



UNIVERSITY OF CALIFORNIA
SANTA BARBARA

UCSB LABORATORY SAFETY MANUAL and CHEMICAL HYGIENE PLAN

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Acknowledgements: thanks to the following for their assistance and expertise in compiling this manual:

MANUAL DESCRIPTION

MANUAL PURPOSE - this manual serves two basic purposes:

1. It is the basic laboratory safety manual for UCSB
2. Serves as the campus **Chemical Hygiene Plan (CHP)** as required by the *California Occupational Safety and Health Administration (Cal-OSHA)*. In short, OSHA requires that a written chemical safety plan address the policies and procedures that an employer has in place to minimize the exposure of its lab employees to chemicals. Workers are required to receive documented training on their CHP. A full summary of the OSHA standard is in Sec. III.

For **lab supervisors**, the most important portion of this manual (Section I) contains links to *Standard Operating Procedures (SOP)* templates for developing their **required Lab-specific Chemical Hygiene Plan**.

MANUAL STRUCTURE

- **Section I: Introduction and Lab-specific Chemical Hygiene Plan.** Forms and templates for customizing your CHP with SOPs and other local information. Links to other lab safety programs.
- **Section II: UC & UCSB policies, procedures and resources.** Summaries of key/core lab safety issues that apply to most/all laboratories. Primarily based on specific OSHA requirements.
- **Section III: Regulatory Framework.** Overview of the OSHA CHP Standard; specific University policies relative to the Lab Standard; roles and responsibilities of UCSB personnel in the program.

OTHER UCSB RESEARCH SAFETY PROGRAMS / REGULATIONS

Given the breadth of research at UCSB, there are other campus safety programs and regulations that can apply to a given operation. In the interests of keeping this manual shorter, more specialized programs are not directly included herein. Instead, links to these programs are provided below and affected individuals should contact these program managers for further information.

[Injury and Illness Prevention Program](#)

The “umbrella” OSHA-required worker safety program that applies to all campus workers, regardless of work activities. Elements include: designation of individuals with the

authority/responsibility for program (Chairs, Directors, etc.); documented safety training and inspections; injury investigation; safety communication to workers, etc. There is significant overlap between IIPP elements and this manual as relates to lab work, particularly the training and inspection components.

[Biological Safety Program](#): Biological Use Authorizations; Aerosol Transmittable Diseases; Bloodborne Pathogens; Medical Waste Management

[Radiation Safety Program](#):

Oversight of radioactive materials; radiation-producing machines and lasers

[Hazard Communication Standard Program](#)

Safety Data Sheets (formerly MSDS); chemical labeling

(for labs, much of the HazCom program is superseded by the CHP program – see SDS pg. in Sec. II)

[Research Diving and Boating Safety Program](#)

Oversight of research projects involving SCUBA and small boats

[Controlled Substance Program](#)

Oversight of research activities using State/Federal regulated narcotic and non-narcotic drugs

[Fire Protection Programs](#)

Includes fire extinguisher training for lab workers, oversight and inspections of fire alarms, sprinklers and other fire protection infrastructure, plus State Fire Marshal approval of plans for lab construction.

[Animal Care and Use](#)

Oversight of care and use of animals used in campus research activities

[Respiratory Protection Program](#) (see pg. II-9)

[Confined Space Program](#)

Campus/OSHA requirements and procedures for entering Permit Required Confined Spaces

[Indoor Air Quality Program](#)

Response to concerns regarding IAQ within and around campus buildings, especially as relates to health and comfort of building occupants

[Hearing Conservation Program](#)

Personnel exposed to occupational noise levels exceeding an 8-hr time-weighted average of 85 dBA must be enrolled in this UCSB/OSHA program

[Heat Illness Program](#)

Establishes campus/OSHA requirements and procedures for individuals who perform outdoor work

Ergonomics Program

Assessments and trainings designed to analyze and evaluate an employee's workspace, equipment, body mechanics, posture, and work flow to promote a more efficient, productive worker and prevent musculoskeletal injuries.

Directions to Customize Your Laboratory-Specific CHP

1. Develop applicable Standard Operating Procedures (SOP). This is the key step.
 - A. **Determine Which SOPs You Need.** [Compare your chemical stocks](#) and lab processes against the [UCSB Standard Operating Procedures Library](#) to see which SOPs you need. In short, per OSHA, "[hazardous chemicals](#)" require an SOP. The library is not comprehensive, but should cover the majority of SOPs needed on campus. SOPs can be based on any of the following as suits your needs:
 - a group of chemicals of similar hazard and control (e.g., acids, carcinogens)
 - a specific chemical, (e.g., formaldehyde)
 - a laboratory process involving chemicals (e.g., distillation)
 - non-chemical processes of concern due to their inherent risk (optional)

Alternatives, if SOPs in the UCSB online library are deemed insufficient:

- EH&S has access to more SOPs from other UCs upon request
- Use blank SOP templates from the SOP library above to create your own SOP

If you have materials you never use, an SOP is not necessary. Unwanted materials can be disposed of free via EH&S, except from teaching labs.

- B. **Customize SOPs Selected from Library to your Lab.** This generally means only completing the sections in red. However, you can/should add more information, if deemed [necessary to protect workers](#). Two of the red-marked sections are sometimes *not* applicable. However, the *Laboratory Specific Information* section is **mandatory** to generate an OSHA-compliant SOP. In many cases this can be satisfied by just a few sentences: [Examples](#).
2. Add completed SOPs to the end of CHP Sec. I (this section).
 3. On next page the PI/supervisor needs to certify/sign that their CHP/SOPs have been approved.
 4. Assemble the above pieces, plus Secs. II and III ([EH&S-provided](#)). Store electronically and/or in the EH&S-provided binder.

5. Ensure your workers have reviewed the sections below and have ready-access to the Plan.

Document the worker reviews on pg. I-6

- your customized SOPs in Sec. I
- Sec. II which covers universal/core lab safety issues (EH&S provided)

CHEMICAL HYGIENE PLAN: CERTIFICATION PAGE

Laboratory PI or Supervisor Name: Umesh Mishra

Applicable Laboratory Location(s) (Buildings /Rooms):

ESB 2313

Date of Last Review of *Chemical Hygiene Plan with Standard Operating Procedures*:

(OSHA mandates Plan be updated as needed, but with minimum of **annual** review)

Laboratory PI or Supervisor Signoff (required). I certify that I have reviewed and approve the attached Laboratory-specific *Chemical Hygiene Plan with Standard Operating Procedures* for my above laboratory locations.

Signature: _____

[This page and the next page will probably need periodic updates with signatures. Therefore, it may be preferable to maintain separate hard copies of these two pages.]

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**[Required: please add your customized Lab-specific Standard
Operating Procedures here, per instructions on pg. I-4]**

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High-frequency Measurement (HFM) Lab Information

General Lab Information

Laboratory location:

Engineering Science Building (ESB, bldg. #225)
Room 2313 (2nd floor)

Laboratory supervisors (PIs):

Professor Umesh Mishra
Email: Mishra@ece.ucsb.edu
Office: ESB 2215C
Phone: (805) 893-3586

Dean Bob York
Email: rayork@ece.ucsb.edu
Office: Kerr Hall 2150A
Phone: (805) 893-2944

Laboratory Manager:

Matt Guidry
Email: mguidry@ece.ucsb.edu
Office: ESB 2213
Phone: (805) 893-5936

Department Safety Representative

Paul Gritt
Email: paulg@ece.ucsb.edu
Office: Harold Frank Hall
Phone: (805) 893-5775

Safety Information

All users are required to take UCSB's Fundamentals of Laboratory Safety online training or live safety training before obtaining access to the lab, and to have read and be familiar with all campus lab safety and hazardous waste policies as documented in this document.

A lab specific safety orientation will be conducted by the lab manager or other delegate once per month. All lab uses must attend this before access to the lab will be granted.

Location of department safety bulletin board:

- **2nd floor in the middle of the hallway by the restrooms**

First Aid kit:

- **On the counter next to the entry door**

Fire extinguisher:

- **asdf**

Safety references:

- UCSB Campus Emergency Flip Chart
- Laboratory Chemical Hygiene plan
- Material Safety Datasheets (MSDS)

Location

asdf
Lab safety binder, on counter next to sink
In the safety binder, on counter next to sink

Chemical shower

- **asdf**

Emergency Information

Evacuation procedures:

- Leave the lab immediately

In case of fire:

- Small fires may be extinguished using the fire extinguisher
- Call fire department by dialing 9-911 on lab phone. All fires including those extinguished MUST be reported per policy.

In case of injury:

- For serious injuries call emergency services by dialing 9-911 on the lab phone or 911 on a cell phone.
- All serious injuries must be documented via the *UCSB Report of Injury to Employee/Student form* as soon as practical.

Cryogenics

CRYOGENS (LIQUID NITROGEN, LIQUID HELIUM, DRY ICE) STANDARD OPERATING PROCEDURE

Type of SOP: Process Hazardous Chemical Hazard Class

HAZARD OVERVIEW

These materials – liquid nitrogen, liquid helium and dry ice - are extremely cold (-100°C to -270°C) and, upon contact, can instantly freeze other materials. Serious tissue damage may occur upon exposure.

Evaporating liquid nitrogen or sublimating dry ice (carbon dioxide) will displace the air within a non-ventilated space possibly leading to **suffocation**. Generally, labs have adequate ventilation to prevent this, but do not work in a confined space with these materials. Note that individuals have died when working in a non-ventilated lab “cold room” where large quantities of dry ice were stored. The OSHA ceiling *Permissible Exposure Limit* for carbon dioxide is 30,000 ppm.

Be aware of ice that can plug or disable pressure-relief devices. Ensure adequate pressure relief mechanisms are functional, i.e., never use tight-fitting stoppers or closures without pressure-relief devices.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Special insulated gloves for working with cryogenics should be employed. General PPE information is under Sec. II of the *UCSB Chemical Hygiene Plan* regarding:

- the UC PPE Policy and policy summary (what a PPE is needed and when/where to use)
- obtaining your PPE via use of the *Laboratory Hazard Assessment Tool*
- glove selection criteria
- respirator use, etc.

ENGINEERING/VENTILATION CONTROLS

Always work in a well-ventilated area with cryogenics to prevent oxygen displacement. Even with dry ice there has been a lab fatality when an individual worked in a “cold room” that did not have any ventilation provided. For this reason, liquid cryogenics should also not be transported on an occupied public elevator.

For further information see these pages in Sec. II of the *UCSB Chemical Hygiene Plan*:

- Fume Hood Usage Guide
- Criteria for Implementing Engineering Controls

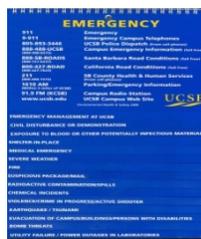
SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

- Do not move an **over-pressurized container**. Evacuate and seal area, call EH&S (x3194) or dial 911.
- Avoid trapping cryogenic liquids between closed sections of an apparatus.
- **Dewar flasks** or other glassware devices should be taped on the outside or provided with shatterproof protection to minimize flying glass particles in case of implosion. Dewar flasks should be vented with a bored or notched stopper.
- Cool cryogenic containers slowly to reduce thermal shock and flashing of the material.
- When utilizing cold baths (cryogen + organic solvent), use in a hood with a catch pan. Be aware of increased fire hazard. Be prepared for **vigorous solvent boiling** upon initial addition of solvent.
- Avoid **condensing oxygen** (blue in color) and/or its contact with organic material when using liquid nitrogen. Flush cold traps with nitrogen or keep under vacuum to avoid condensation of oxygen from air within the trap. Condensed oxygen when contacted with organic materials can cause a powerful explosion.
- To avoid condensing oxygen from the air with liquid nitrogen/helium, check glassware and valves for cracks and other defects before beginning experimental work. Verify that systems assumed to be under vacuum are so by checking vacuum gauges regularly. You should be on the lookout for the possibility of condensed air within the apparatus.
- Storage of liquid nitrogen: use only approved low temperature containers. Make sure liquid nitrogen containers are vented to prevent pressure buildup. You must use extreme care when working with liquid nitrogen. Liquid nitrogen should not be stored in sealed containers, as tremendous pressure could result and an explosion is likely.
- **Liquid helium** requires specialized handling techniques and equipment due to over-pressurization hazards and icing.

SPILL AND INCIDENT PROCEDURES

Flood the area (skin and eyes) immediately with large quantities of cool water. See a doctor immediately if the skin is blistered or if the liquid nitrogen came in contact with your eyes.

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the *UCSB Emergency Information Flipchart* – should already be posted in all labs.



WASTE DISPOSAL

Not applicable to cryogenics – let evaporate. However, low-temperature baths such as those made from dry ice and acetone, do need to have the solvent disposed of properly. See “Chemical Waste” pages in Sec. II of the *UCSB Chemical Hygiene Plan*.

PRIOR APPROVAL/REVIEW REQUIRED

Any user wishing to use the Lakeshore cryogenic probe station should contact the lab manager.

DESIGNATED AREA AND PURPOSE

Liquid nitrogen may only be used with the Lakeshore probe station for its standard use, and not for any other purpose.

FURTHER INFORMATION

Safety Data Sheets (MSDS) found online at: <http://ehs.ucsb.edu/labsafety/msds>

Prudent Practices in the Laboratory (National Research Council): [Liquidified Gases and Cryogenic Liquids \(http://www.nap.edu/openbook.php?record_id=12654&page=172\)](http://www.nap.edu/openbook.php?record_id=12654&page=172)

LAB-SPECIFIC PROTOCOL (required)

Liquid nitrogen (LN2) is used to cool the chuck of the Lakeshore cryogenic probe station for low-temperature measurements. PPE must be utilized as follows:

Situation	PPE required
Filling dewar	<ul style="list-style-type: none">• Insulated cryogenic gloves• Lab Coat• Splash goggles• Face shield (optional)
Connecting or disconnecting dewar with LN2 to probe station by transfer line	
Operating or adjacent to system while in operation with LN2 flowing	Lab coat Safety glasses
Operating or adjacent to probe station when cryogen not being utilized	None

The user must also verify the function of the pressure relief valve each time when filling the tank, and check that pressure remains below 25 psi.

Flammable and Combustible Liquids (incl. acetone and isopropyl alcohol)

FLAMMABLE and COMBUSTIBLE LIQUIDS STANDARD OPERATING PROCEDURE TEMPLATE

(See also these related UCSB SOPs: “Solvent Use: Extractions, Distillations & Still Quenching” and “Peroxide-Forming Chemicals”)

Type of SOP: Process Hazardous Chemical Hazard Class

HAZARD OVERVIEW

Flammable and combustible organic solvents are amongst the most dangerous chemicals in the lab. A measure of how ignitable a particular solvent is the **flashpoint**; defined as the lowest temperature at which a material can form an ignitable mixture with air and produce a flame when a source of ignition is present. **The lower the flashpoint, the more easily the liquid can be ignited.** Most common organic solvents in the lab are readily ignited, with the exception of chlorinated solvents like dichloromethane which require more extreme conditions to burn. Flammable liquids (flash point < 100°F) are divided into three classes:

<u>Class</u>	<u>Flash Point</u>	<u>Boiling Point</u>	<u>Examples</u>
IA	Below 73°F	Below 100 °F	Ethyl Ether
IB	Below 73 °F	At or above 100 °F	Acetone, Benzene, Toluene
IC	At or above 73°F and below 100°F		Isopropanol, Xylene

Combustible liquids (flash point > 100°F) are divided into three classes:

<u>Class</u>	<u>Flash Point</u>	<u>Examples</u>
II	100-139 °F	Acetic acid, cyclohexane, and mineral spirits
IIIA	140-199 °F	Cyclohexanol, formic acid and nitrobenzene
IIIB	200 °F or above	Formalin and vegetable oil

A particular organic solvent may have other hazards beyond their flammability. For example, benzene is recognized carcinogen. Check the Safety Data Sheet for the particular solvents in use.

The international symbol ([Globally Harmonized System](#)) for a flammable liquids/gases/solids is:



Diethyl ether initiated fire

PERSONAL PROTECTIVE EQUIPMENT (PPE)

See the PPE information under Sec. II of the *UCSB Chemical Hygiene Plan* regarding:

- the UC PPE Policy and policy summary (what PPE is needed and when/where to use)
- obtaining your PPE via use of the *Laboratory Hazard Assessment Tool (LHAT)*
- glove selection criteria
- respirator use, etc.

In general, workers who use flammable liquids will be issued a free fire-resistant Nomex lab coat via the LHAT process.

ENGINEERING/VENTILATION CONTROLS

All chemicals should be transferred and used in an annually certified laboratory chemical fume hood with the sash at the certified position or lower. The hood flow indicator should be checked to be operating correctly prior to using the hood. For further information see the following pages in Sec. II of the *UCSB Chemical Hygiene Plan*:

- Fume Hood Usage Guide
- Criteria for Implementing Engineering Controls
- Safety Shielding: Shielding is required any time there is a significant risk of explosion, splash hazard or a highly exothermic reaction. All manipulations of flammable liquids which pose this risk should occur in a fume hood with the sash in the lowest feasible position. Portable shields, which provide protection to all laboratory occupants, are acceptable.
- Special Ventilation: Manipulation of flammable liquids outside of a fume hood may require special ventilation controls in order to minimize exposure and reduce the fire risk. Fume hoods provide the best protection against exposure to flammable liquids in the laboratory and are the preferred ventilation control device. If your research

does not permit the handling of large quantities of flammable liquids in your fume hood, contact EH&S to review the adequacy of all special ventilation.

SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Use in an area that is properly equipped with a certified eye wash and safety shower that is available within ten seconds of travel.

Store in a tightly closed, labeled container and in a cool, dry, well-ventilated area. Segregate from incompatible materials. Repackaged chemicals must be labeled clearly. For example, squirt bottles and acid/base cleaning baths. Follow any substance-specific storage guidance provided in Safety Data Sheet documentation.

- **Flammable Liquid Storage Cabinets**

- ✓ One or more Flammable Liquid Storage Cabinets (**FLSC**) are required by CA Fire Code for laboratories which store, use or handle more than 10 gallons of flammable or combustible liquids.
- ✓ Containers of flammable liquids that are one gallon and larger must be stored in a flammable-liquids storage cabinet.
- ✓ The storage of flammable and combustible liquids in a laboratory, shop, or building area must be kept to the minimum needed for research and/or operations. FLSC are not intended for the storage of highly toxic materials, acids, bases, compressed gases, or pyrophoric chemicals.
- ✓ In most UCSB laboratories, flammable liquids storage is provided under the chemical fume hood. These cabinets are clearly marked “Flammable Storage” and are often ventilated via a stainless steel hose into the fume hood exhaust duct. Flammable liquids storage cabinets are constructed to limit the internal temperature when exposed to fire. When additional storage is needed, NFPA-approved FLSC may be purchased. All containers of flammable liquids must be stored in a FLSC when not in use. The following requirements apply:
 - General Requirements
 - Cabinets shall be marked “Flammable - Keep Fire Away”
 - Cabinets should be kept in good condition. Doors that do not close and latch must be repaired or the cabinet must be replaced.
- ✓ Flammable liquids storage cabinets are equipped with a grounding system that can be connected to a building ground. If you are pouring from a container in the storage cabinet and if the container being poured into is conductive then a bonding strap must be attached between them as explained in PROCEDURES TO AVOID STATIC ELECTRICITY.



FLSC involved in fire

- **Transferring/Dispensing**

STATIC ELECTRICITY HAZARDS IN THE LABORATORY

The flow of flammable and combustible liquids can cause the buildup of static electricity. When enough of a charge is built up a spark can result and potentially cause a fire or explosion. The likelihood of this happening is dependent upon how well the liquid conducts electricity, the flash point, and the capacity to generate static electricity.

Static electricity can be generated when liquid is transferred from one metal container to another. Liquids have the ability to generate static electricity when they move in contact with other materials during pouring, pumping, or agitating. The buildup of this static electricity can cause a spark to form where the solvent exits the container. This could result in a fire or explosion.

PROCEDURES TO AVOID STATIC ELECTRICITY

To avoid the buildup of static electricity that may cause a spark, it is important to bond and ground metal containers, particularly for larger quantities, e.g. 55 or 5 gal. drums.

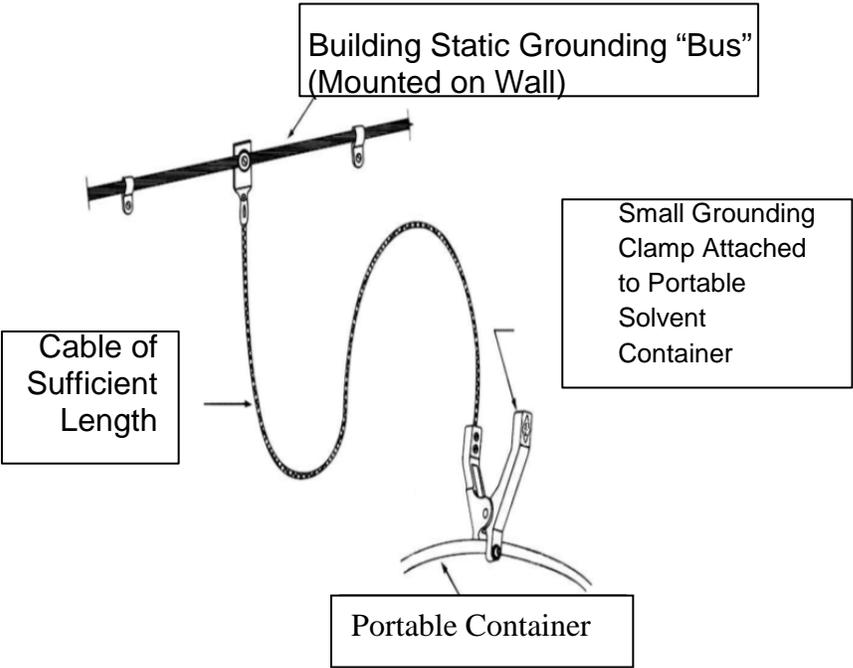
Bonding eliminates the electrical potential between two containers, therefore eliminating the likelihood of sparks. A bonding wire is connected to two conductive objects as seen in the drums pictured below.



Bonding wires between drums

Grounding eliminates the difference in static potential charge between the conductive object and ground. Grounding is accomplished by connecting the conductive object directly to the earth, usually using cold water copper pipes, building steel, or a grounding bus/bar.

Bonding and grounding require good electrical connections. Remove any dirt, paint or rust, ensuring **metal to metal** contact.





Bonding and Grounding wires come in a variety of styles and lengths. They can be purchased through [Fisher Scientific](#);, [Justrite Manufacturing](#); and through [Lab Safety Supply](#):



Hand Clamp



'C' Clamp and Alligator Clip

Static hazards may also exist in non-metallic plastic or glass containers that cannot be grounded. Static may be generated by the free fall and turbulence of the liquid being poured. To minimize this hazard, pour as slowly as possible and use a grounded nozzle extension that allows filling the container from the bottom.

DISPENSING FLAMMABLE LIQUIDS FROM 5 GALLON PAILS

Manual dispensing pumps for 5-gallon pails/cans are available. These pumps are specifically designed to dispense liquids into small laboratory-size bottles without spilling. If you are

Sec. I: Laboratory-specific Chemical Hygiene Plan

pouring into a conductive container, a bonding wire should be attached from the 5-gallon pail to the container being filled. The 5-gallon pail should be grounded.

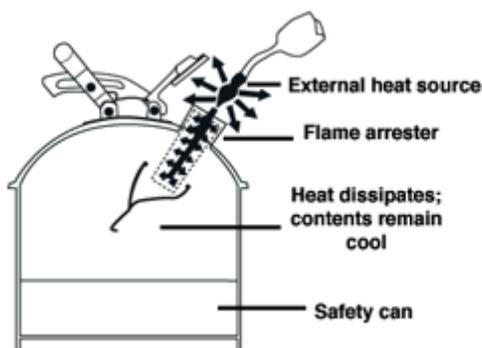
The dispenser shown in the picture below can be purchased through [Fisher Scientific](#). The metal strap in the picture hooks over the bottom of the pail and secures the dispenser while pumping.



Two adapters are provided with the dispensing pump from Fisher (grey and black). Use the appropriate adapter to achieve the correct seal with the solvent container you have. Some solvent containers have a grey fitting at the opening, and others have a black one.

DISPENSING FLAMMABLES FROM SAFETY CANS

Safety cans have self-closing air tight lids and a flame arrester that protects the contents from an external ignition source. Bonding and grounding is still required on safety cans since static electricity generation is possible. The nozzle provides a bonding path to a receiving metallic vessel.



Sec. I: Laboratory-specific Chemical Hygiene Plan

If either of the containers is non-metallic (non-conductive) it is still important to follow the limited velocity and grounded nozzle extension information given previously.



Safety cans do not offer protection from heat when exposed to fire and should be stored in a flammable liquids storage cabinet when not in use.

- **Labeling**
 - ✓ All flammable liquids must be clearly labeled with the correct chemical name.
 - ✓ Handwritten labels are acceptable; chemical formulas and structural formulas are not acceptable.
 - ✓ The label on any containers of flammable liquids should say "Flammable" and should include any other hazard information, such as "Corrosive" or "Toxic", as applicable. Example: lab squirt bottles, or acid/base baths.
- **Heating/Open flame**
 - ✓ Do not permanently store flammable liquids in chemical fume hoods or allow containers of flammable liquids in proximity to heating mantles, hot plates, or torches.
 - ✓ With the exception of vacuum drying ovens, laboratory ovens rarely have any means of preventing the discharge of material volatilized within them. Thus it should be assumed that these substances will escape into the laboratory atmosphere, but may also be present in sufficient concentration to form explosive mixtures within the oven itself. Venting the oven to an exhausted system will reduce this hazard.
 - ✓ Drying ovens should not be used to dry glassware that has been rinsed with organic solvents until all of the solvent has had the opportunity to drain or evaporate at room temperature.

Sec. I: Laboratory-specific Chemical Hygiene Plan

SPILL AND INCIDENT PROCEDURES

See directions under the “*Chemical Incident*” and “*Medical Emergency*” tabs of the *UCSB Emergency Information Flipchart* – should already be posted in all labs.



For those that routinely use flammable liquids, it is strongly recommended that they attend the live version of the EH&S *Fundamentals of Laboratory Safety* class, where **hands-on fire extinguisher training** is conducted. All campus labs should have a fire extinguisher already on-site, generally near the exit door.

DECONTAMINATION

Wear proper PPE, decontaminate equipment and bench tops using [soap and water]. Dispose of all used contaminated disposables as hazardous waste per below.

WASTE DISPOSAL

See “Chemical Waste Disposal” in Sec. II of the *UCSB Chemical Hygiene Plan*.

PRIOR APPROVAL/REVIEW REQUIRED

General solvent use is only approved for two specific purposes:

- Cleaning RF coaxial connectors
- Cleaning vacuum grease or thermal paste residue from mounting chuck or sample in cryogenic probe stations.

These uses are restricted to those who have been trained on this solvent usage in this specific context.

For filling squeeze bottles from stock bottles authorization is required and a flame resistant lab coat is required.

DESIGNATED AREA

Solvents may not be used or stored near heat or ignition sources (listed below). Most instruments warm air from cooling fans usually on the side or rear – squeeze bottles should not be kept near instruments or an exhaust air stream. Users should not use in a manner wear solvent may come into contact with instruments, probe stations, or other equipment.

Sec. I: Laboratory-specific Chemical Hygiene Plan

Ignition sources:

Probe stations:

The MPI, Lakeshore, and MMR probe stations have heated chucks. The MPI station may exhaust warm air while in operation and especially while cooling from elevated temperature. These probe stations therefore create an ignition or vapor hazard. Before use of solvent in the vicinity of these probe stations it should be verified that they are at room temperature.

Other heat sources:

The hot air gun and soldering irons can also reach high temperatures.

SAFETY DATA SHEETS and OTHER REFERENCES

Online SDS can be found at: <http://ehs.ucsb.edu/labsafety/msds>

Prudent Practices in the Laboratory, 2011, see Secs. 4.D and 6.F for flammable liquids
http://www.nap.edu/openbook.php?record_id=12654&page=R15

LAB-SPECIFIC PROTOCOL

- The only approved usage of solvents in the lab is small quantities (<5 mL) of Isopropyl alcohol (IPA) or acetone (ACE) squirted directly on a swab or Kim Wipe for cleaning.
- The approved purposes include cleaning coaxial connectors or the mounting chucks of the Lakeshore or MMR cryogenic probe stations.
- For usage the solvent should be dispensed from a squirt bottle onto a swab or wipe.
- Larger quantities than a swab's worth may not be used in this lab due to lack of fume hoods and suitable waste containers.
- Whenever possible Isopropyl alcohol should be used instead of acetone.
- For filling squeeze bottles from stock bottle a flame resistant lab coat, splash resistant goggles, and gloves are required.
- **Warning!** Solvents are flammable. They should never be used on a hot surface or in vicinity of an ignition source, as described above.
- **Warning!** Squeeze bottles may drip a few drops after application of solvent to a swab. After dispensing place the bottle with the tip above a clear counter surface, away from instruments or heat sources.
- **Warning!** The stock bottles are stored in a flammables cabinet and may only be removed by authorized for filling of squeeze bottles.

Gases Under Pressure (Excluding toxic and highly toxic gases) Standard Operating Procedure Template

Type of SOP: Process Hazardous Chemical X Hazardous Class

To customize this SOP, add lab-specific information to the sections below marked in RED, as applicable. Completion of the last section (“Lab-Specific Information”) is required. Also, any of the content below may be amended with lab-specific information to enhance worker safety as desired.

Purpose

The purpose of this standard operating procedure is to acquaint you with the proper and safe handling, use, storage and disposal of compressed gases. However, the following gases are **excluded** from this SOP:

- *those that considered toxic, or highly toxic*

The common toxic and highly toxic gases are listed in APPENDIX A. Given their high hazard and special regulations that apply to their use, these materials should have their OWN GAS-SPECIFIC SOP, rather than this generic gas SOP. Contact EH&S for assistance. In some cases, the volume or concentration of toxic/highly toxic gas may allow less rigorous control measures.

So, this SOP would typically apply to inert gases like nitrogen, argon and helium, flammable gases like hydrogen, methane, propane, plus oxygen (oxidizer; fluorine and chlorine are also strong oxidizers, but because of their high toxicity should have their own SOP).

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Properties & Hazards

Chemicals in this category present hazards based on one, or more of these characteristics:

- the pressurized nature of their storage and use
- flammability
- oxidizing ability
- high toxicity (as stated above these do not fall under this SOP, but should be addressed separately given their extreme hazard)

All chemicals in this band are considered generally hazardous and the band is general

- gases which are contained in a receptacle at a pressure of 29 p.s.i. (200 kPa) or more at 20 °C
- gases which are liquefied or liquefied and refrigerated

The [Globally Harmonized System of Chemical Classification](#) symbol and hazard codes for compressed gases are:



H280: compressed, liquefied, or dissolved gas

Controls

Basic pressurized gas control measures are noted here. For further information, see Sec. 7D of [Prudent Practices in the Laboratory](#) by the National Research Council. Gas vendors are another good source of information on gas equipment and handling.

A. Administrative Controls

General practices:

1. Be sure to review the Safety Data Sheet (SDS) for all chemicals to be used in the experiment.
2. Avoid working alone. At least one other person must be present in the same laboratory when any work involving hazardous chemicals is being done.
3. Eliminate or substitute for a less hazardous material when possible.

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4. Design your experiment to use the least amount of material possible to achieve the desired result.
5. Verify your experimental set-up and procedure prior to use. Be familiar with the Safety Data Sheets for all chemicals in use. Assess the hazards to ensure that appropriate controls are in place to minimize risk and address emergency shut-down procedures as appropriate.
6. Consult with the PI if the work involves procedure scale-up or other large quantities or there are any questions regarding appropriate safety procedures.

B. Engineering Controls

1. In general, it is preferable to perform all work with hazardous chemicals in a fume hood. Sash height should be kept as low as possible to avoid the escape of vapors, gases and particulates.
2. Supplemental equipment such as blast shields should be used when working with chemicals or processes that may result in explosions or pressure releases.
3. Consider the use of a glove box, toxic gas cabinet or other local exhaust in order to further contain hazards as appropriate. Gas cabinets may be required for some toxic gas applications.

For further information on engineering controls see the following pages in Sec. II of the Chemical Hygiene Plan:

- Fume Hood Usage Guide
- Criteria for Implementing Engineering Controls

C. Personal Protective Equipment (PPE)

See the PPE information under Sec. II of the *UCSB chemical Hygiene Plan* regarding:

- the UC PPE Policy and policy summary (what PPE is needed and when/where to use)
- obtaining your free PPE via use of the *Laboratory Hazard Assessment Tool*
- glove selection criteria
- respirator use, etc.

Special Handling & Storage Requirements

Hazard-specific practices:

Storage Areas

1. Store full and empty cylinders separately to avoid confusion. Serious back flow can occur when an empty cylinder is attached to a pressurized system.
2. Select a cool, dry, and well-ventilated area.
 - a. Cool areas minimize pressure increases that can result from heat or direct sunlight.
 - b. Dryness deters rust and corrosion.
 - c. Ventilation is essential in case of leaks.
 - d. Never store compressed gas cylinders (with the exception of compressed air) in environmental rooms (i.e., refrigerated cold rooms or warm rooms). These rooms are not well ventilated and could pose a serious safety concern should a cylinder fail.
3. Arrange storage facilities to permit inventory rotation, using cylinders in order as received from the supplier.
4. Do not store cylinders next to doors or in corridors where they could possibly obstruct emergency exit from the building.
5. Designate an area to store empty cylinders for return to the supplier. An area on or adjacent to your building's loading dock is suitable.
6. Separate oxidizers or other incompatibles (e.g., oxygen) from flammables by at least 20 feet, or by a non-combustible wall.

Storage Guidelines

1. Implement these ideal storage practices:
 - a. Restrain cylinders - During the 1994 Northridge earthquake, gas cylinders that had been double-chained and bolted to a secure surface stayed in place. Single-chain restraints were not as successful. C-clamps did not work at all. Restrain cylinders as follows:
 - i. Store cylinders upright and secure them to a substantial, fixed surface with upper and lower restraints made of non-combustible material, preferably chain and Unistrut[®].
 - ii. Position the upper restraint no less than 1 foot from the shoulder of the cylinder. Position the lower restraint no less than 1 foot from the floor.
 - iii. C-clamps or bench mounting brackets are not allowed!

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- iv. Multiple cylinder restraint - Limit 3 cylinders to each double-chain restraint system.
 - b. Properly label the cylinders and storage area.
 - c. Cap cylinders when not in use.
 - d. Store cylinders away from non-compatibles.
 - e. Store empty cylinders separately from full cylinders.
2. Do not keep non-corrosive gases longer than 5 years from the last hydrostatic test date (usually stamped just below the neck of the cylinder) unless otherwise regulated.
3. Return all cylinders that appear unsafe or show signs of corrosion, dents, dings, pitting, bulging, etc.
4. Review your cylinder inventory regularly.
 - a. Return cylinders to the vendor if they're no longer being used. This removes potential hazards and saves on cylinder rental fees (cylinders are typically rented or leased, rather than purchased) and possible reconditioning fees.
 - b. Note: Some vendors charge a reconditioning fee on each cylinder that is not returned within 2 years. This fee may be significant in relation to the actual cost of the gas.
5. In addition to standard storage requirements listed above, employ special precautions for cylinders containing flammable, oxidizing, or corrosive gases (empty or full) as described below
 - a. **Flammable gases**
 - i. Separate from cylinders containing oxidizing gases by a minimum distance of 20 feet or by a noncombustible partition
 - ii. When approved gas storage cabinets are used, the cabinets must be equipped with fire sprinklers. (**Note:** Fire code piping and connection requirements may apply for your facility. Consult the EH&S Chemical Hygiene Officer.
 - iii. Never store flammable gas near ignition or heat sources, or unprotected electrical connections.
 - iv. Keep quantities to a minimum. There may be circumstances where using a pure flammable gas may pose unacceptable risks. It may be necessary to purchase a reduced concentration mixture (e.g., 1% hydrogen and 99% argon).
 - v. If you need large volumes (more than 1 large cylinder), contact the EH&S Chemical Hygiene Officer,
 - b. **Oxidizing gases**
 - i. Do not permit oil or grease to come in contact with compressed oxidizing gases — explosions may occur!
 - ii. Separate oxidizers from cylinders containing flammable gases by a

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minimum distance of 20 feet or by a noncombustible partition extending not less than 18 inches above and to the sides of the stored material.

- iii. Never store oxidizers near flammable solvents, combustible materials, unprotected electrical connections, or ignition or heat sources. (**Note:** Fire code piping requirements may apply in your facility. Consult the EH&S Chemical Hygiene Officer.)

c. **Corrosive gases**

- i. Never store lecture bottles of corrosives longer than 6 months and cylinders more than 2 years. (e.g., ammonia, hydrogen chloride, chlorine, and methylamine). Cylinders containing corrosives degrade over time.

Operational Guidelines

1. Know the hazard classification of particular gases you are working with and specific safety requirements as discussed above.
2. Label both the cylinder and gas line with the name of the gas. Do not depend on color codes.
3. Work in a well-ventilated area when using compressed gases.
4. Use the correct regulator. Ensure that each gas in use has its own dedicated regulator. Never use adapters.
5. Never permit a flame or spark to come in contact with any part of a compressed gas cylinder. Have flashback protectors installed on cylinders of flammable gases, such as oxy-acetylene torch units.
6. Use a trap or suitable check valve when discharging gas into a liquid to prevent liquid from getting back into the cylinder or regulator.
7. Lecture bottles use universal threads and valves, and some of them are interchangeable. This increases the risk of accidentally mixing incompatible materials.
8. In addition to standard operational requirements listed above, employ special precautions for cylinders containing flammable, oxidizing, or corrosive gases (empty or full) as described below.
 - a. **Flammable gases**
 - i. Use flow restrictors to prevent a sudden large unexpected release.
 - ii. Detection systems may be required.
 - b. **Oxidizing gases**
 - i. Diligently clean regulators and tubing used with oxidizing gases to remove oil and other reducing agents.

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c. Corrosive gases

- i. Inspect cylinder valves periodically for corrosion.
 1. If a cylinder or valve is noticeably corroded, contact the gas vendor and follow their instructions.
 2. Alert the vendor to any damage that might impair the integrity of the cylinder before the cylinder is returned.
- ii. Use caution if flow does not immediately start when a valve is opened slightly — there could be a plug in the valve.

Transporting Gas Cylinders

1. Leave the valve protection cap in place until the cylinder has been secured against a wall or bench or placed in a cylinder stand, and is ready for use.
2. Use a hand truck or other suitable device to transport cylinders, even for short distances. Secure the cylinder to the hand truck with a chain or strap.
 - a. Do not roll, drag, or slide containers.
 - b. Do not lift cylinders by cylinder caps.
3. Before returning empty cylinders to the supplier:
 - a. Close the valve. Leave some positive pressure in the cylinder.
 - b. Replace any valve outlet and protective caps originally shipped with the cylinder.
 - c. Mark or label the cylinder "empty" and store it in a designated area for the supplier.
4. Move any cylinders that have been left unattended into a secure location as soon as possible.

Spill and Incident Procedures

See directions under the “*Chemical Incident*” and “*Medical Emergency*” tabs of the *UCSB Emergency Information Flipchart* – should already be posted in all labs.



Hazard-specific Incident Practices:

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1. In case of cylinder leaks that can't be stopped by tightening the valve gland or packing nut, do the following:
 - a. For hazardous gases:
 - i. Leave the room, closing the door behind you.
 - ii. Secure the room to prevent entry.
 - iii. Sound the fire alarm, unless the gas leak is relatively slow and contained within a gas cabinet, or fume hood.
 - iv. Call for emergency assistance. Dial 9-1-1, preferably from a cell phone. Tell the dispatcher the name of the gas.
 - b. For non-hazardous gases:
 - i. Close the leaking valve. If it is still leaking, replace the cylinder cap and notify EHS.

Waste Disposal Procedure

See "Chemical Waste Disposal" in Sec. II of the UCSB Chemical Hygiene Plan.

Safety Data Sheet (SDS) Location

Online SDSs can be accessed at <http://ehs.ucsb.edu/labsafety/msds>

PRIOR APPROVAL/REVIEW REQUIRED

Training is required for use of compressed gases in the lab.

DESIGNATED AREA

Compressed gas is only to be in conjunction with the MMR probe station.

LAB-SPECIFIC INFORMATION (required)

Compressed ultra-high-purity (UHP) nitrogen or argon gas is used with the MMR probe station for cooling a small wafer stage for low-temperature measurements. The gas tank has a starting pressure of 6,000 psi and is typically used to 2,000 psi, or to 500 psi with less cooling capability. Usage is infrequent, average of approximately one day per month. Except when transporting a tank in the Materials Dept. tank cart for installation or removal, the tanks should be chained to the wall with the provided chain and clips. The regulator should be attached to the tank with the regulator output connected to the MMR station before opening the main tank valve. Start with the regulator at minimum pressure and ramp up to desired operating pressure. When usage is complete the main tank valve should be shut off then the regulator output pressure ramped down. PPE including lab coat and safety glasses is required when making or undoing any compressed gas connections or operating the cylinder or regulator.

VACUUM SYSTEMS

STANDARD OPERATING PROCEDURE TEMPLATE

Type of SOP: Hazard Class Hazardous Chemical Process

HAZARD OVERVIEW

- An implosion and the possible hazards of flying glass, spattering chemicals and fire
- Cold traps can condense air/oxygen into a system which becomes an explosion hazard when warmed, or when in contact with organics.
- The belt on the pump can catch fingers or clothing
- Improper venting of pump exhaust when using hazardous materials
- The systems are typically complicated and require extensive training prior to use

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Use a face-shield or explosion shield or work behind the sash of a fume hood, particularly with larger glass systems under vacuum.

See the PPE information under Sec. II of the *UCSB Chemical Hygiene Plan* regarding: the UC PPE Policy and policy summary (what a PPE is needed and when/where to use) obtaining your PPE via use of the *Laboratory Hazard Assessment Tool* glove selection criteria respirator use, etc.

ENGINEERING/VENTILATION CONTROLS

For further information see these pages in Sec. II of the *UCSB Chemical Hygiene Plan*:

Fume Hood Usage Guide

Criteria for Implementing Engineering Controls

SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

- Understand the type of vacuum pumps being used and their limitations. Always check with the manufacturer for the appropriate application.
- Prepare for **power outages** whether you are present or not. Some valves close upon loss of power, some open. Understand the effects that a series of valve openings and closings will have upon the system's integrity.
- Always replace the pump **belt guard** to prevent catching fingers or clothing in the mechanism.
- Be aware of the hot surface in **oil diffusion pumps**
- If a glass vacuum line is ever used **above ambient pressure**, it should be shielded from personnel to prevent glass shards from flying if the line were to shatter.
- Glass vessels that are evacuated should be round-bottomed and/or thick-walled and designed for low-pressure work. They should be regularly checked for star cracks and scratches.
- The use of safety glasses is mandatory.

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Traps and Venting

- Use of house vacuum systems must employ appropriate **traps** to prevent chemical, radioactive or biohazardous material from contaminating the building pump and lines. Likewise, use of an aspirator should also employ a suitable trap to avoid contaminating the water stream.
- Mechanical vacuum pumps should be protected by **cold traps** – generally liquid nitrogen based.
- If hazardous materials are used with the vacuum system they should be located in, and **vented** to, a fume hood.
- Pump oil from vacuum system exhaust has been known to accumulate in building ductwork systems increasing the likelihood of fire spread. Pump exhaust should only be done **into the fume hood** proper, or if exhausted directly into building ductwork, an oil trap must be installed.
- Operation of low temperature traps must be thoroughly understood. Both the cooling and warming phases deserve undivided attention. For example, when using liquid nitrogen, the **condensation of air** due to an open valve may cause a serious explosion when the air vaporizes upon warming. The increase in volume/pressure is huge (factor of about 200).
- Dewar flasks are insulated by being under high vacuum and are therefore subject to implosion. They should be wrapped in tape or plastic sheathing and generally come that way.

Chemical Hazards

- Mechanical pump oil can become contaminated with hazardous materials that were being pumped on. During maintenance, proper protective equipment must be employed. A ventilated area should be used for changing pump oil, as harmful vapors may be released. Clean or contaminated pump oil must be disposed of as hazardous waste via EH&S.
- Mechanical pump exhaust may require suitable scrubbing for volatile highly toxic materials. This may involve a relatively simple filter or liquid bubbler.

Practices

Turning ON a High Vacuum System:

- Make sure all valves are closed.
- Turn on vacuum pump.
- Place Dewar around trap flask
- Submerge trap flask in liquid nitrogen. **Make sure system is under vacuum before cooling trap to avoid condensation of liquid oxygen.**

Turning OFF a High Vacuum System

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- Remove all samples and experiments from vacuum line.
- Remove trap flask from Dewar. Allow to warm to room temperature
- Open vacuum system to atmosphere. **Do not do this while trap is cold to avoid condensation of liquid oxygen.**
- Turn off pump.

SPILL AND INCIDENT PROCEDURES

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the *UCSB Emergency Information Flipchart* – should already be posted in all labs.



WASTE DISPOSAL

See “Chemical Waste Disposal” in Sec. II of the *UCSB Chemical Hygiene Plan*.

When using a “house vacuum” system or an aspirator to generate vacuum, you must protect from contamination the vacuum pump for the building and waste water lines. Use a trap such as a vacuum flask. Chemicals pulled into a building vacuum pump can damage the pump.

PRIOR APPROVAL/REVIEW REQUIRED

Training is required before use of a vacuum system in the lab.

DESIGNATED AREA

Vacuum pumps are only to be used with the systems that they are installed on.

SAFETY DATA SHEETS

Found online at: <http://ehs.ucsb.edu/labsafety/msds>

LAB-SPECIFIC INFORMATION (required)

Vacuum pumps are used for the MMR and Lakeshore Cryo probe stations, Hall measurement station for the low-temperature measurements, and a diaphragm pump which is connected to piping throughout the lab supplying the house vacuum which is primarily for probe station vacuum chucks and also exhaust of nitrogen and argon gas for the MMR probe station.

When operating a system under vacuum, pumping down, or venting user must wear lab coat, safety glasses, gloves, and consider use of the face shield. Adjacent users require lab coat and safety glasses. This does not apply to use of house vacuum chucks on probe stations

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Users should not have to adjust vacuum pumps or systems as they are installed in dedicated systems. Pumps with oil gauges must be checked before each use to verify oil level and cleanliness.

Samples placed on probe station vacuum chucks must be clean to avoid clogging the chuck or contaminating the vacuum lines.

Mercury and Organomercury

The use of mercury or any organomercury compound is subject to pre-approval by the Principal Investigator (PI) and/or Supervisor. DO NOT USE MERCURY OR ANY ORGANOMERCURY UNTIL YOU HAVE OBTAINED THE NECESSARY PRE-APPROVAL.

Mercury is primarily used in the manufacture of industrial chemicals or for electrical/electronic applications. It can be found in some thermometers, especially older ones or ones which are used to measure high temperatures. Mercury is also found in the gas phase in fluorescent lamps. It is a reproductive toxicant and acutely toxic by inhalation.

Organomercury compounds are substances with at least one mercury-carbon bond. These substances are primarily used in organic synthesis or as antiseptics and fungicides. Low molecular weight organomercury compounds (e.g. dimethylmercury) can easily penetrate human skin and protective materials. Organomercury compounds are acutely toxic by all exposure routes, and dimethyl mercury is also carcinogenic and flammable.

No organomercury compounds are permitted in the lab.



Personal Protective Equipment & Personnel Monitoring



Lab Coat

Traditional white lab coat. Consider using a flame resistant lab coat when working with dimethylmercury, as it is flammable.



Gloves

Nitrile gloves typically provide adequate protection against minor splashes. Silver Shield/4H gloves worn underneath nitrile gloves can provide added protection when handling large quantities – or whenever dimethylmercury is used.

Do not wear latex gloves.



Eye Protection



Face Shield

ANSI Z87.1-compliant safety glasses or safety goggles, or face shield if a splash hazard is present.

Labeling & Storage

Store upright & tightly closed in a secondary container located in a cool, dry, and well-ventilated place. Keep away from incompatible materials, light, heat, and (especially in the case of dimethylmercury) ignition sources. Incompatible materials include strong oxidizing agents, ammonia, azides, and copper. Each container's label must include a skull-and-crossbones pictogram, the word "Danger", and identify the material as both acutely toxic and a reproductive toxicant or carcinogen. Containers of mercury or organomercury must be stored in leak-proof secondary containment within a Designated Area. Use an unbreakable secondary container when transporting mercury thermometers or other mercury-containing equipment. Dispense mercury over a secondary container to contain spills. Place a plastic tub under equipment containing large amounts of mercury. The secondary container's label must include a skull-and-crossbones pictogram, the word "Danger", and identify the material as both acutely toxic and a reproductive toxicant or carcinogen. Also, if not plainly visible (e.g. through a cabinet window), labeling must be applied to storage locations where these substances are kept to avoid an inadvertent encounter.

Lab-specific information

Mercury is used only in the Materials Development Corp. Mercury probe station in the lab. The stock and wasted is stored in a bin beneath the probe station. Powderless nitrile gloves should be used with the station to prevent powder from contaminating the mercury.

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Engineering Controls, Equipment & Materials

Cover	Mercury containers are to be kept covered when not in use to prevent mercury vapor from reaching lab and prevent dust from contaminating mercury.
Filter	The exhaust filter for the vacuum pump must be connected and not expired date. It is replaced annually.
Segregation of equipment	Equipment used with the mercury probe station including tweezers, adapters, cables, etc. is only for use with the mercury probe station in case of contact with mercury. Accessories except for BNC and T-adapters should be stored within the clear plastic box for the mercury probe station.
No metal-mercury contact	Only plastic tipped tweezers are to be used with samples due to propensity of mercury to form amalgams. The arm should not be lowered unless a sample, glass slide, or other non-metal barrier is in place to prevent mercury contact with the face of the arm.
Guidelines for samples.	To prevent contamination of mercury or formation of mercury compounds samples must be clean and non-reactive with mercury.
Cleanliness of work area	The work area must be kept clear and clean so that mercury spills are apparent and visible.

Housekeeping

Spills	<p>If the spill is small and contained: This may be cleaned up by the user using a pipette to suck up mercury or the provided fluxless tin/lead solder in the basin to pick up a drop by forming an amalgam. Caution: only a small amount of mercury can be easily held in a pipette due to its high density. Mercury drops picked up with solder weakens the solder so before too much is picked up the end of the solder should be clipped with the provided wire cutters.</p> <p>If the spill is large or not contained: Notify others in the area of the spill, including your supervisor. Evacuate the location where the spill occurred. Prevent others from entering the area of the spill. Do not allow any mercury to contact shoes or be tracked into a wider area. Report all spills to EH&S using the number on the flip chart. Remain on-site (at a safe distance) to provide detailed information to first responders.</p>
Decontamination	Decontamination methods will vary based on the materials handled and equipment being used. Please review the chemical SDS for guidance on cleaning materials.
Waste	All waste should be stored in the waste containers. Separate containers are provided for mercury, solder with mercury, items such as pipettes that have been in contact with mercury, and isopropyl (used for cleaning the probe station's mercury channels) that has been in contact with mercury. These must be disposed of through EH&S regularly.

First Aid & Emergencies

Skin Contact	Immediately remove contaminated clothing and shoes; flush skin with water for at least 15 minutes. Get medical attention immediately.
Eye Contact	Check for and remove contact lenses. Immediately flush eyes with water for at least 15 minutes. Get medical attention immediately.
Inhalation	Move person into fresh air. Get medical attention immediately.
Ingestion	Get medical attention immediately.

High Voltages

HAZARD OVERVIEW

High voltages can be hazardous due to potential for stopping the heart or causing burns on the body. The damage thresholds vary based on the path current takes through the body which will vary based on the entry and exit points, the electrical resistance of the skin or other items, moisture, etc.

The risk can be increased greatly if two points of contact are made with skin between a high voltage and its return path (i.e. circuit common or earth ground).

The approximate ranges for electrical hazards are given below (from a UCLA EHS SOP)

- Serious shock:
 - More than: 30 V RMS, 42.4 V peak, 50 V DC
 - 10-75 mA
 - More than 10 J
- Lethal shock:
 - More than 375 V
 - More than 75 mA
 - More than 50 J
- > 50 V = “Hazardous Voltage”
 - Typical threshold above which shocks become potentially lethal
- >200 V = “High Voltage”
 - Significant potential risk
 - Not currently allowed in the lab
- AC Risk
 - 60Hz (wall outlet): extremely dangerous; respiratory and cardiac arrest at low current (figure)
 - Higher frequencies are increasingly less dangerous (up to ~50 kHz)
 - Above 100-200 kHz serious burns can occur

Above 1MHz, a path to ground and direct contact are not needed for burns to occur

PERSONAL PROTECTIVE EQUIPMENT (PPE)

No PPE is called for as user safety is based on a combination of procedures and engineering controls.

ENGINEERING/VENTILATION CONTROLS

- Whenever possible hazardous voltages should be encased within an insulated or grounded shield. Examples include the ground of a coax or triax cable.
- Utilize the built-in current or power limiting functions of instruments to reduce risk, but do not rely on these as a primary safety mechanism.
- If hazardous voltages are exposed:
 - The area must be suitably cordoned off or restricted such that users cannot contact these voltages.
 - Warning signs must be in use and not blocked.

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SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

- All lab users must be made aware through both training and warning labels of areas where hazardous voltages may be in use
- When hazardous voltages are in use if they are not enclosed in a suitable insulated or grounded enclosure

SPILL AND INCIDENT PROCEDURES

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the *UCSB Emergency Information Flipchart* – should already be posted in all labs.



WASTE DISPOSAL

Not applicable.

Prior Approval/Review Required

Training is required before use lab power supplies.

DESIGNATED AREA

Hazardous voltages should only be used in standard test setups including the probe stations used for DC measurements, or RF measurements if a suitable bias tee is used.

SAFETY DATA SHEETS

n/a

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LAB-SPECIFIC INFORMATION (required)

Hazardous voltages (>40V) can be generated by power supplies and measurement instruments. A partial list is given below of applicable instruments. Typically connections are made to probes or other instruments with grounded coaxial or triaxial cables which mostly encapsulates the hazardous voltage by surrounding it with a circuit-common path. Note that some power supplies including Keithley or Keysight SMUs, or parameter analyzers may not use earth ground as circuit common in which case earth ground will not be a suitable shield. This should be verified by the user.

Instrument	Maximum voltage
Keysight B1500A	200 V
HP 4155B	200 V
Keysight B2902A	200 V
AMCAD pulsed-IV	250 V
Tektronix Curve Tracers	2,000 V

Note: Use of the Tektronix Curve Tracers is not currently allowed. There are no current users in need of it, so it is not currently supported by the lab's manager. If a user has a requirement for these measurements they may make a request to the lab manager and PI.

The parameter analyzers should be left with earth ground connected to circuit common (the arrangement seen in the photo below). If you wish to disconnect this tab for floating measurements contact the lab manager, and ensure that the earth to common tab is reconnected at completion of your measurement.



This photo shows the earth ground to circuit common tab on the rear of B1500 and 4155B parameter analyzers. It should be left connected.

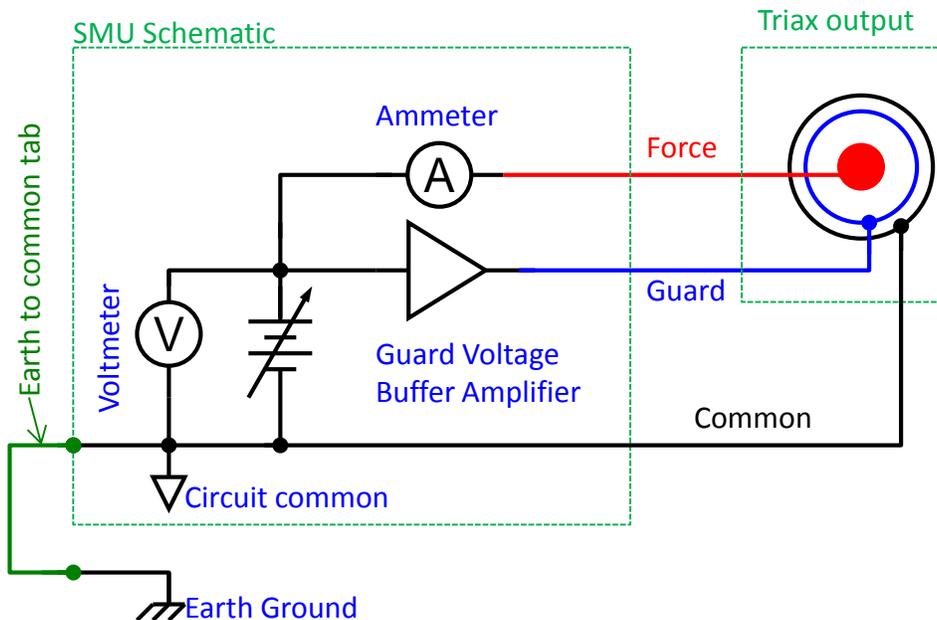
Likely hazards:

- Exposed probe or probe holder. Includes DC, MPI, Signatone, or any station where similar probes are in use.
- Exposed guard on certain triax to coax adapters, or guarded probe holders
 - SEE GUARD VOLTAGE SECTION IF YOU ARE NOT FAMILIAR WITH THE USE OF GUARD VOLTAGES IN USE IN PRECISION DC MEASUREMENT INSTRUMENTS
- Do not touch probes while a measurement is in progress and voltages are being applied to the probes
- Ensure that power supplies are turned off before making or breaking connections, or changing needle probes

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Guard voltages and Triax:

A guard voltage and triaxial connection can be used in many precision DC measurement instruments including the B1500 and 4155B parameter analyzers, B2902A SMU, Keitley 2600 series SMUs. The figure below shows a system schematic of source-measure-unit (SMU) outputs in such instruments. The guard voltage is driven to the same voltage as the signal voltage, and is therefore a potential shock hazard

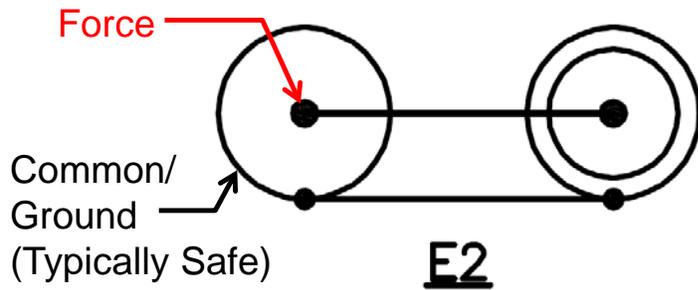


Schematic of SMU output and triax connector. BOTH THE FORCE AND GUARD TERMINAL CAN HAVE DANGEROUS VOLTAGES PRESENT. The guard terminal can be exposed by certain triax to coax adapters and by various probe holders.

Triax to coax adapters:

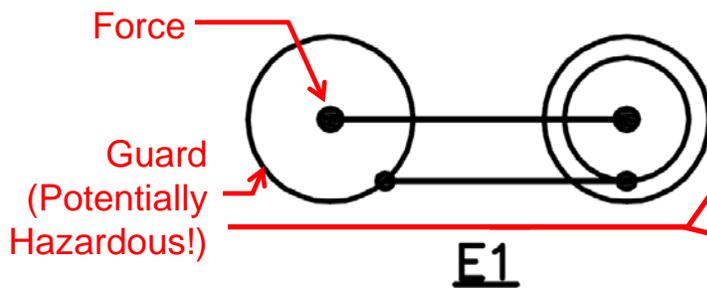
- Triax-to-coax adapters exist in two common types (as well as some less common varieties) to adapt between 3-conductor triax cables to 2-conductor coax cables. One type poses a greater hazard which must be addressed by the user's setup and procedures
- Shielded adapters (Schematic and example shown below) place the triax's shield on the coax's shield. This maintains shielding of a triaxial instrument output when converting to a coaxial cable which increases the safety.

Sec. I: Laboratory-specific Chemical Hygiene Plan



Shielded Coax-triax adapters. Note that the outer metal shield is continuous across the body of the adapter.

- Guarded adapters (schematic and example shown below) place the inner shield of the triax, guard, on the coax's shield. This configuration places potentially hazardous voltages on the shield of the coax! This configuration should only be used when it is necessary for technical reasons. The user is responsible to ensure the following to mitigate risk:
 - The hazardous voltage is physically separated from the user and adjacent users (e.g. by using in the Signatone dark box and connecting dark box to instrument ground).
 - Use of an instrument current limit or series resistor to reduce current or duration or a shock
 - Adjacent users are informed that the hazard is active
 - The instrument output shut off at the completion of the measurement
 - Remove adapters and return to storage drawer upon completion of measurement unless they are used inside the Signatone station darkbox enclosure with ground connected.



Guarded Coax-triax adapters. Note that the outer metal shield is interrupted by a white colored insulator across the body of the adapter

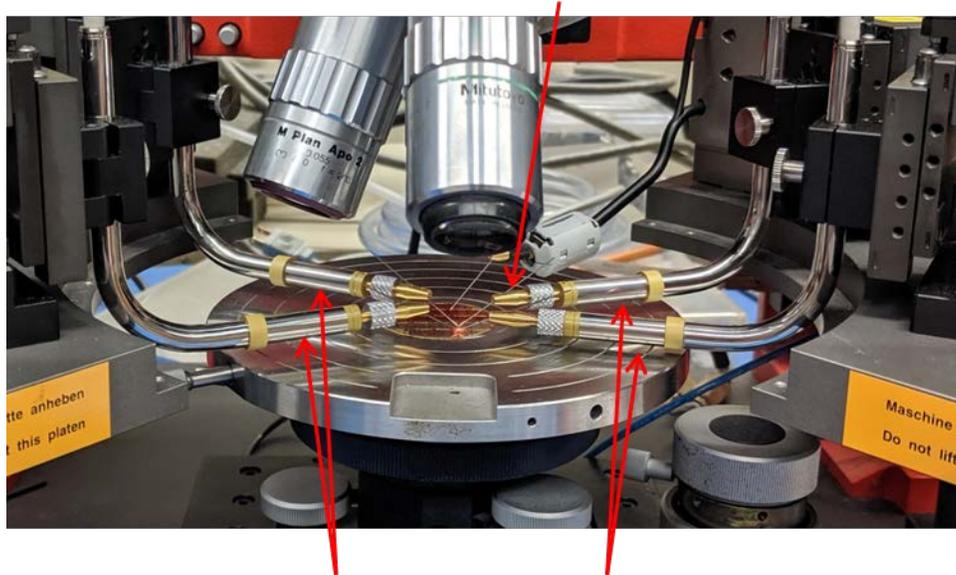
Sec. I: Laboratory-specific Chemical Hygiene Plan

Guarded Probe Holders

Some probe holders have a metal portion which is at the guard potential and potentially hazardous.

DC Probe station:

The DC probe station uses primarily triax-cable probe arms. Common/ground is on the outside of the triax cable. However a portion of the probe arm, just before the section with the collet is at the guard voltage, and can have hazardous voltages applied to it by the parameter analyzer, or another instrument. The figure below shows this:



**These metal sections are at the guard voltage!
Do not touch these sections while a voltage is
applied by the parameter analyzer!**

MPI Probe station:

The gold-colored body of the Kelvin needle probe holders at the MPI station have guard voltage applied to them

Ultraviolet Radiation

HAZARD OVERVIEW

Note: Much of the following information came from https://ehs.unl.edu/sop/s-ultraviolet_rad.pdf

Unfortunately, overexposure to UV radiation often times has no immediate warning signs. Symptoms of overexposure, including different stages of erythema (sunburn) or photokeratitis (welder's flash) typically appear 4-24 hours after an exposure has occurred.

- **Skin-** UV radiation can initiate erythema within exposed skin. This “sunburn” consisting of “redness” and blistering varies in severity, and can occur from only a few seconds of exposure. Symptoms can also vary due to one’s genetic 1 <http://uvp.com/xxseries.html> (Created 3/14) UNL Environmental Health and Safety · (402) 472-4925 · <http://ehs.unl.edu> makeup. Pale to fair skin individuals are more susceptible to burns. In addition various medications (i.e. birth control) can exaggerate symptoms. Chronic exposure to UV radiation has been linked to premature skin aging, wrinkles and skin cancer.
- **Eye-** UV radiation exposure can damage the cornea, the outer protection coating of the eye. Photokeratitis is a painful inflammation of the eye caused by UV radiation-induced lesions on the cornea. Symptoms include a “sand like” feeling in the eye that can last several days. Chronic exposures to short term UV radiation can lead to formation of cataracts.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

If UV radiation is not shielded from users:

- Active user
- Lab coat
- UV face shield
- Gloves

Adjacent user within line of sight of source or reflections

- Lab coat
- UV face shield

ENGINEERING/VENTILATION CONTROLS

- **Containment/Location-** Having equipment located in a separate room, alcove or low traffic area of a lab is ideal. To avoid exposure to other employees, avoid placing equipment in the direct vicinity of desk areas and or other equipment. Use of shields, curtains, UVR absorbing glass, or plastic is recommended.
- **Interlocks-** Some equipment comes with interlock devices. Interlock devices prevents operation of the equipment without use of safety equipment. Interlocks should not be tampered with. They should be replaced or repaired when defective.

Sec. I: Laboratory-specific Chemical Hygiene Plan

- **Eliminating Reflection-** Many surfaces, especially those that are shiny, easily reflect UVR. To reduce the intensity of reflections, painting problematic surfaces with non-UVR-reflective material is effective.

SPECIAL HANDLING PROCEDURES AND STORAGE REQUIREMENTS

Training- As in any activity within a lab setting, personnel should be trained and familiarized with the correct/safe way of using equipment. Users should read and adhere to all operating instructions and precautions of the equipment manufacturer. At a minimum lab personnel should be familiar with the following when working with or around UV light:

- UV Light Producing Equipment
- Warning Signs
- Protective Equipment
- Symptoms

Access- Access should be limited to employees who are directly working with the equipment. In addition, limiting the distance and time an employee is working with or around UVR producing equipment significantly minimizes the risk for injury.

Warning Signs and Labels- UV generating equipment must be equipped with a warning sign.

SPILL AND INCIDENT PROCEDURES

See directions under the “Chemical Incident” and “Medical Emergency” tabs of the *UCSB Emergency Information Flipchart* – should already be posted in all labs.



WASTE DISPOSAL

UV Bulbs typically contain mercury and must be disposed of appropriately as hazardous waste..

Prior Approval/Review Required

Training is required before use of ultraviolet light source.

DESIGNATED AREA

If the measurement can be conducted in the Signatone dark box enclosure this is preferred. Use in other areas in an unshielded configuration is only allowed if it is necessary for a technical reason. If used in other areas where UV is unshielded

SAFETY DATA SHEETS

n/a

Sec. I: Laboratory-specific Chemical Hygiene Plan

LAB-SPECIFIC INFORMATION (required)

If the UV is used in an unshielded area then PPE guidelines above must be followed as well as posting a warning label on the exterior lab door, and informing any other users in the lab. Use the minimum UV power necessary for the measurement.

Turn off UV source when finished and remove the warning label from the door.

SECTION II: UC/UCSB POLICIES, PROCEDURES AND RESOURCES

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Introduction to Section II: UCSB/UC Policies, Procedures and Resources:

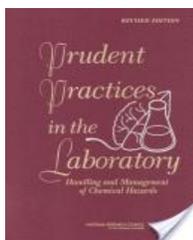
Section II addresses the campus policies, procedures and resources which are core/universal and apply to most labs. In order to free lab supervisors from independently having to address these issues in their Chemical Hygiene Plans (CHP), they are provided herein. In Section 1 *laboratory-specific* issues/SOPs are addressed.

The information here is a formal part of the *UCSB Chemical Hygiene Plan*. Therefore, all lab personnel are responsible for being familiar with this information and following the prescriptions therein as they apply to their work. Almost all of the issues addressed herein are based on current regulations and codes, from Cal-OSHA; Cal-EPA; CA Fire Code, etc.

Addressing Non-Chemical Hazards

The CHP Standard requires the addressing of **chemical** safety issues, but not other lab hazards. For example, biological and radiological hazards, electricity, high/low temperature and pressure, etc. Therefore, those issues are largely *not* addressed in this CHP, but instead are referenced:

- Via the links in the *Introduction* section, e.g., *Radiation Safety Program*; *Biological Safety Program*. These areas have their own requirements addressed therein.
- Via links (pg. II-16) in this section to selected pages of the free reference: ***Prudent Practices in the Laboratory***, from the National Research Council. This reference is widely recognized as a definitive reference on lab safety and all researchers are strongly encouraged to [bookmark its location or buy a hardcopy](#) for their areas.



Researchers are however encouraged to address non-chemical hazards in the lab-specific of their CHP (Sec. 1) via SOPs or protocols.

Minors in Laboratories and Shops:

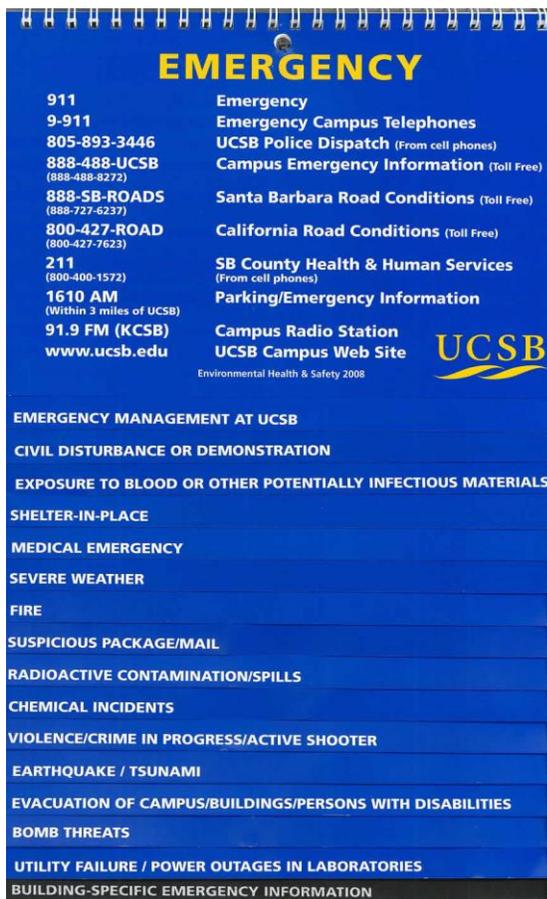
A UC [policy](#) describes the limitations on minors working in these campus areas. A summary of the policy can be found [here](#). The lab supervisor/PI has the primary responsibility for following this policy in their areas.

Emergency Response Procedures

The primary informational tool for response to campus incidents is the **UCSB Emergency Information Flipchart** pictured below. This document **should already be posted** in, or near, every laboratory, as well as in many offices. A Spanish version of the flipchart is available.

The last page (at right) should already be customized to include your *local* building information –such as the locations of the following: your building’s **Emergency Assembly Point**, fire extinguishers and fire alarm pull stations, first-aid kits, Automated External Defibrillators, etc. If it is not customized contact your local Department Safety Rep. Please familiarize yourself with the layout and general content of the flipchart. It can also be viewed [online](#)

Power outages in labs are of particular concern – preparing for them and what to do during and afterwards. A fact sheet with some basic guidelines can be found [here](#)



BUILDING-SPECIFIC EMERGENCY INFORMATION

A copy of this completed document should be posted on departmental safety bulletin boards along with a building floor plan.

Building Name: _____ Building Number: _____
 Building Exit Routes (Note the general locations of exits, e.g., exit stairwell is located on the north side): _____

EXIT

Building Emergency Assembly Point
 (View <http://ehs.ucsb.edu/esp> for the most recent list of the Emergency Assembly Points)

Primary Location: _____ Secondary Location: _____

Paste Photo Here (optional)

Paste Photo Here (optional)

Fire extinguishers and fire alarm pull station

Extinguishers are generally located at the **ends of exit hallways** and/or exit doors. Inside labs, they are located **near the exit door**.

Pull stations are generally located at regular hallway intervals and at the ends of exit hallways.

Type of fire alarm signal for the building
 (Check all that apply. If in doubt, contact the EH&S Fire Safety Division.)

Bells Horns/Strobes Strobe Flashes

Department Safety Rep: _____ Phone: _____
 Alternate Department Safety Rep: _____ Phone: _____

Building Resources

Location of First Aid Kits: _____
(Departmental and/or local work areas)

Location of Automated External Defibrillator (AED), if available: _____
(Device to restore normal heart rhythm to patients in cardiac arrest)

Location of other Emergency Resources (e.g., food, water, radios, flashlights, spill cleanup supplies, etc.): _____

For more information on emergency preparedness and fire prevention visit Environmental Health & Safety online <http://ehs.ucsb.edu>
 Date Prepared: _____ (An electronic version is on the EH&S Web site at <http://ehs.ucsb.edu>)

BUILDING-SPECIFIC EMERGENCY INFORMATION

Recommended Chemical Spill Cleanup Procedures**You should NOT clean up a spill if:**

- You don't know what the spilled material is
- You lack the necessary protection or equipment to do the job safely
- The spill is too large to contain
- The spilled material is highly toxic
- You feel any symptoms of exposure

Instead contact: **x3194** EH&S (24 hr line – after-hours may have to wait up to 30 min for response to campus). OR, if immediately health-threatening call **911** (campus phone)

Spill Response Scheme:*Evaluate and Notify*

- Assess the toxicity, flammability, or other properties of material (see label & MSDS)
- For flammables, remove or turn off ignition sources such as motors, pumps, fridges.
- Determine if there is an immediate health threat to you or your neighbors. If so, alert neighbors, isolate the area and call for help using the phone numbers above.
- If spill is minor, begin cleanup following steps below

Containment/Cleanup

- Don appropriate gloves, eye protection, lab coat, etc.
- Per SDS use absorbents* (e.g., “spill pillows” for solvents), or neutralizers appropriate for the material*, e.g. sodium bicarbonate for acids, citric for bases.
- Protect floor drains with absorbents or barriers around them
- Package and label waste. Include contaminated clothes, rags, equipment, etc.
- Store temporarily in a fume hood if material is volatile

Followup

- Send [Hazardous Materials/ Waste Pickup Request](#) form to EH&S
- Reorder and restock cleanup materials used
- Inform EH&S if there were any personnel exposures, or release to the environment



*Self-help [spill cleanup equipment](#) are available using graduate keys in some buildings.

Fire Extinguishers, First-Aid Kits and Emergency Showers/Eyewashes

Fire Extinguishers: Typically by the lab exit door and are the **ABC** variety (for flammable liquids/paper & wood/electrical, but *not* for flammable metals). EH&S conducts hands-on extinguisher training for most who attend the EH&S *Fundamentals of Laboratory Safety* class. There is also an online “refresher” extinguisher tutorial/video that individuals can complete who have already taken the live hands-on training. All campus individuals are strongly encouraged to view the refresher training when needed.

Online Fire Extinguisher Usage Refresher Training:

[UC Learning Center](#)

Need “UCSB Net ID” to login. Then search on “fire extinguisher”

First-Aid Kits: Individual laboratories should have their own 1st aid kit nearby in a location known to all. Supplies should be checked regularly. Departmental kits may not be accessible after-hours.

Emergency Showers and Eyewashes

- Know where your nearest unit is – they are typically within the lab, or in the corridor nearby. Units must be accessible always- no items should block access.
- In the case of chemical exposure to eyes or skin, flush the injury for a minimum of 15 minutes. Be sure to leave the eyes open under the water to flush them.
- Showers can also be used to extinguish a fire on an individual, or their clothing
- Consult the Safety Data Sheet (SDS) for material and show it to the doctor/nurse.
- Facilities periodically flushes emergency eyewash stations and showers. Lab personnel are urged to flush the eyewashes at least monthly as a precautionary measure. Call Facilities at x2661 if you have concerns regarding a specific unit.
- Eyewashes are plumbed with potable water - unlike the rest of the laboratory which is often on "industrial water"- and is considered safe to use on your body.
- Many eyewash/shower units are not equipped with a floor drain. This is because they are so infrequently used that they did not justify the cost of a drain when the building was constructed. Also, it is illegal to flush materials down the drain.



UC Policy on Laboratory Personal Protective Equipment (PPE)

In 2014, UC instituted a [policy](#) on the use of PPE in labs. The policy is intended to help protect lab workers from injury, meet [Cal-OSHA requirements](#) and bring more consistency to UC PPE practices. All members of the lab community have responsibilities under the policy and the law - particularly supervisors and lab workers.

The most important aspects of the policy are when and where individuals must wear long pants, closed-toe shoes, safety eyewear and a lab coat. This is summarized on a poster which is mounted at the main door to all labs – see next page.

Other Policy Aspects:

- **Exemptions** from wearing PPE (policy requires written exemption from EH&S)
 - hazardous materials/processes-free areas
 - areas protected by adequate distance (some desk locations are problematic)
 - lab areas/desks protected by adequate physical shielding
- Supervisors shall perform a **written assessment** of workplace to determine what PPE is needed – OSHA requirement. This is done via use the online *UC Laboratory Hazard Assessment Tool* ("[LHAT](#)"). The assessment should be updated and re-certified by at least every 3 years, or more often if needed. See pg. II-8.
- Supervisor assures **workers are trained** on when PPE is needed and how to wear, adjust & maintain. Per pg. II-8, use the LHAT to receive the necessary documented training for basic lab coat and safety eyewear use.
- Laboratory coats shall not be **laundered** at private residences, or public laundry facilities. See pg. II-8 for free lab coat laundering program details.
- Safety eyewear must meet *American National Standards Institute* standards. Typical prescription spectacles do **not** meet these standards (are not shatter-proof polycarbonate) unless specifically provided by an eye care professional. Safety goggles that readily fit over glasses are provided free (see pg. II-8).
- **Teaching courses** which include lab/shop/field work are required to indicate PPE requirements in the course syllabus or manual. **The PPE requirements for teaching labs are the same as for research labs.** The instructor of record for the course, or designee, is responsible for determining the appropriate PPE and ensuring that students are familiar with and properly use PPE. However, since teaching labs do not go through the LHAT process above, the instructor is responsible for determining which type of safety eyewear are necessary – [click here](#) for guidance.

U.C. PERSONAL PROTECTIVE EQUIPMENT POLICY

THE BASICS:

Minimum PPE for Entering a Laboratory Area: **Long Pants and Closed Toed Shoes**

PPE While Manipulating Hazardous Materials/Processes: **Appropriate Lab Coat and Safety Eyewear**

PPE While Adjacent to the Manipulation of Hazardous Materials/Processes: **Same PPE as Those Doing the Work**

ADDITIONAL PPE AS DETERMINED BY LHAT AND SOP'S:



Face Shield

Consider use when handling:

- Hazardous liquids with a splash hazard
- Pyrophoric, water reactive or potentially explosive chemicals
- Cryogenic liquids
- High pressure or vacuum systems



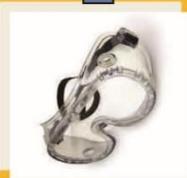
Chemical Resistant Apron

Use when handling:

- Minor spill clean-up
- Corrosives >4L

Consider when handling:

- Hazardous liquids w/splash hazard
- Acutely toxic chemicals
- High pressure or vacuum systems



Splash Goggles

Use when handling:

- Hazardous liquids when >4L or with a splash hazard
- Corrosives when >4L
- Cryogenic or scalding liquids when >4L



Gloves

Use appropriate gloves when handling:

- Hazardous, toxic or corrosive chemicals, engineered nanomaterials, unsealed radioactive materials
- Cryogenic liquids or dry ice
- Biohazards (double glove for BSL-2 or greater)

See full PPE policy, LHAT, and your lab SOP's for more details. Additional requirements may apply as determined by the campus biosafety, radiation and animal care committees

Posted at main doorway to each campus lab

Obtaining Free Laboratory Personal Protective Equipment (PPE) Via the UC Laboratory Hazard Assessment Tool (“LHAT”)

To facilitate the policy summarized on pg. II-6, UC provides the following resources:

1. The online **Laboratory Hazard Assessment Tool** (“LHAT”) <https://ehs.ucop.edu/lhat/> is for supervisor’s to do PPE assessments for their workers. The LHAT can only be accessed via an individual’s UCSB NetID and password. Per UC policy, the LHAT assessment must be re-certified/revised online at least every 3 years, or more often if changes occur. Contact EH&S for assistance.
2. For lab workers, the LHAT provides a summary of the lab’s PPE needs and provides/documents training on basic lab coat and eyewear use and maintenance
3. Free laboratory coats (3 types for different hazards), safety eyewear and communal face shields and lab aprons – see below. [Use & Limitations](#) of UC-provided PPE.
4. Free lab coat laundering services – see below

Obtaining Free PPE: After the lab supervisor completes the LHAT process, their workers login to the LHAT to review the assessment results, watch a short training video, take a short quiz and print out a “PPE voucher”. With the voucher they may pick-up two free lab coats and eyewear at the *Graduate Storeroom* in the Dept. of Chemistry & Biochemistry (Bldg. 557, room 1432). Short-time lab workers may receive a “loaner” coat they return.

For the many **short-term summer intern lab workers** each year, the procedure for obtaining their PPE is generally different – [click here](#)

Lab Coat Laundry Service: There are [seven sites](#) on campus for workers to drop off their dirty lab coats for laundering and pick-up when clean. Each coat will be marked with the coat’s unique identifier number and the individual’s name. Your cleaned coat will be returned to the one site that you designate – [FAQs](#) Lab coats and safety eyewear which are no longer needed should be *recycled* for reuse by placing in the separate designated bins at one of the seven sites noted above.



Respiratory Protection

Use of respirators is highly regulated by Cal-OSHA ([CCR, Title 8, 5144](#)). Per the *UCSB Respiratory Protection Policy* ([5440](#)), all use of respiratory protection equipment (including filtering facepiece respirators (dust masks) must be reviewed and approved by EH&S. Fortunately, a respirator is typically not needed in a laboratory to reduce/eliminate exposures. Under most circumstances, safe work practices and engineering controls (e.g., fume hoods) adequately protect workers. Under certain circumstances, however, respiratory protection may be needed as determined by EH&S. These can include:

- Chemical spill outside the fume hood, or spill of biohazard outside a biosafety cabinet
- An unusual operation that can't be conducted in fume hood or biosafety cabinet
- Weighing powders outside a glove box or other protective enclosure. Disposable filtering face-piece respirators are generally recommended for nuisance dusts.
- When monitoring shows that exposures exist that cannot be otherwise controlled
- As required by a specific laboratory protocol or as defined by applicable regulations

If you believe respiratory protection equipment may be necessary, or if an individual would like to wear equipment voluntarily, please contact the [UCSB Respiratory Protection Program](#) (x-3743, x-8787, or rpp@ucsb.edu) for review and approval. There is a wide variety of respiratory protection equipment available, and each has specific applications, limitations and use requirements. It is extremely important that equipment is selected and used properly, to ensure that the respirator itself does not create an additional hazard.



Selecting the Proper Gloves

The correct gloves protect against chemicals; the wrong gloves enhance chemical contact. **There is no universal glove that protects you from all chemicals. To choose the correct glove, go to a Glove Reference Chart** - links below. Chlorinated solvents are carcinogenic and are particularly challenging to find appropriate gloves for.

All gloves are permeable, only the permeation rate varies, depending on the chemical, the glove material and thickness, temperature, concentration gradient, etc. However, once a material begins to permeate the glove, it will continue until an equilibrium is reached. You must, therefore, decide when it is appropriate to discard dirty gloves.

Check gloves before use for signs of wear or penetration. Disposable gloves can be inflated to check for pinholes. When removing gloves, be careful to avoid touching the outside of the gloves with your bare hands. Always remove gloves before leaving lab.

Disposable gloves provide minimal protection and should be used accordingly. If using concentrated solvents, corrosives or toxics, more heavy-duty gloves should be worn. These provide more protection, but have the drawback of being more cumbersome. Note also that about 15% of the population is [allergic to latex](#) to some degree.

Gloves for Handling Pyrophorics: These chemicals *spontaneously ignite in air*, but are only found in a few departments. Having the proper glove is important to avoid injury from a burning/melting glove. **Per a legal Agreement between UC and Cal-OSHA, all lab workers who handle pyrophorics outside of an inert gas glove box, must use special non-combustible gloves for handling pyrophorics.** In 2016 these gloves were provided free for affected groups and they received special training from EH&S. Free gloves will be provided while funding lasts. An online training for new workers in these groups is available on the [UC Learning Center](#) (search on "Pyrophoric") and all such workers must take this training, or request live training from EH&S.

Glove Reference Charts (*No guarantees are made regarding the accuracy of these charts. Recommend cross-checking at least two sites for consistency.*)

[Microflex Chemical Resistance Guide](#)

[Cole-Parmer](#)

[Ansell Chemical Resistance Guide](#)



UC Policy on Laboratory Safety Training

Documentation of occupationally-related safety training is a legal requirement under Cal-OSHA. In 2013, UC adopted a new policy entitled: [Laboratory Safety Training](#) to satisfy OSHA and improve safety awareness. Lab supervisors/departments have clear and direct responsibilities under the policy and the law. There are two primary requirements of the policy:

1. All “lab workers” complete a **Fundamentals of Laboratory Safety** orientation (live or online) in order to be given access to their lab(s) by their department. Enrollment directions are given below. The trainings are generic and do not address the specific hazards/procedures for a particular lab. Supervisors/Pis are still responsible under the law for ensuring this has been provided – see #2. The fundamentals training covers the core issues common to most/all labs and addresses many specific regulatory training requirements.

Accessing the Fundamentals of Laboratory Safety Orientations (mandatory per UC policy)

- **Live Version:** 3-hour, instructor-led training is offered regularly - generally once per quarter. Enroll via the [UC Learning Center](#) using UCSB NetID*. Search on “LS01”. This training is **more in-depth** than the online version below and generally **includes hands-on fire extinguisher training**.
- **Online Version:** Available via the [UC Learning Center](#) using UCSB NetID*. Search on “LS60”

**note that undergraduate UCSB NetIDs do not work directly in the UC Learning Center, but follow the instructions therein for undergraduate enrollment procedures.*

2. Lab-specific training is addressed in the second major policy mandate. The UC policy requires a **Training Needs Assessment (TNA)** [pdf](#) / [Word](#) to be performed for each lab worker. The form is electronically forwarded when the worker attends the *Fundamentals* class above. The worker is instructed to work with their supervisor, or designee, to complete the assessment and **document** completed training on the form (or elsewhere). The form categorizes training into 3 areas:
 - a. “Day One” lab orientation (e.g., location of emergency equipment, issue PPE, etc.)
 - b. Other EH&S formal classes, if needed (e.g., radiation safety, biosafety, etc.)
 - c. Other lab-specific training (e.g., local protocols, hazards, etc.)

The TNA is also a good tool for labs to use in “on-boarding” new workers since it lists all the basic health and safety tasks to cover with a new lab worker.



Exposure Limits for Laboratory Chemicals & Carcinogens

Under OSHA, there are 500+ chemicals that have [airborne chemical concentration limits](#) known as *Permissible Exposure Limits (PEL)*. **Legally, you cannot be exposed above these limits.** PELs are expressed in parts per million (or mg/m³) in air. PEL values can be for 15 minute or 8 hour exposure periods, or ceiling limits which should never be exceeded. A smaller table of [PEL values](#) for ~50 common lab chemicals is available.

Typically, if these materials are used in a fume hood and proper PPE is utilized, per this manual, then there is little reason to believe exposure levels are a concern. If you believe exposure limits may be exceeded, contact EH&S to schedule an exposure assessment. If exposure limits are exceeded, additional steps must be taken to reduce. EH&S does do occasional quantitative exposure monitoring of targeted operations to confirm acceptable exposure levels.

Human Carcinogens

Of the 500 materials noted above, some are carcinogens which are further/highly regulated under separate OSHA safety standards. They are separated into two classes:

[Regulated Carcinogens](#) fall into a higher hazard class and have extensive additional OSHA requirements associated with them. There are 30 in this category, but the common ones found in the lab are **formaldehyde, methylene chloride and benzene**. It is important to effectively apply safety controls as the regulatory requirements for laboratories that exceed threshold values for these chemicals are very extensive.

[Select Carcinogens](#) are defined under the OSHA Lab Safety Standard as follows.

- Regulated Carcinogens (see above)
- *Annual Report on Carcinogens* published by the *National Toxicology Program*: all of the substances listed as "known to be carcinogens" and some listed as "reasonably anticipated to be carcinogens"
- *International Agency for Research on Cancer*: all of Group 1 "carcinogen to humans" materials; and some in Group 2A/B.



Safety Data Sheets (SDS, formerly known as MSDS)

What is a Safety Data Sheet? SDS – formerly known as Material Safety Data Sheets - are a summary of the health hazards of a chemical material and associated recommended safe work practices. SDS are required by OSHA under the *Lab Safety Standard* and *Hazard Communication Standard* to be made readily available by chemical vendors to the purchasers of their chemicals. The use and relevance of SDS are covered in the mandatory EH&S *Fundamentals of Laboratory Safety* class. If you work in a lab, then OSHA says you must:

- be aware of what an SDS is and their relevance to your health and safety
- be aware of how to access SDS for your work area
- maintain SDSs that are received with incoming chemical shipments and ensure that they are readily accessible to lab employees during each work shift when they are in their work area(s). Electronic access per below is acceptable with a printer.

(M)SDS Sources:

[Google Customized SDS Search](#)

[Laboratory Chemical Safety Summaries](#) (not SDS, but quality info aimed at labs)

[Fisher Scientific](#)

[SIRI](#)

[Sigma-Aldrich SDS](#)

[Matheson's Gases](#)



Chemical Labelling

Under the Cal-OSHA Hazard Communication Standard (CCR, Title 8, 5194) all chemical containers must be properly labeled – unless a material is temporarily put into a new container for immediate use and is not going to be stored after that immediate use. Labeling requirements for all hazardous substances are summarized as follows:

General requirements

- All containers of hazardous materials must be labeled with the identity of the hazardous substance
- The label must contain all applicable hazard warning statements, e.g. flammable, carcinogen, corrosive

For commercial materials in the original vendor's container

- Manufacturer's product labels must remain on all containers, and not be defaced

For materials repackaged in the laboratory

- Labels must be legible, in English, and provide the info above under general requirements
- This includes secondary containers (such as spray bottles and acid/base baths) and must be labeled as above
- New synthesized compounds, or commercial products that are repackaged, must be labeled with the appropriate hazard warnings based on the knowledge of the chemical and physical properties of that substance.

In 2012 Cal-OSHA adopted use of the **Globally Harmonized System (GHS)** of chemical classification and labeling which supersedes earlier systems. Employees using chemicals need to be trained on the new system. On the next page is a summary of the terms used in the system: *Hazard Statements, Hazard Classes, Signal Words and Pictograms, etc.* Campus workers should familiarize themselves with the basic aspects of this system as they will see these terms used on all containers they receive from vendors.



Pictograms and Hazard Codes Used in the Globally Harmonized Chemical Labeling System

Pictograms and Hazard Codes Used in the Globally-harmonized Chemical Labeling System

All chemical containers provided by vendors will eventually use the following labeling system. Per Cal-OSHA employees need to be familiar with the labeling system and its relevance to the hazards of hazardous materials.

Description	Pictogram	Hazard class and hazard category:
Exploding Bomb GHS01		Unstable explosives Explosives of Divisions 1.1, 1.2, 1.3, 1.4 Self reactive substances and mixtures, Types A,B Organic peroxides, Types A,B
Flame GHS02		Flammable gases, category 1 Flammable aerosols, categories 1,2 Flammable liquids, categories 1,2,3 Flammable solids, categories 1,2 Self-reactive substances and mixtures, Types B,C,D,E,F Pyrophoric liquids, and solids, category 1 Self-heating substances and mixtures, categories 1,2 Substances and mixtures, which in contact with water, emit flammable gases, categories 1,2,3 Organic peroxides, Types B,C,D,E,F
Flame Over Circle GHS03		Oxidizing gases, category 1 Oxidizing liquids, categories 1,2,3
Gas Cylinder GHS04		Gases under pressure: - Compressed gases - Liquefied gases - Refrigerated liquefied gases - Dissolved gases
Corrosion GHS05		Corrosive to metals, category 1 Skin corrosion, categories 1A,1B,1C Serious eye damage, category 1
Skull and Crossbones GHS06		Acute toxicity (oral, dermal, inhalation), categories 1,2,3
Exclamation Mark GHS07		Acute toxicity (oral, dermal, inhalation), category 4 Skin and eye irritation, category 2 Skin sensitisation, category 1 Specific Target Organ Toxicity – Single exposure, category 3
Health Hazard GHS08		Respiratory sensitization, category 1 Germ cell mutagenicity, categories 1A,1B,2 Carcinogenicity, categories 1A,1B,2 Reproductive toxicity, categories 1A,1B,2 Specific Target Organ Toxicity – Single exposure, categories 1,2 Specific Target Organ Toxicity – Repeated exposure, categories 1,2 Aspiration Hazard, category 1
Environment GHS09		Hazardous to the aquatic environment - Acute hazard, category 1 - Chronic hazard, categories 1,2

Criteria for Implementing Engineering Controls

The next few pages deal primarily with “engineering controls”, i.e. fume hoods, gas cabinets, glove boxes, etc. **Engineering controls are considered the “first line of defense” in protecting workers. In contrast, PPE is generally considered the final defense.** The Lab Standard requires that the general criteria for implementing control measures be described. The appropriate engineering control is often obvious, but the general criteria are noted here for the common ones. The criteria should be followed unless equivalent protection can be realized. Specific engineering controls should also be described in a lab’s SOPs.

FUME HOODS, WET BENCHES, GAS CABINETS & OTHER EXHAUST VENTILATION

- When using volatile substances that present a significant inhalation hazard
- When necessary to keep exposure levels below OSHA Permissible Exposure Limits
- When using toxic gases, particularly when required by the CA Fire Code
- When indicated in Standard Operating Procedures, or as indicated in SDS

BIOSAFETY CABINETS

- With operations involving biohazardous material as directed by NIH and CDC guidelines, or the OSHA Bloodborne Pathogens Standard
- When stipulated by the Biohazard Use Authorization
- When indicated in Standard Operating Procedures

GLOVE BOXES

- When indicated in Standard Operating Procedures

APPROVED HAZARDOUS MATERIALS STORAGE CABINETS AND SAFETY CANS

- Whenever possible, but particularly when CA fire code volume limits are exceeded
- When indicated in Standard Operating Procedures

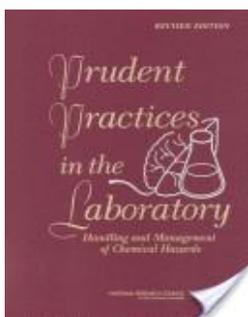
FLAMMABLE STORAGE REFRIGERATORS (APPROVED-TYPE)

- When refrigerated storage of flammable materials is needed



General Procedures for Working with Hazardous Chemicals and Operations

Within UCSB labs exists a great diversity of research and associated hazards. To address this diversity and simultaneously reduce the length of this document, we have provided links below to selected sections of ***Prudent Practices in the Laboratory*** by the National Resource Council (2011). This free text is widely considered to be the definitive publication on general lab safety. The sections selected here are those dealing with the *generic* management of hazardous materials/operations. In contrast, the other sections of this CHP are more related to issues that are UC or UCSB specific, or Cal-OSHA driven.



[4 Evaluating Hazards and Assessing Risks in the Laboratory](#)

- 4.A Introduction
- 4.B Sources of Information
- 4.C Toxic Effects of Laboratory Chemicals
- 4.D Flammable, Reactive, and Explosive Hazards
- 4.E Physical Hazards
 - Compressed Gases
 - Nonflammable Cryogenes
 - High-Pressure Reactions
 - Vacuum Work
 - Ultraviolet, Visible, and Near-Infrared Radiation
 - Radio Frequency and Microwave Hazards
 - Electrical Hazards
 - Magnetic Fields
 - Sharp Edges
 - Slips, Trips, and Falls
 - Ergonomic Hazards in the Laboratory
- 4.F Nanomaterials
- 4.G Biohazards (see also, *UCSB Biosafety Program*)
- 4.H Hazards from Radioactivity (see also, *UCSB Radiation Safety Program*)

5 Management of Chemicals

- 5.A Introduction
- 5.B Green Chemistry for Every Laboratory
- 5.C Acquisition of Chemicals
- 5.D Inventory and Tracking of Chemicals
- 5.E Storage of Chemicals in Storerooms and Laboratories

6 Working with Chemicals

- 6.A Introduction
- 6.B Prudent Planning
- 6.C General Procedures for Working with Hazardous Chemicals
- 6.D Working with Substances of High Toxicity
- 6.E Working with Biohazardous and Radioactive Matls (see UCSB programs)
- 6.F Working with Flammable Chemicals
- 6.G Working with Highly Reactive or Explosive Chemicals
- 6.H Working with Compressed Gases
- 6.I Working with Microwave Ovens
- 6.J Working with Nanoparticles

7 Working with Laboratory Equipment

- 7.A Introduction
- 7.B Working with Water-Cooled Equipment
- 7.C Working with Electrically Powered Laboratory Equipment
- 7.D Working with Compressed Gases
- 7.E Working with High or Low Pressures and Temperatures
- 7.F Using Personal Protective, Safety & Emerg. Equipment (also pgs. II-6 to 10)
- 7.G Emergency Procedures (see also pgs. II-3 to 5)

Fume Hood Usage Guide: Standard Hoods

(“Standard” hoods do not have the “VAV control box” shown on the next page)

Per Cal-OSHA, users of hoods must be trained on use of their hood. Attendance at the live or on-line lab safety orientations described below on the “UC Policy on Laboratory Safety Training” page satisfies that requirement. The information on this page should also be read by all hood users and is posted on campus hoods for easy reference.

Always work with the sash at, or below, the level of the red arrow sticker (picture on next pg.) and close it when not attended. To adequately protect you, your hood should be producing a face velocity of about 100 ft/min. EH&S tests your hood and posts the red arrow stickers at the **proper sash level to:**

- satisfy the required air flow and protect you against airborne chemicals
- protect you better from incidents within the hood
- *All hoods on campus are equipped with an air flow monitor and/or alarm to warn you if the air velocity is too low – pictured below. **If the alarm engages, lower the sash slightly until the alarm stops.** Do **NOT** disengage or over-ride the alarm. If your alarm sounds consistently this could indicate a real problem – call EH&S.
- Always work at least 6 inches inside the hood to maximize capture efficiency and store only a minimum of equipment and chemicals in your hood because:
- Excess materials will block the air flow into the intake slots at the back of the hood. Permanent equipment should be raised on a jack to allow the air to flow smoothly.
- Most fires and explosions occur in the hood. Minimizing chemical volumes will reduce the chances of a small accident escalating into a large one.
- Keep the lab windows closed. Drafts from open windows and doors can significantly affect your hood’s performance (100 ft/min is only a few miles/hr of air).



*“Magnihelic gauge” – note normal gauge position. Significant deviation may indicate low air flow.

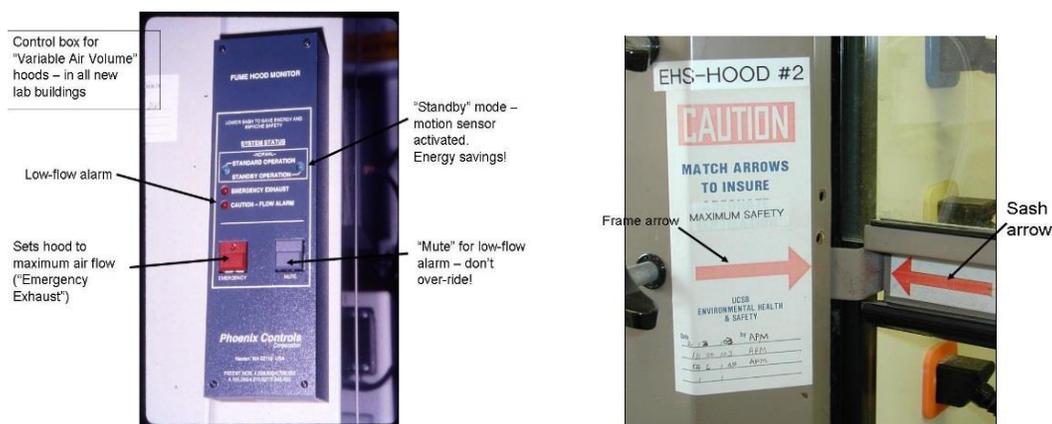


*Visible/audible alarm
Sounds during low-flow condition of

Fume Hood Usage Guide: Variable Air Volume Hoods ("Phoenix" system)

Per Cal-OSHA regulations, users of hoods must be trained on use of their fume hood. Attendance at the live or on-line lab safety orientations described below on the "UC Policy on Laboratory Safety Training" page satisfies that requirement. The information on this page should also be read by all hood users and is posted on all hoods

- Variable Air Volume (VAV) hoods — unlike a standard hood above — automatically adjust the face velocity to stay within safe work levels (~ 100 ft./min). A VAV hood is easily distinguished by the gray control box on the hood - picture below.
- **If the low-flow alarm engages, lower the sash until the alarm stops.** DO NOT over-ride the safety alarm by permanently engaging the "Mute" or "Emergency" button (e.g., with tape). If your hood is consistently alarming call EH&S (x-4899).
- Always work with the sash at or below the level of the **red arrow sticker** (below), because, if most bldg. sashes are raised, this will generate a hood alarm, and at your neighbor's hood, due to the limited capacity of your building's ventilation.
- A lowered sash protects you against airborne chemicals and incidents better than at sash full open.
- The lower the sash, the greater the **energy savings** – lower sash when not in use
- Store only the minimum of equipment and chemicals in your hood because:
 - Excess materials block air flow into the slots at back of the hood. Permanent equipment should be raised on a stand to allow good air flow
 - Most lab fires/explosions occur in hoods. Minimizing chemical volumes will reduce the chances of a small accident escalating into a large one.
- Always work at least 6 inches inside the hood to maximize hood capture efficiency.



Refrigerators and Freezers in Labs

Certain refrigerator/freezer units are designed specifically for the storage of flammable materials, and to prevent potentially explosions. This is critical, since flammable vapors coupled with an ignition source could result in an explosion. In other words, a normal kitchen refrigerator is not safe for the storage of chemicals. Before purchasing a new unit, or using an existing one, consider if chemicals will be stored there. Note that many lab refrigerators will be around for decades and so one cannot guarantee that a normal unit will never be used for flammables storage.

FLAMMABLE MATERIAL STORAGE REFRIGERATORS/FREEZERS:

These have no internal electrical components which could trigger an explosion. These must always be used for storage of volatile materials. Also known as “lab-safe” or “de-sparked” refrigerators.

All refrigerator/freezer purchases and modifications on campus **must be pre-approved** by EH&S at X8243. In addition, all approved units for storing flammable materials must be labeled with signage reading, *“Approved For Chemical Storage, No Food Storage”*. All refrigerator/freezer units not approved for storage of flammable materials must be signed as *“Explosion Hazard”*, or equivalent. Contact EH&S for your free labels.



Examples of signage on campus lab refrigerators

UCI refrigerator which exploded when chemicals were stored in a unit which was not designed for flammables



EH&S Laboratory Inspection and Lab Outreach Programs

EH&S inspects all lab spaces on campus at least annually. However, it is strongly recommended that labs initiate periodic self-inspections (recommend minimum of twice-a-year).

Prior to the EH&S visits a [Self-Inspection Checklist](#) is generally distributed to aid laboratories in establishing their own audits. The list does not include every possible safety issue, but are general guidelines. Most items are based on applicable regulations or UC policy. Radiation and biohazard issues are not addressed in the checklist because they are highly specialized and these labs receive targeted EH&S visits.

In 2017 EH&S instituted a “lab outreach program” in which an EH&S rep contacts each research group for an appointment to meet with a knowledgeable group rep. The sit-downs are generally less than an hour. Due to the large number of new UC lab safety policies/procedures in recent years, it is a good opportunity to review a group’s understanding, answer questions and hear from researchers about their concerns.

For both the EH&S lab inspection and outreach programs, the results are summarized within an online tool known as “UC Inspect”. The app allows for efficient communication and tracking of findings and corrections.



Chemical Waste Disposal

REGULATIONS: Hazardous waste regulations are stringent and penalties for violations can be severe. Santa Barbara County inspects UCSB labs for compliance on a regular basis.

STORAGE

- Store chemical waste in a designated area. Label as, "**HAZARDOUS WASTE STORAGE AREA**"
- Store chemicals in containers compatible with, and durable enough for, the waste.
- Liquid waste must be in screw-top containers. Do not overfill - allow for expansion.

LABELING

- Identify waste by proper chemical name (no abbreviations or chemical structures).
- List chemical names of hazardous components in that mixture by percent weight
- Deface existing labels when reusing containers
- Label and date container(s) when the first drop of waste is added. Hazardous waste shall be given to EH&S for disposal within **nine months** of start date.
- Use **UCSB HAZARDOUS WASTE** label on all waste containers. Available for free – see below.

SEGREGATION: group waste into the following categories:

- | | |
|--|---|
| -halogenated solvents | -non-halogenated solvents |
| -acids with pH 2 or less | -alkaline solutions of pH 12.5 or greater |
| -alkali metals and other water reactives | -heavy metal solutions and salts |
| -strong oxidizers (e.g., nitric acid) | -cyanides |
| -unstable chemicals | |

DISPOSAL

- Chemicals may not be disposed in regular trash, sink disposed, or allowed to evaporate.
- Complete a *UCSB Waste Pick-up Request Form*. Send by campus mail or fax(X8659).
Also available on the [EH&S website](#) for electronic submission
- EH&S cannot accept responsibility for improperly labeled, packaged, and/or segregated chemicals, and will not pick them up.
- Waste containers become the property of EH&S and will not be returned



UCSB Hazardous Waste Label

Laboratory Sharps Disposal

“Sharps waste” means any device having acute rigid corners, edges, or protuberances capable of cutting or piercing, including, but not limited to, all of the following: hypodermic needles, syringes, razor blades and scalpel blades. Glass items contaminated with biohazards, such as pipettes, microscope slides and capillary tubes are also a “sharps waste.” **Under no circumstances should “sharps waste” be disposed of in the normal trash. Sharps must be disposed of through EH&S, or a medical waste management company.**

Sharps Contaminated with Hazardous Chemical Waste

1. Place in a rigid, puncture-resistant container which, when sealed, is leak proof. Examples below.
2. Label the container with a hazardous waste label and include the chemical constituents.
3. Submit an online *Chemical Waste Collection Request* via the EH&S website. Please note on the request that the material is not biologically contaminated and deface any biohazard symbols, if present.

Sharps Contaminated with Radioactive Materials

1. Place in a rigid, puncture-resistant container which, when sealed, is leak proof. Examples below.
2. Label the container with a radioactive waste label and include the radioactive isotope.
3. Submit an online *Radioactive Waste Collection Request* via the EH&S website. Please note on the request that the material is not biologically contaminated and deface any biohazard symbols present.

Sharps Contaminated with Medical or Biohazardous Waste

See the EH&S website at this address: <http://www.ehs.ucsb.edu/biosafety/biosafety-guide> and see the documents “Biohazards Sharps Use and Disposal” or “Medical Waste Procedures”.

Unused or Non-Contaminated Hypodermic Needles

1. Place in an approved biohazardous sharps container that is rigid, puncture-resistant and which, when sealed, is leak proof and cannot be opened without great difficulty - examples below.
2. Deface any biohazard symbols, if present.
3. Submit an online *Chemical Waste Collection Request* via the EH&S website. Please note on the request that the material is not biologically contaminated.



Laboratory Glass Disposal

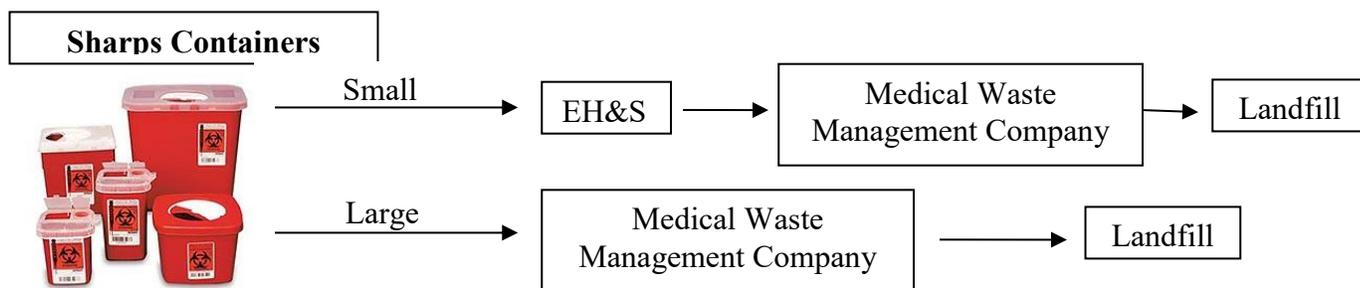
Definition: Laboratory glass is defined as equipment generally made of pyrex, borosilicate, and quartz glass used for scientific experiments. Examples of laboratory glass include, but are not limited to, the following: beakers, flasks, graduated cylinders, stirring rods, test tubes, microscope slides, glass pipettes, glass petri dishes, and glass vials. **Glass items contaminated with biohazards, such as pipettes,**

microscope slides, and capillary tubes are considered “sharps waste”. Under no circumstances should “sharps waste” be disposed of in the normal trash. Sharps must be disposed through EH&S or a certified medical waste management company.

Directions:

1. Prior to utilizing the cardboard lab glass box, duct tape the bottom to ensure the container is secure.
 - Labs can use a 32gal. red lidded cart to house cardboard lab glass box for ease of transport.
(loose lab glass cannot be placed in red lidded cart)
2. Place unwanted lab glass in the cardboard lab glass box. Non-lab glass, such as beverage containers should be placed in recycling receptacles, and not disposed along with laboratory glass waste.
3. When full, use duct tape to secure the lid to the body of the box. Be sure that the lid is securely fastened to the body of the box so the contents remain inside.
4. Bring the cardboard lab glass box down to your building’s red lidded carts and place inside. Then lock the cart. If you are using the 32gal. cart to house the cardboard glass box, roll the cart down to the dumpster corral and leave for pick-up. Carts are serviced on Saturdays.

Sharps Disposal Basic Flowchart (see above for specific types of hazmat-contaminated sharps)



Cardboard Lab Glass Boxes



Section III: REGULATORY FRAMEWORK**A. THE CAL-OSHA LABORATORY SAFETY STANDARD**

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A. THE CAL-OSHA LABORATORY SAFETY STANDARD

1. Background

The Standard for *Occupational Exposure to Hazardous Chemicals in Laboratories* (commonly known as the “Laboratory Standard”, or “Chemical Hygiene Plan”) was adopted by the California Occupational Health & Safety Administration (Cal/OSHA) Standards Board on February 21, 1991. The Standard is summarized on the following page and the [complete text](#) is available online.

The intent of the Laboratory Standard is to protect laboratory employees from harm due to chemicals. The design of the Laboratory Standard is based on a recognition by OSHA that laboratory work is typically different in character from industrial operations in their use and handling of chemicals. In contrast to many industrial operations, laboratory chemical work often involves a relatively large number of chemicals in small scale procedures that can change significantly over time to reflect evolving research.

2. Applicability

Labs meeting the following four criteria are subject to the Laboratory Standard:

- Chemical manipulations are on a lab scale, i.e., easily and safely manipulated by one person
- Multiple chemical procedures are used
- Procedures are not part of a production process, nor simulate a production process
- Protective laboratory practices and equipment are available and commonly used

Clearly, most research and teaching laboratories at UCSB, meet these criteria. Students in teaching laboratories are not University employees and therefore do not fall under the provisions of the Standard. However, it is the judgment of the University that, it is obligated to develop policies and course materials which attempt to provide the same level of protection for students. It should be noted that teaching assistants, faculty and staff in instructional labs are covered by the Lab Standard and therefore need to be included in a Chemical Hygiene Plan.

3. Summary of the Laboratory Safety Standard

The [Laboratory Standard](#) contains the following elements.

- **Chemical Hygiene Plan (CHP)**— A written plan (this document) must be developed to control and minimize chemical exposure in laboratories. The CHP must be readily available to affected employees, who need to be oriented to its provisions and relevance to their health and safety. A CHP is required where hazardous chemicals, as defined by OSHA, are used in the workplace. The CHP must be:
 - (A) Capable of protecting employees from health hazards associated with hazardous chemicals
 - (B) Capable of keeping exposures below OSHA Permissible Exposure Limits

- **Responsibilities**— Personnel responsible for implementation of the CHP must be designated, including the appointment of a Chemical Hygiene Officer. [Sec. III.B]
- **Employee Information and Training**— The employer shall provide employees with information and training to ensure that they are informed of the hazards in their work area and their avoidance. [Sec. III.C.1]
- **Standard Operating Procedures**— SOPs must be developed for incorporation into the CHP relevant to safety and health when lab work involves the use of hazardous chemicals. [Secs. I and III.C.2]
- **Particularly Hazardous Substances**— Provisions must be specified for additional employee protection for work with substances such as "select carcinogens", high acute toxicity substances and reproductive toxins. Provisions are generally incorporated into the SOPs [Secs. I and III.C.3]
- **Control Measures**— Criteria must be established that the employer will use to determine, implement and adequately maintain control measures to reduce employee exposures, including lab ventilation, personal protective equipment. Control measures generally incorporated into SOPs. [Sec. III.C.4]
- **Maintenance of Engineering Controls, Personal Protective Equipment and Emergency Equipment** – fume hoods must comply with Title 8 5154.1 and protective equipment function properly. [Sec. III.C.5]
- **Hazard Identification**— Safety Data Sheets and other reference materials need to be available. Labeling of chemicals is strictly regulated. [Sec. III.C.6.]
- **Prior Approval**— Circumstances must be stipulated under which a particular laboratory operation requires prior approval from the lab supervisor. Generally incorporated into SOPs [Sec. III.C.7]
- **Employee Exposure Determination**— As appropriate, measurements must be taken to verify that exposure limits are not exceeded. [Sec. III.C.9]
- **Medical Consultation and Examinations**— Workers are entitled to medical attention when a significant chemical exposure is suspected. [Sec. III.C.8]

B. RESPONSIBILITIES**a. Management**

Department heads, deans, supervisors, vice-chancellors and the chancellor are responsible for ensuring that individuals under their management have the training and authority to implement appropriate health and safety policies and practices relative to the Laboratory Standard and per campus policy #5400.

b. Laboratory Supervisors/Principal Investigators

The term “supervisor” at UCSB refers to anyone having direct supervisory authority, and includes staff administrators, class instructors, research assistants, managers, and faculty. The supervisor is the key individual in a successful lab safety program. Supervisors are responsible for developing and implementing the CHP for their laboratories, particularly the development of appropriate SOPs. A [helpful guideline](#) to many common specific tasks of a lab supervisor can be found online. Supervisors can delegate tasks, but cannot delegate their overall responsibility.

c. Environmental Health & Safety (EH&S)

Develop safety education and monitoring programs to help maintain a safe and healthy environment for all, in order to facilitate the research and teaching functions of the University. Support research and instructional activities by developing legally-mandated programs; provide technical guidance and consulting; and assist departments in program implementation. Make every effort to keep operations functioning smoothly in labs.

d. Chemical Hygiene Officer

The Lab Standard specifically calls for the appointment of a *Chemical Hygiene Officer*: **“An employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan.”** This CHO role at UCSB is now assigned as follows:

-UCSB Departments: Chemistry & Biochemistry; Materials; Chemical Engineering, Electrical and Computer Engineering: Alex Moretto, Chemical Laboratory Safety Officer, Physical Sciences Building North 2660, (805) 893-6630, moretto@chem.ucsb.edu

-All Other UCSB Laboratory Departments/Units: Currently vacant. Contact: Hector Acuna, x-8243.

CHO Duties: develop and distribute the *UCSB Chemical Hygiene Plan* to laboratory supervisors. Assist and advise faculty and staff in the customization and implementation of their CHP as requested/needed. Describe the provisions of the CHP to those attending the *Fundamentals of Laboratory Safety* orientations. Monitor and evaluate the effectiveness of the CHP. As a member of the *Laboratory Safety Committee*, advise campus management on the effectiveness of CHP implementation and make recommendations for upgrades to the program. Serve as interface with Cal-OSHA regarding CHP issues.

e. Laboratory Safety Committee

The committee is co-Chaired by the Vice Chancellor of Research and the Associate Vice-Chancellor of Administrative Services. The LSC functions as a venue for EH&S/CHOs to receive

input from the campus laboratory community on the content and effectiveness of the CHP and other lab safety issues. Other research-related committees include: Biosafety; Radiation Safety; Institutional Animal Care and Use; Diving Control Board.

f. Departments and Organized Research Units

- Under the campus *Injury and Illness Prevention Program* (Cal-OSHA requirement), and the associated [UCSB written program](#), the **department/unit Head or Chair is identified as the individual with the authority and responsibility to implement the IIPP**. The IIPP is the umbrella OSHA regulation, under which all worker safety programs exist.
- To assist the Chair/Unit Head, each department has a *Department Safety Representative (DSR)* who coordinates health and safety program elements in the department and serves as a liaison with EH&S.
- General oversight of department operations and communicating with supervisors and personnel any relevant safety issues, problem solving, and preplanning for emergencies.
- Per UC policy, depts. are responsible for ensuring that all new lab workers attend a *Fundamentals of Laboratory Safety* orientation before lab access is granted - Sec. III.C.1.
- Ensure that all operations under departmental control develop and implement lab-specific CHPs. While individual lab supervisors have the primary responsibility, department administrations need to coordinate and support these efforts.

g. Laboratory Workers (non-supervisors)

General responsibilities are below - a more [complete list](#) is online.

- Follow established work policies and procedures, including the UC Personal Protective Equipment policy; Laboratory Safety Training policy, CHP and authorizations from campus safety committees.
- Attend and actively participate in appropriate safety training.
- Notify the laboratory supervisor or EH&S of any unsafe or potentially unsafe condition.

Workers have rights under the law - See also the *UCSB Injury & Illness Prevention Program*

- to be informed of the hazards in their workplace
- to be properly trained on safe work practices
- to be provided appropriate personal protective equipment needed for the job at no cost
- to file a complaint with Cal-OSHA if they feel they are being exposed to unsafe conditions and no reprisals can be taken against them.

h. Facilities Management - see Section III.C.5

C. PROGRAM ELEMENTS OF THE UCSB CHEMICAL HYGIENE PLAN

1. Employee Information and Training

One of the major provisions of the Laboratory Standard and the OSHA *Injury and Illness Prevention Program* is a requirement for employee information and training. The employer must convey information to the employee regarding occupational hazards identified in the workplace. In general, training is required for:

- All new employees and employees given new job assignments involving exposure situations for which training has not previously been received
- Whenever the employer is made aware of a new or previously unrecognized hazard for which training has not previously been received

UC Laboratory Safety Training Policy

In October 2014, UC adopted a new policy entitled [UC Laboratory Safety Training Policy](#) to reinforce and support OSHA requirements and increase safety. Lab supervisors have the primary responsibilities for implementing the policy provisions, which include:

1. Ensure all “lab workers” complete an EH&S “*Fundamentals of Laboratory Safety*” training in order to be given access to their labs. Class enrollment directions and descriptions are in Sec. II. The training covers most of the issues mandated in the Lab Standard (see below).
2. However, the fundamentals course does *not* address lab-specific training issues and it is incumbent on the lab supervisor to do so. This is done via a **Training Needs Assessment** ([pdf](#); [Word](#)) to be performed for each lab worker as mandated in the UC policy. See pg. II-21.

Safety Training Required by the Laboratory Safety Standard

(* = topic covered/documented in the EH&S *Fundamentals of Laboratory Safety* class per UC policy)

*Worker rights & responsibilities per *Laboratory Standard* and the *Injury & Illness Prevention Program*

*Contents of the generic portions (Sec. II) of the *UCSB Chemical Hygiene Plan*

*Concept of *Permissible Exposure Limits* for OSHA-regulated substances and access to list

*Hazardous materials labeling, storage, and signage requirements

*Relevance and access to SDSs and other informational references and resources pertinent to the lab

*Spill response, waste disposal and emergency procedures

-Contents of the lab-specific *Chemical Hygiene Plan*, including any SOPs [**Lab supervisor responsibility**]

-The hazards of hazmat including signs and symptoms of overexposure, including Particularly Hazardous Substances - Sec. III.C.3. As appropriate, training can address entire classes of materials rather than individual substances. [**Major classes of chemical hazards are covered by EH&S*, but not lab-specific hazards. These should be addressed in a lab’s SOPs - CHP Sec. I]**

-Appropriate use of control measures including engineering controls, personal protective equipment, and work practices. [**Generic control measures covered by EH&S***]

2. **Standard Operating Procedures**

The OSHA Laboratory Safety Standard states that a laboratory's CHP include: ***“Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals”***, defined as:

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

It is incumbent on lab supervisors to develop lab-specific SOPs for operations which involve the use of a “hazardous chemical”. **Specific guidance on how to prepare SOPs are given in Section I.** In short, EH&S has developed SOP templates for the common classes of hazardous chemicals (e.g., oxidizers, corrosives), or in some cases specific chemicals (e.g., formaldehyde) that labs only need to customize with some local information. In general:

- SOPs should contain information about hazards and how these hazards will be mitigated
- Special focus should be on SOPs for “Particularly Hazardous Substances” (PHS) – human carcinogens and reproductive toxins, acutely toxic materials. (see C.6). In many cases chemicals with similar hazards and safety controls can be grouped together into a single SOP (“control banding”).
- SOPs should be written by lab personnel who are most knowledgeable of the experimental process and approved by the supervisor
- SOPs within a CHP must be reviewed by lab workers and be kept where workers can easily access them

3. **Particularly Hazardous Substances (PHS)**

The Laboratory Standard states that: ***“The Chemical Hygiene Plan shall include... provisions for additional employee protection for work with hazardous substances, including “select carcinogens,” reproductive toxins and substances which have a high degree of acute toxicity***

SELECT CARCINOGENS— Includes carcinogens as listed by the following organizations: OSHA; the National Toxicology Program; the International Agency for Research on Cancer. See also Sec. II.

REPRODUCTIVE TOXINS— A chemical which affects human reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

HIGH ACUTE TOXICITY SUBSTANCES— Substances such as hydrogen cyanide or hydrogen sulfide which may be fatal or cause damage to target organs as a result of a single exposure or exposures of short duration.

It is the responsibility of individual lab supervisors to institute SOPs for using a specific Particularly Hazardous Substance in their laboratories. **See Section I for template forms and instructions.**

- The PHS section of the Lab Standard goes on to say: “**Specific consideration should be given to the following provisions which shall be incorporated where appropriate:**

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

Again, directions/templates for addressing these issues is provided in section 1 of this CHP.

4. Criteria for Determination and Implementation of Control Measures

The Laboratory Standard states that the CHP “.... **shall include criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals**” Hazard controls are generally classified into three broad groups: engineering controls, administrative procedures and personal protective equipment. Guidance on control measures are delineated here.

A. General

- Lab supervisors shall determine and implement appropriate control measures and preferably incorporate them into their lab’s individual SOPs
- Environmental Health & Safety shall be responsible for assisting the above in determining these control measures upon request. EH&S may do periodic evaluations of control measures on campus as deemed necessary and notify lab supervisors of their results and recommendations.

B. Engineering Controls—Criteria for Implementation (see Sec. II-15)

C. Administrative Controls—Criteria for Implementation

The variety of possible administrative controls to reduce hazard levels in laboratories is large, e.g., training, signage, labeling, SOPs, etc. The controls instituted by a given laboratory shall be determined by the lab supervisor in consultation with EH&S, as needed. In general, measures shall be implemented:

- As indicated in Standard Operating Procedures
- As mandated by health and safety regulations, or as called for by accepted good practice

D. Personal Protective Equipment—Criteria for Implementation

Appropriate personal protective equipment (PPE) practices are stipulated in the UC policy titled: [Personal Protective Equipment](#) (March 2014). The key provisions of the policy are summarized in Sec. II, pgs. 6 to 10 of this manual.

5. Maintenance of Engineering Controls, Personal Protective Equipment and Emergency Equipment

Per the Laboratory Standard: **“.....a requirement that fume hoods comply with section 5154.1 (Title 8, CCR), and that all protective equipment shall function properly and that specific measures shall be taken to ensure proper and adequate performance of such equipment....”**

General Responsibilities:

FACILITIES MANAGEMENT (FM): Responsible for routine maintenance, replacement and installation of University-owned building emergency systems and environmental controls. Must inform affected departments and/or individuals in a timely way when building systems are, or will be, non-functional.

ENVIRONMENTAL HEALTH & SAFETY: Responsible for evaluating effectiveness of engineering control measures and emergency equipment used. Will make recommendations to FM and users on implementation of appropriate equipment and control measures as needed.

LAB SUPERVISOR/LAB PERSONNEL: Responsible for monitoring status and effectiveness of equipment and control measures. Responsible for reporting to appropriate campus entity if equipment is not functional. Responsible for maintaining and testing equipment they own.

Specific Responsibilities:

FUME HOODS/GAS CABINETS (per CCR, Title 8, 5154.1)

Maintenance:	Facilities Management
Annual certification:	EH&S

BIOSAFETY CABINETS (per CCR, Title 8, 5154.2)

Maintenance:	Owner (generally lab supervisors)
Annual certification:	Generally, owner covers cost of outside vendor certification – generally TSS, Inc. via UC contract. Biosafety Committee typically requires cabinet use as part of their authorization

LAB-OWNED or SPECIALIZED LOCAL EXHAUST VENTILATION (e.g., laminar flow hoods)

Maintenance:	Owner responsibility. Given the specialized nature of these, FM does not have the expertise to maintain these.
Certification testing:	Owner responsibility. Given the specialized nature of these, FM nor EH&S have the capability to test these and should be performed by an outside testing company like TSS, Inc. under UC contract.

EMERGENCY SHOWERS AND EYEWASHES (per CCR, Title 8, 5162)

Maintenance & testing	Facilities shall check on a regular basis by running water through them until the water runs clear and repair as needed and keep records.
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RESPIRATORS (per CCR, Title 8, 5144)

Administration:	EH&S has sole responsibility for approval, fit-testing and issuance. Supervisors are responsible for identifying and directing individuals to EH&S who may require respirators.
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Maintenance: Lab supervisor or designee

OTHER PERSONAL PROTECTIVE EQUIPMENT (per CCR, Title 8, 3380-3387)

Maintenance: Generally provided by UCSB, or the lab supervisor – maintenance & replacement are the responsibility of the supervisor and lab personnel. See Sec. II-6 to -10.

FIRE EXTINGUISHERS, DETECTORS, ALARMS, SUPPRESSION SYSTEMS (per CA Fire Code and Building Code)

Administration: The campus Fire Marshal's office is responsible for evaluation and approval of these systems

Maintenance: Facilities Management

GAS DETECTION/ALARM SYSTEMS (per CA Fire Code and Building Code)

Administration: EH&S has responsibility for evaluation and approval of code-required gas detection/alarm systems

Maintenance: Facilities Management, or Cleanroom staff

EMERGENCY PHONES

Maintenance: Communications Services

HAZARDOUS MATERIALS SPILL RESPONSE EQUIPMENT (per CCR, Title 8, 5192)

Maintenance: EH&S is responsible for equipping, maintaining and using the primary hazmat response equipment stores for the campus. Individual labs or departments may have local supplies.

6. Hazard Identification

Policies and regulations on hazard identification with respect to labeling and SDS are:

- Labels on incoming containers of hazardous chemicals are not to be removed or defaced.
- The primary campus access to Safety Data Sheets is through the internet - see Sec. II-13. Individual labs are encouraged to maintain their own hardcopy files as well.
- For chemical substances developed in University laboratories, the provisions for hazard determination, training and labeling shall be those stated in the Laboratory Standard.

7. Prior Approval

Another provision of the Laboratory Standard is for incorporating policies into the CHP on: ***“The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer’s designee before implementation.”***

Given the diversity of chemical work done in campus laboratories, it is impossible to specify the operations which would require prior approval. **It is therefore the responsibility of individual lab supervisors to establish these criteria, if any, for their operations. Establishment of prior approval criteria is solely the prerogative of the lab supervisor.** These criteria should be incorporated into lab’s SOPs. There is a field in the UCSB SOP templates for including.

8. Medical Consultation and Examination

The Laboratory Standard states that: ***“The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances”:***

- ***When an employee develops signs or symptoms associated with a hazardous chemical to which that employee may have been exposed***
- ***Where exposure monitoring reveals an exposure level routinely above the action level or PEL for an OSHA-regulated substance***
- ***Whenever an event takes place in the work area such as a spill, leak, or explosion resulting in the likelihood of a hazardous exposure”***

The University has established the following procedures, when it is known or suspected that a worker has been exposed to a hazardous chemical(s) or is otherwise injured on campus.

- All employees suffering from chemical exposure or other work-related injury incurred at UCSB shall be [evaluated/examined](#) at University expense. Students are covered by their required medical insurance.
- If the injured/exposed person is safe to transport, escort them to either Student Health Services (undergraduate students), Goleta Valley Community Hospital, or their primary physician for evaluation. Contact EH&S at x3194, or x4440 immediately to initiate medical coverage procedures.
- In some cases a work-related chemical exposure may be suspected but not certain. For example, some low-level but chronic exposures may be difficult to identify or relate to specific symptoms. In these instances, contact the Chemical Hygiene Officer at x4899 to arrange a review of the suspected exposure.
- The Laboratory Standard includes specific provisions regarding the employer’s exchange of information with the examining physician. The provisions of the Standard will be followed as stipulated therein.

9. Criteria for Establishing Exposure Monitoring

The legal limits for occupational exposure to ~500 chemicals which are toxic by inhalation, or skin contact, are codified by OSHA in so-called [Permissible Exposure Limit \(PEL\)](#) values.

Exposure monitoring for any substance regulated by OSHA will be done if there is reason to believe that exposure levels exceed the action level, or Permissible Exposure Limit. The tasks of determining if monitoring is required and performing the monitoring shall be the sole responsibility of EH&S. For “regulated carcinogens” (See Sec. II-11) EH&S does periodic reviews of usage practices and monitoring to establish if there is reason to suspect there are exposures.