following:

- Human or animal specimen cultures from medical and pathological laboratories, cultures and stocks of infectious agents from research laboratories, waste from the

production of bacteria, viruses or the use of spores, discarded live and attenuated vaccines, culture dishes and contaminated devices used to transfer, inoculate, and mix cultures.

- Human surgery specimens or tissues removed at surgery or autopsy, which are suspected by the attending physician or dentist of being contaminated with infectious agents' known to be contagious to humans.

- Animal parts, tissues, fluids, or carcasses suspected of being contaminated with infectious agents.

- Waste which contains recognizable blood, blood products, containers, or equipment containing blood or blood from animals, having been infected with diseases that are highly communicable to humans.

- Waste containing discarded materials contaminated with excretion, exudates, or secretions from humans who are required to be isolated to protect others from communicable diseases or isolated animals having been infected with diseases.

- Waste which is hazardous only because it is comprised of human surgery specimens or tissues which have been fixed in formaldehyde or other fixatives, or only because the waste is contaminated through contact with, or having previously contained chemotherapeutic agents, including, but not limited to, gloves, disposable gowns, towels, and intravenous solution bags and attached tubing which are empty. (Chemotherapeutic agent means an agent that kills or prevents the reproduction of malignant cells.)

- Waste that is hazardous only because it is comprised of pharmaceuticals.

2. ***Medical Waste***

Medical waste is biohazardous or sharps waste which is generated or produced as a result of:

- Diagnosis, treatment, or immunization of human beings or animals
- Research, producing or testing biologicals. (Biologicals mean medicinal preparations made from living organisms and their products, including, but not limited to, serums, vaccines, antigens, and antitoxins.)

3. ***Sharps Waste***

Any device having acute rigid corners or edges, or projections capable of cutting or piercing, including hypodermic needles, syringes, blades, needles, broken glass items, pipettes and vials which are contaminated with other medical waste.

III. CONTROL OF BIOLOGICAL HAZARDS

A. Working with Biohazards

Follow the recommended biosafety level practices and procedures for the agent(s) used in the lab. (See

APPENDIX N - Recommended Biosafety Levels) Some key practices to be followed when working with biohazards:

TOC1 TOC2 Index1 Index2

- A hazard warning sign incorporating the biohazard symbol must be posted on access doors and on equipment where biohazards are used or stored.
- Use personal protective equipment such as gloves, lab coat, etc., when handling biohazards.
- Use a biosafety cabinet when handling biohazardous materials, particularly when procedures may generate aerosols or splashing and for all research at Biosafety Level 2 or greater.
- Decontaminate all work surfaces after completion of work and when gross contamination is present.
- Properly dispose of all waste generated from working with biohazardous materials. Contact EH&S at (949) 824-6200 for additional information.

B. Biosafety Cabinets

Biosafety cabinets are designed to protect you from splashes and aerosols that are contaminated with biohazards. (See **APPENDIX O – Biosafety Cabinets**)

1. *Airflow*

- Place necessary materials in the biosafety cabinet before beginning work to minimize the number of arm movement disruptions across the fragile air barrier of the cabinet.
- Ensure that the front grille of the cabinet is not blocked with any materials (i.e., absorbent paper, notebook, etc.) or equipment to allow cabinet to function properly.
- Place all materials as far back as practical, toward the rear edge of the work surface and away from the front grille of the cabinet to take advantage of the air split in the center of the cabinet.
- Delay manipulation of materials for approximately five minutes after placing hands/arms inside the cabinet to allow stabilization of air in the cabinet.

2. *Control Methods for Contamination*

- Disinfect the work surface, interior walls, and interior surface of window of the cabinet to reduce contamination of materials to be used in the cabinet. (See **APPENDIX O, Table 1 - Table of Disinfectants**)
- Disinfect surfaces of materials and containers placed into the cabinet to minimize contamination of cultures.
- Do not bring potentially contaminated materials out of the cabinet until they have been surface decontaminated or placed in a closeable container for proper decontamination.
-

- Decontaminate surfaces of all containers and equipment removed from the cabinet when work is completed.

- Wipe down the cabinet's work surface, sides, back, and interior of the glass at the end of the procedure.

- Decontaminate biosafety cabinets before HEPA filters are changed or internal work is done and before cabinet is relocated. The most common method for this type of decontamination is the use of formaldehyde gas. An EH&S approved vendor must conduct this decontamination procedure. Contact EH&S at (949) 824-6200 or TSS at 1 (800) 877-7742.

3. *Work practices*

- Turn cabinet on for five minutes to allow it to purge or remove any particulates in the cabinet.

- Wear personal protective equipment such as lab coat, gloves, goggles, etc., to protect the worker from contact with biohazardous materials used in the cabinet.

- Chairs/stools used while using the biosafety cabinet must be vinyl or be easily cleanable if contaminated.

- Adjust stool/seat height so that worker's face is above the front opening of the cabinet.

- Place plastic-backed absorbent paper on the work surface (note: ensure that grilles are not blocked by the absorbent paper), if desired. This facilitates routine cleanup and reduces splatter and aerosol formation during a spill. Absorbent toweling must be properly decontaminated prior to disposal.

- Arrange materials within the cabinet to allow active work to flow from the clean to contaminated area across the work surface. (Limit the movement of "dirty" items over "clean" items.) This reduces the potential for cross-contamination in the cabinet.

- Place bulky items such as biohazard bags, discard pipette trays, and suction collection flasks to one side of the interior of the cabinet to minimize risk of cross-contamination.

- Do not tape biohazard collection bag to the outside of the cabinet. Do not use upright pipette collection containers in the cabinet or place them on the floor outside the cabinet. Frequent inward and outward movement needed to place objects in these containers is disruptive to the integrity of the cabinet air barrier and can compromise personnel and product protection.

- Follow good microbiological techniques when working in a cabinet. For example, techniques to reduce splatter and aerosol generation will minimize the potential for personnel exposure to infectious materials manipulated within the cabinet.

- **Do not use open flames in a cabinet**. An open flame in a biosafety cabinet creates turbulence that disrupts the pattern of air supplied to the work surface. Open flames are not required in the near microbe-free environment of a

biosafety cabinet. If absolutely necessary, touch-plate micro-burners equipped with a pilot light to provide a flame on demand may be used. (Internal cabinet air disturbance and heat buildup will be minimized.) Inspect gas tubing regularly for cracks and wear in order to prevent the risk of fire.

TOC1 TOC2 Index1 Index2

4. *Certification*

- Annual certification of all biosafety cabinets is required in order to determine that it is functioning properly in order to protect personnel. An EH&S approved vendor must conduct this decontamination procedure. Contact EH&S at (949) 824-6200 or TSS at 1 (800) 877-7742.

C. Handling Waste

1. ***Biohazardous Waste***

- All biohazard bags must conspicuously be labeled with the words "biohazardous waste" or with the international biohazard symbol and the word "biohazard."

- All bags must be tied to prevent leakage or expulsion of contents during future storage, handling, or transport. (**Bags should not be more than 2/3 full. Autoclave tape must be used to indicate that the bag has reached proper temperature for disinfection.**)

- Bags must be placed for storage, handling or transport in a rigid secondary container, which may be disposable, reusable, or recyclable. Containers must be leak resistant, have tight fitting covers and be kept clean and in good repair. The secondary containers may be any color and labeled with the words "biohazardous waste" or the international biohazard symbol and the word "biohazard" on the lid and on the sides so as to be visible from any lateral direction.

- Biohazard waste must not be stored for more than **seven days.**

- Biohazardous waste must be separated from other waste at the point of origin in the producing facility. The color of biohazard bag to be used is based on the biosafety level of the lab.

i. White/Opaque Bag

- EH&S has approved the use of **white/opaque autoclave bags for BSL 1 only labs** that generate non-sharp Risk Group 1 agent research waste. You may autoclave the white/opaque bags in any autoclave.

- This option allows BSL 1 only labs to accumulate non-sharp items in white/opaque autoclave bags. These shall be autoclaved, and then placed in the regular trash for custodial pick-up. **However**, EH&S provides biomedical waste collection services for BSL1 labs, as long as the BSL1 lab agrees to package waste in red biohazard bags, in the manner described below. Request Biomedical Waste collection service at: **http://www.ehs.uci.edu/programs/enviro/.**

- Spill containment is still important both before and after autoclaving, do not set any waste bags directly on floors or counters at any point.

White/opaque autoclave bags are available from the Campus Storehouse. Biohazardous bags must be placed in secondary containment.

ii. Red Bag

- **BSL 2 and BSL 3 labs shall accumulate non-sharp biological research waste in red biohazard bags, and all sharps from all labs regardless of agent's Risk Group must to be accumulated in sharps containers with the International Biohazard Symbol**. These items must be placed in the medical waste barrels for destruction off-site or steam sterilized by a "certified" autoclave. EH&S utilizes the CDC/NIH categorization system to determine an agent's Risk Group.

TOC1 TOC2 Index1 Index2

- Red bags can be disposed of as non-regulated waste (regular trash) IF it has been sterilized in a **"certified"** medical waste autoclave approved by Orange County Health Agency and has a visible indication of decontamination (i.e. autoclave tape). Certified autoclaves are not common at UC Irvine.

- Most commonly, EH&S provides medical waste collection services directly to laboratories. Request Biomedical Waste collection service at: **http://www.ehs.uci.edu/programs/enviro/.**

2. ***Chemotherapy Waste***

Waste, which is contaminated through contact with, or having previously contained chemotherapeutic agents, shall be segregated for storage and disposed. This type of waste must be placed in a secondary container, which shall be labeled on the lid and the sides with the words "Chemotherapy Waste", "CHEMO", or other labels approved EH&S. The label must be visible from any lateral direction, to ensure treatment of the biohazardous waste. Request Chemotherapy Waste collection service at: **http://www.ehs.uci.edu/programs/enviro/,** by selecting Biomedical Waste Collection. Chemotherapy waste is picked up by EH&S for final treatment at an off-site facility. Contact EH&S at (949) 824-6200 for additional information.

3. ***Human Surgery Specimens or Tissue Waste***

Biohazardous waste comprised of human surgery specimens or tissues that have been fixed with formaldehyde or other fixatives is called Pathology Waste. It shall be segregated for storage, and then disposed of by incineration at an off-site facility. EH&S collects Pathology Waste. Request Pathology Waste collection service at: **http://www.ehs.uci.edu/programs/enviro/**, by selecting Biomedical Waste Collection.

4. *Radioactive Biohazardous Waste*

All radioactive biohazardous waste must be chemically disinfected and then disposed of through EH&S as radioactive waste.

- Visit **www.ehs.uci.edu**
- Click on “Hazardous Waste Collection Request”

- Fill out the "Radioactive Waste Collection Form" or the "Chemical Waste Collection Form"

5. ***Pharmaceutical Waste***

a. *Non-Controlled substances*

TOC1 TOC2 Index1 Index2

Dispose of by placing the material in a cardboard box (no larger than 12inx12inx12in). The box must be securely taped-shut and labeled "Pharmaceutical Waste". Provide a list of pharmaceutical waste inside the box. Include drug/chemical name and container size. Manage as a biomedical waste, transferring to EH&S within 7 calendar days using the **on-line biomedical waste pick up request**.

b. ***Controlled substance***

Unused controlled substances must be returned to EH&S Controlled Substances Program by completing request form at: **http://www.ehs.uci.edu/apps/waste/controlsub/cscollect.jsp**. EH&S will collect materials directly from lab with a copy of the **Usage Log**.

6. *Liquid or Semi-Liquid Biohazardous Waste*

Liquid or semi-liquid biomedical wastes (blood, cultures, etc.) must be chemically disinfected for 30 minutes with a fresh mixture of 1 part household bleach to 10 parts liquid waste, then disposed of down the drain.

7. ***Sharps Containers***

Full sharps containers must be tightly sealed or taped to ensure that contents will not spill. **Do not overfill sharps containers!** Sharps containers should be closed and disposed when the contents reach ¾ full in order to minimize risk of puncture.

a. *Sharps Contaminated with Infectious Materials*

Contaminated needles, syringes, pipette tips, scalpels, blades, broken glass, etc. must be placed in rigid, puncture and leak resistant containers, which are labeled with the words "Sharps Waste" and with the international biohazard symbol or the word "Biohazard". The containers are picked-up by EH&S or a vendor for off-campus incineration. Request Biomedical Waste collection service at: **http://www.ehs.uci.edu/programs/enviro/** for disposing of sharps containers.

b. *Broken glass NOT Contaminated with Infectious Materials*

Broken glass can be placed in rigid, puncture and leak resistant containers and taped shut before disposal in the regular trash. Broken glass can be placed in a broken glass container or rigid box, taped shut, and disposed as regular trash.

c. *Sharps Contaminated with Radioactive Materials*

Sharps can be contained in rigid, puncture resistant non-biohazardous containers then disposed through EH&S as dry radioactive waste. Label containers "Radioactive Waste." The composition would be dry sharps.

TOC1 TOC2 Index1 Index2

d. *Sharps Contaminated with Hazardous Materials*

Sharps must be contained in rigid, puncture resistant non-biohazardous containers, then disposed of through EH&S. Label containers as "Hazardous Waste." The composition would be solid sharps.

To schedule a pick up of hazardous or radioactive waste

- Go to **www.ehs.uci.edu**.
- Click on the pertinent waste pick-up request link.
- EH&S will pick up your waste within 1-3 days.

8. *Transgenic Animal Carcasses*

Transgenic animals are whole animals in which the animal's genome has been altered by stable introduction of recombinant DNA, or DNA derived there from, into the germ-line.

When a transgenic animal is euthanized or dies, the entire carcass must be managed a Pathology Waste. Arrange collection from EH&S.

9. ***UCIMC Medical Waste Locations for Disposal***

Researchers must properly package and transfer medical waste to Environmental Services staff.

a. *Sharps Containers*

When at contents reach the fill-line, close off containers and place in main lab aisle way for Environmental Services staff to collect.
Environmental Services staff will usually replace full containers with new ones. If needed, request new sharps containers by calling Environmental Services at (714) 456-5494.

b. *Biohazard Bags*

When full, biohazard bags are tied, and transported to large gray or red barrels marked with "Biohazard" provided by Environmental Services. Please replace the lid after depositing biohazard bags. If you need a barrel placed on your floor, or in need of a replacement barrel, please contact Environmental Services at (714) 456-5494. Please double bag if disposing of disposable blunt-tip volumetric pipettes to reduce bag tears and spills.

c. *Liquids and semi-liquids*

Disinfect by adding 1 part household bleach to 9 parts waste. Mix thoroughly and allow disinfecting for 30 minutes. Protecting eyes from splash, carefully pour disinfected waste down sink followed by ample running water.

TOC1 TOC2 Index1 Index2

Source(s):

Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Edition, CDC, NIH, U.S. Dept. of Health and Human Resources, December 2009.

California Medical Waste Management Act, Division 20, Chapter 6.1, California Health and Safety Code

Primary Containment for Biohazards: Selection, Installation and Use of Biological Safety Cabinets, 2nd Edition, CDC, NIH, U.S. Dept. of Health and Human Services, Sept. 2000.

Section 5

Radiation Hazards - Recognition, Evaluation, and Control

I. IONIZING RADIATION

A. Recognition of Ionizing Radiation Hazards

Ionizing radiation is radiation that interacts with matter to form ions; high-energy electromagnetic radiation and high-energy particle radiation are capable of producing ions in their passage through matter. Types of ionizing radiation include alpha particles, beta particles, x-rays, neutrons, and gamma rays. Commonly used radioisotopes on campus include P-32, S-35, C-14, H-3, and I-125.

B. Evaluation of Ionizing Radiation Hazards

1. *Sources of Ionizing Radiation*

   a. *Radioisotopes* - These are most often used for tracing biological or medical processes.

   b. *Radiation-producing Machines* - X-ray machines are used for geological, metallurgical, chemical, medical, and material science analyses including x-ray crystallography, and for irradiation of biological samples. Accelerators are used in high-energy physics research and for C-14 analyses.

B. Control Methods for Ionizing Radiation Hazards

In order to keep exposures to ionizing radiation *as low as reasonably achievable (ALARA)*, there is a system at UCI to safely use radioisotopes and radiation-producing machines. Radiation users should refer to the UCI Radiation Safety Manual, the UCI Radiation Safety Factsheet, the Syllabus for New Users of Radioactive Materials, and the Syllabus for New Users of X-ray Machines for more information.

1. *Work/Storage Area Identification*

Each entrance to an area where an ionizing radiation source is being used or stored must be posted with an appropriate warning sign that includes the radioactive material/radiation trefoil symbol.

2. *Working with Ionizing Radiation Sources*

It is important to understand the type of radiation emitted (i.e., gamma rays, beta particles, alpha particles, x-rays) and the radiation energy as these determine the handling procedures, shielding, and monitoring equipment to be used.

a. Those working with ionizing radiation must be trained in radiation safety. *Radiation Safety Part I* is an online course and is required **prior** to beginning work with radioactive materials. *Radiation Safety Part II* is 90-minute classroom session required within 6 months of taking *Radiation Safety Part I*. The *Radiation-producing Machine Safety Orientation* is a 90-minute classroom session and it needs to be taken **prior** to beginning work with x-ray machines or accelerators.

b. Responsible PIs using radioactive materials must be issued Radiation Use Authorizations (RUAs). All users must be listed on the RUA. The RUA indicates the amounts and types of radioactive materials and/or radiation-producing machines being used, by whom, where, how, and with what safety precautions.

c. More hazardous or delicate procedures should be handled by experienced personnel (i.e., pipetting high-level radioisotope stock solutions or aligning x-ray machine beams).

d. Regular testing for radioactive contamination must be conducted.

e. Users may receive a whole body dosimeter badge or finger ring to monitor radiation dose, if deemed necessary by EH&S.

f. All appropriate lab personnel must be informed of the potential hazards and safety procedures involved in the use of radiation sources, including:

- The nature of the radiation hazard and the properties of other materials being used which could affect radiation exposure.
- Radiation detection instrumentation, and how to use it.
- Minimizing exposure (shielding, remote handling tools, dry runs, contamination control, protective clothing, written procedures).
- Appropriate radioactive waste disposal practices.
- General lab safety; housekeeping.
- Emergency guidelines.

g. If unsure of any of the above, refer to the UCI Radiation Safety Manual, your course protocol, your supervising professor, or EH&S.

II. NON-IONIZING RADIATION

A. Recognition of Non-ionizing Radiation Hazards

Non-ionizing radiation is electromagnetic radiation that is not of sufficient energy to ionize matter, although it is capable of causing injuries. Non-ionizing radiation can cause photochemical and thermal effects by exciting electrons in atoms to higher energy levels and by producing molecular excitation. Laser radiation, radio-frequency and microwave radiation, infrared (IR) radiation, and ultraviolet (UV) radiation are all examples of non-ionizing radiation.

B. Evaluation of Non-ionizing Radiation Hazards

1. *Sources of Non-ionizing Radiation*

a. *UV Radiation*

Chronic exposure to UV radiation may cause premature skin aging, excessive wrinkling of the skin, skin cancer, and cataracts (clouding in the lens of the eye).

i. UV-A (315 - 400 nm) - "Black Light". Effects include tanning (and some burning) of the skin, and fluorescing of ocular media (corneal and lens effects, such as cataracts).

ii. UV-B (280 - 315 nm) - "Erythemal UV". Effects include "sunburn" of the skin, inflammation of the cornea of eye, and cataracts.

iii. UV-C (100 - 280 nm) - "Germicidal UV". Principal effect is inflammation of the cornea of the eye.

b. *Infrared (IR) Radiation*

i. IR-A (700 nm - 1.4 μm) - "Near IR". High intensity may cause skin burns and retinal thermal injury.

ii. IR-B (1.4 - 3.0 μm) and IR-C (3.0 μm - 1 mm) - "Far IR". High intensity may cause skin burns and corneal inflammation/burns.

c. *Radio-frequency (RF) and Microwave (MW) Radiation*

i. RF (0.3 - 30 MHz) and MW (30 MHz - 300 GHz) - Effects may include formation of cataracts, neurological effects, male sterility and possibly cancer.

d. *Laser Radiation*
("Light Amplification by Stimulated Emission of Radiation")

i. Lasers can emit UV, visible, or IR radiation.

ii. Laser radiation has unique properties: monochromatic (one wavelength emitted), coherent (all waves in phase), highly directional (low beam spreading), high energy density (power/area).

iii. Additional laser hazards -

- Electrical - most lethal hazard! Only qualified individuals may perform laser power supply service or maintenance.
- Chemical - dyes in liquid laser media, toxic gases.
- X-radiation - from high voltage vacuum tubes.
- Fire - Class 4 laser beam (generally IR laser).
- Mechanical - ergonomic injuries.

C. Control Methods for Non-Ionizing Radiation

1. *UV Radiation*

Eye protection (goggles, safety glasses, face shields) and protective clothing (labcoat, nitrile gloves) should be worn when working with high-level unenclosed UV sources. UV sources should be enclosed or shielded to prevent exposures. When fully enclosed and interlocked UV sources are used, protective eyewear and clothing are not needed.

2. *IR Radiation*

Same as UV (eye and skin protection). Measures to avoid hyperthermia (over-heating of the body; burns) may be needed.

3. *Radiofrequency (RF) and Microwave (MW) Radiation*

Sources must be properly isolated and shielded.

4. *Laser Radiation*

Lasers are classified Class 1-4, depending upon their capacity to produce injury. Each class is governed by specific guidelines regarding engineering, administrative and personal protection control measures:

a. *Class 1 (exempt laser) - i.e., laser in CD or DVD player*

- Laser should be labeled (label inside protective enclosure).
- Laser must be enclosed and interlocked (for fully-enclosed Class 3b or 4 laser).

b. *Class 2 (low power laser) - i.e., supermarket bar code scanner*

- Laser must be properly labeled.
- Do not stare into the beam!

c. *Class 3a (medium power laser) - i.e., laser pointer*

- Laser must be properly labeled and a warning sign ("Caution") should be posted in some cases (for research lasers only).
- Do not stare into beam or view directly with optical instruments!
- Eye protection may be needed in rare circumstances.

d. *Class 3b (medium power laser) - i.e., some research lasers*

- Laser must be properly labeled and a warning sign ("Danger") must be posted.
- Laser operators must be adequately trained (including laser safety).
- Written operational safety procedure are required.
- Many engineering controls are required (keyed master switch, beam stops, laser interlocks, beam tubes, etc.).
- Laser controlled area must be established.
- Avoid exposure to direct and specularly scattered beam (scatter from mirror-like surfaces)!
- Eye protection is required.

e. *Class 4 (high power laser) - i.e., most medical & research lasers*

- All measures listed above for Class 3b lasers.
- Avoid eye or skin exposure to direct or scattered (specular and diffuse) radiation!
- Eye protection (and occasionally skin protection) is essential.
- Activation warning systems (alarms, lights) must be installed in most cases.

Contact the UCI Laser Safety Officer (LSO) for laser safety information - (949) 824-6200.

Ten Most Common Causes of Laser-Produced Eye Injuries

1. **Unanticipated eye exposure during beam alignment.**
2. **Fatigue, leading to carelessness or inappropriate shortcuts; horseplay.**
3. **Misaligned optics, upwardly- directed beams, beams crossing walkways, or beams at eye-level.**
4. **Available eye protection not worn, or the wrong eyewear worn.**
5. **Overconfidence; feeling of complacency or invincibility.**
6. **Inadequate beam containment or isolation; beam directed off of the plane of the optical table**
7. **Operator unfamiliar with laser equipment (not sufficiently trained).**
8. **Unneeded reflective items on optical table causing stray radiation.**
9. **Failure to follow standard operating procedures due to hurrying, etc.**
10. **Manufacturer-installed safety features bypassed.**

Section 6

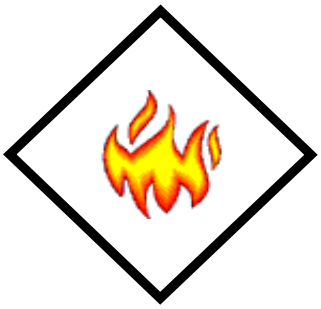
Emergencies

A good safety program, training, and use of precautions will reduce the number and seriousness of accidents. Laboratory accidents can range from fires to chemical spills to slips and falls.

Your laboratory should prepare plans for major and/or minor emergencies. These plans should match the nature of your laboratory and the specific hazards likely to be involved with any emergency. These plans and other safety policies should be described in your laboratory's Chemical Hygiene Plan (CHP). All lab personnel should become familiar with these procedures and follow them. Emergency plans are described in the Campus-Wide **UCI Emergency Blue Flipchart**. Ask your department administration for details.

I. FIRE SAFETY

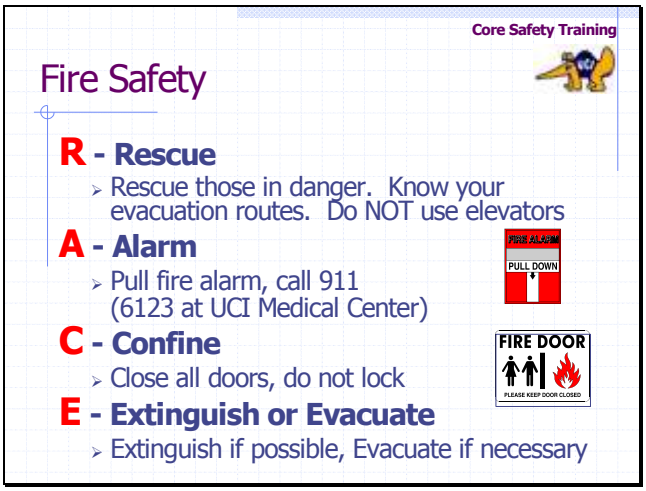
A. Preparation



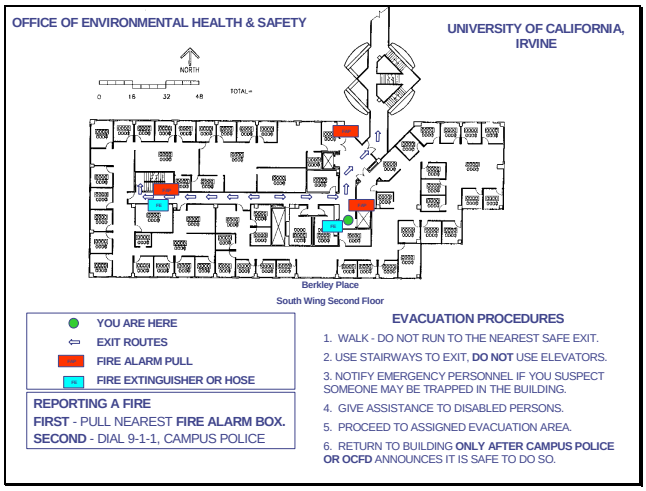
1. Know the location of fire extinguishers and fire alarms;
2. Know where and how to evacuate from any location in your department.
3. Know your departmental disaster plan; it should include an escape route with at least two exits.
4 Keep your work area clean.
5. Observe the University's "No Smoking" policy located in section 903-14 of the UCI Policies and Procedures manual.

B. In the Event of a Fire

1. Remember the acronym RACE.



2. Get out of the building/area quickly.



3. Never use an elevator, exit down a stairway.

4. **Know how to report a fire** – 9-1-1 (Campus); 6123 (UCI Medical Center); (949) 824-5223 or 9-1-1 (Cell Phone).

5. **9-1-1 on any "campus" phone** will automatically connect you with the UCIPD. If there is a fire, UCIPD has the ability to have simultaneous contact with the Irvine Fire Department. Both UCIPD and Orange County Fire Authority (OCFA) will then be dispatched.

   - GIVE THE FOLLOWING INFORMATION TO THE DISPATCHER:
     - Your name and phone number.

- The department you work for.
- And the location of the fire.

- STAY ON THE PHONE. FOLLOW THE DISPATCHER'S INSTRUCTIONS.

6. **Do not open hot doors; the heat of the door is a signal that the fire is nearby.**

7. **If you are trapped in a room; place a towel (wet if possible) at the bottom of the door, stay low to the ground below the smoke level. If possible, open some windows.**

8. If your clothes catch fire - DO NOT RUN

STOP	**Stop whatever you are doing.**
DROP	**Drop to the floor or ground.**
ROLL	**Roll to smother the flames.**

9. **If someone else's clothing is on fire, wrap them in a rug or blanket to smother the flames.**

10. **Once you are out of the building, NEVER GO BACK INSIDE for any reason until you are allowed to do so.**

C. **How to Use a Fire Extinguisher**

To help you remember the proper procedure for fire extinguishers, think of the word:

PASS

1) PULL the safety pin at the top of the extinguisher.

2) AIM the nozzle, horn, or hose at the base of the flames.

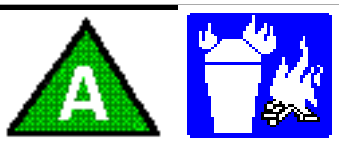
3) SQUEEZE or press the handle.

4) SWEEP from side to side at the base of the fire until it goes out.

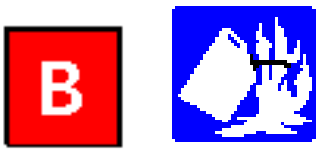
D. Fire Extinguishers

Know the ABC's of fires and the appropriate extinguishers used to fight them. Look for universal symbols on extinguishers. Universal symbols and/or pictograph systems are found on most fire extinguishers to indicate the particular class of fire that the extinguisher fights.

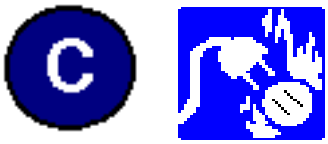
An "A" in a green triangle represents Type A extinguishers that fight ordinary combustibles such as burning trash, wood, rubber, cloth and plastics.



A "B" in a red square represents Type B extinguishers that fight flammable liquids, gases and greases such as oils, paints, and gasoline.



A"C" in a blue circle represents Type C extinguishers that fight energized electrical fires such as burning wires, switches, machinery, and home appliances.



A "D" in a yellow star represents Type D extinguishers that fight combustible metals fires. Do not attempt to extinguish metal fires with ordinary fire extinguishers. Certain laboratories are equipped with Class D extinguishers or sand to extinguish these fires. This type of fire should be handled by the fire department or individuals with special training.

II. HAZARDOUS MATERIAL SPILLS

A. Respond to HazMat Spills

There are several factors to consider when determining how to handle a hazmat spill cleanup, including:

- The size of the spill.
- The toxicity or other hazardous properties of the material.
- Clean-up materials available in the department.
- The level of knowledge and training of the person doing the clean up.
- The availability of assistance.

Clean-up procedures for one situation may be ineffective or even harmful in another. The most appropriate clean-up guidelines are those specific to the material involved in the spill. Therefore, employees and students can best prepare themselves by reviewing with their Principal Investigator or instructor, any spill procedures or SOPs to be followed for the chemicals they use in the lab before they actually use them. Material Safety Data Sheets (SDS) are available for materials in use in labs. SDS provide information on many topics including proper handling, protective equipment, and spill/leak procedures. If you are unfamiliar with the properties of the material spilled and are not equipped to handle spills, call 911 to request assistance.

1. *Small Spill (< one cup) Clean-Up Guidelines for trained personnel*

   a. *Inform Others in Area of the Spill.*

   - Inform other staff regarding the identity of the substances, the location of the spill, the amount and approximate rate of release of the chemical.

   b. *Provide Safety and Protection*

   - Evacuate personnel who do not have spill-containment responsibilities.
   - Make sure appropriate personal protective equipment is being used. Read the SDS or other spill cleanup information. At a minimum wear:
     - Proper respirator (ONLY if approved by EH&S)
     - Splash goggles
     - Lab coat or apron.
     - Gloves: appropriate type of chemical resistant gloves designed to protect you from exposure to the material involved.

   c. *Perform Containment and Clean-Up*

   - Use best available clean-up materials (you may have spill sheets or pillows, vermiculite, paper towels, or other absorbent materials). Wipe with soap and water using as minimal material as possible to avoid generating unnecessary waste. Disinfect if warranted.

- Double bag it and put it in a box; store temporarily in a fume hood if material is volatile.
- Keep record of:
  - Date, place, and time
  - Material and amount
  - Measures taken and materials used
  - Personnel involved

d. *Dispose of Waste Material*

- Label with UCI Hazardous Waste Label and dispose of as hazardous waste.
- Submit an EH&S Waste Pickup request available online at **http://www.ehs.uci.edu/programs/enviro/index.html**
- NEVER put contaminated material into the trash!

2. *Do Not Clean a Spill If:*

- You feel it is unsafe to do so.
- You don't know what the spilled material is, or lack the necessary protection or clean-up materials to do the job safely.
- The spill is large (would take more than 15 minutes to clean).
- The spilled material is highly hazardous.
- You feel any physical symptoms of exposure (eye irritation, difficulty breathing, coughing, dizziness, nausea, skin irritation). See Section III. Lab Injuries.

If unable to clean-up the spill, you should:

- Isolate the spill (if possible).
- Evacuate area and keep people away.
- Call EH&S (8 AM - 5 PM), **(949) 824-6200**
  After hours, weekends or holidays call UCI Police (24 hrs) at extension **911**
  If anyone is injured call **911**

3. *Special Situations*

Mercury, Radioactive, or Carcinogenic materials: For spills involving these materials, call EH&S (46200) immediately for information.

4. *"What Must Be Reported?"*

- All spills of extremely flammable/pyrophoric materials (flash point less than 20 F)
- All spills of extremely corrosive materials (e.g., HF acid)
- All spills of extremely toxic materials (e.g. carcinogens)

- All mercury spills
- All personal contamination
- All leaking containers
- All uncontrolled compressed gas releases
- All highly infectious micro-organisms

(See **APPENDIX K - Spill Clean-Up** for additional information)

III. LAB INJURIES

If a person is unconscious or an injury which is life threatening or requires immediate medical treatment occurs, call 911. **UC Irvine Injuries and Medical Treatment**, a poster displayed in the laboratory, provides locations where injuries can be treated which are not life threatening.

All injuries must be submitted on the on-line **Incident Report** within 24 hours by the employee, student, or lab supervisor.

The basic first aid measures below should be started immediately for all chemical exposures. Coworkers should assist the injured person whenever possible. Call 911 if assistance is needed by the UC Irvine police department.

The **Anteater Recreation Center** offers American Red Cross training. All staff including TAs are encouraged to be trained in first aid and CPR. First Aid kits may be purchased for use in the laboratory by each department.. If you have questions about what type of First Aid kit may be most appropriate for your laboratory, call Occupational Health at 949-824-8024.

IV. BASIC FIRST AID FOR HAZARDOUS MATERIALS EXPOSURE

A. Eye Contact

- FLUSH eyes at eyewash (or other source of fresh water) for a minimum of 15 MINUTES.
- Help victim HOLD EYELIDS OPEN (there is a strong reflex to shut them).
- In all cases, SEEK MEDICAL ATTENTION as soon as possible.

B. Skin Contact

- FLUSH skin with water for at least 15 minutes.
- For chemical exposure use EMERGENCY SHOWER.
- REMOVE CONTAMINATED CLOTHING while IN THE EMERGENCY SHOWER
- SEEK MEDICAL ATTENTION as soon as possible.

C. Inhalation

- Check that the scene is safe before entering

- Assist victim to FRESH AIR.
- Keep victim WARM.
- If BREATHING STOPS PROVIDE CPR, IF CERTIFIED. CALL 911 AS SOON AS POSSIBLE.
- If victim is UNCONSCIOUS, CALL 911 AS SOON AS POSSIBLE.
- SEEK MEDICAL ATTENTION as soon as possible.

V. EARTHQUAKE SAFETY

A. What you need to know to survive an earthquake

1. To reduce the impact of a disaster in the workplace:
   - Know your department's Disaster Plan
   - Enroll in first aid/CPR training class.
   - Examine and become familiar with your work area.
   - Work with your department to preplan evacuation routes
   - Know what your role is when an emergency occurs:
     - Know the supplies and resources you need and where to find them.
     - Know where and how to report an emergency (at Campus dial 911 at UCI Medical Center 6123)
2. **Assemble an emergency kit**. Kits should be kept at home, at work, and in your car. Recommended contents include the following:

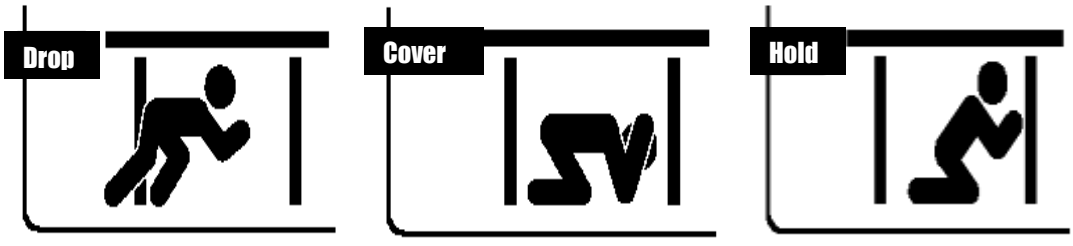
HOME	WORK/CAR
Legal papers First aid supplies & manual Proper tools e.g. wrench, pliers, etc. Fire extinguisher Two flashlights and extra batteries/bulbs Heavy duty leather gloves Battery operated AM/FM radio Extra batteries Toilet articles (toilet paper, soap, etc.) Clothing (include sturdy shoes) 3 day water supply, at least 1 gal/person/day 3 day food supply, preferably canned Manual can opener Cooking and eating utensils Medication Telephone lists Money (ATMs may not be operative) Plastic bags Whistle Special items for infants, elderly, disabled persons & pets	Flashlight Non perishable food Water First aid kit Walking shoes Money

B. Prior to an Earthquake

1. Secure any tall or movable objects that could fall on persons or block exiting.
2. Secure all items that could present a hazard during an earthquake such as chemicals, heavy equipment, furnishings, and gas cylinders.
3. Keep all large, heavy, and breakable objects waist level or lower.
4. Know your Assembly Area in case you need to evacuate. Visit: http://www.ehs.uci.edu/em/zonemap.html.
5. Have the phone number of someone out of the area that family members can call in case they are separated. This person would be the centralized contact for family members.
6. Become familiar with the earthquake procedures used at the school or day-care center your children are attending. Tell your children that if there is an earthquake, they may need to stay at school. Make arrangements to have someone else pick them up if after a quake you are unable to. The school will need this person's identity in advance.
7. Have an alternate meeting place for your family in case your house or neighborhood is unsafe.
8. Develop emergency preparedness skills: Join **C-SAR the Campus Search and Rescue** volunteer group.

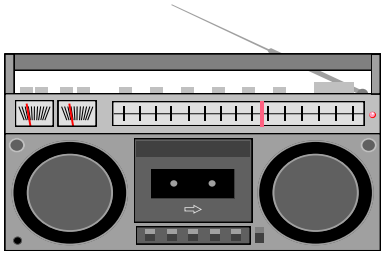
C. During an Earthquake

1. Stay calm.
2. Take cover; get under a desk, or a heavy table.
3. Get away from and stay away from all windows.
4. Do not use elevators under any circumstance
5. If you are outdoors, move to an open area, away from power lines and large structures.



D. **After an Earthquake**

1. Check everyone in the vicinity for injuries; if necessary administer first aid in accordance with your training.
2. Give assistance to any physically challenged individuals, if they request it.
3. Use the phone only in case of severe injury, fire, or imminent danger.
4. Use vehicles only in emergency.
5. Do not use elevators.
6. Check for gas and water leaks.
7. Do not use candles or other flames.
8. Do not flush toilet if you suspect broken sewer lines.
9. If you smell or hear gas, leave the area immediately. Do not light a match or turn power on/off.
10. Tune your portable radio/TV to the following channels for Emergency Broadcast Systems (EBS) information:



- KFI 640 AM
- KNX 1070 AM
- KWVE 107.9 FM

E. **Be Prepared for Aftershocks**

VI. CAMPUS EMERGENCY PREPAREDNESS

A. **Written Campus Program details how the campus responds to disasters and emergencies.**

1. Procedures for various emergencies.
2. Integrating with community wide emergency preparedness.
3. Manage needs of staff, students for supplies and security.
4. Evacuation plans and care & shelter locations.
5. Training and Drills.

B. There are pre-established zones throughout campus. Each zone has a Zone Captain, Building Coordinators, Floor Wardens, and evacuation assembly areas. Zone Crew members volunteer to help building occupants with orderly evacuations and shelter-in-place implementation.

C. **"UC Ready" Continuity Planning**

A process used by campus organizations to identify means and methods for restarting and continuing the most essential academic and business functions after a disaster, during a crisis, or any disruption to business-as-usual. Examples of disruptions and emergent crises include a widespread building fire, earthquake damaged facilities, and pandemic influenza.

UC Irvine Administrative Policies & Procedures Sec. 903-10: Environmental Health & Safety (EH&S) Policy

Appendix A

Responsible Administrator: Director - Environmental Health & Safety
Revised: January 2005

References / Resources

U.S. Occupational Safety & Health Administration

UC Policy on Management of Health, Safety and the Environment

UC Contract & Grant Manual, 3-200 University Policy on Environmental Health and Safety

UCI Environmental Health and Safety Programs

Contact: EH&S at (949) 824-6200

A. Policy

All University of California, Irvine employees have the right to a safe and healthful workplace. Environmental Health & Safety (EH&S) ensures that UCI complies with applicable health, safety and environmental laws, regulations and requirements; and, that activities are conducted in a manner that protects students, faculty, staff, visitors, the public, property, and the environment. UCI is committed to excellence in health, safety and environmental performance and strives to achieve:

- Zero injuries or illnesses
- Zero environmental incidents
- Zero property loss or damage

Achieving these goals is the responsibility of everyone at UCI and supervisors have particular responsibility for individuals reporting to them. The University implements best practices, and the Integrated Safety and Environmental Management System (ISEM) is used at UCI to manage health, safety, and environmental concerns, such as the sustainable use of natural resources, in all campus activities.

B. Responsibilities

The Chancellor is responsible for the allocation of appropriate resources and the implementation of UCI's EH&S policy at all facilities under campus authority. All faculty, staff and students are responsible for compliance with this policy as it relates to operations under their control, or activities in which they participate. Specific responsibilities follow:

1. **Vice Chancellors and Deans** provide a safe teaching and research environment by:

- Providing school/department oversight
- Allocating appropriate resources
- Fostering a climate that facilitates open discussion and resolution of potential risks and safety problems
- Promoting required EH&S training to employees.

2. **Department Directors and Chairs** provide a safe teaching and research environment for departmental activities by:
    - Providing department-wide oversight
    - Delegating authority and accountabiliity to one person for developing, implementing, and overseeing the department-wide Injury and Illness Prevention Program (IIPP).
    - Fostering a climate that facilitates open discussion and resolution of potential risks and safety problems.
    - Promoting required EH&S training to employees.
3. **Principal Investigators, Administrators and Supervisors** provide safe working, teaching, and research environments by:
    - Identifying a Safety Representative to handle IIPP responsibilities specific to the work unit: a) hazard assessment, b) training, and c) developing and implementing safe work practices
    - Reporting hazards, incidents, and injuries to EH&S.
    - Discussing accidents or "near misses" with all staff and students.
4. **All Employees and Students** will learn, practice, and keep up-to-date on UCI and departmental safety practices by:
    - Participating in safety training appropriate to the job or position
    - Reporting hazards, incidents, injuries, and safety concerns to a supervisor or manager
    - Implementing safe work practices
    - Reporting "near-misses" even though accidents did not occur.
5. **Environmental Health & Safety** provides campus-wide program direction, consultation, and liaison services by:
    - Defining and communicating a UCI Injury and Illness Prevention Program
    - Evaluating potential hazards and coordinating campus programs to prevent injuries and work-related illnesses
    - Working with academic departments and administrative services to develop training, monitoring, and accident prevention programs
    - Providing health and safety program direction to all campus entities

- Providing consultation and technical assistance in all areas of health, safety, and environmental protection
- Acting as liaison with regulatory agencies on behalf of the campus
- Providing emergency management and response assistance for hazardous materials
- Performing health, safety, and environmental protection audits as needed to determine compliance with regulations, laws, and University policy
- Seeking resolution, within the University structure, of health, safety, and environmental protection deficiencies.

C. EH&S School Coordinators

EH&S School Coordinators are representatives located in academic Schools who will answer health and safety questions, and explain state and federal regulatory requirements. They coordinate services with EH&S, identify and report unsafe conditions, and provide compliance assistance. Common activities include investigating accidents, inspecting and moving labs, orienting new faculty, and responding to odor concerns.

D. EH&S Programs

1. **Administration**

   EH&S Administration provides support for departmental activities that directly impact campuswide programs, such as Emergency Management, legislative analysis, regulatory agency liasison, and recharge administration.

2. **Training**

   Specific training requirements are mandated by State and federal regulations. EH&S helps faculty, staff and students understand safety issues, identify individual training requirements, and recognize specific hazards that may be associated with their work or environment. EH&S offers a wide variety of training program formats that include regularly scheduled courses, online training, and customized training designed to meet special needs.

3. **Safety Management**

   EH&S Safety Management is responsible for assessing and facilitating the University's compliance with applicable State and federal Occupational Safety & Health Administration safety regulations. Frequently requested services involve ergonomics, compressed gases, forklift operations, the Injury and Illness Prevention Program, motorized cart safety, and personal protective equipment.

4. **Occupational Health**

   The Occupational Health Program (OHP) is representative of UCI's commitment to providing a safe and healthy work environment for all employees. Federal and State laws require that certain services and medical monitoring be provided to employees who perform specific work. Eligibility to participate is discussed in the specific health service or medical monitoring program.

Alcohol and drug testing of transportation employees
Automated External Defibrillators (AED) Program
Controlled substances
Hepatitis B immunization and titers
Laboratory Animal Occupational Health Program (LAOHP)
Reproductive health
Smoking Policy
Tuberculosis screening for research environment

5. **Environmental Sanitation**

The California State Department of Health Services has designated EH&S as the Local Enforcement Agency (LEA) for all properties owned by The Regents of the University of California.

Disinfection Procedure for Water Distribution Lines
Drinking Water Program
Food Safety and Permit Program
Swimming Pool Water Quality Program
Refrigerator and Freezer Purchasing Procedure for UCI Laboratories

6. **Fire Safety**

EH&S is responsible for fire prevention activities on campus, and the Campus Fire Marshal (designated State Fire Marshal representative) works to ensure reasonable and consistent protection for the campus community from injury, business interruption, and property damage resulting from fires and related perils. Responsibilities include evacuation plans; oversight of fire alarms, extinguishers, and sprinklers; State Fire Marshall plan reviews and construction inspections; welding permits; and Research Assistant training.

7. **Industrial Hygiene**

The Industrial Hygiene Program focuses on anticipating, recognizing, evaluating, and controlling potential health and safety hazards. Oversight responsibilities of EH&S include hazardous chemicals and other environmental factors that can affect the health, comfort, or productivity of the campus community. Chemical exposure assessment includes asbestos, carcinogens, and lead. Responsibilities include oversight of the EH&S Emergency Response Team (ERT); hazardous materials transportation; auditory and respiratory protection; and vivarium safety.

Indoor Environmental Quality During Construction Projects
Laboratory & Research Information Resources
Material Data Safety Sheets (SDS)

8. **Biological Safety**

The Biological Safety Program provides oversight of research and clinical work involving infectious agents, bloodborne pathogens, select agents and other biohazardous materials.

Biological Use Authorization (BUA)

9. **Environmental Management**

EH&S is responsible for assessing and facilitating UCI's compliance with environmental laws and regulations, and for ensuring the safe handling and storage of hazardous materials and waste. Program responsibilities include air quality, oil spill prevention, storm and waste water management, PCB and CFC waste management, and monitoring storage tanks.

Hazardous Waste Management Program
Air Quality Management Program
Water Quality Management

10. **Radiation and Laser Safety**

    Radiation and Laser Safety staff provides assistance to radiation users on campus. They ensure safety procedures are followed and that radiation exposures are reduced to levels that are As Low As Reasonably Achievable (ALARA) for ionizing and non-ionizing radiation.

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Appendix C

Chemical Hygiene Plan (CHP)

Chemical Hygiene Plan has moved to:

http://www.ehs.uci.edu/programs/lsg/CHP2013.pdf

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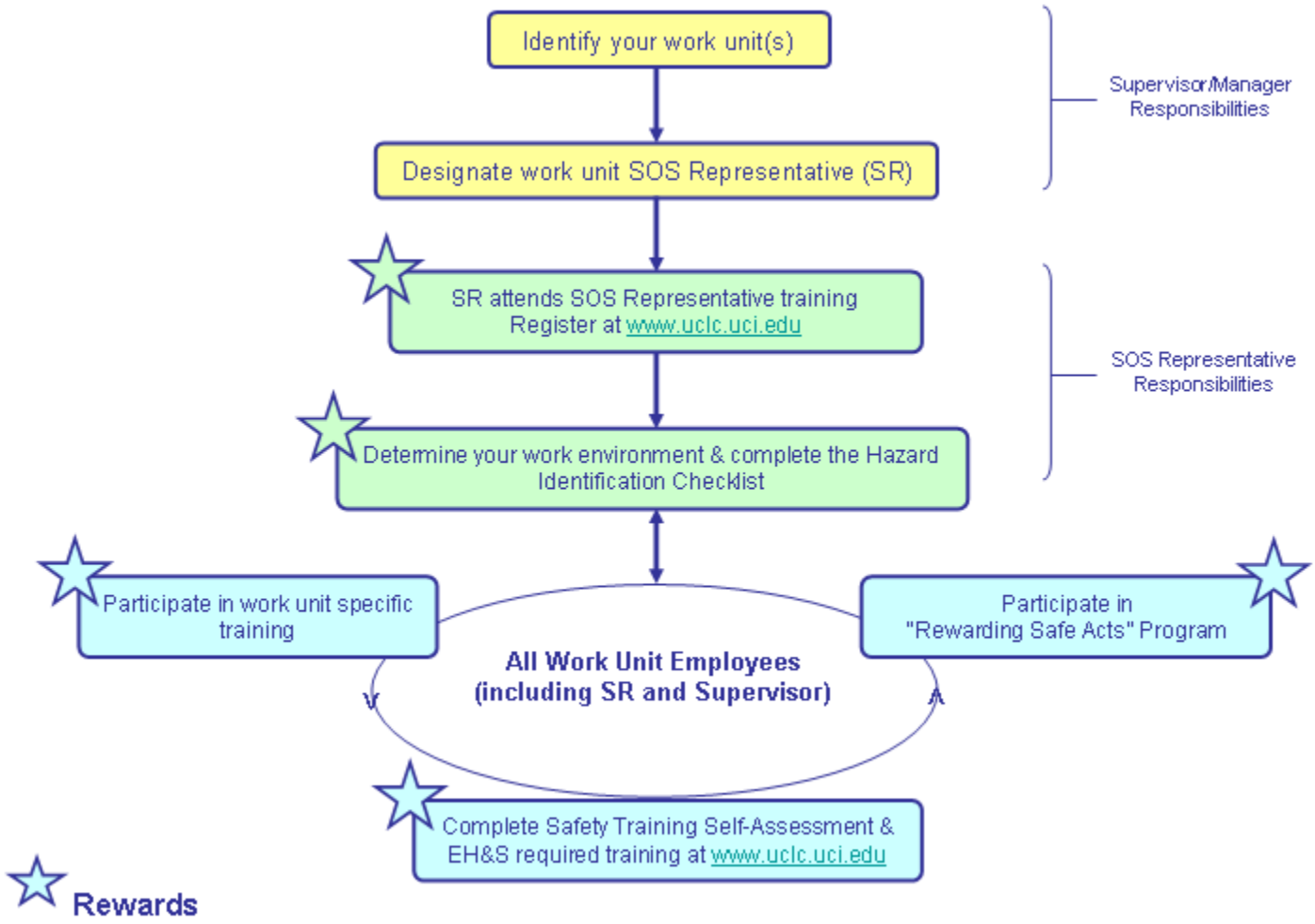
Safety On Site (SOS):
The employee portion of the UC Irvine Injury & Illness Prevention Program.

Appendix B

Safety on Site (SOS) Program Implementation Steps



How to update SOS Work Unit Progress

Guidelines/Resources

- Frequently Asked Questions (FAQ)
- SOS Representative Training Presentation
- SOS Rewards Program
- Rewarding Safe Acts Program
- Work Unit Specific Training

Forms & Tools

- SOS Work Unit Progress Update
- SOS Work Environments and Hazard Identification Checklists
- Work Unit Hazard Assessments & Corrections Tool
- Work Unit Specific Training Roster Template

- Safety Training Resources
- Standard Operating Procedures (SOP's)
- Instruction for Identifying EH&S Required Training
- UC Learning Center at www.uclc.uci.edu
- IIPP Program Document
- Safety and Wellness Toolkit
- Basic Research Requirements Matrix
- Laboratory Risk Assessment Tool
- PI Specific Training Documentation Template
- SOS Listserv

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Appendix D

Standard Operating Procedure (SOP)

Safety considerations will be included in initial experimental design.
SOPs will be developed and documented for hazardous chemicals when the chemical is used routinely in the laboratory. Sections 4 and 5 provide information regarding SOPs. SOPs are lab specific and are required for ALL **carcinogens**, reproductive toxins, acutely poisonous/toxic agents, explosives, and pyrophoric materials. The material's original container label from the vendor will communicate if the substance has one of these properties. EH&S maintains and SOP Library at **http://www.ehs.uci.edu/programs/sop_library/**. These SOPs must be tailored to the specifics of each lab to be most effective. Visit the **Frequently Asked Questions (FAQs) about SOPs** page at the **EH&S Laboratory & Research** web area.

ALWAYS READ AND REVIEW THE SDS BEFORE USING ANY MATERIAL FOR THE FIRST TIME.

Elements to be addressed when designing experiments or procedures are:

- Material hazards
- Availability of alternative safer materials
- Engineering controls
- Personal protective equipment (PPE) required
- Spill or release potential and possible consequences
- Other special considerations such as extreme reactivity

SOP's are developed for:

- Process, such as distillation, peptide synthesis
- Each extremely hazardous chemical, such as cyanogen bromide (see UC SOP template http://www.ehs.uci.edu/programs/sop_library/index.html)
- Pyrophoric materials (see Pyrophoric Reagent (SOP) and Pyrophoric Safety (Video) at http://www.ehs.uci.edu/programs/sop_library/index.html)
- Class of hazardous chemicals, such chemotherapy or antineoplastic drugs
- Highly hazardous operations (template available at: **http://www.ehs.uci.edu/programs/sop_library/High Hazard Operations SOP.doc**)
- Animal protocols involving highly hazardous substances requiring specialized handling and waste management to protect people and the environment (template available at: **http://www.ehs.uci.edu/programs/sop_library/Animal_SOP.doc**

SOP elements may be addressed in the laboratory notebook as part of the experiment or process description, or using the format provided on the SOP form.

Suggested Strategy for Getting SOPs in Place and Improving Them Over-Time

1. Size up the situation (some labs use none, others many)

   a. At next lab meeting, ask staff to review labels of chemicals they use now, looking for PHS keywords. Have them make a list of the PHSs they use. Here is a suggested format for the list.

User Name	PHS Name	Type (C,R,HP, U)[1]	Article 110[2] or Select Agent[3](Y/N)	Max % Conc. handled	Typical working % Conc.	Location used	Waste Stored	Protocol Name

   1. Compile master list for lab.

   2. Check the EH&S SOP Library for published SOPs related to your needs.

   3. If no SOP is available, user can proceed to develop an SOP using the **Generic ISEM SOP template**. User can seek assistance from the EHS Coordinator.

   4. During periodic lab meetings and lab audits, ask around whether new PHS use has begun (prompt users with PHS keywords to look for). If so, begin with Step 3 by asking EHS Coordinator if SOP exists.

   5. Encourage users to pencil improvement suggestions on side-page of current SOPs.

   6. Email your SOPs to the EH&S Chemical Hygiene Officer to add it to the Campus SOP Library.

A sample SOP for formaldehyde use during animal perfusion can be found on the next page.

[1] **(C) Carcinogen**; (R) Reproductive Toxin; (HP) Highly Poisonous; (U) Unstable, Explosive, Pyrophoric, Water Reactive.
[2] **Article 110 carcinogens** are a subset of carcinogens with special Cal-OSHA requirements.
[3] **Select Agents** are biological agents restricted by United States Department of Human Health Services.

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READ AND REVIEW ANY APPLICABLE MANUFACTURER/ VENDOR SAFETY INFORMATION BEFORE DEVELOPING STANDARD OPERATING PROCEDURE AND PERFORMING WORK.

PI Name: _____

Name of Work Unit:_____

Generic Integrated Safety & Environmental Management (ISEM) Standard Operating Procedure (SOP) for_____

#1	Scope of Work/Activity: State the process/operation/equipment that the SOP concerns.
#2	Specific Safety and Environmental Hazards: State the specific hazard and consequences if procedure not followed to person, environment, or property. Carcinogen. Combustible Liquid, Corrosive, Sensitizer. All users must complete formaldehyde online training at: www.uclc.uci.edu All tasks having potential for exposure (dose preparation, injection) are to be performed by trained staff and must have read the Material Safety Data Sheet www.ucmsds.com
#3	Engineering Controls: Formaldehyde containing solutions and preserved samples should be dispensed and used only in a properly operating fume hood. Routine use outside of a fume hood is acceptable only when formaldehyde levels are monitored and are below 0.5 ppm. Know location of closest eyewash/shower.
#4	Designated Area: Indicate the designated area for performing this process in the laboratory. Conduct all work in Room ____.
#5	Personal Protective Equipment (PPE): State the personal protective equipment selected and required. Use nitrile gloves. If disposable gloves are used, discard after use. Consult with glove manufacturer to determine breakthrough times. Wear chemical goggles or safety glasses and lab coat. Adhere to strict hygiene controls. Contact EH&S for proper fit testing and selection prior to respirator use, if needed.
#6	Important Steps to Follow: List the specific sequence staff should follow to avoid hazard. Make sure all containers are labeled with the name of the material and with a warning label. Animals should be restrained or sedated prior to injecting animals. Syringes for injection must be safety engineered (self-sheathing syringes). Use disposable bench paper with impervious backing during preparation of toxic agents to limit surface contamination.

#7	Emergency Procedures: a. Describe immediate medical treatment required in case of personnel exposure. 1. If skin is exposed, wash immediately with soap and water. Flush eyes and mucous membranes with large amounts of water. Use emergency drench shower in case of extensive contamination. 2. Ingestion: Seek medical attention. 3. Inhalation: Remove victim to fresh air and obtain medical attention. 4. Remove all sources of ignition from the spill area. 5. Respiratory protection is required to clean up spills outside of the fume hood. Contact EH&S for respirator certification. **-Complete online incident report form at www.ehs.uci.edu**
#8	Control Procedures for animal care and housing requirements: a. Will animals excrete toxic levels of chemicals? - If so, identify waste streams under Section 9, including bedding. If ULAR staff will be handling animal care, establish any special hazard warning tags for the cages and handling procedures that may be required for bedding and cage handling, e.g., dust respirators, lab coats, etc.
#9	Identify waste stream and disposition of animal carcass, waste, and unused stock of chemicals (Identify if waste is biohazardous, pathological waste, or hazardous waste, etc.) Please note that any drugs identified as a human carcinogen or pose a hazard to human health or environment because of its **carcinogenicity** must be managed as hazardous waste. Additional guidelines regarding hazardous waste and pathological waste can be found at **http://www.ehs.uci.edu/programs/enviro/** • Surplus chemicals will be disposed of as hazardous chemical waste. • Disposable lab ware, bench paper, personal protective equipment, contaminated carcasses for the duration of the experiment as "pathology waste" for incineration. Containers available in the vivarium. • Sharps will be disposed of in "Sharps" container. • At Irvine locations, utilize the on-line system for requests by requesting a "Chemical Waste" Pickup via the Internet: a. Visit **http://www.ehs.uci.edu/programs/enviro/** • At UCIMC locations, contact Erica Gonzalez (egonzal3@uci.edu) for pathology waste incineration barrels
#10	Decontamination and spill clean-up procedures 1. Absorb small liquid spill with absorbent paper. 2. Use respiratory protection if cleaning up spill outside of the hood. Wash work surfaces with soap and water. 6. Use absorbent pads or vermiculite to clean up small fume hood spills or to dike spill area. Clean up spill area with additional pads or Kim Wipes. 7. Call **911** in the event of a spill beyond lab's capability. 8. After clean-up, room air must be monitored by EH&S prior to occupancy. 9. Dispose of waste through EH&S. Use appropriate PPE.

As the Principal Investigator, it is your responsibility to ensure that all individuals listed in this protocol is taught correct procedures for the safe handling of hazardous materials involved in this study. It is also your responsibility to assure that your personnel attend Lab Core Safety Training and other applicable safety training courses.

Both PI and all persons associated with the protocol must sign the following acknowledgement:
I have read, asked questions, and understand the hazards of and safe working procedures for the activity/materials described herein.

PI Signature: DATE
Other Personnel:

Name/ Signature DATE

Appendix E

Classes of Hazardous Materials


POISON

OXIDIZER



EXPLOSIVE

FLAMMABLES



CORROSIVE

CARCINOGEN


Proper segregation and storage of hazardous chemicals is challenging in a laboratory environment characterized by the presence of many different chemicals having multiple hazardous properties. Particular attention to proper segregation, storage and handling is warranted for materials labeled with extremely, highly or acutely, such as in "strong oxidizer", "extremely flammable" or "highly toxic."

CONTENTS

(For additional information regarding chemical hazards, consult the on-line NIOSH Pocket Guide to Chemical Hazards at: **www.cdc.gov/niosh/npg/pgintrod.html)**, and visit the EH&S Standard Operating Procedures (SOPs) & Resources page at http://www.ehs.uci.edu/programs/sop_library/index.html.

I. ACIDS

Characteristics	• Typically all acids are soluble in water and release heat • Specific properties of individual acids must be ascertained prior to commencing clean-up procedures	
Storage Precautions	• Store large bottles of acids on low shelf or in acid cabinets • Segregate oxidizing acids from organic acids, flammable and combustible materials • Segregate acids from bases and active metals such as sodium, potassium, magnesium, etc. • Segregate acids from chemicals which could generate toxic or flammable gases upon contact such as sodium metal, cyanide, and iron sulfide • Use bottle carriers for transporting acid bottles • Have spill control pillows or acid neutralizers available in case of acid spills • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• Inorganic acids are not usually flammable, organic acids are flammable
	Explosion	• Container may explode due to heat or fire
	Health	• Vapors irritating • Corrosive to skin, eyes, and lungs • Contact can result in severe burns • Some are toxic beyond irritation or corrosiveness
Detection of Release	• Turns Litmus paper red • Eye, nose, throat, skin irritation • Air monitoring	
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Stop leak if without risk to personnel • Do not touch spilled liquid • If on fire extinguish using suitable extinguishing agent • Neutralize with (bi)-carbonates when feasible	
Personal Protection	• Avoid breathing vapors • Avoid bodily contact • Keep upwind • Wear neoprene gloves, boots, and goggles • Full protective clothing may be necessary if significant contact with material	
First Aid	• Move victim to fresh air • Remove contaminated clothing • In case of contact, flush skin or eyes with water • Keep victim quiet and warm • Keep victim under observation for delayed effects • Seek medical attention for hydrogen fluoride burns	

Common Acids:

Acetic Acid†	Hydrofluoric Acid	Phosphoric Acid
Benzoic Acid†	Hydroiodic Acid	Phosphorous Acid
Chloroacetic Acid†	Iodic Acid‡	Propionic Acid†

Chromic Acid‡	Muriatic Acid	Sulfamic Acid†
Hydrobromic Acid‡	Nitric Acid‡	Sulfanilic Acid†
Hydrobromous Acid	Nitrous Acid	Sulfuric Acid‡
Hydrochloric Acid	Perchloric Acid‡	Sulfurous Acid
Hydrochlorous Acid	Phenol†	

†*Indicates organic acids.*
‡*Indicates strong oxidizing acids.*

II. HYDROFLUORIC ACID

Characteristics	• Extremely hazardous • Highly corrosive acid that attacks silicates such as glass. • Pure hydrofluoric acid ***dissolves*** glass, leaving a dull, acid-polished surface	
Storage Precautions	• Store in a cool, dry, well-ventilated place away from incompatible materials • Avoid contact with glass, concrete, metals, water, acids, oxidizers, reducers, alkalis, combustibles, organics, and ceramics • Secondary containment trays, constructed of polyethylene are recommended • **Never store in glass containers**	
	Health	• Skin contact with hydrofluoric acid may cause severe burns. • **Burns may not manifest immediately at concentrations of less than 50%.** • Fluoride ions penetrate the skin easily and can cause considerable damage • Eye contact can result in destruction or opacification of the cornea • Blindness may result from severe or untreated exposure, immediate first aid is necessary • Concentrated solution and anhydrous hydrofluoric acid produce pungent fumes on contact with air. These fumes can cause nasal congestion and bronchitis, even in low concentrations. • Burns that occur when the vapors or liquid contact the oral mucosa or upper airway may cause severe swelling, to the point of airway obstruction • Mode of action is to bind calcium whenever contact occurs with skin or other body tissues • **Tissue destruction and neutralization may proceed for days** • Because calcium is necessary for cell life, its binding can bring about rapid cell death • If exposure is extensive, excessive amounts of calcium may be inactivated and adequate supplies of calcium may be unavailable for vital bodily functions
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
Personal Protection	• Be sure that you are using protective equipment that has been shown to effectively protect against hydrofluoric acid exposure • Always handle in a properly functioning fume hood and insure that the area is equipped with a safety shower and eyewash • Wear goggles, face shield, neoprene gloves, and acid resistant apron • Familiarize yourself with the SDS before handling.	

First Aid	• Move victim to a safe location, and seek medical attention • Use protective equipment when handling a contaminated victim • **Skin:** Immediately flush the exposed skin for 5 minutes with water and apply calcium gluconate gel. Use two pairs of nitrile gloves while applying gel. Reapply calcium gluconate gel every 10 minutes until emergency help arrives. • **Eyes:** Immediately flush eyes with water for 15 minutes**. Dial 911** • **Inhalation: Dial 911** • **All hydrofluoric acid burns are to be evaluated by a physician** * Obtain calcium gluconate gel from Physical Sciences Storehouse.

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III. BASES

Characteristics	• Typically soluble in water and release heat • Specific properties of individual bases must be ascertained prior to commencing clean-up procedures	
Storage Precautions	• Segregate bases from acids • Store solutions of inorganic hydroxides in polyethylene containers • Have spill control pillows or caustic neutralizers available for caustic spills • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• Typically soluble in water
	Explosion	• Container may explode due to heat or fire
	Health	• Damage to eyes, skin from corrosive action • Fine dust can cause damage to eyes, upper respiratory tract and lungs • Skin irritant
Detection of Release	• Turns Litmus paper blue, pH range above 8.6 • Slippery feeling in solution • Eye, nose, throat, skin irritation • Air monitoring	
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Stop leak if without risk to personnel • Do not touch spilled liquid • Neutralize with dilute acid, e.g. citric acid, by trained response personnel • Capture spilled material for later disposal	
Personal Protection	• Avoid breathing dust or mist (for most inorganic acids), or vapors (for ammonium hydroxide and organic acids) • Avoid bodily contact • Keep upwind • Wear appropriate chemical protective gloves, boots, and goggles • Full protective clothing may be necessary if significant contact with material is anticipated	
First Aid	• Move victim to fresh air • Remove and isolate contaminated clothing • In case of contact, flush skin or eyes with water	

Common Bases:

Ammonium Hydroxide	Carbonates, Salts of[2]	Potassium Hydroxide
Bicarbonates, Salts of[1]	Calcium Hydroxide	Sodium Hydroxide
		Amines

[1]*Potassium bicarbonate, sodium bicarbonate, etc.*
[2]*Calcium carbonate, sodium carbonate.*

IV. SOLVENTS

Characteristics		• May be flammable, toxic, or carcinogenic • Fire and explosion hazard • Most are easily absorbed through skin
Storage Precautions		• Store in approved safety cans or flammable storage cabinets (OSHA approved) • Use approved containers. Restrict size of a container to Fire Code limits for storage of flammable liquids • Segregate from oxidizers • Keep away from any source of ignition: flames, localized heat or sparks • Before heating, know and keep below the auto-ignition temperatures of the chemicals volatilized • Metal safety cans or drums containing flammable liquids should be grounded and bonded when transferring material to avoid static generated sparks • Keep fire fighting equipment readily available • Have spill cleanup materials handy • Do not exceed the recommended maximum container size for flammable and combustible liquids (Call EH&S for more information) • Store in cool, dry, well-ventilated location
Potential Hazards	Fire	• Maybe flammable • May be ignited by heat • Vapors may travel to ignition source
	Explosion	• Container may explode due to heat or fire • Vapor explosion hazard indoors, outside, and in confined spaces
	Health	• Some are toxic • Can replace oxygen and cause suffocation • Irritation of eyes, nose, throat, lungs • May cause headaches, dizziness, and sleepiness • Higher levels of exposure may cause unconsciousness, brain and central nervous system effects • Skin contact may cause dryness, irritation and dermatitis • Chronic effects: liver, kidney, central nervous system, and brain damage
Detection of Release		• **Odor thresholds vary widely from person to person, don't depend on odor for warning** • Some solvents produce "olfactory fatigue" - rapid loss of ability to smell the odor • Solvent vapors are invisible • Detected by industrial hygiene instruments
Immediate Action		**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury
		• Stop leak if without risk to personnel
Personal Protection		• Avoid breathing vapors • Wear appropriate protective clothing • Wear self-contained breathing apparatus

First Aid	• Move victim to fresh air • Remove contaminated clothing • In case of contact, flush skin or eyes with water • Keep victim quiet and warm • If not breathing give artificial respiration

Common Solvents:

Acetaldehyde	Ethylamine*	Methyl Ethyl Ketone
Acetone	Ethyl Benzene	Methyl Formate
Acetyl Chloride	Ethylene Dichloride	Methyl Isobutyl Ketone
Allyl Alcohol*	Ethyl Ether	Methyl Methacrylate
Allyl Chloride	Ethyl Formate	Methyl Propryl Ketone
N-Amyl Acetate	Furan	Morpholine*
N-Amyl Alcohol	Gasoline	Napthalene*
Benzene*	Heptane	Nitromethane†
N-Butyl Acetate	Hexane*	Octane
N-Butyl Alcohol*	Hydrazine*	Pentane
N-Butylamine*	Isobutyl Alcohol	Piperidine
Carbon Disulfide*	Isopropyl Acetate	Propanol*
Chlorobenzene	Isopropyl Alcohol	Propylene Oxide
Cyclohexane	Isopropyl Ether	Pyridine
Diethylamine*	Mesityl Oxide	Styrene
Diethyl Carbonate	Methanol*	Tetrahydrofuran
p-Dioxane*	Methyl Acetate	Toluene*
Ethanol	Methyl Acrylate*	Turpentine
Ethyl Acetate	Methylal	Vinyl Acetate
Ethyl Acrylate	Methyl Butyl Ketone*	Xylene

* Readily absorbed through the skin.
†Most nitrohydrocarbons are flammable.

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V. OXIDIZERS

Characteristics	May generally, by yielding oxygen, cause or contribute to the combustion of other material	
Storage Precautions	• Store in a cool, dry place, well-ventilated location in original containers. • Keep away from flammable and combustible materials (such as paper, wood, etc.) • Keep away from reducing agents such as zinc, alkaline metals, and formic acid.	
Potential Hazards	Fire/Explosion	• Chlorites, chlorates, and perchlorates are potentially explosive in contact with combustibles, sulfur organic materials, metal powders. • All oxidizers can be explosive when mixed with flammables • Can explode if subjected to shock, friction, or heat.
	Health	• May be irritating to eyes, nose, throat, or case burns. • Poisonous if ingested.
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
Personal Protection	• Use inside a fume hood. • Use appropriate chemical resistant gloves. • Use eye protection	
First Aid	• In case of contact, flush skin or eyes with water for 15 minutes. • Remove and isolate contaminated clothing. • Move victim to fresh air. • If not breathing, give artificial respiration, if trained.	

Common Oxidizers:

Chlorites	Chlorates
Perchlorates	Nitrites
Nitrates	

Oxidation Reactions

These reactions tend to generate heat and are often explosive. The following examples of typical oxidizers may:

Increase Rate of Combustion

Aluminum Nitrate	Perchloric Acid 60% or less
Ammonium Persulfate	Potassium Chloriate
Barium Chlorate	Potassium Dichromate
Barium Peroxide	Potassium Nitrate
Calcium Chlorate	Potassium Persulfate
Calcium Nitrate	Silver Nitrate
Calcium Peroxide	Silver Nitrite
Cupric Nitrate	Sodium Perborate
Hydrogen Peroxide	Sodium Perchlorate
Lead Nitrate	Sodium Persulfate

Lithium Hypochlorite
Lithium Peroxide
Magnesium Nitrate
Magnesium Perchlorate
Magnesium Peroxide
Nickel Nitrate
Nitric Acid 70% or less
Strontium chlorate
Strontium nitrate
Strontium nitrite
Thorium nitrite
Uranium nitrate
Zinc chlorate
Zinc peroxide

Cause Spontaneous Ignition

Calcium Hypochlorite
Chromic Acid
Hydrogen Peroxide (27.5-52%)
Nitric Acid
Potassium Bromate
Potassium Permanganate
Sodium Chlorite (40%)
Sodium Peroxide
Sodium Permanganate
Trichloroisocyanuric Acid
Sodium Dichloroisocyanurate

Decompose with Catalyst or Heat

Ammonium Dichromate
Hydrogen Peroxide (52-91%)
Calcium Hypochlorite (>50%)
Perchloric Acid (60-72.5%)
Potassium Dichloroisocyanurate
Sodium Dichloroisocyanurate

Cause Explosive Reaction when exposed to Catalyst, Heat, Shock, or Friction

Ammonium Perchlorate
Ammonium Permanganate
Perchloric Acid
Potassium Superoxide

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VI. TOXIC COMPOUNDS

Characteristics	• Can be a solid, liquid or gas • Substances are assigned to one of the five toxicity categories on the basis of LD_{50} (oral, dermal) or LC_{50} (inhalation). • Effects can be acute and/or chronic. • Warning: These chemicals are dangerous or extremely dangerous to health and life when inhaled, swallowed, or absorbed by skin contact. Take proper precautionary measures to avoid exposure	
Storage Precautions	• Store according to hazardous nature of chemical, using appropriate security when necessary • Store in cool, dry, well-ventilated location	
Potential Hazards	Fire	• May be ignited by sparks or flames
	Explosion	• Container may explode due to heat or fire
	Health	• Poisonous by inhalation, ingestion, or skin contact • May cause burns to skin or eyes
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
Personal Protection	• Avoid breathing vapors • Avoid bodily contact • Wear appropriate chemical protective clothing • Handle only inside a fume hood	
First Aid	• Move victim to fresh air • Remove and isolate contaminated clothing • In case of contact, flush skin or eyes with water for at least 15 minutes • Keep victim quiet and warm • If not breathing give artificial respiration • Keep victim under observation for delayed effects	

Common Toxics:

Solids

Antimony Compounds
Arsenic Compounds
Barium Compounds
Beryllium Compounds
Cadmium Compounds
Calcium Oxide
Chromates, Salts of
Cyanide, Salts of
Fluorides, Salts of
Iodine
Lead Compounds
Mercuric Compounds
Oxalic Acid
Phenol
Phosphorous, Yellow
Phosphorous Pentachloride
Phosphorous Pentasulfide
Picric Acid
Potassium
Selenium Compounds
Silver Nitrate
Sodium Hydroxide
Sodium Hypochlorite

Liquids

Aniline
Bromine
Carbon Disulfide
Carbon Tetrachloride
Chloroform
Chromic Acid
p-Dioxane
Formic Acid
Hydrazine
Hydrobromic Acid
Hydrochloric Acid
Hydrofluoric Acid
Hydrogen Peroxide
Mercury
Perchloric Acid
Phosphorous Trichloride
Sulfuric Acid
Tetrachloroethylene

Gases

Carbon Monoxide	Formaldehyde	Nitrogen Dioxide
Chlorine	Hydrogen Bromide	Ozone
Cyanogen	Hydrogen Chloride	Sulfur Dioxide
Diborane	Hydrogen Cyanide	
Fluorine	Hydrogen Sulfide	

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VII. WATER REACTIVE CHEMICALS

Characteristics	• Warning: Substances which on contact with water emits Flammable Gases which may yield toxic gases or other hazardous conditions.	
Storage Precautions	• Store in a cool, dry, well-ventilated location • Avoid water or moisture • Store at least 24" off of floor	
Potential Hazards	Fire	• May react vigorously in presence of water causing fire or explosion • Many are flammable
	Explosion	• May explode violently
	Health	• May produce toxic gas • May cause severe burns
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury • Evaluate the area	
	• Keep material dry • Do not use water, carbon dioxide, or halon on material; use dry chemical ABC or D-type extinguisher	
Personal Protection	• Avoid breathing vapors • Wear appropriate personal protection • Keep upwind	
First Aid	• Move victim to fresh air • Remove contaminated clothing • Wipe material from skin immediately • In case of contact, flush skin or eyes with water for at least 15 minutes	

Common Water Reactive Chemicals:

Solids
Aluminum Chloride, Anhydrous
Calcium Carbide
Lithium
Magnesium
Phosphorous Pentachloride
Phosphorous Pentasulfide
Potassium
Sodium
Organometallic compounds

Liquids
Acetyl Chloride
Phosphorous Trichloride
Silicon Tetrachloride
Stannic Chloride
Sulfur Chloride
Thionyl Chloride
Aluminum Borohydride
and all other hydrides

VIII. PYROPHORIC SUBSTANCES

Characteristics	• Warning: Pyrophoric substances ignite spontaneously upon contact with air. • All are flammable. May be solid, liquid or gas. • Pyrophoric solids, even in small quantities, are liable of igniting within five minutes after coming into contact with air. • **Notify EH&S of use of pyrophoric prior to purchase to ensure proper safety equipment is available.**	
Storage Precautions	• Use pyrophoric gases only in a gas cabinet**. Obtain approval from Fire Marshall prior to use.** • **Flow Restricting Orifice must be used when using silane.** • Store in cool, dry, well-ventilated location • Materials must be stored under a blanket of inert gas.	
Potential Hazards	Fire	• Ignites spontaneously on contact with air • May react violently with water oxidizing agents, halogenated hydrocarbons and alcohols
	Explosion	• May be explosive when mixed with oxidizing materials
	Health	• Can cause severe burns • Inhalation of some alkyl metal fumes can cause metal fume fever
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing injury	
	• For fire, use dry sand or vermiculite • For phosphorous use water • Refer to SDS – response must be material specific	
Personal Protection	• Isolate area, and deny entry • Avoid breathing fumes • Keep upwind • Keep unprotected personnel away • Wear appropriate personal protection	
First Aid	• Move victim to fresh air • Remove and isolate contaminated clothing • Remove material from skin immediately • In case of contact, flush skin or eyes with water for at least 15 minutes	

Common Pyrophoric Substances:

Boron	Diborane	Methyllithium
Butyllithium	Dichloroborane	Nickel†
Cadmium†	2-Furaldehyde	Phorphorous, Yellow‡
Calcium†	Iron†	Titanium†
Chromium†	Lead†	Selectride
Cobalt†	Manganese†	Silane

†Finely divided metals form a pyrophoric hazard.
‡Phosphorous, Yellow should be stored and cut under water.

See Pyrophoric Reagent (SOP) and Pyrophoric Safety (Video) athttp://www.ehs.uci.edu/programs/sop_library/index.html

IX. CRYOGENIC FLUIDS

Characteristics	• Extremely low boiling temperature (< -100°F) • Very large range of expansion from liquid to gas phase	
Storage Precautions	• Store only in Dewar flasks • Store in well-ventilated location	
Potential Hazards	Fire	• Many are flammable • Fluids with Boiling point below -183 C or 90 deg K will condense oxygen from air
	Explosion	• Container may rupture if exposed to fire or relief valve fails
	Health	• Although many are non-toxic, vapors in confined spaces can cause dizziness or asphyxiation • Contact can cause severe frostbite, burns. Eyes vulnerable to exposure
Detection of Release	• Cold boil off-gases condenses creating fog. • Most cryogenic liquids are colorless, odorless, tasteless except LOX which is blue.	
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Extinguish fire using a suitable agent • Cool affected container, so not use water on material itself • Stop leak if you can do so without risk	
Personal Protection	• Keep unprotected personnel away • **Wear appropriate cryogenic protective clothing, eye protection and face shield** • **Use only in well ventilated places.** • Cryogenics displaces oxygen.	
First Aid	• Move victim to fresh air • If not breathing give artificial respiration • For frostbite, thaw frosted parts with water • Keep victim quiet • Maintain normal body temperature	

Common Cryogenic Fluids:

Oxygen (LOX)	Nitrogen (LN_2)
Argon	Hydrogen
Helium	Neon
Xenon	Liquefied natural gas (LNG)

Expansion Ratio* (gas: liquid):

Cryogenic	Expansion Ratio
Liquid argon	840 to 1
Liquid fluorine	980 to1
Liquid helium	700 to 1
Liquid hydrogen	848 to 1
Liquid krypton	695 to 1

Cryogenic	Expansion Ratio
Liquid natural gas	635 to 1
Liquid neon	1,445 to 1
Liquid nitrogen	694 to 1
Liquid oxygen	857 to 1
Liquid xenon	560 to 1

* Source: The Common Sense Approach to Hazardous Materials, F.L. Fire, Fire Engineering, New York, New York, 1986.

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X. ASPHYXIANT GASES

Characteristics	• Mostly inert, non-reactive gases; some flammable or toxic gases can also be simple asphyxiants • **Consult with gas suppliers to ensure proper piping and manifold compatibility** • **Do not use in confined spaces with poor ventilation.**	
Potential Hazards	Fire	• Some asphyxiants are flammable, may release toxic gases
	Explosion	• Gas cylinders may rupture in a fire
	Health	• Possible asphyxiation, may cause frostbite. Some may react with air forming toxic compounds
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Check for oxygen depletion • Extinguish fire using suitable agent • Stop leak if you can do it without risk, and have been trained	
Personal Protection	• Safety glasses and face shield • Rubber gloves • Closed toed shoes	
First Aid	• Move victim to fresh air • If not breathing, give artificial respiration • If breathing is difficult, give oxygen	

Common Asphyxiant Gases:

Nitrogen	Helium
Argon	Other inert gases

XI. FLAMMABLE GASES

Characteristics	• Compressed or liquefied gases in cylinders • Gases may be mixtures in cylinders • May be toxic and/or caustic • **Use flame arresters to prevent flashbacks.** • **Delivery pressure for acetylene gas should not exceed 15 psi gauge pressure.**	
Storage Precautions	• Store in upright position and in cool, dry, well ventilated areas • Keep away from flammable liquids and from highly combustible materials and similar substances. • Keep away from arcing electrical equipment, open flames or other sources of ignition. • **Consult with gas suppliers to ensure proper piping and manifold compatibility**	
Potential Hazards	Fire	• Extremely flammable • May be ignited by heat • Vapors may travel to ignition source
	Explosion	• Containers may explode in heat of fire • Vapor explosion hazard indoors, outside, and confined spaces • **Acetylene forms explosive compounds with copper, silver, and mercury.**
	Health	• Some are toxic • All can replace oxygen and cause suffocation
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Stop leak if you can do it without risk, and have been trained	
Personal Protection	• Avoid breathing fumes • Wear appropriate protective clothing • Wear self contained breathing apparatus	
First Aid	• Move victim to fresh air • If not breathing, give artificial respiration • For frostbite, thaw frosted parts with water • Keep victim quiet and warm	

Common Flammable Gases:

Acetylene	Hydrogen
Propane	Oxygen

XII. TOXIC GASES

Characteristics	• Gases may be chemical asphyxiants, corrosives, and/or poisonous (other than a chemical asphyxiant)	
Storage Precautions	• **Must be used inside a gas cabinet and toxic gas monitors installed.** • **Corrosive gases should be stored for the shortest possible period before use, preferably < 3 months** • **Consult with gas suppliers to ensure proper piping and manifold compatibility** • **Notify Fire Marshal or Chemical Hygiene Officer prior to using highly toxic gases**	
Potential Hazards	Fire	• Many toxic gases are highly flammable • Vapors may travel to ignition source and flash back • Cylinders may rupture and rocket
	Explosion	• Containers may explode in heat of fire • Vapor explosion hazard indoors, outside, or in sewers
	Health	• Poisonous if inhaled or absorbed • Contact may cause burns to skin or eyes • Contact with liquid may cause frostbite • Respiratory irritant
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury	
	• Do not extinguish fire unless flow can be stopped • Consult with SDS for techniques for specific gases • Keep material out of water sources	
Personal Protection	• Avoid breathing vapors • Avoid bodily contact with material • Wear appropriate chemical protective clothing	
First Aid	• Move victim to fresh air • If not breathing, give artificial respiration • In case of contact with material, flush with running water for at least 15 minutes • Remove contaminated clothing • Call physician immediately	

Common Toxic Gases:

Phosgene	Hydrogen Cyanide
Hydrogen Sulfide	Carbon Monoxide
Chlorine	Fluorine

Facts About Selected Toxic Gases

GAS	*ARSINE*	PHOSPHINE	**GERMANE**	**HYDROGEN SELENIDE**	***SILANE***
MAJOR HAZARDS	Extremely toxic Flammable	Extremely toxic Flammable	Extremely toxic Flammable	Extremely toxic Flammable	Pyrophoric
COLOR	None	None	None	None	None, White smoky fire
ODOR	Garlic-like	Dead fish	Pungent, Nauseating	Rotten egg, Pungent, Irritating	None
TLV, **ppm**	0.05	0.3	0.2	0.05	0.5
ODOR THRESHOLD RANGE, ppm	0.1	0.02-2.6	------	0.0004-3.3	------
DANGER LEVEL	~10 ppm	~100 ppm			~1000 ppm
TARGET ORGANS	Blood cells Kidneys	Cellular Oxidase System	Blood cells Kidneys	Lungs, Eyes, Liver	Fire is main Hazard
PHYSIOLOGICAL EFFECTS					
ACUTE	Abdominal pain, Nausea, Vomiting	Vertigo, Weakness, Cramps, Tremors	Hemolysis, Kidney failure, Anemia	Respiratory distress, Nausea	Thermal burns
DELAYED 2-24 Hrs.	Respiratory distress, Anemia	Respiratory distress, CNS difficulty, Pulmonary edema		Eye inflammation	Headaches & Nausea
4-6 Hrs.	Bloody urine		Bloody urine		
12-48 Hrs.	Jaundice		Jaundice		Coma
>12 Hrs.	Kidney failure, Liver, Heart damage	Lung, Kidney failure	Kidney failure, Central nervous system (CNS) collapse	Pulmonary edema	
FIRE EXPLOSION HAZARD	Similar to hydrogen	Autoignition temp 212°f	Explodes above 330°c		Pyrophoric gas
LEL/UEL	4%/74% for Hydrogen	4%/74% for hydrogen			0%/100%
COMMENT		May explode in contact with halogen or oxygen. Do not use halogen fire extinguishers			Can cause severe explosion under some undefined conditions
REACTIVITY WITH WATER	Dissolves readily	Soluble	Soluble	No data, probably somewhat soluble	Rapidly hydrolyzed to SiO_2

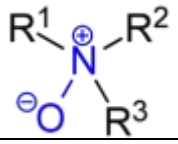
XIII. REACTIVE OR EXPLOSIVE CHEMICALS

Characteristics	• Warning: These chemicals are sensitive to heat and shock • Peroxide forming chemicals, under proper conditions will form explosive peroxides which can be detonated by shock or heat.	
Storage Precautions	• Avoid exposure to heat and mechanical shock • Label storage unit "Potential Explosion Hazard" • Label containers with receiving, opening, and disposal dates. • Dispose of peroxide forming chemicals before expected date of first peroxide formation in accordance with lab policy (6 months after opening or by manufacturers expiration date.) • Test for the presence of peroxides periodically. • Store in cool, dry, well-ventilated location • Do not open bottles of liquid ethers containing crystallized material; contact EH&S for disposal.	
Potential Hazards	Fire	• Many ignite a chain reaction with other chemicals that could become violent
	Explosion	• Containers may detonate by mechanical shock, elevated temperatures and chemical reactions. • Catalytic effect of metallic contamination can lead to explosive situations
	Health	• May cause severe burns and injuries
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury • Do not extinguish fire until chemical reaction has ceased • Evacuate all personnel from the area.	
Personal Protection	• Safety glasses with side shields or goggles should be worn • When possible, use the reactive chemical in a fume hood • Use of heavy, transparent plastic explosion shield on all sides should be installed to provide extra protection in addition to the hood window. • If feasible, wear heavy leather gloves when handling reactive compounds. • Wear appropriate clothing (i.e., flame resistant lab coat like NOMEX)	
First Aid	• Seek medical attention immediately	

Common Reactive and Explosive Chemicals:

Acetylides	Diazo compounds	Perchlorates
Azides	Nitrates	Peroxides, Organic
Bromates	Nitrates, Organic	Picrates
Chlorates	Nitro compounds	
Chlorites	Nitroso compounds	

Table of Unstable Chemical Functional Groups

CHEMICAL NAME	Unstable Group#
Perchlorate	$-ClO_4$
Nitro	$-NO_2$
Polynitro	
Nitroso	-N=O
N-oxide (oxide of tertiary amines)	
Hydroxylamine, Oxime	>N-OH
Tetrazole	
Triazene, triazole	
Diazo	
Azo	-N=N-
Hydrazine	
Substituted Hydrazine	
- N-N- in a ring	
Imidazole	N–C-N (ring)
Oxazole	N-C-O (ring)
Thiazole	N-C-S (ring)
Tetrazole + nitro	
Substituted Hydrazine +nitro	

Classes of Chemicals that Can Form Peroxides Upon Aging:

1. Class I

Unsaturated materials, especially those of low molecular weight, may polymerize violently and hazardously due to peroxide initiation.

Acetaldehyde	Isopropyl Ether	Styrene
Acrylic Acid	Lithium Metal	Tetraethyl Lead
Acrylonitrile	Lithium Hydride Methyl	Tetrafluoroethylene
Amyl Nitrite	Methacrylate	Tetranitromethane
Benzoyl Peroxide	Methyl Magnesium Bromide	Trinitroanisole
Butadiene	Methyl Magnesium Chloride	2,4,6-Trinitrobenzoic Acid
Chlorobutadiene	Nitrocellulose	2,4,6-Trinitrocresol
(Chloroprene)	2-Nitropropane	2,4,6-Trinitrotoluene
Chlorotrifluoroethylene	Perchloric Acid	Vinyl acetate
Decaborane	Picric Acid	Vinyl acetylene
2,4,6-Dinitrophenylhydrazine	Potassium Metal	Vinyl chloride
Ethyl Acrylate	Propylene Oxide	Vinyl chloride
Ethyl Chloride	Sodium Amide	Vinyl pyridine
Ethyl Nitrite	Sodium Borohydride	Vinylidene Chloride
Fluorine	Sodium Metal	

2. Class II

The following chemicals are a peroxide hazard upon concentration (distillation/evaporation). A test for peroxide should be performed if concentration is intended or suspected.

Anhydrous Ether	Diethyl Ether	Methylacetylene
Acetal	Diethylene Glycol	Methylcyclopentane
Cellosolves	Diglyme	Methylisobutyl Ketone
Cumene	Dioxane (*p*-Dioxane)	Peracetic Acid
Cyclohexene	[Ethylene Glycol Ether	Phenyl Ether
Cyclooctene	Acetates]	Picryl Chloride
Cyclopentene	[Ethylene Glycol	Tetrahydrofuran
Decahydronaphthalene	Monoethers]	Tetrahydronathalene
Diacetylene	Furan	Vinyl Ethers
Dicyclopentadiene	Glyme	

3. Class III

Peroxides derived from the following compounds may explode without concentration.

Organic	Inorganic
Divinyl Ether	Potassium Hydride
Divinyl Acetylene	Potassium Metal
Isopropyl Ether	Potassium Amide
Vinylidene Chloride	Sodium Amide

Test for peroxides using peroxide test strips that are available from PS Stores. See **peroxide testing procedure** for additional information.

Specific Hazards that May Lead to Fires or Explosions:

The combination of certain compounds or classes of compounds can result in a violent chemical reaction leading to an explosion or fire. Other compounds pose explosion or fire hazards when exposed to heat, shock, or other conditions. Some of the specific compounds and combinations of compounds that may pose explosion or fire hazards and may be encountered in laboratories are listed below. This list is not complete. Researchers are expected to learn about the hazardous properties of chemicals involved in their research before using them. Use explosion shields to protect yourself and others.

1. Acetylenic compounds are explosive in mixtures of 2.5%-80% with air. At pressures of 2 or more atmospheres, acetylene subjected to an electrical discharge or high temperature decomposes with explosive violence. Dry acetylides can detonate with the slightest shock. Many heavy metal acetylides are also shock sensitive explosives.

2. Aluminum chloride should be considered a potentially dangerous material. If moisture is present, there may be sufficient decomposition (generating hydrochloric acid (HCl)) to build up considerable pressure. If a bottle is to be opened after long standing, it should be completely enclosed in a heavy towel.

3. Ammonia reacts with iodine to give nitrogen triiodide, which is explosive, and with hypochlorites to give chlorine. Mixtures of ammonia and organic halides sometimes react violently when heated under pressure.

4. Dry benzoyl peroxide is easily ignited and sensitive to shock and may decompose spontaneously at temperatures above 50 °C. It has reported to be desensitized by the addition of water to 20%.

5. Carbon disulfide is both very toxic and very flammable; mixed with air, its vapors can be ignited by a steam bath or steam pipe, a hot plate, or a glowing light bulb.

6. Chlorine may react violently with hydrogen or with hydrocarbons when exposed to sunlight.

7. Diazomethane and related compounds should be treated with extreme caution. They are very toxic (potent carcinogens), and the pure gases and liquids explode readily.

8. Dimethyl sulfoxide decomposes violently on contact with a wide variety of active halogen compounds. Explosions from contact with active metal hydrides have been reported.

9. Diethyl, diisopropyl, and other ethers (particularly the branched-chain type) sometimes explode during heating or refluxing because of the presence of peroxides. Ferrous salts or sodium bisulfite can be used to decompose these peroxides, and passage over basic active alumina will remove most of the peroxidic material. In general, however, old samples of ethers should be disposed properly through EH&S.

10. Ethylene oxide has been known to explode when heated in a closed vessel. Experiments using ethylene oxide under pressure should be carried out behind suitable barricades.

11. Halogenated compounds such as chloroform, carbon tetrachloride, and other halogenated solvents should not be dried with sodium, potassium, or other active metals. Violent explosions are usually the result of such attempts.

12. Hydrogen peroxide in concentrations greater than 3% can be dangerous. Contact with the skin may cause severe burns. Thirty percent (30%) hydrogen peroxide may decompose violently if contaminated with iron, copper, chromium, or other metals or their salts.

13. Liquid-nitrogen cooled traps that are open to the atmosphere rapidly condense liquid air. When the coolant is removed, an explosive pressure buildup occurs, usually with enough force to shatter glass equipment. Only sealed or evacuated equipment should be cooled.

14. Lithium aluminum hydride should not be used to dry methyl ethers or tetrahydrofuran. Fires from this practice are very likely. The products of a LiAlH 4 reaction with carbon dioxide have been reported to be explosive. Carbon dioxide or bicarbonate extinguishers should not be used on lithium aluminum hydride fires, which should be smothered with sand or some other inert substance. LiAlH4 reactions should be carried out in a fume hood, behind an explosion shield, and with proper safeguards to avoid exposure of the effluent hydrogen gas to spark or flame. Any stirring device must be spark-proof.

15. Oxygen cylinders : Serious explosions have resulted from contact between oil and high-pressure oxygen. Oil should not be used on connections to any cylinder.

16. Ozone is a highly reactive and toxic gas. Ozone is formed by the action of ultraviolet light on oxygen (air) and, therefore, certain ultraviolet sources may require venting to the exhaust hood. Liquid and solid ozone are explosive substances.

17. Palladium on carbon, platinum on carbon, platinum oxide, Raney nickel, and other catalysts should be filtered from catalytic hydrogenation reaction mixtures carefully. The recovered catalyst is usually saturated with hydrogen and highly reactive and, thus, will inflame spontaneously on exposure to air. Particularly in large-scale reactions, the filter cake should not be allowed to become dry. The funnel containing the still-moist catalyst filter cake should be put into a water bath immediately after completion of the filtration.

18. Another hazard in working with such catalysts is the danger of explosion if additional catalyst is added to a flask in which hydrogen is present.

19. Parr bombs used for hydrogenations have been known to explode. Parr bombs should be handled with care behind explosion shields, and the operator should wear goggles.

20. Perchlorates : The use of perchlorates should be avoided whenever possible. Perchlorates should not be used as drying agents if there is a possibility of contact with organic compounds, or in proximity to a dehydrating acid strong enough to concentrate the perchloric acid to more than 70% strength (e.g., in a drying train that has a bubble counter containing sulfuric acid). Safer drying agents should be used. Seventy-percent perchloric acid can be boiled safely at approximately 200 ° C, but contact of the boiling undiluted acid or the hot vapor with organic matter, or even easily oxidized inorganic matter (such as compounds of trivalent antimony), will lead to serious explosions. Perchlorate esters have the same shattering explosive effect as nitroglycerine. Oxidizable substances must never be allowed to contact perchloric acid. Beaker tongs, rather than rubber gloves, should be used when handling fuming perchloric acid. Perchloric acid evaporations should be carried out in a hood that has a good draft and a built-in water spray for the ductwork behind the baffle. After use, washing out the hood and ventilator ducts with water is necessary to avoid danger of spontaneous combustion.

21. Permanganates are explosive when treated with sulfuric acid. When both compounds are used in an absorption train, an empty trap should be placed between them.

22. Peroxides (inorganic) : When mixed with combustible materials, barium, sodium, and potassium peroxides form explosives that ignite easily.

23. Phosphorus (red and white) forms explosive mixtures with oxidizing agents. White phosphorus should be stored under water because it is spontaneously flammable in air. The reaction of phosphorus with aqueous hydroxides forms phosphine, which may ignite spontaneously in air or explode.

24. Phosphorus trichloride reacts with water to form phosphorous acid, which decomposes on heating to form phosphine, which may ignite spontaneously or explode. Care should be taken in opening containers of phosphorous trichloride, and samples that have been exposed to moisture should not be heated without adequate explosion shielding to protect the operator.

25. Potassium is in general more reactive than sodium. It ignites quickly upon exposure to humid air and, therefore, should be handled under the surface of a hydrocarbon solvent such as mineral oil or toluene. Oxidized coatings should be very carefully scraped away before cutting the metal (explosions can otherwise occur). Potassium metal can form explosive peroxides. Metal that has formed a yellow oxide coating from exposure to air should not be cut with a knife, even when wet with a hydrocarbon, because an explosion can be promoted.

26. Residues from vacuum distillations have been known to explode when the still was vented to the air before the residue was cool. Such explosions can be avoided by venting the still pot with nitrogen, by cooling it before venting, or by restoring the pressure slowly.

27. Sodium should be stored in a closed container under kerosene, toluene, or mineral oil. Scraps of sodium or potassium should be destroyed by reaction with n-butyl alcohol. Contact with water should be avoided because sodium reacts violently with water to create explosions and fire. Reactions with sodium should be carried out in a fume hood, behind an explosion shield, and with proper safeguards to avoid exposing the effluent gas hydrogen to spark or flame. Any stirring device must be spark-proof. Carbon dioxide, bicarbonate, and carbon tetrachloride fire extinguishers should not be used on alkali metal fires.

28. m-chloroperbenzoic acid should only be stored in plastic containers. Researchers should take special care to do this after purifying commercial material to 99%. A sample of 99+% material stored in a glass sample bottle exploded in a laboratory in 1995 causing an injury to a researcher.

XIV. CARCINOGENS

Characteristics	• A substance or agent that causes cancer
Storage Precautions	• A hazard warning sign incorporating the carcinogen symbol must be pos at all areas where carcinogens are used or stored • Segregate carcinogens • Consult with EH&S prior to handling • Store in cool, dry, well-ventilated location 
Potential Hazards	Consult SDS for each chemical.
Immediate Action	**NOTIFY EH&S OF ANY RELEASE:** • Beyond immediate work area • Causing personal injury
Personal Protection	• The Standard Operating Procedures (SOP) outlines safety procedures that should be followed when working with carcinogens • Users of any regulated carcinogens are required to fill out a SOP and **Supplemental Information Form for Chemicals Requiring Cal/OSHA Registration** and submit the form to EH&S for review and approval. • Use only inside fume hoods and regulated areas.
First Aid	Notify EH&S of any exposures.

Cal-OSHA Reportable Hazardous Chemicals:

Scope: Applies to occupational settings where these chemicals are manufactured, processed, used, repackaged, released, stored or otherwise handled.

Table 1: Must complete Supplemental Information Form for Chemical Requiring Registration with Cal-OSHA:

Name	**If above % weight or volume**
2-Acetylaminofluorene	1.0
4-Aminodiphenyl	0.1
Benzidine (and its salts)	0.1
3,3'-Dichlorobenzidine (and its salts)	1.0
4-Dimethylaminoazobenzene	1.0
alpha-Naphthylamine	1.0
beta-naphthylamine	0.1
4-Nitrosodimethylamine	1.0
N-Nitrosodimethylamine	1.0
beta-Propiolactone	1.0
bis-Chloromethyl ether	0.1
Methyl chloromethyl ether	0.1
Ethyleneimine	1.0

Table 2: May have to complete Supplemental Information Form for Chemical Requiring Registration with Cal-OSHA. Contact the Chemical Hygiene Officer at 824-5730 for assistance.

Name	**If exposure occurring above:**
Acrylonitrile	PEL[4] (2ppm)
Asbestos	PEL (0.1ff/cc[5]) or 30 minute-excursion (1ff/cc)
Benzene	STEL[6] (5ppm) or PEL (1ppm)
Cadmium	PEL (5ug/m3)
Beryllium	any potential exposure
Ethylene Dibromide	any exposure level where composition ≥ 0.1%[7]
Ethylene Oxide	STEL (5ppm) or PEL (1ppm)
Formaldehyde	STEL (2ppm) or PEL (0.75ppm)
Inorganice Arsenic	PEL (0.01mg/m3)
Methylene Chloride	STEL (125ppm) or PEL (25ppm)
Methylenedianaline	any potential exposure
Vinyl Chloride	STEL (5ppm) or PEL (1ppm)
1,3 Butadiene	any exposure level where composition ≥ 0.1%
1,2 Dibromo-3-Chloropropane (DBCP)	PEL (1ppb)
4,4'-Methylenebis(2-Chloroaniline)	any exposure level where composition ≥ 0.1%

[4] PEL Cal-OSHA permissible exposure limit 8-hour time weighted average.
[5] ff/cc Friable fibers per cubic centimeter of air
[6] STEL Cal-OSHA short-term exposure limit 15 minute.
[7] % by weight or volume.

The list above only represents "regulated" carcinogens. There are however many other suspect carcinogens. For a complete list of all categories of carcinogens, go to the following Internet sites:

- International Agency for Research of Cancer (IARC): http://monographs.iarc.fr/ENG/Classification/index.php.
- National Toxicology Program (NTP): http://ehp.niehs.nih.gov/roc/toc10.html
- National Institute of Occupational Health (NIOSH): http://www.cdc.gov/niosh/npotocca.html
- **FAQs** about developing Standard Operating Procedures for carcinogens.

XV. CDC SELECT AGENTS, USDA HIGH CONSEQUENCE LIVESTOCK PATHOGENS OR PLANT PATHOGENS

Definition	UCI policy states that all Select Agent users register with EH&S **BEFORE** any agent can be ordered. Contact the Biosafety Officer at (949) 824-9888 or Associate Biosafety Officer at (949) 824-4365 for more information. • Pursuant to 42 USC 262a and 7 USC 8401, select agents and toxins are a subset of biological agents and toxins that the Departments of Health and Human Services (HHS) and Agriculture (USDA) have determined to have the potential to pose a severe threat to public health and safety, to animal or plant health, or to animal or plant products. The current list of select agents and toxins can be found at 42 CFR §§ 73.3, 73.4, 9 CFR §§ 121.3, 121.4, and 7 CFR § 331.3. • A current list of select agents and toxins can also be found at: http://www.selectagents.gov/Select%20Agents%20and%20Toxins%20List.html .
Primary Objectives	• Establish system of safeguards to be followed when specific agents are transferred, used or possessed. • Collect and provide information concerning the location where certain potentially hazardous agents are transferred. • Track the acquisition and transfer of these specific agents. • Establish a process for alerting appropriate authorities if an unauthorized attempt is made to acquire these agents.
List of Restricted	**USDA High Consequence Livestock Pathogens and Toxins**

"Select Agents" by Category		African Horse Sickness Virus African Swine Fever Virus Akabane Virus Avian Influenza Virus (Highly Pathogenic) Blue Tongue Virus (Exotic) Bovine Spongiform Encephalopathy Agent Camel Pox Virus Classical Swine Fever Virus Cowdria Ruminantium (Heartwater) Foot And Mouth Disease Virus Goat Pox Virus Japanese Encephalitis Virus Lumpy Skin Disease Virus Malignant Catarrhal Fever Virus Menangle Virus Mycoplasma Capricolum/M.F 38/M.Mycoides Capri (Contagious Caprinepleuropneumonia Agent) Mycoplasma Mycoides (Contagious Bovine Pleuropneumonia Agent) Newcastle Disease Virus (Exotic) Peste Des Petits Ruminants Virus Rinderpest Virus Sheep Pox Virus Swine Vesicular Disease Virus Vesicular Stomatitis Virus (Exotic)

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List of Restricted "Select Agents" by Category (Cont.)	**DHHS-CDC Select Agents**	
		Cercopithecine Herpes Virus (Simian Herpes B Virus) Coccidioides posadasii Crimean-Congo Haemorrhagic Fever Virus Ebola Viruses Lassa Fever Virus Marburg Virus Rickettsia prowazekii Rickettsia rickettsii South American Haemorrhagic Fever Viruses (Junin, Machupo, Sabia, Flexal, Guanarito) Tick-Borne Encephalitis Complex (flavi) Viruses (Central European Tick-borne encephalitis, Far Eastern Tick-borne encephalitis, Russian Spring and Summer encephalitis, Kyasanur Forest disease, Omsk Hemorrhagic Fever) Variola Major Virus (Smallpox Virus) and Variola Minor Virus (Alastrim) Viruses Causing Hantavirus Pulmonary Syndrome Yellow Fever Virus Yersinia pestis Abrin Conotoxins Diacetoxyscirpenol Ricin Saxitoxin Tetrodotoxin

USDA-DHHS CDC Overlap Agents	
	Bacillus anthracis Brucella abortus Brucella melitensis Brucella suis Burkholderia (Pseudomonas) Mallei Burkholderia (Pseudomonas) Pseudomallei Clostridium Botulinum Coccidioides Immitis Coxiella Burnetii Eastern Equine Encephalitis Virus Equine Morbillivirus (Hendra Virus) Francisella tularensis Nipah Virus Rift Valley Fever Virus Venezuelan Equine Encephalitis Virus Botulinum Neurotoxin producing species of Clostridium Botulinum Neurotoxins Clostridium Perfringens Epsilon Toxin Shigatoxin and Shiga-like ribosome inactivating proteins Staphylococcal Enterotoxins T-2 Toxin
USDA-APHIS Plant Pathogens	
	Plum pox potyvirus Liberobacter africianus, Liberobacter asiaticus Xanthomonas oryzae pv. Oryzicola Xylella fastidiosa (citrus variegated chlorosis strain) Peronoscleospora philippinensis Phakopsora pachyrhizi Sclerophthora rayssiae var zeae Synchytriun endobioticum
Poliovirus or Materials Potentially Containing Poliovirus	

Please notify UCI Biosafety Officer if your laboratory has any of the listed Select Agents at 824-9888. See **Select Agent Program** for information.

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XVI. ANESTHETIC GASES

Common Anesthetic Gases	• Nitrous Oxide • Halogentated Agents such as Enflurane, Chloroform, Halothane, Methoxyflurane • EH&S strongly recommends the substitution of ether with less flammable and less volatile anesthetic.
Potential Hazards	• Potential health hazards exist for exposure to trace gases. Symptoms include: nausea, dizziness, headaches, fatigue, and irritability, as well as sterility, miscarriages, birth defects, cancer, and liver and kidney disease. • Read the Material Safety Data Sheet prior to handling the chemical. • For additional information visit: **Controlling Exposure to Waste Anesthetics at UC Irvine** **(http://www.ehs.uci.edu/programs/ih/controllingwasteanesthetics.doc)**
Work Practices	• Any facility using anesthetics should institute and maintain a control program for waste anesthetic gases. • A complete waste anesthetic gas management program includes at the outset the application of a well-designed waste anesthetic gas scavenging system. Contact EH&S for assistance or visit: **Controlling Exposure to Waste Anesthetics at UC Irvine** **(http://www.ehs.uci.edu/programs/ih/controllingwasteanesthetics.doc)** • Open bench surgeries involving gaseous anesthetics should employ waste gas scavenging systems like snorkel exhaust devices. • Consult the Campus Veterinarians for appropriate selection of anesthetic agents.: http://www.research.uci.edu/ora/acup/veterinaryconsultation.htm. • When using low vapor pressure anesthetic agent like methoxyflurane, An anesthetic chamber (bell jar) may be used. Place the jar inside a fume hood to minimize employee exposures.
Exposure Concentrations	• No worker should be exposed to concentrations of waste anesthetic gases greater than 2 parts per million of any halogenated anesthetic agent. Controlled agents and their respective weights corresponding to 2 ppm are: chloroform, 9.76 mg/cubic meter (m^3), halothane, 16.15 mg/ m^3; methoxyflurane, 13.5 mg/ m^3; enflurane, 151 mg/ m^3; fluroxene, 10.31 mg/ m^3 • The occupational exposure to nitrous oxide, when used as the sole anesthetic agent, shall be controlled so that no worker is exposed at eight-hour time weighted average (TWA) concentrations greater than 25 ppm during anesthetic administration.
Spill Clean-up and Disposal	• Small spills of liquid anesthetic agents (<10 ml) evaporate readily and may dissipate before any clean-up attempt is initiated. • When large spills occur such as a bottle of liquid agent breaks, only equipped and trained personnel may clean-up the spill. Leave the area and contact EH&S. • All contaminated absorbent pads must be disposed of as hazardous waste.

XVII. REPRODUCTIVE HAZARDS

Chemical Hazards	• Arsenic • Benzene • Boron • Carbaryl • Carbon disulfide • Chloroprene • Cytotoxic drugs • Damium • Dibromochloropropane • Dinitrotoluene • Epichlorhydrin • Ethylene dibromide • Ethylene glycol ethers • Ethylene oxide • Halothane • Kepone • Lead • Mercury • Nitrous oxide • Polybrominated biphenyls • Toluenediamine • Trichloroethylene • Triethyleneamine
Potential Hazards	Mutagenic, teratogenic, fetal toxin
Work Practices	• Before working with hazardous chemicals, read container labels and SDSs to identify potential reproductive hazards. • Follow manufacturer's directions for safe handling. • Avoid exposure to reproductive hazards by handling in chemical fume hood and wearing personal protective equipment. • If pregnant or considering, contact EH&S Reproductive Hazards Program specialist for specific consultation.
Exposure	• Immediately wash contaminated area with soap and water. • If inhaled, move away to fresh air. • Seek medical attention.
Spill Clean-up and Disposal	• If trained to clean up incidental spills, proceed or ask colleagues for assistance. Follow procedures for Hazardous Materials Incidents. • For more than incidental spills, contact EH&S for help.

Appendix F

Formaldehyde

Formaldehyde (also called formic aldehyde or methyl aldehyde) is used as a tissue preservative or organic chemical reagent. Formaldehyde itself is a colorless gas, but it is more commonly purchased and used in aqueous solution (called formalin solution), with a maximum concentration of 40%. Formalin solutions often contain some amount of methanol as well. Both formaldehyde gas and solutions have a characteristic pungent, unpleasant odor. Because of formaldehyde's hazards, Cal/OSHA has enacted specific regulations regarding its safe handling.

I. HAZARDS AND PRECAUTIONS

A. ***Health Hazards***

When present in the air at a concentration above 0.3 parts per million, formaldehyde can cause watery eyes, nausea, coughing, chest tightness, wheezing, skin rashes, allergenic reactions, and burning sensations in the eyes, nose, and throat. Formaldehyde has been shown to cause cancer in laboratory animals and may cause cancer in humans. It is also a possible mutagen and teratogen. It is highly toxic if swallowed, inhaled, or absorbed though skin or mucous membranes. Formaldehyde reacts vigorously with oxidizers and, at its highest concentrations, is a combustible liquid. In addition, formaldehyde reacts with hydrochloric acid (HCl) to produce bis (chloromethyl) ether vapor, a very potent carcinogen.

B. ***Eye and Skin Exposure***

Formaldehyde is corrosive, and the eyes are especially vulnerable. An air concentration of two parts per million (2 ppm) is quickly irritating to the eyes, and 20 ppm can cause permanent clouding of the cornea after only one exposure. Formaldehyde is also a sensitizing agent. Subsequent exposures can produce symptoms more quickly and at lower concentrations. Symptoms of exposure may include coughing, eye or skin irritation, allergic reactions, vomiting, and diarrhea.

C. Inhalation of Vapor

Exposure to concentrations of formaldehyde in air greater than 25 ppm can cause severe injury, including fatal pulmonary edema (water in the lungs). Cal/OSHA limits employees' exposure to airborne concentrations of formaldehyde to an average of 0.75 ppm over an 8-hour workday. Formaldehyde's odor threshold (the lowest concentration you can smell) is less than 1 ppm. As a sensitizer, subsequent formaldehyde exposures can produce symptoms more quickly and at lower concentrations, while olfactory fatigue can significantly raise the odor threshold concentration. Symptoms of exposure may include coughing, allergic reactions, difficulty breathing, vomiting, and diarrhea.

II. SAFETY PRECAUTIONS FOR FORMALDEHYDE USE

A. Employee Information and Training

Employees who handle formaldehyde must receive documented training on the hazards of formaldehyde and what to do in case of an exposure or spill.

All employees working with formaldehyde on outside of chemical exhaust hoods must complete the online Formaldehyde Safety training annually at **www.uclc.uci.edu**.

A Material Safety Data Sheet (SDS) for formaldehyde should always be kept in the work area where formaldehyde is being used. The SDS and this Fact Sheet are excellent tools for training employees on the hazards of formaldehyde. SDSs are available via the web at **www.ucmsds.com**.

B. Exposure Monitoring

Exposure monitoring may be required to ensure that employees are not over-exposed. Contact EH&S (824-6200) for assistance in determining exposure monitoring needs in your laboratory if you work with formaldehyde.

C. Ventilation

Formaldehyde should always be used with adequate ventilation, preferably in a fume hood, to minimize inhalation of vapor.

D. Eye Protection

Always use chemical goggles or a face shield when handling formaldehyde to minimize the risk of even a small splash or vapor exposure to the corneas.

E. Body Protection

Wear a laboratory coat and never wear shorts or open-toed shoes when handling formaldehyde.

F. ***Gloves***

Medium or heavyweight nitrile, neoprene, or PVC gloves should be worn when handling concentrated formaldehyde. Disposable (exam) nitrile gloves may be used when handling dilute concentrations (10% or less). If you have questions about glove selection, see **Appendix J - Gloves Selection** or contact EH&S, 824-6200. Gloves that **are not** contaminated with formaldehyde may be discarded in the regular trash.

G. ***Safe Work Practices***

Be sure that formaldehyde solutions are clearly labeled with the chemical's name and hazards. All containers of formaldehyde must be labeled with:
FORMALDEHYDE
CARCINOGEN
STRONG SENSITIZER
Avoid inhalation and any skin contact!

Obtain a blank label at:

http://www.ehs.uci.edu/programs/enviro/HazardousMaterialInteractiveLabel.xls

As with any laboratory chemical, do not mouth pipette formaldehyde solutions. Do not eat, drink, or smoke where formaldehyde is handled, processed, or stored, since the chemical can be swallowed. Always wash hands thoroughly after using formaldehyde, even if gloves are worn.

H. ***Storage***

Store formaldehyde in labeled, chemically compatible containers, away from heat and flame. Always place large-volume containers on a low, protected shelf or in another location where they will not be accidentally spilled or knocked over. Containers larger than 4L (1 gallon) should be stored inside a deep pan or other secondary containment. Do not store formaldehyde bottles in any area where a leak would flow to a drain.

I. ***Waste Disposal***

Place formaldehyde waste in a chemically compatible container with a sealed lid and label clearly. Contact EH&S Environmental Management for hazardous waste labeling and disposal at: **http://www.ehs.uci.edu/programs/enviro/**.

III EMERGENCY PROCEDURES

A. ***Formaldehyde Spills***

If formaldehyde is spilled outside a chemical fume hood, evacuate the area, close the laboratory doors, and post the area to prevent others from entering. If the incident occurs during regular work hours (Monday to Friday, 8 a.m. to 5 p.m.), call EH&S (824-6200) for assistance in cleaning up the spill. After hours, call UCIPD (824-5222).

B. Inhalation of Formaldehyde Vapor

If there is concern that someone has inhaled a high concentration of formaldehyde vapor, immediately move the person to fresh air and seek **appropriate medical attention**. If the person is having trouble breathing, call 911 for immediate medical attention. The supervisor or the affected employee must submit an on-line **Incident Report** must be submitted within 24 hours of the incident.

C. Splash of Formaldehyde to Eyes or Skin

For eye or skin exposure, immediately flush with plenty of water for at least 15 minutes. Remove contaminated clothing and seek **appropriate medical attention**. In case of ingestion or a severe reaction, call 911 for immediate medical attention. The supervisor or the affected employee must submit an on-line **Incident Report** must be submitted within 24 hours of the incident.

IV. RESOURCES

A. EH&S

All employees working with formaldehyde must receive annual via classroom or line training. Training is available at **www.uclc.uci.edu**.

We can also perform exposure monitoring in your workplace. Material Safety Data Sheets about formaldehyde-containing products are available at **www.ucmsds.com**.

B. Cal/OSHA FORMALDEHYDE STANDARD (Title 8 CCR §5127)

The following is a summary of the standard:

- No worker may be exposed to airborne concentrations over 0.75 ppm as an 8-hour time-weighted average (TWA) without the use of a respirator. This is known as the Permissible Exposure Limit (PEL).

- In addition, no worker may be exposed to airborne concentrations over 2.0 ppm, averaged over any 15-minute period, without the use of a respirator. This is known as the Short Term Exposure Limit (STEL).

- Wherever airborne concentrations exceed 0.5 ppm when averaged over an 8-hour period (known as the Action Level), workers must receive free medical surveillance. Other requirements include annual documented worker training on formaldehyde hazards and worker exposure monitoring at least every 6 months.

- All work involving potential airborne exposure to formaldehyde must be evaluated by EH&S to determine employee exposures. Contact EH&S (824-6200) immediately if your work has not already been evaluated.

- Workers must handle formaldehyde in a fume hood if one is available. A respirator must be used if a fume hood or other engineering control isn't available and the air concentration exceeds either the PEL or STEL.

- Workers must wear gloves, eye protection, and a lab coat when working with formaldehyde.

- Everyone using formaldehyde must receive annual documented training on:

  - The hazards and symptoms of overexposure to formaldehyde
  - A description of the processes in which formaldehyde is used
  - An explanation of the applicable safe work practices
  - The contents of the Cal/OSHA formaldehyde standard and the appropriate SDS(s)
  - The purpose for and contents of the medical surveillance program
  - Instructions for handling spills and other emergencies
  - The importance of engineering controls
  - The purpose for, proper use of, and limitations of personal protective clothing

- Suspected exposure incidents must be reported to EH&S for follow-up evaluation

Acknowledgement: UCI EH&S would like to recognize UC Berkeley EH&S for the contents of this section.

Appendix G

Chemical Incompatibility Table

Alkali metals such as calcium, potassium, and sodium with water, carbon dioxide, carbon tetrachloride, and other chlorinated hydrocarbons.

Acetic Acid with chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides, and permanganates.

Acetone with concentrated sulfuric and nitric acid mixtures.

Acetylene with copper (tubing), fluorine, bromine, chlorine, iodine, silver, mercury, and their compounds.

Ammonia, Anhydrous with mercury, halogens, calcium hypochlorite, hydrogen fluoride, iodine.

Ammonium Nitrate with acids, metal powders, flammable fluids, chlorates, nitrates, sulfur, and finely divided organics or combustibles.

Aniline with nitric acid, hydrogen peroxide.

Bromine with ammonia, acetylene, butadiene, butane, hydrogen, sodium carbide, turpentine, and finely divided metals.

Chlorates with ammonium salts, acids, metal powders, sulfur, finely divided organics or combustibles, carbon.

Chromic Acid with acetic acid, naphthalene, camphor, alcohol, glycerine, turpentine, and other flammable liquids.

Chlorine with ammonia, acetylene, butadiene, benzene, and other petroleum fractions, hydrogen, sodium carbide, turpentine, and finely divided powdered metals.

Cyanide with acids.

Hydrogen Peroxide with copper, chromium, iron, most metals or their respective salts, flammable fluids, and other combustible materials, aniline, and nitro-methane.

Hydrogen Sulfide with nitric acid, oxidizing gases.

Hydrocarbons, general with fluorine, chlorine, bromine, chromic acid, sodium peroxide.

Iodine with acetylene ammonia.

Mercury with acetylene, fulminic acid, hydrogen.

Nitric Acid with acetic, chromic and hydrocyanic acids, aniline, carbon, hydrogen sulfide, flammable media, fluids or gases, and substances which are readily nitrated.

Oxygen with oils, grease, hydrogen, flammable liquids, solids and gases.

Oxalic Acid with silver, mercury.

Perchloric Acid with acetic anhydride, bismuth and its alloys, alcohol, paper, wood and other organic materials.

Potassium Permanganate with glycerine, ethylene glycol, benzaldehyde, sulfuric acid.

Sodium Peroxide with any oxidizable substances, for instance: methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, furfural.

Sulfuric Acid with chlorates, perchlorates, permanganates and water.

Appendix H

Target Organ Categorization

The following is a target organ categorization of effects that may occur, including examples of signs and symptoms and substances that have been found to cause such effects. These examples are presented to illustrate the range and diversity of effects and hazards found in the workplace, and the broad scope employees and/or students must consider in this area, but are not intended to be all-inclusive.

I. **HEPATOTOXINS** - Substances that produce liver damage.

A. Signs and Symptoms: Jaundice; liver enlargement.

B. Substances: Carbon tetrachloride; nitrosamines.

II. **NEPHROTOXINS** - Substances that produce kidney damage.

A. Signs and Symptoms: Edema; proteinuria.

B. Substances: Halogenated hydrocarbons; uranium.

III. **NEUROTOXINS** - Substances which produce their primary toxic effects on the nervous system.

A. Signs and Symptoms: Narcosis; behavioral changes; decrease in motor functions.

B. Substances: Mercury; carbon disulfide

IV. **AGENTS WHICH ACT ON THE BLOOD OR HEMATOPOIETIC SYSTEM** -Decrease hemoglobin function; deprive the body tissues of oxygen.

A. Signs and Symptoms: Cyanosis; loss of consciousness.

B. Substances: Carbon monoxide; cyanides.

V. **AGENTS WHICH DAMAGE THE LUNG** - Substances which irritate or damage the pulmonary tissue.

A. Signs and Symptoms: Cough; tightness in chest; shortness of breath.

B. Substances: Silica; asbestos.

VI. **REPRODUCTIVE TOXINS** - Substances which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

A. Signs and Symptoms: Birth defects; sterility.

B. Substances: Lead; DBCP

VII. **CUTANEOUS HAZARDS** - Substances that affect the dermal layer of the body.

A. Signs and Symptoms: Defatting of the skin; rashes; irritation.

B. Substances: Ketones; chlorinated compounds.

VIII. **EYE HAZARDS** - Substances that affect the eye or visual capacity.

A. Signs and Symptoms: Conjunctivitis; corneal damage.

B. Substances: Organic solvents; corrosives.

IX. **CARCINOGENS**:

A. A1 –Confirmed Human carcinogen: Substances that can cause cancer in humans. Examples: benzene, arsenic, beta-napthylamine, insoluble hexavalent chrome

B. A2 – Suspected Human carcinogen: Human data are accepted as adequate in quality but are conflicting or insufficient to classify the agent as a confirmed human carcinogen. There is limited evidence of carcinogenicity in experimental animals with relevance to humans.

Examples: Formaldehyde, methylene chloride, MOCA (4,4,-mthylene bis(2-chloroaniline)

Appendix I

Personal Protective Equipment (PPE)

I. What is PPE?

Personal Protective Equipment (PPE) is comprised of clothing or equipment that is used to isolate a worker from direct exposure to workplace hazards. It is used in conjunction with engineering and administrative controls to provide worker health and safety. PPE should provide adequate protection if it is properly worn and appropriately used. Prior to usage, consult EH&S to ensure proper PPE selection.

PPE is certified by the National Institute of Occupational Safety and Health (NIOSH) and/or by the American National Standards Institute (ANSI), where appropriate. Please refer to **UCI's Lab PPE Assessment Tool** for additional guidance or contact EH&S at extension (949) 824-6200.

II. PPE examples include:

- Partial and full body protective garments (aprons, lab coats and coveralls)
- Headwear (hard hats and helmets)
- Face and eyewear (safety glasses, goggles and face shields)
- Gloves (leather, chemical resistant or aluminized)
- Footwear (shoe covers, safety shoes/boots and toe caps))
- Respirators (disposable, air purifying and air supplied)
- Hearing protectors (earplugs and earmuffs)
- Other devices used in fall protection such as harnesses

III. ***Choose PPE depending on the hazardous condition!***

Examples of Hazards Requiring PPE*

HAZARD	RECOMMENDED PPE	
Biological Contamination	• Safety goggles • Gloves (latex)	• Lab coats • Disposable coveralls
Chemical Contamination/splashes	• Safety goggles • Face shields • Gloves (neoprene, nitrile)	• Lab coats • Disposable coveralls (Tyvek)
Elevated Heights	• Hard hat • Safety goggles	• Gloves • Fall protection (harness)

*NOTE: **This is only a guide. Other PPE may be needed.** Consult your supervisor or EH&S before use.

IV. **Work areas requiring PPE usage may be anywhere on campus.**

- Classrooms
- Facilities maintenance shops
- Laboratories
- Offices
- Student housing, etc.

V. **EH&S Has Identified Certain Hazards Which May Require Additional Training.**
Contact EH&S Before Working Near Areas With The Following Hazards:

- Biohazards
- Radiation
- UV light
- High Energy/Voltage/Electrical
- Gas leakage and inhalation
- Confined areas
- Asbestos
- Elevated locations

SAFETY TIPS FOR USING PPE
• ***PPE PROTECTS DIFFERENTLY FOR EACH HAZARD*** It does not provide protection against all hazards. Choose appropriate PPE depending on the hazard and task you are performing. ***Remember:*** USING THE WRONG PPE MAY BE AS BAD AS USING NO PPE!
• ***PPE DOES NOT ELIMINATE THE HAZARD*** Know the limitations of PPE. Follow SAFETY PRECAUTIONS while working.
• ***USE AND MAINTAIN PPE PROPERLY TO ENSURE ITS PERFORMANCE*** Safety goggles will not provide the proper protection, if they are resting on your head.
• ***BE AWARE THAT THERE MAY BE HAZARDS WITH USING PPE*** Talk to your supervisor or EH&S before using PPE.
• ***PPE DOES NOT PROTECT WORKERS THE SAME WAY*** PPE should be properly sized and fitted for individuals to ensure its adequacy.
• ***WEAR MORE THAN THE MINIMUM PPE***
• ***LEAVE YOUR PPE AT WORK*** Have it laundered there if a service is provided. Do not wear potentially contaminated PPE outside of the immediate work area.
• ***TAKE OFF YOUR JEWELRY*** (i.e. rings and watches). This reduces chemical seepage, contact with electrical sources, and prevents entanglement with certain equipment.

VI. What Are Everyone's Responsibilities?

1. Employee Responsibilities:

- Wear required PPE as identified by the supervisor, and as a result of EH&S or your work unit conducting a hazard assessment.
- Maintain and store PPE in a clean and sanitary condition.
- Routinely inspect and ensure PPE is in good operating condition before wearing it.
- Communicate to the supervisor if:
  - Unforeseen hazards arise which may require additional PPE
  - PPE is defective or damaged
  - PPE is uncomfortable or does not fit properly. PPE must not be altered or removed even though an employee may find it inconvenient. Do not use PPE that looks defective or damaged.

2) **Supervisor Responsibilities:**

a) Conduct all appropriate **Hazard Identification Checklist**, to identify potential hazards. Using the **PPE Assessment Tool**, determine and provide the appropriate PPE necessary to perform the work activities.

b) Ensure employees wear the required PPE.

c) Train employees:

- When PPE is necessary
- What type to use and its limitations
- How to put on, take off, adjust, and wear appropriate PPE
- Maintenance, storage, disposal, and useful life of the PPE
- Document training using the **PPE Assessment Tool** form.

d) As necessary:

- Notify EH&S when new hazards are introduced, such as the use of new chemicals, materials or processes.
- Refer employees to EH&S at x46200 before using any type of respirator
- Refer employees to EH&S at x46200 for potential exposure to high levels of noise.

3. **EH&S Responsibilities**

· Assist supervisors with completing a workplace **PPE Assessment Tool**.
· Provide assistance in determining the type of PPE necessary based on the hazards involved.

Appendix J

Gloves - Chemical Resistance & Selection

Gloves afford hand protection by minimizing skin contact with the contaminant but donning gloves often mislead and provide a false sense of security. No one glove can provide protection against all chemicals so it is important to select the appropriate glove and to know its limitations.

I. SELECTION

A. Hazard Assessment

In order to find the right glove, it is critical to perform a hazard assessment to identify the hazards involved. This information can be found on a chemical's label and/or material safety data sheet (SDS).

B. Effectiveness

The effectiveness of a glove to protect against chemicals is based on *degradation*, *permeation*, and *breakthrough time*, so each of these properties must be evaluated when selecting the type of glove.

1. *Degradation*

Degradation is the change in one or more physical characteristics of a glove caused by contact with a chemical. Degradation appears as swelling or shrinking, stiffening or softening, slight discoloration, cracking, or having a rough or gummy surface.

Degradation tests vary with each manufacturer and it is very important to consult each manufacturer's glove chart

2. *Permeation Rate*

The permeation rate refers to the speed at which a chemical penetrates the glove material. This term is expressed in micrograms per square centimeter per unit or as "Excellent", "Good", "Fair", "Poor", and "Not Recommended".

3. *Breakthrough Time*

The breakthrough time is the elapsed time between initial contact on the outside of the glove with a chemical to the first detection of chemical on the inside surface.

Select gloves that have Permeation Rate ratings of "Excellent" or with the longest breakthrough times. Try to select a glove with a breakthrough time of at least 60 minutes.

C. **Material Type**

Gloves are made of many different types of material yet no one material type affords protection against all chemicals. For certain chemical mixtures, there are no materials that will protect for more than an hour after initial contact; **AND, DISPOSABLE LATEX GLOVES PROVIDE LIMITED CHEMICAL PROTECTION FOR SPECIFIC CHEMICALS**.

The following is a list of common glove types and their uses:

GLOVE TYPE	USE
Butyl Rubber	**Good** for many organics, ketones, esters; **Poor** for aliphatic, aromatic hydrocarbons, halogenated hydrocarbons, gasoline
Natural Rubber	**Good** for very dilute acids and bases; **Poor** for organics
Neoprene	**Good** for acids and bases, peroxides, fuels, hydrocarbons, alcohols, phenols **Poor** for halogenated and aromatic hydrocarbons
Polyvinyl chloride (PVC)	**Good** for acids and bases, some organics, amines, and peroxides; **Poor** for most organics
Polyvinyl alcohol (PVA)	**Good** for aromatic and chlorinated solvents; **Poor** for water-based solutions- *water destroys the gloves!*
Silver Shield™	**Good** for wide variety of toxic and hazardous chemicals; provides the highest level of chemical resistance. Flexible laminate glove; **Poor fit**- comes in small, medium, large
4H™	**Good** resistance to many chemicals; better dexterity than Silver Shield™
Nitrile	**Good** for wide variety of solvents, oils, greases, some acids and bases and biohazardous materials
Viton™	**Exceptional** resistance to chlorinated and aromatic solvents; **Good** resistance to cuts and abrasions

D. **Latex Gloves**

· Allergic reactions may result from using latex glove.

· Reactions may include appearance of an itchy rash (dermatitis). A more serious reaction may occur in sensitized individuals such as wheal, urticaria and asthma (wheezing,

coughing) from minutes to hours following latex allergen exposure. Rarely, life-threatening anaphylaxis may follow.

- If users experience any of the above symptoms, remove the glove, wash your hands, and report to your laboratory supervisor and seek medical attention, if necessary.

- Select gloves that are powder-free and low in residual accelerators and extractable latex proteins or switch to non-latex gloves to prevent latex allergies.

E. **Performance**

Durability, thickness, and length of the glove material as well as dexterity requirements, sensitive skin or allergies and worker comfort are just some of the factors that must be considered before selecting gloves.

1. **ALL** *disposable gloves*, regardless of material type are designed for intermittent chemical exposure. If working with toxic agents, consider triple gloving with disposable nitrile gloves. Always remove first layer once contamination has occurred. Replace glove appropriately.
2. *Reusable gloves* should be washed prior to removal and air dried in the laboratory after coming into contact with a chemical. Do not come into contact with water when working with polyvinyl alcohol (PVA) gloves!

II. INSPECTION & MAINTENANCE

- All gloves should be inspected before and after each use, and periodically while in use. Inspect for:
  - Any holes or punctures,
  - Signs of degradation,
  - Chemical discoloration,
  - Swelling, stiffness, cracking, or
  - Signs of prior contamination or breakthrough.
- If the integrity of the gloves is in question, they should be replaced immediately.
- Disposable gloves should be changed frequently; do not clean or reuse.
- Once a chemical has begun to diffuse into a glove, it will continue to diffuse into the elastomer even after the chemical on the surface is removed because of the concentration gradient that develops within the protective glove. Due to this problem, extreme caution is advised when using any chemical protective clothing that has been exposed to highly toxic chemicals. In fact, it is prudent practice to use disposable protective clothing where highly toxic chemicals are involved.
- **Always wash your hands after removing the gloves**. Some chemicals may be absorbed through the glove material, and may contact your skin. Your hands may also become contaminated from handling the gloves while removing them.

III. RESOURCES

A. Manufacturers

Manufacturers can provide degradation/permeation resistance charts that list the performance characteristics of their glove types to given chemicals. To request a chart, call the manufacturer whose gloves are utilized in your lab.

- Best Gloves, 1-800-241-0323
- Ansell Edmont, 1-800-800-0444
- Cole-Parmer, 1-800-323-4340
- North Safety, 1-800-430-4110
- MAPA Gloves, 1-800-772-6733

Chemical Compatibility Chart For Disposable Gloves

Warning: The information in this chart was supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting gloves for chemical compatibility testing. Variability in material thickness, chemical concentration, temperature, and length of exposure to chemicals will affect specific performance. Always test the products with the specific chemicals and under the specific conditions of your application. Cole-Parmer does not warrant (neither expressed nor implied) the accuracy or completeness of this chart or that any material is suitable for any purpose.

Compatibility Ratings
A — Very Good or Excellent
B — Good
C — Fair
D — Not recommended
— — No data available

Brand of glove	Microflex®				Ansell	Best™ N-DEX®
	Diamond Grip™ Plus	NeoPro™	Nitron One®	Freeform™	Touch-N-Tuff™	
Glove material	Latex	Chloroprene	Nitrile	Nitrile	Nitrile	Nitrile
Chemical	**Compatibility rating**					
Acetic Acid	A	A	A	A	A	D
Acetone	A	B	D	D	D	D
Acetonitrile	—	A	—	—	C	D
Ammonium Hydroxide	A	A	A	A	B	A
Carbon Tetrachloride	D	C	B	B	—	D
Chloroform	D	B	D	D	—	D
Ethanol	A	A	A	A	—	D
Ethyl Ether	B	A	B	B	B	D
Formaldehyde	A	A	A	A	A	A
Hexane	D	C	B	B	A	A
Hydrochloric Acid	B	A	B	B	A	A
Isopropanol	—	A	—	—	A	—
Kerosene	C	—	A	A	A	A
Methanol	A	A	A	A	—	A
Nitric Acid; 10%	D	B	C	C	A	A
Phosphoric Acid	B	A	A	A	—	A
Potassium Hydroxide	A	A	A	A	—	A
Sodium Hydroxide	A	A	A	A	A	A
Sulfuric Acid; 47% Battery Acid	A	B	B	B	A	B

B. **Internet**

1. The following glove manufacturers have established Internet sites for glove information: (**NOTE**: These sites only reflect their own products)

Ansell Edmont (**www.ansell-edmont.com**) **Ansell Edmont Resistance Guide**	MAPA Professional (**www.mapaglove.com**)
Best Gloves (**www.chemrest.com**)	Microflex brand **Latex/Nitrile Glove Chart**
Cole-Parmer (http://www.coleparmer.com/TechInfo/GloveChemComp.asp)	Kimberly Clark **Kimberly Clark Safeskin Gloves**
North Safety **www.northsafety.com**	

2. NIOSH Guide to Hazards: **http://www.cdc.gov/niosh/npg/npg.html**

C. **EH&S**

For further assistance, consult with EH&S at 949-824-6200.

Source:

Chemical Health and Safety, November/December 1997, American Chemical Society and ACS Division of Chemical Health and Safety

Personnel Protection and Safety, United States Environmental Protection and Safety, Office of Emergency and Remedial Response, Environmental Response Team.

Appendix K

Spill Clean Up

I. SCOPE

This procedure applies to all students, staff, and faculty who in the course of their job duties, handle, transport, or use hazardous materials, or waste within UCI.

II. RESPONSIBILITIES

It is the responsibility of all students, staff, and faculty who in the course of their job duties, handle, transport, or use hazardous materials within UCI to read the Material Safety Data Sheet prior to handling the chemical.

The PI is responsible for training the laboratory staff on the hazards of the chemicals and determines the appropriate spill clean-up procedure when handling small spills.

III. PURPOSE

This procedure provides guidance for the proper clean up of very small amounts (< one cup) of a spilled hazardous material. Follow this procedure to protect students, staff, faculty, and to minimize business, and environmental impact.

IV. PRECAUTION

If you feel the spill is larger than you can handle, do not hesitate to call EH&S at 824-6200. If there is anyone injured, call 911.

V. PERSONAL PROTECTIVE EQUIPMENT (PPE) AND SUPPLIES FOR CLEANUP

A. Minimum required PPE

1. Splash Goggles
2. Lab coat
3. Thick Nitrile or neoprene gloves

B. Recommended spill cleanup materials

1. *Consumable generic supplies*

   a. 1 gallon plastic container with lid
   b. 1 heavy duty plastic trash bags

c. 1 box polypropylene pads or universal absorbent materials

2. *Spill Kit*

a. 1 box activated carbon
b. 1 box liquid acid neutralizer or solid sodium bicarbonate
   i. 40% triethanolamine (approximately)
   ii. Appropriate pH indicator for 7-10 range

c. 1 box liquid caustic neutralizer or solid citric acid
   i. 40% citric acid
   ii. Sufficient triethanolamine to bring pH to 4
   iii. Appropriate pH indicator for 7-10 range

d. Hazardous waste labels
   i. Must be legible and properly filled out after the spill cleanup is complete (Available online at www.uci.edu)

e. Dust pan and broom
f. Laboratory tongs or forceps

VI. CLEAN UP PROCEDURES

A. Don appropriate protective equipment

B. Stop the source of the spill

1. Place container in upright position
2. Place container on a polypropylene pad in a safe location
3. Replace lid on container

C. Control spread of any spilled chemical

1. Place polypropylene pads around chemical
2. Use caution around broken glass

D. Absorb free-standing liquids

1. *Non-flammable liquids*

a. Use polypropylene pads
b. Check behind drawers and equipment
c. Place clean up debris into trash bag

2. *Flammable liquids*

a. *Use activated carbon*

   i. Use approximately 2 pounds of activated carbon per pint (.5) liters of spilled liquid.
   ii. Use dust brush to thoroughly mix activated carbon with liquid

iii. Use dustpan and brush to collect all residue
iv. Place clean up debris into trash bag

3. *Acidic liquids*

a. Dike and contain liquid with solid neutralizer.
b. Spread sufficient material over spill to cover surface with light coating.
c. Mix solid neutralizer thoroughly with the acid and absorb
d. A small amount of water may be added to cool the slurry, or increase the rate of neutralization.
e. pH should be 5-9

4. *Caustic Liquids*

a. Dike and contain liquid with solid neutralizer.
b. Spread sufficient material over spill to cover surface with light coating.
c. Mix solid neutralizer thoroughly with the caustic and absorb
d. A small amount of water may be added to cool the slurry, or increase the rate of neutralization.
e. pH should be 5-9

E. **Decontaminate area**

1. *Acids and Caustic spills*

d. Spray neutralizer on all surfaces affected
e. Soak up neutralizer
f. Remove neutralizer with water
g. If area sticky, use soap to remove remaining neutralizer.

2. *All others*

a. Wipe up all residues from affected area.
b. Ensure there are no unsafe conditions present.

F. **Dispose of waste generated**

1. Seal debris from spill into plastic bag.
2. Seal lid on any broken glass containers and place into plastic bag with debris
3. Properly label waste
4. Submit an EH&S Chemical Waste Pickup request available online at http://www.ehs.uci.edu/programs/enviro/.

G. **Restock spill kit**

VII. BIOLOGICAL SPILL

A. **Don appropriate protective equipment**

B. **Minimum personal protective equipment for clean-up**:

1. Splash Goggles
2. Lab coat
3. Nitrile or neoprene gloves
4. In addition, respiratory protection may be required based on the infectious agent used

C. **Stop the source of the spill**

1. Place container in upright position
2. Place container on a polypropylene pad or paper towels in a safe location
3. Replace lid on container

D. **Control spread of any spilled biohazardous material**

1. Place polypropylene pads around spill
2. Use caution around broken glass and mechanical device (dustpan and broom or forceps) to pick-up

E. **Decontaminate and absorb free standing liquids**

1. Decontaminate the spill with a 10% bleach solution or other appropriate disinfectant for a 30-minute contact time
2. Dispose of all waste as medical waste in red biohazard bags
3. All medical waste must be decontaminated prior to disposal

Reference: American Chemical Society at: **http://membership.acs.org/c/ccs/pubs/spill_guide_online.htm**; September 2007.

Appendix L

Labeling of Hazardous Materials

I. SCOPE

This procedure applies to all students, staff, and faculty who in the course of their job duties, generate, accumulate, store, or handle hazardous materials within UCI.

II. RESPONSIBILITIES

It is the responsibility of all students, staff, and faculty who in the course of their job duties, generate, accumulate, store, or handle hazardous materials within UCI to follow this procedure.

III. PURPOSE

This procedure provides guidance for the proper labeling of hazardous material containers in order to protect students, staff, and faculty, and to assure compliance with all Federal, State and local regulations.

IV. PRACTICE

A. Labeling requirements for chemicals in the manufacturers' containers:

Cal/OSHA's Hazard Communication Standard requires that manufacturers provide chemical labels that indicate:

- Contents of the container
- Appropriate physical and health hazard warnings
- Name, address, and emergency phone number of the manufacturer

B. Labeling requirements for chemicals in non-manufacturer's container:

1. Labels must be complete, legible and permanent.

2. All non-manufacturer containers intended for use and storage of hazardous materials for more than immediate use should be appropriately labeled as follows:

Hazardous Material University of California, Irvine Irvine, CA 92697	
Prep Date:	
By:	
Chemical Name	Conc.

Health Hazard	Physical Hazard	Target Organ
☐ Carcinogen	☐ Combustible	☐ Lungs
☐ Toxic	☐ Compressed Gas	☐ Skin
☐ Highly Toxic	☐ Explosive	☐ Eyes
☐ Reproductive Toxin	☐ Flammable	☐ Nervous System
☐ Irritant	☐ Organic Peroxide	☐ Blood
☐ Corrosive	☐ Oxidizer	☐ Teratogen
☐ Sensitizer	☐ Air/Water Reactive	☐ Kidney
☐ Mutagen	☐ Unstable Reactive	☐ Liver

C. **Labeling requirements for hazardous waste containers:**

1. Labels must be complete, legible and permanent.
2. Labels must be placed on the hazardous waste container upon start of the accumulation.
3. All hazardous waste containers must be appropriately labeled as follows:

Hazardous Waste University of California, Irvine Irvine, CA 92697	
PI/Supv.	Ext.
Date Waste First Generated:	8/22/07
Transfer to EH&S Before:	2/18/08
Chemical Name	Conc.

Physical State		
☑ Gas	☐ Liquid	☐ Solid

Hazard Category		
☐ Flammable	☐ Corrosive	☐ Toxic
☐ Air/Water Reactive	☐ Oxidizer	☐ Explosive

TOC1 TOC2 Index1 Index2

D. **Hazardous Materials and Hazardous Waste labels can be obtained:**

1. By Internet at: http://www.ehs.uci.edu/programs/enviro/
2. By contacting EH&S at 824-4578

E. **For specific information on chemicals, consult a Materials Data Safety Sheet (SDS). A SDS can be obtained:**

1. By Internet at http://www.ehs.uci.edu/msds.html
2. By contacting the manufacturer
3. By contacting EH&S at 824-8791

Appendix M

Chemical Compatibility & Storage of Hazardous Materials

I. SCOPE

This procedure applies to all students, staff, and faculty who in the course of their job duties, generate, accumulate, store, or handle hazardous materials within UCI.

II. RESPONSIBILITIES

It is the responsibility of all students, staff, and faculty who in the course of their job duties, generate, accumulate, store, or handle hazardous materials within UCI to follow this procedure.

III. PURPOSE

This procedure provides guidance for the proper storage of chemicals in the laboratory in order to protect students, staff, and faculty, and to assure compliance with all Federal, State and local regulations.

IV. PRACTICE

A. The safe storage of chemicals is an essential part of a laboratory health and safety program. An effective chemical storage plan requires appropriate facilities, equipment and work practices. In addition to this procedure, each lab may have its own specific polices and procedures with which all employees should be familiar.

B. All chemicals and waste chemicals must be segregated into categories to prevent incompatible mixtures. The table provided below may be used when separating incompatible chemicals.

Hierarchy of Storage Groups	
1. Radioactive Material A1	11. Non Flammable - Non Toxic Gas G4
2. Explosive E1	12. Flammable Liquid F1
3. Herbicides P1	13. Oxidizers R1
4. All other Pesticides P2	14. Pyrophoric R4
5. Flammable - Toxic Gas G1	15. Water Reactive R3
6. Non Flammable -Toxic Gas G3	16. Reducers R2
7. Flammable - Non Toxic Gas G2	17. Corrosive Acid C1
8. Acetylene Gas G7	18. Corrosive Base B1
9. Oxygen/Oxidizer G6	19. Toxic Chemicals T1
10. Chlorine Gas G5	

Note: Group hierarchies are used to determine the placement of items in storage when more than one compatibility code applies.

Chemical Segregation: recommended storage by compatibility groups.

F1	C1	B1	R3	G6	G7	A1
E1	R2	T1	R1	R4	P1, P2	G 1-5

Note: Separate blocks mean separate storage locations.

(Excerpt from: "Hazardous Materials Storage and Handling Handbook," Defense Logistics Agency, Cameron Station, Alexandria, VA, 27 April 1984, pp. 45-46.)

C. **Chemical Storage**

- Chemicals must always be appropriately labeled. (See **APPENDIX L – Labeling of Hazardous Materials**).
- Mark storage areas according to the type of chemicals kept there (“Corrosive”, “Flammable”, etc.).
- Storage of hazardous waste in fume hoods or under sinks is not recommended.
- Keep storage areas clean, appropriately ventilated, and at a consistent cool temperature.
- Containers should always be closed when not in use.

D. **Chemical Waste Storage**

- The “Chemical Storage” requirements listed above remains applicable.
- Containers must be inspected weekly for signs of leaks, corrosion or deterioration.

- Containers must have secondary containment to adequately contain all of the contents of the container/spilled materials.
- Chemical waste must be transferred to EH&S for **disposal** within 6 months of being generated.
- Chemical waste that meets the following criteria, must be transferred to EH&S for disposal within 3 days of reaching the set volumes.

    - 55 gallons of hazardous waste.
    - 1 quart of acutely hazardous waste.
    - 1 quart of extremely hazardous waste.

E. **Empty Container Management-Containers That Once Stored Hazardous Materials**

Empty Containers

- Liquid hazardous material containers - no liquid can drain from it when tilted in any direction.
- Solid hazardous material containers (powder, sludge, grease, thick resin, crystals, etc.) - the walls of the container cannot contain any adhered or encrusted materials. Interior surfaces must be scraped clean so no build-up remains inside the container.

Empty Aerosol Containers

- An empty aerosol container must have its contents and pressure completely dispensed, the spray mechanism in place and functional, and must not have contained an extremely or acutely hazardous substance.

At no time should full or partially full containers or containers that do not comply with these instructions be placed in the regular trash.

EMPTY Container Disposal Table			
CONTAINER TYPE / SIZE	**UC Irvine Hazardous Waste Collection**	**Place In General Solid Waste Trash Bin**	**Return To Supplier**
Containers that held "extremely hazardous" or "acutely hazardous" substances	Required	No	No
Glass, Plastic, Fiber, or Metal Containers 5 Gallons or Less	No	Yes, deface the label.	No
All Containers Greater Than 5 Gallons	Required	No	No
Aerosol Cans	No	Yes	No
Lecture bottles and non-refillable cylinders	Required	No	No
Compressed Gas Cylinders (all sizes)	Required, if supplier will not accept returns.	No	Yes, if refillable (most lecture bottles are not refillable).

F. **Waste Minimization**

- Review each experimental protocol.
- Ensure that hazardous and radioactive reagents are used efficiently.
- Conduct micro-scale research when possible.
- Minimize amounts of hazardous materials used and generated.
- If possible, use substances that can be neutralized or stabilized either physically or chemically.
- Use radioactive materials that can be practically stored for decay (half-lives less than 90 days).
- Use less hazardous substitutes when feasible.

G. **Disposal of Hazardous Waste**

- Do not dispose of chemicals via sinks or trashcans.
- Do not use hoods to intentionally evaporate chemicals.
- Visit the Hazardous Waste Collection website at **http://www.ehs.uci.edu/programs/enviro/.**
- Click on "Chemical Waste Collection".
- Fill out and submit the on-line form.

Additional Resources: Flinn Scientific, Inc. at:
http://www.flinnsci.com/Sections/Safety/chemicalSafety/hazardousStorage.asp

Appendix N

Recommended Biosafety Levels

I. BIOSAFETY LEVEL 1

Biosafety Level 1 is suitable for work involving well-characterized agents not known to consistently cause disease in immunocompetent adult humans, and present minimal potential hazard to laboratory personnel and the environment. BSL-1 laboratories are not necessarily separated from the general traffic patterns in the building. Work is typically conducted on open bench tops using standard microbiological practices. Special containment equipment or facility design is not required, but may be used as determined by appropriate risk assessment. Laboratory personnel must have specific training in the procedures conducted in the laboratory and must be supervised by a scientist with training in microbiology or a related science.

The following standard practices, safety equipment, and facility requirements apply to BSL-1.

A. Standard Microbiological Practices

1. The laboratory supervisor 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 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 are present. The sign may include the name of the agent(s) in use, and the name and phone number of the laboratory supervisor or other responsible personnel. Agent information should be posted in accordance with the institutional policy.

10. An effective integrated pest management program is required. (See Appendix G.)

11. The laboratory supervisor 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.

B. Special Practices

None required.

C. Safety Equipment (Primary Barriers and Personal Protective Equipment)

1. Special containment devices or equipment, such as 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.

D. Laboratory Facilities (Secondary Barriers)

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.

II. BIOSAFETY LEVEL 2

Biosafety Level 2 builds upon BSL-1. BSL-2 is suitable for work involving agents that pose moderate hazards to personnel and the environment. It differs from BSL-1 in that: 1) laboratory personnel have specific training in handling pathogenic agents and are supervised by scientists competent in handling infectious agents and associated procedures; 2) access to the laboratory is restricted when work is being conducted; and 3) all procedures in which infectious aerosols or splashes may be created are conducted in BSCs or other physical containment equipment.

The following standard and special practices, safety equipment, and facility requirements apply to BSL-2.

A. Standard Microbiological Practices

1. The laboratory supervisor 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 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 are present. Posted information must include: the laboratory's biosafety level, the supervisor's name (or other responsible personnel), telephone number, and required procedures for entering and exiting the laboratory. Agent information should be posted in accordance with the institutional policy.

10. An effective integrated pest management program is required. (See Appendix G.)

11. The laboratory supervisor 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.

B. Special Practices

1. All persons entering the laboratory must be advised of the potential hazards and meet specific entry/exit requirements.

2. Laboratory personnel must be provided medical surveillance, as appropriate, and offered available immunizations for agents handled or potentially present in the laboratory.

3. Each institution should consider the need for collection and storage of serum samples from at-risk personnel.

4. A laboratory-specific biosafety manual must be prepared and adopted as policy. The biosafety manual must be available and accessible.

5. The laboratory supervisor must ensure that laboratory personnel demonstrate proficiency in standard and special microbiological practices before working with BSL-2 agents.

6. Potentially infectious materials must be placed in a durable, leak proof container during collection, handling, processing, storage, or transport within a facility.

7. Laboratory equipment should be routinely decontaminated, as well as, after spills, splashes, or other potential contamination.

   a. Spills involving infectious materials must be contained, decontaminated, and cleaned up by staff properly trained and equipped to work with infectious material.

   b. Equipment must be decontaminated before repair, maintenance, or removal from the laboratory.

8. Incidents that may result in exposure to infectious materials must be immediately evaluated and treated according to procedures described in the laboratory biosafety manual. All such incidents must be reported to the laboratory supervisor. Medical evaluation, surveillance, and treatment should be provided and appropriate records maintained.

9. Animal and plants not associated with the work being performed must not be permitted in the laboratory.

10. All procedures involving the manipulation of infectious materials that may generate an aerosol should be conducted within a BSC or other physical containment devices.

C. Safety Equipment (Primary Barriers and Personal Protective Equipment)

1. Properly maintained BSCs, other appropriate personal protective equipment, or other physical containment devices must be used whenever:

   a. Procedures with a potential for creating infectious aerosols or splashes are conducted. These may include pipetting, centrifuging, grinding, blending, shaking, mixing, sonicating, opening containers of infectious materials, inoculating animals intranasally, and harvesting infected tissues from animals or eggs.

   b. High concentrations or large volumes of infectious agents are used. Such materials may be centrifuged in the open laboratory using sealed rotor heads or centrifuge safety cups.

2. Protective laboratory coats, gowns, smocks, or uniforms designated for laboratory use must be worn while working with hazardous materials. Remove protective clothing before leaving for non-laboratory areas, e.g., cafeteria, library, and administrative offices). Dispose of protective clothing appropriately, or deposit it for laundering by the institution. It is recommended that laboratory clothing not be taken home.

3. Eye and face protection (goggles, mask, face shield or other splatter guard) is used for anticipated splashes or sprays of infectious or other hazardous materials when the microorganisms must be handled outside the BSC or containment device. Eye and face protection must be disposed of with other contaminated laboratory waste or decontaminated before reuse. 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. Gloves must not be worn outside the laboratory. In addition, BSL-2 laboratory 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.

5. Eye, face and respiratory protection should be used in rooms containing infected animals as determined by the risk assessment.

D. Laboratory Facilities (Secondary Barriers)

1. Laboratory doors should be self-closing and have locks in accordance with the institutional policies.

2. Laboratories must have a sink for hand washing. The sink may be manually, hands-free, or automatically operated. It should be located near the exit door.

3. The laboratory should be designed so that it can be easily cleaned and decontaminated. Carpets and rugs in laboratories are not permitted.

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. Laboratory windows that open to the exterior are not recommended. However, if a laboratory does have windows that open to the exterior, they must be fitted with screens.

6. BSCs must be installed so that fluctuations of the room air supply and exhaust do not interfere with proper operations. BSCs should be located away from doors, windows that can be opened, heavily traveled laboratory areas, and other possible airflow disruptions.

7. Vacuum lines should be protected with liquid disinfectant traps.

8. An eyewash station must be readily available.

9. There are no specific requirements for ventilation systems. However, planning of new facilities should consider mechanical ventilation systems that provide an inward flow of air without recirculation to spaces outside of the laboratory.

10. HEPA filtered exhaust air from a Class II BSC can be safely recirculation back into the laboratory environment if the cabinet is tested and certified at least annually and operated according to manufacturer's recommendations. BSCs can also be connected to the laboratory exhaust system by either a thimble (canopy) connection or directly exhausted to the outside through a hard connection. Provisions to assure proper safety cabinet performance and air system operation must be verified.

11. A method for decontaminating all laboratory wastes should be available in the facility (e.g., autoclave, chemical disinfection, incineration, or other validated decontamination method).

III. BIOSAFETY LEVEL 3

Biosafety Level 3 is applicable to clinical, diagnostic, teaching, research, or production facilities where work is performed with indigenous or exotic agents that may cause serious or potentially lethal disease through the inhalation route of exposure. Laboratory personnel must receive specific training in handling pathogenic and potentially lethal agents, and must be supervised by scientists competent in handling infectious agents and associated procedures.

All procedures involving the manipulation of infectious materials must be conducted within BSCs or other physical containment devices.

A BSL-3 laboratory has special engineering and design features.

The following standard and special safety practices, equipment, and facility requirements apply to BSL-3.

A. Standard Microbiological Practices

1. The laboratory supervisor 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 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. A method for decontaminating all laboratory wastes should be available in the facility, preferably within the laboratory (e.g., autoclave, chemical disinfection, incineration, or other validated decontamination 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 are present. Posted information must include the laboratory's biosafety level,

the supervisor's name (or other responsible personnel), telephone number, and required procedures for entering and exiting the laboratory. Agent information should be posted in accordance with the institutional policy.

10. An effective integrated pest management program is required. (See Appendix G.)

11. The laboratory supervisor 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.

B. Special Practices

1. All persons entering the laboratory must be advised of the potential hazards and meet specific entry/exit requirements.

2. Laboratory personnel must be provided medical surveillance and offered appropriate immunizations for agents handled or potentially present in the laboratory.

3. Each institution should consider the need for collection and storage of serum samples from at-risk personnel.

4. A laboratory-specific biosafety manual must be prepared and adopted as policy. The biosafety manual must be available and accessible.

5. The laboratory supervisor must ensure that laboratory personnel demonstrate proficiency in standard and special microbiological practices before working with BSL-3 agents.

6. Potentially infectious materials must be placed in a durable, leak proof container during collection, handling, processing, storage, or transport within a facility.

7. Laboratory equipment should be routinely decontaminated, as well as, after spills, splashes, or other potential contamination.

   a. Spills involving infectious materials must be contained, decontaminated, and cleaned up by staff properly trained and equipped to work with infectious material.

   b. Equipment must be decontaminated before repair, maintenance, or removal from the laboratory.

8. Incidents that may result in exposure to infectious materials must be immediately evaluated and treated according to procedures described in the laboratory biosafety manual. All such incidents must be reported to the laboratory supervisor. Medical evaluation, surveillance, and treatment should be provided and appropriate records maintained.

9. Animals and plants not associated with the work being performed must not be permitted in the laboratory.

10. All procedures involving the manipulation of infectious materials must be conducted within a BSC, or other physical containment devices. No work with open vessels is conducted on the bench. When a procedure cannot be performed within a BSC, a combination of personal protective equipment and other containment devices, such as a centrifuge safety cup or sealed rotor must be used.

C. Safety Equipment (Primary Barriers and Personal Protective Equipment)

1. All procedures involving the manipulation of infectious materials must be conducted within a BSC (preferably Class II or Class III), or other physical containment devices.

2. Workers in the laboratory where protective laboratory clothing with a solid-front, such as tie-back or wrap-around gowns, scrub suits, or coveralls. Protective clothing is not worn outside of the laboratory. Reusable clothing is decontaminated before being laundered. Clothing is changed when contaminated.

3. Eye and face protection (goggles, mask, face shield or other splash guard) is used for anticipated splashes or sprays of infectious or other hazardous materials. Eye and face protection must be disposed of with other contaminated laboratory waste or decontaminated before reuse. Persons who wear contact lenses in laboratories must 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. Gloves must not be worn outside the laboratory. In addition, BSL-3 laboratory workers:

   a. Changes gloves when contaminated, glove integrity is compromised, or when otherwise necessary. Wear two pairs of gloves when appropriate.

   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.

5. Eye, face, and respiratory protection must be used in rooms containing infected animals.

D. Laboratory Facilities (Secondary Barriers)

1. Laboratory doors must be self-closing and have locks in accordance with the institutional policies. The laboratory must be separated from areas that are open to unrestricted traffic flow within the building. Laboratory access is restricted. Access to the laboratory is through two self-closing doors. A clothing change room (anteroom) may be included in the passageway between the two self-closing doors.

2. Laboratories must have a sink for hand washing. The sink must be hands-free or automatically operated. It should be located near the exit door. If the laboratory is segregated into different laboratories, a sink must also be available for hand washing in each zone. Additional sinks may be required as determined by the risk assessment.

3. The laboratory must be designed so that it can be easily cleaned and decontaminated. Carpets and rugs are not permitted. Seams, floors, walls, and ceiling surfaces should be sealed. Spaces around doors and ventilation openings should be capable of being sealed to facilitate space decontamination.

   a. Floors must be slip resistant, impervious to liquids, and resistant to chemicals. Consideration should be given to the installation of seamless, sealed, resilient or poured floors, with integral cove bases.

   b. Walls should be constructed to produce a sealed smooth finish that can be easily cleaned and decontaminated.

   c. Ceilings should be constructed, sealed, and finished in the same general manner as walls.

   Decontamination of the entire laboratory should be considered when there has been gross contamination of the space, significant changes in laboratory usage, for major renovations, or

maintenance shut downs. Selection of the appropriate materials and methods used to decontaminate the laboratory must be based on the risk assessment.

4. Laboratory furniture must be capable of supporting anticipated loads and uses. Spaces between benches, cabinets, and equipment must 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. All windows in the laboratory must be sealed.

6. BSCs must be installed so that fluctuations of the room air supply and exhaust do not interfere with proper operations. BSCs should be located away from doors, heavily traveled laboratory areas, and other possible airflow disruptions.

7. Vacuum lines must be protected with HEPA filters, or their equivalent. Filters must be replaced as needed. Liquid disinfectant traps may be required.

8. An eyewash station must be readily available in the laboratory.

9. A ducted air ventilation system is required. This system must provide sustained directional airflow by drawing air into the laboratory from "clean" areas toward "potentially contaminated" areas. The laboratory shall be designed such that under failure conditions the airflow will not be reversed.

   a. Laboratory personnel must be able to verify directional airflow. A visual monitoring device, which confirms directional airflow, must be provided at the laboratory entry. Audible alarms should be considered to notify personnel of air flow disruption.

   b. The laboratory exhaust air must not re-circulate to any other area of the building.

   c. The laboratory building exhaust air should be dispersed away from occupied areas and from building air intake locations or the exhaust air must be HEPA filtered.

   HEPA filter housings should have gas-tight isolation dampers, decontamination ports, and/or bag-in/bag-out (with appropriate decontamination procedures) capability. The HEPA filter housing should allow for leak testing of each filter and assembly. The filters and the housing should be certified at least annually.

10. HEPA filtered exhaust air from a Class II BSC can be safely re-circulated into the laboratory environment if the cabinet is tested and certified at least annually and operated according to manufacturer's recommendations. BSCs can also be connected to the laboratory exhaust system by either a thimble (canopy) connection or directly exhausted to the outside through a hard connection. Provisions to assure proper safety cabinet performance and air system operation must be verified. BSCs should be certified at least annually to assure correct performance. Class III BSCs must be directly (hard) connected up through the second exhaust HEPA filter of the cabinet. Supply air must be provided in such a manner that prevents positive pressurization of the cabinet.

11. A method for decontaminating all laboratory wastes should be available in the facility, preferably within the laboratory (e.g., autoclave, chemical disinfection, or other validated decontamination method).

12. Equipment that may produce infectious aerosols must be contained in primary barrier devices that exhaust air through HEPA filtration or other equivalent technology before being discharged into the laboratory. These HEPA filters should be tested and/or replaced at least annually.

13. Facility design consideration should be given to means of decontaminating large pieces of equipment before removal from the laboratory.

14. Enhanced environmental and personal protection may be required by the agent summary statement, risk assessment, or applicable local, state, or federal regulations. These laboratory enhancements may include, for example, one or more of the following: an anteroom for clean storage of equipment and supplies with dress-in, shower-out capabilities; gas tight dampers to facilitate laboratory isolation; final HEPA filtration of the laboratory exhaust air; laboratory effluent decontamination; and advanced access control devices, such as biometrics.Laboratory Biosafety Level Criteria: BSL-4 45

15. The BSL-3 facility design, operational parameters, and procedures must be verified and documented prior to operation. Facilities must be re-verified and documented at least annually.

IV. BIOSAFETY LEVEL 4 (BSL-4)

Biosafety Level 4 is required for work with *dangerous and exotic agents that pose a high individual risk of aerosol-transmitted laboratory infections and life-threatening disease*. Agents with a close or identical antigenic relationship to Biosafety Level 4 agents are handled at this level until sufficient data are obtained either to confirm continued work at this level, or to work with them at a lower level. Members of the laboratory staff have specific and thorough training in handling extremely hazardous infectious agents and they understand the primary and secondary containment functions of the standard and special practices, the containment equipment, and the laboratory design characteristics. They are supervised by competent scientists who are trained and are experienced in working with these agents. The laboratory director strictly controls access to the laboratory. The facility is either in a separate building or in a controlled area within a building, which is completely isolated from all other areas of the building. A specific facility operations manual is prepared or adopted.

Within work areas of the facility, all activities are confined to Class III biological safety cabinets, or Class II biological safety cabinets used with one-piece positive pressure personnel suits ventilated by a life support system. The Biosafety Level 4 laboratory has special engineering and design features to prevent microorganisms from being disseminated into the environment.

BSL-4 research is not permitted at UCI.

V. ANIMAL BIOSAFETY LEVELS

See: http://www.cdc.gov/biosafety/publications/bmbl5/BMBL5_sect_V.pdf

Appendix O

Biosafety Cabinets

BIOSAFETY CABINET CHECKLIST

NOTE: Use of open flames inside biosafety cabinets is NOT RECOMMENDED**.**

	Preparing for Work in the Biosafety Cabinet
	Turn cabinet on for approximately three to five minutes to allow it to purge or remove any particulates in the cabinet.
	Disinfect the work surface, interior walls, and interior surface of window of the cabinet to reduce contamination of materials to be used in the cabinet. (Refer to Table 1 - *Table of disinfectants*.)
	Disinfect surfaces of materials and containers placed into the cabinet to minimize contamination of cultures.
	Place necessary materials in the biosafety cabinet before beginning work to minimize the number of arm movement disruptions across the fragile air barrier of the cabinet.
	Wear personal protective equipment such as lab coat, gloves, etc. to protect the worker from contact with biohazardous materials used in the cabinet.
	Ensure that the front grille of the cabinet is not blocked with any materials or equipment to allow cabinet to function properly.
	Adjust stool/seat height so that worker's face is above the front opening.
	Delay manipulation of materials for approximately one minute after placing hands/arms inside the cabinet to allow stabilization of air in the cabinet.
	Placement of Materials in the Cabinet
	Place plastic-backed absorbent toweling on the work surface, if desired. This facilitates routine cleanup and reduces splatter and aerosol formation during a spill. Absorbent toweling must be properly decontaminated prior to disposal.
	Place all materials as far back as practical, toward the rear edge of the work surface and away from the front grille of the cabinet to take advantage of the air split in the center of the cabinet.
	Arrange materials within the cabinet to allow active work to flow from the clean to contaminated area across the work surface. (Limit the movement of "dirty" items over "clean" items.) This reduces the potential for cross-contamination in the cabinet.
	Place bulky items such as biohazard bags, discard pipette trays, and suction collection flasks to one side of the interior of the cabinet to minimize risk of cross-contamination.
	Do not tape biohazard collection bag to the outside of the cabinet. Do not use upright pipette collection containers in the cabinet or place them on the floor outside the cabinet. Frequent inward and outward movement needed to place objects in these containers is disruptive to the integrity of the cabinet air barrier and can compromise personnel and product protection.
	Do not bring potentially contaminated materials out of the cabinet until they have been surface decontaminated or placed in a closeable container for proper decontamination.

	Operations within a Cabinet
	Follow good microbiological techniques when working in a cabinet. For example, techniques to reduce splatter and aerosol generation will minimize the potential for personnel exposure to infectious materials manipulated within the cabinet.
	Keep clean materials at least one foot away from aerosol-generating activities to minimize potential for cross-contamination.
	Clean opened tubes or bottles should not be held in a vertical position
	Petri dishes and tissue culture plates should not be held with lid above the open sterile surface to minimize direct impaction of downward air
	Bottle or tube caps should not be placed on the absorbent toweling on the work surface; items should be recapped or covered as soon as possible
	Do not use open flames in a cabinet. An open flame in a biosafety cabinet creates turbulence, which disrupts the pattern of air supplied to the work surface. Open flames are not required in the near microbe-free environment of a biosafety cabinet. If absolutely necessary, touch-plate microburners equipped with a pilot light to provide a flame on demand may be used. (Internal cabinet air disturbance and heat buildup will be minimized.)
	Connect aspirator bottles or suction flasks to an overflow collection flask containing appropriate disinfectant, and to an in-line HEPA or equivalent filter. This combination will provide protection to the central building vacuum system or vacuum pump, as well as to personnel who service this equipment. Aspirated materials are inactivated by placing sufficient chemical decontaminant solution into the flask to disinfect the microorganisms as they are collected.
	Decontamination of the Cabinet
	Decontaminate surfaces of all containers and equipment removed from the cabinet when work is completed.
	Wipe down the cabinet's work surface, sides, back, and interior of the glass at the end of the workday.
	Decontaminate biosafety cabinets before HEPA filters are changed or internal work is done and before cabinet is relocated. The most common method for this type of decontamination is the use of formaldehyde gas. An EH&S approved vendor must conduct this decontamination procedure. (See Following Section).
	Certification of the Cabinet
	All biosafety cabinets must be certified annually by an EH&S approved vendor to ensure that the performance of the unit meets the minimum standard specified in the National Sanitation Foundation (NSF) Standard 49 and the cabinet is functioning properly.
	The following is the EH&S approved vendor to certify OR decontaminate biosafety ventilation equipment. Make note to contact the vendor directly to schedule the certification or decontamination of a biosafety cabinet or laminar flow hood. The prices listed may not include labor.

TSS 7570 Trade Street San Diego, CA 92121 1-800-877-7742 www.techsafety.com	RECERTIFICATION		DECONTAMINATION
	Biosafety Cabinets	Laminar Flow Hoods	Biosafety Cabinets (Only as needed)
	$150	$50	$175

	Cabinets must be certified: · Upon initial installation, and prior to use · After moving the cabinet · After replacing the filters · At least annually

Table of Disinfectants

	Ethylene Oxide	Paraform-aldehyde (gas)	Quaternary Ammomium Cmpds.	Phenolic Cmpds.	Chlorine Cmpds.	Iodophor Cmpds.	Alcohol (ethyl or isopropyl)	Formalde-hyde	Glutaral-dehyde
USE PARAMETERS									
Conc. of active ingredient	400-800 mg/L	0.3 g/ft^3	0.1-2%	0.2-3%	0.01-5%	0.47%	70-85%	4-8%	2%
Temp. (□C)	35-60	>23							
Relative Humidity (%)	30-60	>60							
Contact Time (min.)	105-240	60-180	10-30	10-30	10-30	10-30	10-30	10-30	10-600
EFFECTIVE AGAINST									
Vegetative Bacteria	+	+	+	+	+	+	+	+	+
Bacterial Spores	+	+			±			±	+
Lipo Viruses	+	+	+	+	+	+	+	+	+
Hydrophilic viruses	+	+		±	+	±	±	+	+
Tubercle bacilli	+	+		+	+	+		+	+
HIV	+	+	+	+	+	+	+	+	+
HBV	+	+		±	+	±	±	+	+
APPLICATIONS									
Contaminated liquid discard					+			±	
Contaminated glassware	±		+	+	+		+	±	+
Contaminated instruments	±			+				±	+
Equipment total decontamination	±	+							

KEY: "+" denotes very positive response
"±" denotes a less positive response
Blank denotes a negative response or not applicable

Source:

Biosafety in the Laboratory, Prudent Practices for the Handling and Disposal of Infectious Materials, National Research Council, National Academy Press, Washington DC, 1989

Appendix P

Laboratory Fume Hoods

Fume Hood Training

As a user of laboratory fume hoods, you are required to be trained:

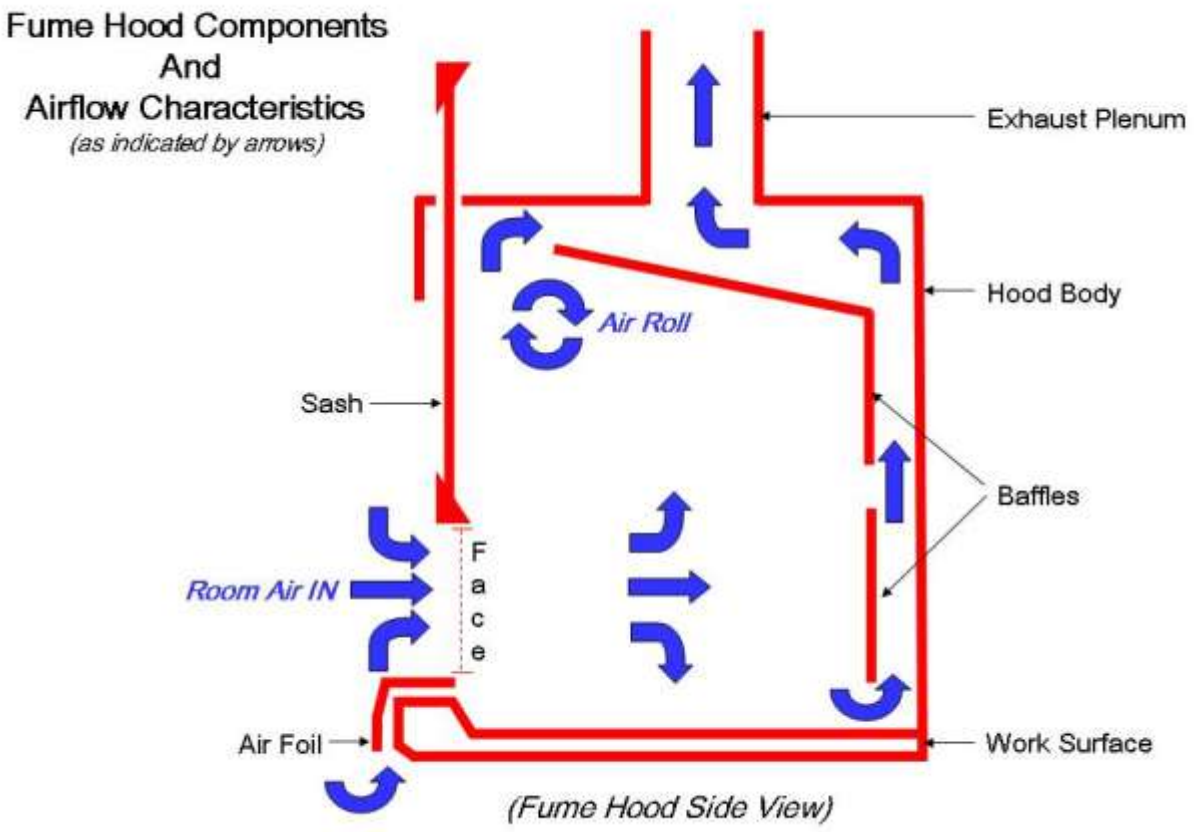
- To understand the general hood purpose, airflow characteristics, and potential for turbulent airflow and escape of hazardous substances from the hood;
- To use the hood and its features safely;
- To determine, if applicable, the date of the last performance testing and if the hood performance met the requirements of the test;
- To know where the quantitative airflow monitor or alarm system is located on the hood and how it is used to indicate an inward flow during hood operation.

The purpose of the laboratory fume hoods is to serve as the primary engineering control method for protection against the inhalation of hazardous vapors and gases. When used correctly, a fume hood minimizes a user's potential for exposure to airborne contaminants and prevents the contaminants from reaching the user's breathing zone. A fume hood can also provide protection from unanticipated fires, explosions, and chemical splashes.

The typical fume hood is comprised of the following components:

- **Hood body**- The "box" part of the chemical fume hood that encloses the hazardous vapors & gases
- **Sash** – A sliding glass door or panel on the front of the hood
- **Airfoil** – Generally found along the bottom "lip" of the hood (some fume hoods also have airfoils along the side). The airfoil affects air flowing into the hood to minimize turbulence. When the sash is completely closed, the airfoil also provides a path for makeup air from the room to enter the exhaust system. Removing the airfoil can cause turbulence and loss of containment
- **Work Surface** – The bench top within the fume hood where experiments take place. It can also be the floor for floor-mounted fume hoods.
- **Baffles** – The adjustable panels along the back of the hood body. Baffles keep the airflow uniform across the hood opening to eliminate dead spots and optimize capture efficiency
- **Exhaust plenum/duct** – The pathway for air leaving the fume hood. It also helps to distribute airflow evenly across the face of the hood.

- **Face** – The imaginary plane that runs from the bottom of the sash to the work surface. This plane is where the face velocity of the hood is measured.



There are several types of laboratory fume hoods found on the UCI campus. Regardless of type, the optimum airflow (or face velocity) of a fume hood is 80-120 feet per minute (fpm). This range allows the hood to properly contain and exhaust contaminants, reduces the chance for escape of fumes due to turbulence and outside air movement. Face velocities below 80 fpm are likely to allow contaminants to escape from the hood and face velocities above 120 fpm can cause excessive turbulence and can also allow contaminants to escape. Ask your laboratory manager, facility manager, or EH&S for the specific type in your work area.

- **Constant Air Volume (CAV)/ Conventional Hood** –The volume of airflow within this type of fume hood remains constant and all air enters through the sash opening. Lowering or raising the sash increases or decreases the velocity of the airflow, respectively. Setting the sash too low will result in very high face velocities. Raising the sash too high lowers face velocity, allowing contaminants to escape from the hood. Proper sash position is important in maintaining the optimum face velocity.

- **Bypass Hoods** – Essentially the same as a conventional/CAV hood, this type of fume hood has an air bypass above the sash that provides an additional source of room air when the sash is closed. The bypass area becomes exposed as the sash is lowered, which reduces the rate of increase in the face velocity and reduces the chance for turbulence and loss of containment. As with the conventional/CAV hoods, it is important to properly position the sash in order to maintain optimum face velocity.

- **Variable Air Volume (VAV)** – These sophisticated fume hoods have the ability to maintain a constant face velocity as the sash height is lowered or raised. The exhaust volume is adjusted when the sash is moved so that the average face velocity is maintained within set parameters. The sash of a VAV hood should be closed when not in use in order to conserve energy. Variable air volume (VAV) hoods are the most sophisticated of the hood types, requiring technically proficient design, installation and maintenance.

- **Perchloric Acid Hood** – Perchloric acid hoods are used when perchloric acid is to be used above ambient temperature or at concentrations above 72%. When heated above ambient temperature, perchloric acid will vaporize and may condense on hood, duct and fan components. The condensed vapors are highly corrosive and can react with hood gaskets, greases, and other collected materials to form explosive perchloric salts and esters. A perchloric acid hood is built with welded stainless steel hood surfaces, ductwork, and fan to minimize the corrosive and reactive effects. More importantly, perchloric acid hoods have a wash-down system of water fog nozzles dispersed throughout the hood and exhaust system. Washing down the hood following each use of heated perchloric acid removes any materials deposited within the system and prevents the buildup of hazardous perchlorates.

- **Ductless Hood** – These hoods filter air through HEPA or charcoal filters and then discharge the filtered air back into the laboratory. They may not be used without approval of the EH&S office.

While the laboratory fume hood is a very effective engineering control, it does not provide absolute containment or protection. The laboratory fume hood and its associated features must be used correctly in order to enhance the protection and safety of the user. The following work practices should be followed when using the fume hood:

- Conduct operations & experiments that generate air contaminants above the exposure limit inside a fume hood.

- Operate the hood at the proper sash height. This is indicated by an arrow on the yellow sticker affixed to the front side of the hood. When the sash is placed at the proper operating height, it will also provide a barrier against any unanticipated explosions, fires, spills, or splashes.

"Inspector's Sticker"

- Place apparatus a minimum of six inches back from the face of the hood.

- Do not place your head inside the hood when contaminants are being generated.

- Do not store excessive amounts of chemicals or apparatus in the hood since these items can greatly impair fume hood performance.

- Ensure that the fume hood is operational prior to use (A simple way to make sure that the hood is pulling in air is to tape a Kimwipe® to the bottom of the sash. If it is not pulled back towards the inside of the hood, it may not be on or may be broken.)

- Do not obstruct the slots of the baffles along the back of the hood. No more than 25% of the bottom slot should be blocked.

- Do not remove the fume hood sashes or panels except when it is necessary to set-up apparatus. They must be replaced before any operations begin.

- If there is a chance of explosion or eruption, use an appropriate barricade or shield.

- All chemical hoods should have spill protection lips along the front of the hood. If your hood has a cup sink, it should have a lip as well.

- If the hood sash is supposed to be partially closed for operation, the hood should be labeled as so. The appropriate closure point should be clearly indicated.

- It is suggested that all large equipment be elevated 1-2 inches above the working surface of the hood. This reduces the amount of baffle blockage and maintains the hoods performance.

Information on performance testing on the laboratory fume hood is also found on the yellow sticker affixed to the front of the fume hood. The stickers contain information on average face velocity, the date of the inspection/performance testing, the name of the inspector, and the next retest due date. Recently, some UCI fume hoods were subjected to further performance testing by an outside consultant to comply with changes in the regulations. These fume hoods were tagged accordingly by the consultant. If you have further interest, ask your laboratory manager, facility manager, or EH&S for the details of this testing.

The laboratory fume hoods also come with monitors or devices whose function is to provide the user of the hood with important information concerning airflow & face velocity. Monitors will alarm and alert the user when there is a problem with the airflow. There are several varieties of monitors and alarms installed at UC Irvine. Ask your laboratory manager, facility manager, or EH&S for the specific type and operating procedures for the monitors on your laboratory fume hood.

Appendix Q

Controlled Substances

The U.S. Department of Justice, Drug Enforcement Administration (DEA), cooperates with the State of California to control the acquisition and use of all controlled substances, which come under the jurisdiction of federal, and State of California Controlled Substances Acts. UCI has the responsibility for ensuring that all activities concerned with the acquisition, control, storage, reporting, and disposition of controlled substances are conducted in compliance with federal and state regulations and University policy. These guidelines apply to all campus activities, including those under contacts or grants.

I. CONTROLLED SUBSTANCES (DEFINITION)

Controlled substances are drugs, both narcotic and non-narcotic, which come under the jurisdiction of the Federal and State of California Controlled Substances Acts. There are five schedules of controlled substances (Schedules I, II, III, IV, and V). Certain precursor chemicals—those used in the manufacturing of controlled drugs—are controlled substances under these regulations.

In general terms the most addictive drugs with no currently accepted medical use are considered Schedule I, while a Schedule V substance is considered to have a low potential for abuse. Most controlled substances used on campus are Schedule II (Cocaine, Pentobarbitol) or Schedule III (Ketamine, Buprenorphine).

II. CONTROLLED SUBSTANCE GUIDELINES

A. Limit your inventory as feasible.

B. All employees, students, and faculty involved in the purchase, use, or transport of controlled substances must become an "Authorized User". Authorized Users must submit an Application for Controlled Substance Use and complete the on line training. See **www.ehs.uci.edu/programs/occhlth/control.html**.

C. Only those with Authorized User status on file with EHS can pick-up/deliver controlled substances to labs.

D. A complete signature audit trail must be maintained from purchase through final use or disposal.

E. Record must include the PIs name, drug name, strength, quantity used, balance remaining, and signatures of all individuals using or initiating the records. Researchers must utilize the CS Usage Log at **www.ehs.uci.edu/programs/occhlth/control.html**. Usage logs must adequately secured with the supply of controlled substances.

F. Regularly reconcile inventory records with physical inventory. EHS conducts an inventory every 2 years.

G. Expired on no longer needed drugs must be disposed of according to UCI policy. Submit the on-line Disposal Request form at **www.ehs.uci.edu/programs/occhlth/control.html**. EH&S staff will contact you to schedule a pick up of drugs.

H. Researchers must notify EHS and UCI police immediately if you suspect a loss or theft or a controlled substance.

I. Two (2) signatures must verify wastage of a controlled substance.

III. CONTROLLED SUBSTANCES POLICY

The University policies and procedures governing the acquisition and use of controlled substances are:

A. UCI Policy 903-15: Guidelines on Acquisition and Use of Controlled Substances and Precursor Chemicals in Research **http://www.policies.uci.edu/adm/procs/900/903-15.html**

B. EH&S **Controlled Substances Program**. This link provides training on approval, record keeping, disposal, and security requirements for the controlled substance program.

For additional information, contact the EH&S Office 824-6200.

UCI CONTROLLED SUBSTANCE PROGRAM

Effective 11/2011

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Record of Controlled Substances (II-V) Administered/Dispensed

One log sheet must be completed for each container of Controlled Substances

This grey section must be filled out upon receipt			PI's Name:	CSUA#:	Date Received:	Drug Name:
Unique Bottle ID # (assigned by laboratory):			Container Amount i.e 100 mg, 100 mL:		Lot or serial #:	
	Date	In Vitro/ /IACUC Protocol #	Authorized Personnel Name	Authorized Personnel Signature	Amount removed (units) from Original Vial i.e 100 mg, 100 mL	Balance (units)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

If this controlled substance is no longer needed, submit pick-up request www.ehs.uci.edu/ controlled substance.

- You must keep the original log sheet(s) in your files for 3 years either from the date of disposal or date of complete use. **Retain until:** ______________
- When this controlled substance is completely used up, request disposal of empty bottles at https://www.ehs.uci.edu/apps/waste/controlsub/cscollect.jsp & have copies of the log sheet available.
- All controlled substances and usage log sheets must be kept adequately secured in a proper drawer or safe.
- Any log discrepancies, suspected misuse, or theft of controlled substances must be reported immediately to EH&S 949-824-6200.
- Ensure Schedule II controlled substance inventory and records are maintained separately from Schedule III – V controlled substances.

Appendix R

Field Safety

The following checklist is provided for planning travel and events at
UC Irvine by researchers taking work related field trips. This will be replaced by a more thorough Field Safety Planning Tool being developed by the UC Field Safety Work Group under the charter of the UC EH&S Directors. The particular event or travel will determine as to which items apply as a program is developed.

Checklist for planning field trips safely
UC IRVINE

The following checklist is provided for planning travel and events at UC Irvine by researchers taking work related field trips. This will be replaced in due time by a more thorough Field Safety Planning Tool being developed by the UC Field Safety Work Group under the charter of the UC EH&S Directors. The particular event or travel will determine as to which items apply as a program is developed.

I. RESPONSIBILITIES AND PRINCIPLES

☐ Define the scope of activities and all the processes involved.

☐ Identify known hazards and associated risks with the activities and try to develop standard operating procedures and implement them. Contact UC Irvine Risk Management Coordinator Rick Coulon (**rcoulon@uci.edu**, 824-7419) for assistance in planning, insurance and waivers as needed.

☐ Consider safety training in specific areas of risk applicable to the event. Contact UC Irvine Environmental Health and Safety for assistance in obtaining training. Examples: Confined Space, Hazard communication, Respiratory protection, please visit – **www.uclc.uci.edu** for further information on training available.

II. PREPARATION ARRANGEMENTS

☐ Review and approve the composition of the field team in field research activities and accommodations that may be necessary at the site.

☐ Go to www.uctrips-insurance.org and complete UC Traveler Insurance Coverage form.

☐ Appoint group leaders and supervisors. Establish method of communication and train users.

☐ Do not allow working alone.

☐ Determine the appropriate clothing, personal equipment, and field equipment to support the research.

☐ Establish an emergency contingency plan and provide this information to the participants. Keep a copy in the department office.

☐ Advise participants to seek medical guidance and information from their health care provider regarding health and immunization needs and other preventive measures appropriate to the areas to be visited.

☐ Advise participants to contact their health care plan regarding medical coverage while in a foreign country to familiarize themselves with out-of-area coverage provisions, exclusions, and claims-filling procedures.

☐ Provide participants with applicable campus emergency contact phone numbers and e-mails.

☐ Have list of contacts, including police and hospital at destination.

☐ Provide itinerary to the home department including duration, destination and how the group can be contacted.

III. INITIAL FIELD ENTRY PROCEEDURES

☐ Identify local emergency medical, public safety, fire, and aid centers.

☐ Inform local police or ranger station.

☐ Check the different means of communication used in emergencies; cell phone, public phone, radio, etc.

☐ Confirm your arrival with the department office or other designate.

IV. TRANSPORTING PERSONNEL AND EQUIPMENT

☐ Check the local rules and requirements for safe driving.

☐ Determine needs for shipping and transporting tools and equipment; check rules for what may be admitted or denied, check on local regulations for sample items to be sent out of local areas.

☐ Review arrangement for transportation before, during, and after returning from the event location.

☐ Review Customs requirements and appropriate visa and identity papers that may be required. Some countries may require that you have your passport on your person at all time.

☐ Review **export licensing requirements** for restricted items, countries, and individuals.

V. HAZARDOUS MATERIALS SHIPPING

☐ Arrange for shipping and transportation of hazardous materials to and from your site.

☐ Finalize your list of hazardous materials that may be used in the field and need to be shipped. EH&S can provide guidance regarding proper shipment. It is unlawful to offer dangerous goods to commercial carriers unless you possess current certification of hazardous materials shipping training.

To get started please visit the Shipping Hazardous Materials pages at **http://www.ehs.uci.edu/programs/dgoods/index.html**.

Researchers must properly package and label all hazardous material. Furthermore, if offering hazardous materials packages to commercial carriers for shipment to your destination, you must complete Shipper's Declaration Forms. Failure to do so can result in injury, loss of research materials and civil or criminal charges and penalties. There are firms that specialize in packaging, labeling, and completing Shipper's Declarations for dangerous goods.

DOT policies are found in the U.S. code of Federal Regulations CFR title 49. DOT regulates transportation of hazardous materials by authority of the Hazardous Materials Transportation, Act (HMTA) of 1974.

DOT provides specific information on packaging, labeling, and declaring hazardous materials shipments at **http://hazmat.dot.gov/hazhome.htm**

☐ Review **export licensing requirements** for restricted materials, countries, and individuals.

VI. OTHER REFERENCES AND RESOURCES

- Powerpoint available from UC Irvine Environmental Health & Safety, call 824-6200.
- Federal Research Division - Country Studies
- Los Alamos: http://www.ees1.lanl.gov:80/Group/hcp_sop_fieldwork.html
- University of Toronto: http://www.ehs.utoronto.ca/resources/manindex/policies/fieldres.htm
- McMaster University: http://www.mcmaster.ca/policy/hlthsafe/field.htm
- Southhampton Univ.: http://www.soton.ac.uk/~imw/safety.htm
- Field Safety for Geologists Univ. of Derby http://people.man.ac.uk/~ukescc/products/safety.html
- Glen Kuban: htthttp://paleo.cc/kpaleo/palesafe.htm
- UCSB Diving Safety - http://ehs.ucsb.edu/units/diving/dsp/ucsbdsp.html

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Appendix S

Shipping of Dangerous Goods

Anyone packaging or shipping dangerous goods (such as infectious, biological, chemical, or radioactive materials) is required to receive special training or must be supervised by EH&S. For training requirements, visit **http://www.ehs.uci.edu/programs/dgoods/index.html**.

Shippers are directly responsible for the correct and legal transport of dangerous goods by surface or air. Anyone who packages or ships hazardous materials must contact EH&S at 824-6200.

Persons seeking to create fear or cause harm in the community may target packages of hazardous materials for theft or vandalism. Therefore, all packages of hazardous materials must be stored in a secured area until handed directly to the commercial courier personnel. Report suspicious activity & persons immediately to campus (911) or hospital security (714-456-5222).

The following persons can provide assistance in filling out the proper shipping papers and selection of packaging materials:

School of Physical Sciences Affiliates: PS Stores – 824-5889

All others:

Chemical shipment: Chemical Hygiene Officer - 824-5730
Infectious agents/biological specimens: Biosafety Officer - 824-9888
Radiological materials: Radiation Safety - 824-4862

Please contact EH&S at least one week prior to the shipment date of the material to ensure that the shipment will reach its destination in a timely manner.

Additional Resources:

Shipping Dangerous Goods **http://www.ehs.uci.edu/programs/dgoods/index.html**

Export Controls **http://www.research.uci.edu/ora/exportcontrol/index.htm**

EH&S School Coordinators **http://www.ehs.uci.edu/coord.html**

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Appendix T

Glossary of SDS Terms

A

- **action level** - exposure level at which (USA) OSHA regulations take effect. This is generally one-half of the PEL.
- **acute effect** - one which involves severe symptoms which develop rapidly and may quickly reach a crisis.
- **acute exposure** - a short-term exposure usually occurring at high concentration.
- **acute hazard** - one to which a single exposure may cause harm, but which is unlikely to lead to permanent damage.
- **acute health effect** - an effect that develops either immediately or a short time after exposure.
- **Allergic Contact Dermatitis** - type of skin hypersensitivity. Its onset may be delayed by several days to as much as several years, for weaker sensitizers. Once sensitized, fresh exposure to the sensitizing material can trigger itching and dermatitis within a few hours.
- **Ames Test** - used to assess whether a chemical might be a carcinogen. It assumes that carcinogens possess mutagenic activity, and uses bacteria and mammalian microsomes to determine whether a chemical is a mutagen. Approximately 85% of known carcinogens are mutagens. The Ames test, therefore, is a helpful but not perfect predictor of carcinogenic potential.
- **Argyria** or **Argyrism** - an irreversible bluish-black discoloration of the skin, mucous membranes or internal organs caused by ingestion of, or contact with, various silver compounds.
- **auto-ignition temperature** (of a chemical) - the lowest temperature at which the material will ignite without an external source of ignition.

B

- **breakthrough time** - the time taken in standard tests for permeation of a chemical through a protective barrier (such as a rubber glove) to be detected.
- **boiling point** - the temperature at which a liquid changes from a liquid to a gas, at normal atmospheric pressure.

C

- **carcinogen** - chemical known or believed to cause cancer in humans. The number of known carcinogens is comparatively small, but many more chemicals are suspected to be carcinogenic. A partial list of known and suspected carcinogens is located at **http://physchem.ox.ac.uk/MSDS/#Carcinogens**.

- **CAS Registry number** - a unique, identifying number assigned to a chemical by the Chemical Abstracts Service (CAS).
- **chemical formula** - sometimes called the molecular formula, indicates the elements that make up a chemical.
- **chemical name** - a proper scientific name for the active ingredient of a product.
- **chronic exposure** - a long-term exposure, usually occurring at low concentrations.
- **chronic hazard** - chemical which has the potential to cause long-term damage to health, often as a consequence of repeated or prolonged exposure to it.
- **chronic health effect** - an effect that appears a long time after exposure.
- **Chrysiasis** - development of a blue-grey pigmentation in skin and mucous membranes. May be caused by exposure to gold compounds.
- **coefficient of oil/water distribution** - the ratio of the solubility of the chemical in oil to its solubility in water. (see Partition Coefficient)
- **combustible liquid** - a liquid which has a flash point above 37.8 C (100° F).
- **compressed gas** - a material which is a gas at normal room temperature (*20 C*) and pressure but is packaged as a pressurized gas, dissolved gas or gas liquefied by compression or refrigeration.
- **condensation** - the process of reducing from one form to another denser form such as steam to water.
- **corrosive material** - a material that can attack (*corrode*) metals or cause permanent damage to human tissues such as skin and eyes on contact.
- **COSHH** (Control of Substances Hazardous to Health) - COSHH regulations impose a number of obligations on employers; the object of the regulations is to promote safe working with potentially hazardous chemicals.
- **cryogenics** - materials which exist at extremely low temperatures, such as liquid nitrogen.
- **cutaneous hazard** - a chemical which may cause harm to the skin, such as defatting, irritation, skin rashes or dermatitis.

D

- **degradation** - term generally used to describe the loss of resilience of material used for protective gloves. Degradation may cause the material to soften, swell, become hard and brittle, or - in severe cases - disintegrate.
- **density** - the weight of a material in a given volume. It is usually given in grams per milliliter (*g/ml*).
- **dilution ventilation** - dilution of contaminated air with uncontaminated air in a general area, room or building for the purposes of health hazard or nuisance control, and/or for heating and cooling.
- **dose** - amount of the agent that has entered the body through the various routes of entry.

- **D.O.T**. - Common abbreviation for the U.S. Department of Transportation, which regulates the transport of chemicals in the U.S.A.

- **DOT hazard codes**

1	Explosives
2.1	Flammable gas
2.2	non-flammable gas
2.3	Poisonous gas
3	Flammable liquid
4.1	Flammable solid
4.2	Spontaneously combustible
4.3	Dangerous when wet
5.1	Oxidizer
5.2	Organic peroxide
6.1	Poison- keep away from food
6.2	Infectious material
7	Radioactive
8	Corrosive
9	Miscellaneous

E

- **ED50** (Effective Dose 50) - the amount of material required to produce a specified effect in 50% of an animal population. (See qualification in the definition of LD50).

- **EINECS** - acronym for European Inventory of Existing Commercial Chemical Substances.

- **ELINCS** - acronym for European List of Notified Chemical Substances.

- **embryotoxins** retard the growth or affect the development of the unborn child. In serious cases they can cause deformities or death. Mercury compounds and certain heavy metals, aflatoxin, formamide and radiation are known embryotoxins.

- **etiologic agents** - microscopic organisms such as bacteria or viruses, which can cause disease.

- **evaporation rate** - the rate at which a liquid changes to vapor at normal room temperature.

- **explosive (flammable) limits** - the lower explosive (*flammable*) limit (*LEL*) is the lowest concentration of vapor in air which will burn or explode upon contact with a source of ignition. The upper explosive *(flammable*) limit (*UEL*) is the highest concentration of vapor in air which will burn or explode upon contact with a source of ignition.

- **explosive (flammable) range** - the range between the lower explosive limit (*LEL*) and the upper explosive limit (*UEL*).

-

- **exposure limits**- established concentrations which, if not exceeded, will not generally cause adverse effects to the worker exposed. Exposure limits differ in name and meaning depending on origin. For example:

  1. **PEL** Permissible Exposure Levels are legally enforceable exposure limits, set by OSHA. PELs are not available for all chemicals. Different exposure limits include:

     TWA *Time-Weighted Average*: The average airborne concentration of a biological or chemical agent to which a worker may be exposed in a work day or a work week.

     STEL *Short Term Exposure Level*: - The maximum airborne concentration of a chemical or biological agent to which a worker may be exposed in any 15 minute period, provided the TWAEV is not exceeded.

     CEILING *Ceiling Exposure Level:* The maximum airborne concentration of a biological or chemical agent to which a worker may be exposed at any time.

     SKIN: This notation indicates that direct or airborne contact with the product may result in significant absorption of the product through the skin, mucous membranes or eyes. Inclusion of this notation is intended to suggest that preventative action be taken against absorption of the agent through these routes of entry.

  2. Threshold Limit Values *(TLVs)* are exposure guidelines developed by the American Conference of Governmental Industrial Hygienists (ACGIH). They are not legally enforceable, but because they are updated regularly, they represent good professional practice. They are expressed as follows:-

     TLV-TWA *Threshold Limit Value - Time-Weighted Average:* The time-weighted average concentration for a normal 8 hour work day and a 40 hour work week, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.

     TLV-STEL *Threshold Limit Value - Short Term Exposure Limit:* a 15 minute time-weighted average exposure which should not be exceeded at any time during a work day even if the 8 hr TWA is within the TLV. Exposures at the STEL should not be repeated more than 4 times a day and there should be at least 60 minutes between successive exposures at the STEL.

     TLV-C *Threshold Limit Value - Ceiling:* the concentration that should not be exceeded during any part of the working exposure.

     Other exposure limits include the Permissible Exposure Limits (*PEL*) which are legal exposure limits in the United States.

- **eye hazard** – substances that affect the eye or visual capacity.

F

- **f/cc** - fibers per cubic centimeter of air.
- **FDA** - U.S. Food and Drug Administration.
- **flammable limits** - "See Explosive Limits".
- **flashback** - occurs when the flame in a gas torch burns back into the torch or hose; this is often accompanied by a hissing or squealing sound, and a pointed or smoky flame.
-

- **flash point** of a chemical is the lowest temperature at which a flame will propagate through the vapor of a combustible material to the liquid surface. It is determined by the vapor pressure of the liquid, since only when a sufficiently high vapor concentration is reached, can it support combustion. It should be noted that the source of ignition need not be an open flame, but could equally be, for example, the surface of a hot plate, or a steam pipe.

- **freezing point** - the temperature at which a liquid becomes a solid, at normal atmospheric pressure.

G

H

- **hazard**- the potential for harmful effects.

- **hazard codes** - see UN hazard codes.

- **hazardous decomposition products** - formed when a material decomposes (*breaks down*) because it is unstable, or reacts with materials such as water or oxygen in air.

- **hazardous polymerization** - Polymerization is a process of forming a polymer by combining large numbers of chemical units or monomers into long chains (*polyethylene from ethylene or polystyrene from styrene*). Uncontrolled polymerization can be extremely hazardous. Some polymerization processes can release considerable heat or can be explosive.

- **hematopoietic agent** - chemical which interferes with the blood system by decreasing the oxygen-carrying ability of hemoglobin. This can lead to cyanosis and unconsciousness. Carbon monoxide is one such agent, familiar to smokers.

- **hepatotoxin** - chemical capable of causing liver damage.

- **HSE** - Health and Safety Executive. The HSE web site can be reached through **http://www.hse.gov.uk/**. The HSE is responsible for proposing and enforcing safety regulations throughout UK industry and academia. Publications are available on a wide variety of safety-related issues.

- **hypoxia** - a condition defined by a low supply of oxygen.

I

- **inhibitor** - material which is added to a chemical to prevent an unwanted reaction. For example, BHT (2,6-di-t-butyl-p-cresol) is often added to tetrahydrofuran to prevent potentially dangerous polymerization.

- **ingestion** - means taking a material into the body by mouth (*swallowing*).

- **inhalation** - means taking a material into the body by breathing it in.

- **IARC** - International Agency for Research in Cancer. The IARC home page is at **http://www.iarc.fr/**

- **IOSH** - Institute for Occupational Safety and Health. IOSH has its home page at **http://www.iosh.co.uk/**

- **irritant** - chemical which may cause reversible inflammation on contact.

J

K

L

- **LC50 (Lethal Concentration 50)** - the concentration of a chemical which kills 50% of a sample population. This measure is generally used when exposure to a chemical is through the animal breathing it in, while the LD50 is the measure generally used when exposure is by swallowing, through skin contact, or by injection. (See also LD50).
  LD50 (Lethal Dose 50) - the dose of a chemical which kills 50% of a sample population. In full reporting, the dose, treatment and observation period should be given. Further, LD50, LC50, ED50 and similar figures are strictly only comparable when the age, sex and nutritional state of the animals is specified. Nevertheless, such values are widely reported and used as an effective measure of the potential toxicity of chemicals. (See also LC50).

- **LDLO** - Lethal Dose Low

- **LEL (Lower Explosive Limit)** - See "Explosive Limits".

- **local exhaust ventilation** - involves the capture of pollutants at the source.

- **lung hazard** – substances which irritate or damage the pulmonary tissue.

M

- **median lethal dose (MDL)** - see LD50.

- **MEL (Maximum Exposure Limit)** - the maximum permitted concentration of a chemical to which a worker may be exposed over an extended period of time. Typically, MELs are quoted in ppm for an 8-hour reference period, though shorter periods may be quoted for some materials. MELs are, in many countries, enforceable by law. A list of chemicals for which MELs are defined in the UK is held at **http://physchem.ox.ac.uk/MSDS/mels.html**

- **melting point** - the temperature at which a solid material becomes a liquid.

- **MSDS** - a widely used abbreviation for Material Safety Data Sheet, which contains details of the hazards associated with a chemical, and gives information on its safe use. Term changed to Safety Data Sheet (SDS).

- **mutagen** - an agent that changes the hereditary genetic material which is a part of every living cell. Such a mutation is probably an early step in the sequence of events that ultimately leads to the development of cancer.

N

- **NA Number** - See "UN number".

- **NIOSH** (National Institute for Occupational Safety and Health)- sets OELs and provides services in occupational health and safety investigations in the USA. The NIOSH home page is at **http://www.cdc.gov/niosh/**

- **nephrotoxin** - a chemical which may cause kidney damage. Common examples include antimony compounds, dimethyl sulphoxide, dimethylformamide and tetrahydrofuran.

- **neurotoxin** - chemical whose primary action is on the CNS (Central Nervous System). Many neurotoxins, such as some mercury compounds, are highly toxic, and must only be used under carefully-controlled conditions.

- **nuisance material** is one which can cause transient irritation or discomfort, but which has no long-term or systemic effects.

O

- **OEL (Occupational Exposure Limit)** - A (generally legally-enforceable) limit on the amount or concentration of a chemical to which workers may be exposed.
- **odor threshold** - the lowest airborne concentration, usually in part per million, of a vapor in air which can be detected by smell.
- **OES** - Occupational Exposure Standard
- **oxidizing material** - gives up oxygen easily or can readily oxidize other materials.

P

- **partition coefficient**
- **PEL (Permissible Exposure Limit)** - a time-weighted average (TWA) or absolute value (usually prescribed by regulation) setting out the maximum permitted exposure to a hazardous chemical.
- **peroxidizable materials** can form peroxides in storage, generally when in contact with the air. These peroxides present their most serious risk when the peroxide-contaminated material is heated or distilled, but they may also be sensitive to mechanical shock. The quantity of peroxides in a sample may be determined using a simple peroxide test strip.
- **pH** - a measure of the acidity or passivity (*alkalinity*) of a material when dissolved in water.
- **Photoallergic Contact Dermatitis** - a skin condition brought on by exposure to light following skin contact with certain types of chemicals, such as sulphonamides.
- **Pictographs** - widely-used pictorial representations of the hazards presented by chemicals.
- **Poison Class A or B** - classified by the DOT into two classes. Those in Class A are highly toxic materials which, even in very small quantities, present a hazard to life. Examples of such gases are cyanogen, phosgene and hydrocyanic acid. Class B poisons, though less toxic, are presumed to present a serious threat to health during transportation.
- **polymer** - a natural or man-made material formed by combining units, called monomers, into long chains.
- **polymerization** - a process of forming a polymer by combining large numbers of chemical units or monomers into long chains.
- **PPB (Parts Per Billion)** - used to specify the concentration (by volume) of a gas or vapor at very low concentration, or a dissolved material at high dilution.
- **PPM (Parts Per Million)** - used to specify the concentration (by volume) of a gas or vapor at low concentration, or a dissolved material at high dilution.
- **pulmonary hazard** – substance which irritates or damages the lung tissue

- **pyrophoric materials** ignite spontaneously in air. Since a wide variety of chemicals will burn if heated sufficiently, it is usual to define a pyrophoric material as one which will ignite spontaneously at temperatures below about 45 C.

Q

R

- **reactive materials** - materials that may undergo vigorous condensation, decomposition or polymerization. They may react violently under conditions of shock or increase in pressure or temperature. They may also react vigorously with water or water vapor to release a toxic gas.
- **reproductive toxin** - (such as vinyl chloride or PCBs) - a chemical which may cause birth defects or sterility.
- **risk phrases**, coded in the form R34, R61 etc are now included in SDS sheets for chemicals purchased in the UK. A list of the meaning of these codes is available at **http://physchem.ox.ac.uk/MSDS/risk_phrases.html**
- **RTECS number** - A substance's identification number set by the US Registry of Toxic Effects of Chemical Substances. For further information, connect to the RTECS home page at **http://www.cdc.gov/niosh/rtecs.html**

S

- **SDS** - a widely used abbreviation for Safety Data Sheet, which contains details of the hazards associated with a chemical, and gives information on its safe use. Formerly Material Safety Data Sheet (MSDS).
- **sensitization** - the development, over time, of an allergic reaction to a chemical.
- **sensitizer** - a chemical which may lead to the development of allergic reactions after repeated exposure.
- **solubility** - the ability of a material to dissolve in water or another liquid.
- **solvent** - a material which is capable of dissolving another chemical.
- **specific gravity** - the density of a liquid compared to the density of an equal amount of water.
- **stability** - the ability of a material to remain unchanged in the presence of heat, moisture or air.
- **STEL (Short Term Exposure Limit)** - the maximum permissible concentration of a material, generally expressed in ppm in air, for a defined short period of time (typically 5 minutes). These values, which may differ from country to country, are often backed up by regulation and therefore may be legally enforceable.
- **systemic poisons** have an effect which is remote from the site of entry into the body.

T

- **target organ** - a tissue or organ that is affected by a specific hazard. Examples: kidneys, liver, nervous system, blood, lungs, reproductive organs, eyes, skin.
- **TD50** - TD50 may be defined as follows: for a given target site(s), if there are no tumors in control animals, then TD50 is that chronic dose-rate in mg/kg body wt/day which would induce tumors in half the test animals at the end of a standard lifespan for the species. Since the tumor(s) of interest often does

occur in control animals, TD50 is more precisely defined as: that dose-rate in mg/kg body wt/day which, if administered chronically for the standard lifespan of the species, will halve the probability of remaining tumorless throughout that period. A TD50 can be computed for any particular type of

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neoplasm, for any particular tissue, or for any combination of these. The range of statistically significant TD50 values for chemicals in the CPDB that are carcinogenic in rodents is more than 10 million-fold.

- **teratogen** - chemical which may cause genetic mutations or malformations in the developing fetus. Agents or compounds that a pregnant woman takes into her body that generate defects in the fetus.

- **TLV (Threshold Limit Value)** - the maximum permissible concentration of a material, generally expressed in parts per million in air for some defined period of time (often 8 hours). These values, which may differ from country to country, are often backed up by regulation and therefore may be legally enforceable. See "Exposure Limits".

- **TLV-C (ceiling exposure limit)** - an exposure limit which should not be exceeded under any circumstances.

- **toxicity** - ability of a substance to cause harmful effects.

- **trade name** - the name under which a product is commercially known.

- **TSCA (Toxic Substances Control Act)** - regulates the manufacture, transport and use of toxic substances in the USA.

- **TWA (Time Weighted Average)** - term used in the specification of Occupational Exposure Limits (OELs) to define the average concentration of a chemical to which it is permissible to expose a worker over a period of time, typically 8 hours. See "Exposure Limits"

U

- **UEL (Upper Explosive Limits)** - See "Explosive Limits".

- **UN Hazard codes**

Class 1	Explosive
Class 2	Gases
Class 3.1	Flammable liquids, flash point below -18C
Class 3.2	Flammable liquids, flash point between -18C and 23C
Class 3.3	Flammable liquids, flash point between 23C and 61C
Class 4.1	Flammable solids
Class 5.1	Oxidizing agents
Class 5.2	Organic peroxides
Class 6.1	Poisonous substances
Class 7	Radioactive substances
Class 8	Corrosive substances

Class 9 Miscellaneous dangerous substances

NR Non-regulated

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- **UN Number** - a four digit number assigned to a potentially hazardous material or class of materials. UN (*United Nations*) numbers are internationally recognized and are used by fire fighter and other emergency response personnel for identification of materials during transportation emergencies. NA (*North American*) numbers are assigned by Transport Canada and the US

  Department of Transport to materials they consider hazardous and to which a UN number has not been assigned.

V

- **vapor** - a gaseous form of a material which is normally solid or liquid at room temperature and pressure.
- **vapor density** - the density of a vapor compared to the density of an equal amount of air.
- **vapor pressure** - the pressure of a vapor in equilibrium with its liquid or solid form.
- **ventilation** - the movement of air.
- **vesicant** - a chemical which, if it can escape from the vein, causes extensive tissue damage, with vesicle formation or blistering.
- **VOCs** -Volatile Organic Compounds.
- **volatility** - the ability of a material to evaporate.

W

XYZ

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Environmental Health & Safety

Administrative & Business Services
UC Irvine, 4600 Health Sciences Road
Irvine, CA 92697-2725

EMERGENCIES

Fire	Dial 911
Medical Emergency	Dial 911
Chemical Spills	824-6200, after hours 911
Radiation Incident	824-6200, after hours 911
Safety Incidents	824-6200, after hours 911
Student Health Services	824-5301
Maintenance Emergency (Campus)	824-5444
Maintenance Emergency (UCIMC)	(714) 456-5700
Poison Control	1-800-876-4766
UCI Emergency Information (Activated only during a disaster)	1-866-IRV-NEWS
UCI Police from Cell Phone/Non-Campus Phone	949-824-5223
UCI Medical Center Emergencies	714-456-6123/5222

EH&S Information	**824-6200**
EH&S Coordinator School of Biological Sciences	824-2221
EH&S Coordinator School of Medicine	824-4660
EH&S Coordinator School of Engineering	824-9850
EH&S Coordinator Physical Sciences	824-2518
Asbestos & Lead Information	824-8791
Biosafety & Bloodborne Pathogens	824-9888
Chemical Hygiene Officer	824-5730
Controlled Substances	824-3757
Ergonomics	824-9524
Emergency Management Information	824-7147
Environmental Protection Information	824-2188
Fire Safety Information & Assistance	824-4077
Food & Water Sanitation	824-4170
General Safety	824-9940
Hazardous (Chemical, Radioactive, Biological) Waste Pick-up	824-4578
Industrial Hygiene (Exposure, Ventilation) Information	824-8342
Injury & Illness Prevention Program (SOS Program)	824-6982
Laboratory Safety Information & Assistance	824-5730
Laser Safety Information & Assistance	824-6098
Medical Center Safety Officer	714-456-6738
MSDS (SDS) Information	824-4817
Occupational Health & Surveillance	824-3757
Personal Protection Equipment	824-5730
Radiation Safety Information & Assistance	824-1081 or 824-8772
Radioactive Shipments	824-7100
Respiratory Protection Program	824-4817
Training Information & Assistance	824-6634

Anonymous Hazard Reporting: To anonymously report a hazard or health and safety concern, call 949-824-6200, or email safety@uci.edu. If you are concerned about the caller ID system, consider using a pay phone.

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