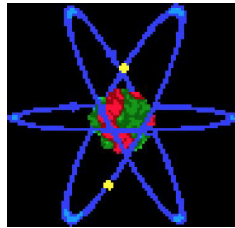


UNIVERSITY OF CALIFORNIA AT BERKELEY
DEPARTMENT OF NUCLEAR ENGINEERING

SAFETY MANUAL



EMERGENCY PHONE NUMBERS

Fire Police Ambulance
911

UC Police
642-6760
24-hour service
UC Police, Emergency Only: 911 or from cell (510) 642-3333

Environmental Health and Safety (EH&S)
642-3073
Hazardous spills, general info, etc.

UC Berkeley Physical Plant/Campus Services
642-1032
24-hour service; elevators, electricity,
water, ventilation, sewer, grounds

Etcheverry Hall Building Manager
Dan Essley, 6161 Etcheverry Hall
642-7789

NE Department Safety Officer
Jeff Bickel, 4163 Etcheverry Hall
642-5015

Nuclear Engineering Manuals
Department Safety Manual

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Table 1. Nuclear Engineering Faculty Phone List

FACULTY	Office	Phone Lab in Etcheverry	E-Mail (.berkeley.edu)
Joonhong Ahn	4157	642-5107	ahn@nuc
Ehud Greenspan	4107	643-9983	gehud@nuc
Peter Hosemann	4169	643-3288	peterh@
Daniel M. Kammen	310 Barrows	643-2243	dkammen@socrates
William E. Kastenber	4103	642-7055	kastenbe@nuc
Ka-Ngo Leung	4103	642-7055	knleung@lbl.gov
	LBNL	486-7918	
Edward C. Morse	4161	642-7275	morse@nuc
	1140	642-1984	
Eric Norman	4109	643-3288	enorman@lbl.gov
Donald R. Olander	4103	642-7055	olander@nuc
Per F. Peterson	4167	642-3477	peter@nuc
Stanley G. Prussin	4113	642-5274	prussin@nuc
Karl van Bibber, Chair	4153	643-7749	karl.van.bibber@nuc
Kai Vetter	4171	642-7071	kvetter@nuc
Jasmina L. Vujic	4105	643-8085	vujic@nuc

Table 2. Nuclear Engineering STAFF Office and Phone List

Staff	Office	Phone	E-Mail (.berkeley.edu)
Dan Essley , Building Manager	6161	642-7789	dessley@nuc
Chair Assist , Computer Resources	4155	642-4077	
Lisa Zemelman , Student Services	4149	642-5760	lisaz@nuc
Dan Chivers , Development Engineer			chivers@
Jeff Bickel , Dept. Laboratory Safety Officer	4163	642-5015	jbickel@
Karen Wong , NNSC Program Manager	4111	643-2065	wongk@
Nancy Lin , Unix & Network Support	1109A	642-7291	nlin@newton

Table 3. Nuclear Engineering Laboratories, Student Offices Phone List

Conference rooms	1106	643-9273
	4101	643-3328
Reactor Room (Morse)	1140	642-1984
Experimental Area (Morse)	1140	642-5224
Plasma Physics Group (Morse)	4116	643-2055
Thermal Hydraulics Lab (Peterson)	4118	642-0421
Fuel Cycle, Design Lab (Ahn, Vujic, Greenspan)	3115b	643-9247

Computational Materials Lab (Hosemann)	3117a	643-3280 (students)
	3317b	643-3281 (postdocs)
Reactor Design Group	3115a	642-1719
Grad Students (TA's, 1 st year)	4126	642-2130
Visiting Scholars	4151	642-8425

ACRONYMS

EHC	EXCEPTIONALLY HAZARDOUS CHEMICALS
EH&S	Environment, Safety and Health
ERSO	Engineering Research Support Organization
JHA	Job Hazard Analysis
SOP	Standard Operating Procedure
NE	Department of Nuclear Engineering
PI:	Principal Investigator
PM:	Project Manager
UCB:	University of California, Berkeley
UCB NE:	University of California, Berkeley Nuclear Engineering Department

1. INTRODUCTION

The University is required by law to maintain an Injury and Illness Prevention Program for all employees. For your own personal safety, it is essential that:

- You are aware of the potential hazards in your working area.
- You know the rules and protective measures for working safely.
- You know whom to contact in the event of an emergency.
- You know the procedures to follow in the event of an emergency.

The Nuclear Engineering Safety Committee has prepared this Safety Manual as a training tool and a reference for department members. It presents a summary of emergency procedures and guidelines for some of the most commonly encountered safety problems. It is not intended to supersede University, State, or Federal safety regulations.

All persons working in Nuclear Engineering offices or labs are required to read this manual and comply with its provisions.

The Manual incorporates minimum safety requirements established by UCB that apply to all campus units and all faculty, staff, and students who work in these shops. Additionally, it reinforces the responsibility and accountability of all personnel for safety within their individual work areas.

All faculty, staff, students, administrators, and visitors all have responsibility for complying with, communicating, and ensuring adherence to environmental, health, and safety regulations, and safe work practices. This Manual is an important tool in communicating these expectations, and it is important that the Manual be available, accessible, and implemented in each workspace.

Your active use of the Manual will help make NE shops and laboratories healthy and safe places to work and will protect our campus community and environment.

Personal copies of this manual are given to all graduate students, staff and faculty. In addition, each shop, laboratory and administrative office must keep a reference copy of the NE Safety Manual, to be available to all employees during working hours. Laboratory Supervisors are responsible for maintaining the reference copy of the Safety Manual for their unit. Supplemental safety materials relevant to the individual lab or office may be added. Copies of any supplemental material must be given to the NE Safety Committee. This manual may be downloaded from the Nuclear Engineering web site at http://www.nuc.berkeley.edu/files/2008-12_NE_Safety_Manual.pdf.

Under the provisions of the Injury and Illness Prevention Program, each department has an IIPP Coordinator who is responsible for initiating and administering injury and illness prevention activities. The IIPP Coordinator maintains written documentation for the program. In addition, faculty, principal investigators, and supervisors have direct responsibility for implementing procedures and practices in their own units. Each laboratory is also required to have a "Chemical Hygiene Plan" which provides specific guidelines for that work area. The Chemical Hygiene Plan is maintained by the Lab Safety Contact. In the event of any problem or question, you should know that the following sources of information and assistance are available to you at all times:

Table 4. NE Faculty and Staff lists key personnel that that support achievement of Injury and Illness free environment.

Table 4. NE Faculty and Staff

Position	Name	Location
Professor and Chair, IIPP Coordinator	Karl van Bibber	4155 Etcheverry Hall, 3-7749
Safety Committee Chair	Ed Morse, Peter Hosemann	4169 Etcheverry Hall 3-3288
Department Safety Coordinator (DSC),	Jeff Bickel	4163 Etcheverry Hall 2-5015
Etcheverry Hall Building Manager	Dan Essley	6161 Etcheverry Hall, 2-7789
Safety Contact for your Lab or Office		
Office of Environment, Health & Safety		University Hall, 2-3073

If you have a safety concern, "Report of Unsafe Condition or Hazard" forms are available outside Rm. 4108 Etcheverry Hall. A report may be turned in to any member of the NE Safety Committee.

2. INJURY AND ILLNESS PREVENTION PROGRAM (IIPP)

The Nuclear Engineering Injury and Illness Prevention Program (IIPP) is intended to establish a framework for identifying and correcting workplace hazards within the department, while addressing legal requirements for a formal, written IIPP. The Department Chair has primary authority and responsibility to ensure departmental implementation of the IIPP and to ensure the health and safety of the department's faculty, staff and students. This is accomplished by communicating the Berkeley campus's emphasis on health and safety, analyzing work procedures for hazard identification and correction, ensuring regular workplace inspections, providing health and safety training, and encouraging prompt employee reporting of health and safety concerns without fear of reprisal.

The Nuclear Engineering Safety Committee has the ongoing responsibility to maintain and update the IIPP, to assess departmental compliance with applicable regulations and campus policies, to evaluate reports of unsafe conditions, and to coordinate any necessary corrective actions. The Safety Committee meets quarterly and includes representatives from the technical staff and the major experimental groups, each led by a Principal Investigator (PI) including Fusion, Thermal Hydraulics, Nuclear Detection and Nuclear Materials. Each PI has a designated representative on the committee. Department Safety Committee meetings are open meetings and everyone in the department is encouraged to attend to raise pertinent issues.

The entire text of the IIPP can be downloaded from the NE Department web site at http://www.nuc.berkeley.edu/people/safety/illness_Accident_Prg.html

3. EMERGENCY RESPONSE PLAN

It is expected that every person working in the Department will act responsibly in any Department emergency. In most cases the observer of an emergency is faced with the decision to leave the scene to summon help or to stay and provide help. The basic rule is as follows:

Unless you are sure that you are not putting yourself in any danger and you know you can make a difference, summon help.

The Etcheverry Hall Emergency Plan, prepared by Dan Essley may be downloaded from the NE Department web site at http://www.nuc.berkeley.edu/people/safety/emergency_plan.pdf. This document contains details for handling any emergency in Etcheverry Hall. Essential matters are summarized below.

3.1 EVACUATION PROCEDURES

EXIT BUILDING VIA THE STAIRWAYS. DO NOT USE ELEVATORS. Take time to familiarize yourself with evacuation routes in advance. Maps showing location of all emergency exits and fire alarms and extinguishers are posted on all floors.

ASSIST THE INJURED AND HANDICAPPED WHEN POSSIBLE. Do not move the seriously injured unless there is danger of further injury. Ask disabled persons in wheelchairs how best to assist them. If there are deaf or hearing impaired persons nearby, be sure they know there is an emergency. If it is necessary to leave someone in the building, try to leave him in a relatively secure place (e.g., the stairwell is one of the safer places to be in a fire). After you have evacuated the building, find the proper officials and report the location and condition of persons who need assistance.

DESIGNATED SAFETY OFFICERS FOR INDIVIDUAL LABS AND OFFICES ARE RESPONSIBLE FOR CLEARING ALL ROOMS IN THEIR UNIT. Efforts to clear rooms should be limited to five minutes. As rooms are cleared, all doors should be closed. Safety Contacts must go immediately to nearest Emergency Control Point to verify that their unit has been fully evacuated and to report any problems.

ONCE OUTSIDE THE BUILDING, keep at least 100 feet away from the building to avoid danger from falling glass, etc. **GO DIRECTLY TO THE MEETING AREA NEXT TO SANDBOX EAST OF ETCHEVERRY HALL.**

DO NOT RE-ENTER THE BUILDING UNTIL POLICE OR FIRE PERSONNEL HAVE DETERMINED THAT IT IS SAFE.

3.2 FIRES (see also fire safety plan below)

IF THE FIRE ALARM SOUNDS, TURN OFF ANY ELECTRICAL EQUIPMENT YOU ARE OPERATING AND EVACUATE THE BUILDING IMMEDIATELY. Close all doors to help prevent fires from spreading. Exit via stairwells. Do not use elevators.

TO REPORT A FIRE: PULL NEAREST FIRE ALARM, and **CALL 911 TO GIVE LOCATION AND EXTENT OF FIRE.** State if there are any special circumstances, such as the presence of animals or dangerous chemicals. Fire alarms in Etcheverry are located near the elevator at each end of the building and in hallways of each floor (look for small red boxes on the wall).

DO NOT ATTEMPT TO FIGHT A FIRE UNLESS YOU HAVE BEEN TRAINED IN FIRE EXTINGUISHER USE AND THE FIRE IS VERY SMALL. If your lab or office does not have an extinguisher, there are extinguishers located throughout hallways on each floor. When fighting a fire, always position yourself between the exit and the fire to ensure an escape route. IF THE FIRE CANNOT BE CONTAINED, GET OUT QUICKLY!

3.3 EARTHQUAKES

The Berkeley Campus lies on an active fault. It is very likely that at some time there will be a major earthquake affecting the campus.

SEEK SHELTER UNDER A DESK, TABLE, COUNTER, OR DOOR FRAME. If possible, move away from experimental setups, tall bookcases, and glass windows. If outside, move into open areas away from overhead power lines.

DO NOT ATTEMPT TO LEAVE BUILDING WHILE TREMOR IS OCCURRING. (If outside, remain outside.)

WHEN TREMOR STOPS, LEAVE BUILDING AS SOON AS IT APPEARS SAFE. DO NOT USE THE ELEVATOR. CARRY OR ASSIST DISABLED PERSONS DOWN THE STAIRS. In case of possible gas leaks, do not light matches and do not operate electrical switches or appliances. Flashlights are ok.

DO NOT TIE UP PHONE LINES EXCEPT TO REPORT EXTREME EMERGENCIES. Help keep phone lines from being overloaded by replacing any receivers that have been knocked off their hook. An emergency phone is located at the North Gate entrance to campus.

3.4 OTHER EMERGENCIES

Injuries. For life-threatening emergencies, CALL 911 for medical aid and for transportation to hospital. To dial from a cell phone for campus police in an emergency (510) 642-3333 For less serious injuries or illness, first aid can be obtained at University Health Service, 2222 Bancroft Way (2-3188). Report all injuries to room 4149 Etcheverry and complete an injury report form.

Elevator Failures. Report elevator problems to the Facilities Office (2-1032) or the Building Manager (Dan Essley, 2-7789). During non-business hours, report emergencies directly to the Office of Physical Resources, 2-6556. If there are people trapped inside the elevator, try to communicate to them that help is on the way. If you are trapped inside, call for help by pressing the alarm bell or using the emergency phone in the elevator. (You can access a direct phone line to campus police by pressing the red emergency button located down at knee level on the control panel.)

Flooding/Plumbing Failure. Call for help immediately: 2-1032 (Physical Plant) after-hrs. : 2-6556. If flooding occurs around energized electrical devices, do not touch equipment. Cut power source at main electrical panel.

Hazardous and Toxic Spills. Call EH&S (2-3073) for assistance and advice on spills of any quantity involving materials on the following list:

- Carcinogens and mutagenic materials
- Bio-hazardous materials
- Highly toxic chemicals

Concentrated acids and bases
Radioisotopes (call 642-3073 during business hours)

If the spill presents an EXTREME hazard, evacuate the building. Pull the fire alarm, dial 911 and give exact location and nature of spill. If you are unfamiliar with the toxicity of the substance you are working with, contact your supervisor. Minor spills should be cleaned up promptly.

Gas Leak and Other Utility Failures. Report immediately to: 2-1032 (after hours 2-6556) (Office of Physical Resources), or Dan Essley at 2-7789. If necessary, evacuate building by pulling fire alarm and notify Police by calling 911 or 2-6760. In the event of gas leaks, do not operate any electrical switches as this may produce sparks. Flashlights are ok.

4. FIRE SAFETY PLAN

Know what to do in the event of a fire. Become familiar with the emergency response procedures listed above. More detailed information is included below.

4.1 Fighting Small Fires

Always pull the fire alarm first (or send someone to do this), before attempting to fight a fire. Do not try to fight a fire unless you feel it can be done safely and there is a clear escape route.

Know where the closest fire extinguisher is located. Also, be sure you are using the proper type of extinguisher: A = paper only; ABC = multi-purpose; B=flammable liquids; C = electrical equipment.

If your laboratory or office does not have its own extinguisher, there are several available throughout the building on each floor. These are mounted in several places along each hallway.

Before opening any doors to investigate a possible fire, feel the top part of the door with the back of your hand. If it is hot, do not open the door. If door is cool, open it a crack to see if the fire is still confined and small; if not, close door and leave immediately.

If the fire is small, enter the room and try to extinguish the flames. Direct the extinguisher at the base of the fire. Be careful to keep yourself between the fire and the door. Do not allow the fire to block your exit from the room.

If you are able to put out a fire successfully, remain at the site to make a report to the Fire Department or UCPD.

4.2 Fire Prevention and Maintenance Information

Fire Extinguishers. It is recommended that each laboratory order its own fire extinguisher through the Office of Physical Resources. If an extinguisher is installed by OPR, it will automatically be scheduled for an annual inspection and will be refilled when necessary.

In areas where combustibles are used and stored, remove all open flame devices and use grounded electrical devices in good service condition.

Use only approved containers for combustible waste. A list of containers approved by the State Fire Marshal is available from EH&S (2-4409).

Remove all combustibles and obstructions from corridors and exits.

Familiarize yourself with alternative exits. Walk through them now; this will make it easier for you during an emergency. (Remember; do not use elevators during a fire.)

Report problems with fire alarms, fire extinguishers, or other built-in fire protection to the Building Coordinator or the Campus Fire Marshal (642-4409). Other potential fire hazards should also be reported. For example: defective exit doors or defective exit lights, obstructed corridors, accumulated waste materials.

Special training courses, films, and technical training advice are available from EH&S Training Staff (643-3482).

5. POWER FAILURES

5.1 Planning for Power Failures: Tips for Laboratories

Like any other part of the infrastructure, electrical power to the campus can fail, either as an isolated incident or as part of a larger emergency. Planning for power failures and knowing what to do when they happen can keep the incident from creating a disaster for your research and possibly you. Familiarize yourself with exits and locations of telephones.

Back up your computer files often so that you do not lose data if there is a sudden power loss.

More detailed advice on planning for Power failures may be found on the EHS Fact Sheet on Power failures located at <http://www.ehs.berkeley.edu/pubs/factsheets/16powerfail.html>

5.2 If the Electricity Goes Off while you are in a lab:

Call Ed Morse (642-7275), Dan Essley (642-7789), or Jeff Bickel (642-5015 after hours 510 333-9300) and report your situation.

Shut down experiments that can be run again when power (and safety equipment) is available.

Make sure that any experiments that must continue running are stable and are not creating uncontrolled hazards such as dangerous vapors in a non-functioning fume hood.

Check and secure fume hoods. Stop any operations that may be emitting hazardous vapors. Cap all chemical containers that are safe to cap, and then close the fume hood sashes. Leave the room if you notice any odors or physical symptoms.

Check equipment on emergency power. It will take 20-30 seconds for the emergency power to kick in. Items not permanently connected to these outlets should not be connected during a power interruption.

Disconnect equipment that runs unattended, and turn off unnecessary lights and equipment. This will reduce the risk of power surges and other unforeseen damage or injury that could result when the power comes on unexpectedly.

Check items stored in cold rooms and refrigerators. You may need to transfer vulnerable items to equipment served by emergency power. Another solution is to use dry ice to protect

critical materials. Note: Do not use dry ice in walk-in refrigerators or other confined areas, as hazardous concentrations of carbon dioxide gas will accumulate.

5.3 When the Electricity Returns

Reset/restart/check equipment. In particular, check that the airflow of your fume hood has been restored. If your fume hood has not automatically re-started, call your zone's PP-CS representative. Keep the sashes closed, and do not use the hood until the ventilation system is working again.

6. BUILDING SECURITY

In recent years, thefts of personal property and equipment from the campus have been serious, and the threat of personal injury always exists. All exterior doors must be kept shut during hours they are locked and, whenever possible, office and lab doors should be locked. Valuable personal property (wallets, purses, etc.) that you bring to the campus should be kept on your person or in locked drawers or cabinets.

Be aware that the University specifically excludes personal property from its insurance coverage. Students and staff should arrange for valuable mail (checks, etc.) to be delivered to their homes. Report all thefts or mysterious disappearances at your first opportunity to Dan Essley at 2-7789.

6.1 Unauthorized Persons in the Building

6.1.1 During regular work hours

If you observe any unauthorized person (anyone whose actions appear suspicious) in the building, challenge his/her presence unless you feel uncomfortable doing so. The challenge must not be confrontational. Simply ask the question, "May I help you?". Depending on the level of your comfort, and upon receiving an answer, continue the questioning or stop. Any time that you conclude that the person might be unauthorized, call the Campus Police (2-6760) and report the incident. Make sure you can describe the person and the direction that he/she is going.

6.1.2 During off-work hours

If you observe any unauthorized person (anyone whose actions appear suspicious) in or around the building do NOT challenge his/her presence. Go to the nearest telephone and report the incident to the police by calling 911. Make sure you can describe the person and the direction that he/she is going. When approaching a building entrance, observe if anyone is loitering around the area where he/she might attempt to enter behind you.

If anyone is loitering, use another entrance if possible.

If anyone attempts to enter behind you, and only if you feel comfortable, advise that he/she is not allowed to enter the building.

If a person enters behind you and you do not feel comfortable talking, ignore his/her presence, go to a telephone as soon as possible and report the incident to the police by calling 911.

6.2 PERSONAL SAFETY

You can significantly reduce your chances of being the victim of an accident or a crime by taking some simple precautions:

- Be aware of your surroundings at all times
- Report suspicious persons to the Campus Police (2-6760)
- Close and lock your office or lab door when working after hours
- Let another person know where you are and how long you expect to be there
- Keep your personal belongings out of sight
- Walk in pairs or groups after dark, or dial B-SAFE for an escort

The campus has several resources for information on crime prevention and training in safety techniques and self-defense. See the Public Safety and Transportation Services Home Page for further details.

Reporting a Crime: Call 911 if personal danger or injury.
Call 2-6760 to report a theft.
Call 2-1032 for a building maintenance emergency (2-6556 after hours).

Reporting an Injury: Call 911 if serious. For minor injuries, report to the University Health Service (Tang Center) at 2222 Bancroft Way. All injuries should be reported within 24 hours to the Department Safety Coordinator, Jeff Bickel. The DSC will assist PI and or supervisor in completing required forms.

Should an injury or occupational illness occur, required forms must be submitted to the Department of Workers Compensation (DWC) as outlined in the Workers' Compensation Manual for Supervisors. .

Students who are not employees who are injured or involved in an accident should report the incident to their instructor. In either case, if immediate medical treatment beyond first aid is needed, call 911. The injured party will be taken to the appropriate hospital or medical center. If non-emergency medical treatment for work-related injuries or illnesses is needed, call the Tang Center's Occupational Health Clinic (2-6891) or Urgent Care Clinic (2-3188).

7. WRITTEN PROCEDURES

7.1 Standard operating procedures

Standard Operating Procedure (SOP) are written instructions that document how to safely perform work involving hazardous materials or hazardous operations. SOPs are required by Cal/OSHA under the Laboratory Safety Standard. This manual and the Nuclear Engineering SOPs provide general instructions for many common tasks performed in NE. In addition to this document, Environment, Health & Safety (EH&S) provides Fact Sheets that can serve as SOPs for some common hazardous chemicals and operations. These Fact Sheets are available on the EH&S web site at <http://ehs.berkeley.edu/pubs/factsheets.html>. For specific hazards that are not covered by this manual or if EH&S Fact Sheets are not adequate, either develop a specific SOP or request the DSC to develop an NE SOP. If a specific need develops, write a laboratory-specific SOP. SOPs for the most hazardous chemicals and processes should be developed first. Anything capable of causing death, explosions, blindness, severe burns, etc., is a candidate for an SOP. If there has been a close call in the lab recently, this is another candidate for an SOP. SOPs should be approved by the PI and either the laboratory Chemical Hygiene Officer, the

laboratory safety committee representative, or the DSC. For common laboratory equipment (e.g., ultracentrifuges), the manufacturer's operations and maintenance manual may serve as, or supplement, the SOP.

SOPs may focus on any of the following:

- Process (e.g., welding, peptide synthesis, distillation)
- Hazardous chemical (e.g., liquid nitrogen, carbon monoxide, perchloric acid)
- Class of hazardous chemical (e.g., heavy metals, organic solvents)

The EH&S SOP Template provides a physical format for writing an SOP. The standard SOP contains 12 sections. The NE SOP template has corresponding sections.

Figure 1. SOP **Template**

7.2 Job (Task) Hazard Analysis

Job (Task) Hazard Analysis (JHA) are written documents that supplement the SOP or are stand alone instructions that document how to safely perform work involving hazardous operations, hazardous materials, or other activities. A JHA describes job tasks in step-by-step fashion, identifies associated hazards at each step, and outlines proper hazard controls (training, protective measures) that minimize the risk of injury.

The JHA process is in wide use in industry, government and academia. While SOPs are required by Cal/OSHA for chemical laboratories, JHA's are required by UC Berkeley Policy for Shops¹. The NE safety manual provides general instructions for many common tasks performed in NE, but is not as specific as the JHA. Consider writing a JHA for common hazardous activities that will be performed over-and-over, where the SOP or Fact Sheet is not specific as to PPE, training or work practices. JHAs may be shared among NE Labs, Departments, or Campus-wide. A Job Hazard Analysis (JHA) library for UC Berkeley is available at <http://ehs.berkeley.edu/jsa/alphalibrary.html>. A sample JHA is included as Figure 2. Job Hazard Analysis **Template**. The DSC can draft a JHA but the users should review and finalize the document. Shop supervisor should approve all JHA within their purview.

8. OFFICE SAFETY

8.1 General

Staff members who work exclusively in offices should be aware that they have the RIGHT TO KNOW any laboratory hazards in the surrounding area and they should feel free to discuss any questions or concerns with any member of the Department Safety Committee.

It is the responsibility of each employee to perform his or her job in a safe manner. Safety is as important in the office as it is in the laboratory.

Offices should be inspected by the occupants for earthquake hazards. Tall bookshelves and cabinets (including lateral file cabinets) must be anchored to the wall or made secure by other approved means (contact Dan Essley, 2-7789 for advice). There should be no overhead storage that could create a falling hazard.

Extension cords are generally not to be used. Approved multi-plug strips may be used as long as they have an internal breaker and are not run in series with other cords (daisy-chained). All cords should be inspected for wear; frayed cords are to be replaced.

Use of space heaters has been specifically prohibited by the State Fire Marshal. Problems with room heat should be reported to Physical Plant-Campus Services (PP-CS), 2-1032.

Furniture arrangement in offices should permit a quick exit in an emergency. Quantities of paper or other combustibles must be kept at a minimum.

EH&S (2-3073) has many brochures available regarding display terminals (VDT) and other office machinery.

¹ Shops are characterized by noise, machine tools, heavy machinery repair, heavy material handling equipment, fabrication, welding and similar activities.

Tang Center has many topics available has many brochures available regarding <http://www.uhs.berkeley.edu/home/healthtopics/index.shtml> health issues related to the work environment.

8.2 COMPUTER SAFETY

As more and more activities – work, study, recreation, etc. – involve computers, everyone needs to be aware of the hazard of Repetitive Strain Injury to the hands and arms resulting from the use of computer keyboards and mice. This can be a serious and very painful condition that is far easier to prevent than to cure once contracted, and can occur even in young physically fit individuals. It is not uncommon for people to have to leave computer-dependent careers as a result, or even to be permanently disabled and unable to perform tasks such as driving or dressing themselves.

What are the Symptoms of RSI?

- Tightness, discomfort, stiffness, soreness or burning in the hands, wrists, fingers, forearms, or elbows.
- Tingling, coldness, or numbness in the hands.
- Clumsiness or loss of strength and coordination in the hands.
- Pain that wakes you up at night.
- Feeling a need to massage your hands, wrists, and arms

Correct typing technique and posture, the right equipment setup, and good work habits are much more important for prevention than ergonomic gadgets like split keyboards or wrist rests. Emerging research suggests that a monitor position lower and farther away may be better. The chair and keyboard should be set so that the thighs and forearms are level (or sloping slightly down away from the body), and that the wrists are straight and level - not bent far down or way back. If the table is too high to permit this, you may do better to put the keyboard in your lap. The typist should be sitting straight, not slouching, and should not have to stretch forward to reach the keys or read the screen. Anything that creates awkward reaches or angles in the body will create problems. Please note that even a "perfect" posture may result in problems if it is held rigidly for long periods of time: relax, MOVE and shift positions frequently. This isn't just about your hands and arms, either: the use or misuse of your shoulders, back and neck may be even more important than what's happening down at your wrists.

Handouts offering guidelines and advice about proper computer use and various techniques for preventing health problems associated with computer use are available in 4149 Etcheverry or may be viewed at <http://www.uhs.berkeley.edu/home/healthtopics/index.shtml> or <http://ehs.berkeley.edu/pubs/factsheets/60officesafety.pdf> for general office safety.

Basic information is summarized here:

Keyboard/Mouse Height: The height of the keyboard and mouse should allow the user to sit with shoulders relaxed, elbows bent, and forearms, wrists, and hands approximately parallel to the floor. The keyboard angle should be adjusted to promote a neutral/flat position of the wrists. This may be achieved in a number or combination of ways, such as:

A bi-level table easily adjustable for screen and keyboard height

A lower or higher table that promotes a straight wrist while keying (ie., a table height

approximately two inches below the user's elbow)

A height adjustable keyboard tray that can be attached to existing desk or table and provides both the appropriate keyboard/mouse height and adequate leg room for the user

A mouse tray

A chair that is height adjustable; may need to provide footrest

A keyboard that is detachable from the monitor and adjustable for angle

Screen height: The top of the display screen should be approximately at, but no higher than, eye level; lower and possibly closer for bi-focal wearers. The user should not have to assume awkward neck postures to view the screen or hard copy documents. Retrofitting options include the following:

Bi-level table adjustable for screen and keyboard height

Raise monitor by putting it on top of hard disk drive, boxes, or books

Lower monitor by removing it from the hard disk drive or other platform

Adjustable monitor arm

Firm posture support: Chairs should firmly support a comfortable posture, providing support to the lower back region and avoiding pressure on the back of the thighs. Retrofitting may include a number or combination of options such as:

Chair adjustable for height and tilt of seat and backrest.

VDT users should be able to adjust chairs from seated position without use of tools.

Armrests, if provided, should be height adjustable or removable to avoid interfering with natural movement of the arms.

Lumbar support cushion if chair does not provide adequate lower back support.

Seat cushion or seat wedge.

Footrest if VDT user's feet do not rest firmly and comfortably on the floor.

Wrist support: Wrist rests may be helpful in promoting a neutral/flat position of the wrists.

Retrofitting options include: Padded, movable wrist rest, same height as keyboard home row, a cushioned mouse pad

Accessories: Workstation accessories can prevent awkward neck positions. Accessories that should be provided if needed include:

Document holders adjustable to screen height for users who type from hard copy

Documents. Lightweight telephone headsets for users assigned to continuous telephone work in conjunction with VDT use.

Lighting: Overhead lights, windows, or other light sources may contribute to visual discomfort. It is generally recommended that room lighting for use of VDTs with dark background screens be lowered to about half of normal office lighting. External sources of light (windows, overhead lights, etc.) should not be in the visual field of the VDT user, nor should their reflections be visible on the screen.

Temporarily shield peripheral light sources from view with a file folder. If this provides relief, try to eliminate the bright source in one of the following ways:

Use blinds or curtains over windows when necessary

Position monitor screen at right angle to window

- Turn off some overhead lights; use task lighting, if needed
- Remove every other fluorescent bulb, if necessary
- Position monitors to avoid direct light in user's eyes

Screen reflections: Reflections on the screen reduce text visibility by decreasing screen contrast. Turn off the computer and look for bright reflections on the screen. Eliminate these reflections in one of the following ways:

- Position monitor to avoid direct light on user's screen
- Use blinds or curtains over windows when necessary
- Position screen between banks of overhead lights
- Position monitor screen at right angle to window
- Make cardboard glare hood for top of monitor
- Use glare screen (glass preferred)

9. LABORATORY SAFETY

9.1 General Guidelines

Research labs and shops are full of potential hazards that can cause serious injury. Working alone in laboratories is forbidden if you are working with hazardous substances or equipment. At least two people should be present so that one can shut down equipment and call for help in the event of an emergency. ***Working alone in any kind of lab is not recommended under any circumstances, but if you must do so, notify someone of your location.***

Although all N.E. staff and students are expected to have appropriate English-language ability, many foreign languages are spoken in the department. If there is a need for training in another language, please notify the safety committee.

Safety training should be provided by a faculty member, lab safety contact, or staff member at the beginning of a new assignment or when a new hazard is introduced into the workplace. Particularly hazardous substances may require campus registration and approval. Such material includes radioactive, biohazardous, and regulated carcinogens. Check with EH&S (2-3073), the DSC or NE Safety Committee if in doubt about approval requirements for a substance.

Lab-specific hazard and emergency information is contained in the Chemical Hygiene Plan (flip chart) posted in every lab. Lab safety contacts are responsible for filling in the appropriate lab-specific information.

All laboratory personnel are entitled to a medical consultation and examination under certain conditions (possible overexposure to hazardous substances, or adverse symptoms associated with chemical use or exposure). Contact the Occupational Health Program (2-1553) to arrange for a medical examination or consultation.

9.2 Personal Safety in the Lab

Smoking is not allowed in any indoor areas on campus.

Wear safety glasses or safety glasses and face shields when working with hazardous materials and/or equipment.

Wear gloves when using any hazardous or toxic agent. They should be removed before leaving the lab, using phones, opening refrigerators, or entering common areas. For detailed glove selection guidelines see

<http://www.cchem.berkeley.edu/cchasp/Manual/Section%208/section8.html> and select the Chemical Compatibility Chart for Reusable Gloves' or contact the DSC.

Wear ear protectors when working with noisy equipment. As a general rule, noise exceeds the Permissible Exposure Limit (PEL) when persons in the area find it hard to understand one another without raising their voices while standing at arm's length. Notify your supervisor about possible excessive noise levels in the lab. For detailed guidelines see <http://www.EHS.berkeley.edu/pubs/factsheets/39hearingconserv.html>.

Clothing: When handling dangerous substances, wear gloves, laboratory coats, and safety glasses, safety goggles and safety shield. Shorts and sandals should not be worn in the lab. Hard top closed shoes are required when working in the machine shops.

Do not use any equipment unless you are trained and approved as a user by your supervisor.

Pregnant women should take special care with exposure to radiation and certain chemicals which can be harmful to fetal development. For further information, see <http://www.EHS.berkeley.edu/pubs/factsheets/45reprodhaz.html>

Wash hands before leaving the lab and before eating.

Tie back medium length and long hair when working near flames or entangling equipment.

If leaving a lab unattended, turn off all ignition sources and lock the doors.

9.3 Lifting Loads Safely

Your body is not designed to lift heavy weights. The way you carry a heavy object can subject your back to pressures two to ten times the object's actual weight. The pressure is increased more as you hold the load away from the body.

Safe lifting is a function of both the amount of weight being lifted and the lifting technique used. Always test the weight of unfamiliar loads before lifting. If a load is too heavy or awkward, have a coworker help, or use equipment such as a cart or dolly. Here are some hints to help you lift safely:

- Know where you are going before you lift a load. Pre-plan your lift.
- Keep your legs shoulder width apart for good balance.
- Take a deep breath and tighten your stomach muscles. Conditioned stomach muscles can serve the same purpose as back straps to protect your back when lifting.
- Bend at your knees and hips, not your waist. Try to keep the natural curves in your back when bending and lifting.
- Lift using your leg muscles to reduce the load on your back.
- Lift smoothly; don't jerk as you lift. Sudden movement and weight shifts can injure your back.
- Keep your back in alignment, with your ears, shoulders and hips lined up. Your nose and your toes should be facing the load when lifting.
- Hold the load close to your body at waist height to reduce the force on your back.
- Turn with your feet, not your back to avoid twisting when lifting.

9.4 General Laboratory Safety

Maintain unobstructed access to all exits, fire extinguishers, electrical panels, emergency showers, and eyewashes. Keep aisles clear.

Do not use corridors for storage or work areas.

Make sure all cabinets, bookcases, etc., taller than 42" are anchored.

Shelves 48" or higher and all shelves with chemicals should have restraining straps or lips.

Do not store heavy items above table height. Any overhead storage of supplies on top of cabinets should be limited to lightweight items only. Also, remember that a 36" diameter area around all fire sprinkler heads must be kept clear at all times.

Spills should be cleaned up immediately.

Areas containing lasers, biohazards, radioisotopes, and carcinogens should be posted accordingly. However, do not post areas unnecessarily and be sure that the labels are removed when the hazards are no longer present.

Be careful when lifting heavy objects (see above). Only shop staff may operate forklifts or cranes.

9.5 Electrical Safety

9.5.1 General Electrical Safety

All electrical outlets should be labeled with panel and breaker box numbers.

Electrical equipment must be GFI-protected (i.e. "grounded") when used near any water source. If water or fluid is spilled in or around electrical equipment, FIRST shut off circuit breaker, then unplug the equipment before cleaning up the spill.

Maintain a 36" unobstructed access to all electrical panels.

Consult the Mechanical Engineering Machine Shop staff, 1166 Etcheverry, or the Department Safety Officer, 4163 Etcheverry, before operating any high voltage equipment.

Major rewiring or other electrical modifications must be discussed with the Building Coordinator and the Department Safety Officer prior to commencement of work.

Avoid using extension cords whenever possible. If you must use one, obtain a heavy-duty one that is electrically grounded, with its own fuse, and install it safely. Extension cords should not go under doors, across aisles, be hung from the ceiling, or plugged into other extension cords.

9.5.2 High Voltage and Installation Safety

UCB's Electrical Safe Work Policy is as follows:

- All researchers, PIs, staff, project managers, contractors and students ensure they and others around them are working in a safe manner. Everyone supports a "Stop Work Policy". It is the responsibility of everyone to exercise this policy when observing unsafe work conditions or practices.
- UCB complies with CalOSHA regulations, the California Electrical Code and other established safety standards to reduce or eliminate the dangers associated with working with or around electrical energy.
- All electrical wiring and equipment complies with the California Electrical Code and CalOSHA regulations for electrical safety and engineering.

- Work on or near equipment operating within the electrical hazard conditions identified in this document is performed in an electrically safe state (verified de-energized) or is formally approved and documented through a “Hot Work Permit” process.
- Anyone at UCB who works on or near hazardous energized electrical circuits or components must be “qualified” and “authorized” prior to performing such work.
- Work is only performed on energized electrical circuits or components operating at greater than 50 volts and capable of an electrical current greater than 5 milliamperes or power greater than 1000 watts when it is demonstrated that de-energization introduces additional or increased hazards or is infeasible due to equipment design or operational limitations.
- Energized parts that operate at less than 50 volts and less than 1000 watts are not required to be de-energized if there will be no exposure to electrical burns or to explosion blast due to electric arcs.
- When work on energized electrical circuits or components operating at voltages greater than 50 volts to ground and capable of an electrical current greater than 5 milliamperes is justified and approved, engineering controls (guards, covers, shields, insulated tools, fused probes, remote methods, etc.) and personal protective equipment is used to reduce the potential for contact with energized components.
- All research or test devices operating at a voltage greater than 50 volts or storing more than 1000 watt/seconds (joules) is protected by an enclosure with secured or interlocked covers, or isolated in a manner that will prevent inadvertent contact with exposed live parts.
- Fabrication of research and test equipment is done following UCB design and engineering review as prescribed in the Electrical Safe Work Program.
- All electrically energized equipment is used in a safe manner as intended by the manufacturer and within the equipment’s NRTL listing.

Refer to the Electrical Safe Work Program for details

9.6 Cryogenic Safety

Cryogenic liquids are extremely cold liquids that at normal temperature and pressure would be a gas. These very cold liquids provide a fluid media that is useful for researchers to preserve their sample materials and for laboratory experimental processes. The NE SOP provides a summary of the hazards and safe work practices for users of cryogenics. The most common cryogenics are nitrogen and helium.

Cryogenic liquids boil well below temperatures that we normally consider “cold”, and may boil violently in containers at room temperature. They are odorless and colorless when vaporized to a gas, but as the gas boils off, it condenses moisture in surrounding air creating a highly visible fog that is often mistaken for cryogenic gas (which is invisible). Proper PPE (face mask, gloves, long-sleeved shirts/lab coats) should be worn when handling cryogenic fluids.

9.7 Gas Cylinder Safety

This section contains basic guidelines and rules to help ensure the safe handling and storage of compressed gas cylinders. A complete guide is available from EH&S (<http://ehs.berkeley.edu/pubs/gascylindersbooklet.pdf>). Compressed gases are used several labs. Gases under high pressure present a number of hazards. Mishandled cylinders may rupture

violently, release their hazardous contents or become dangerous projectiles. If a neck of a pressurized cylinder should be accidentally broken off, the energy released would be sufficient to propel the cylinder to over three-quarters of a mile in height. A standard 250 cubic foot cylinder pressurized to 2,500 PSIG can become a rocket attaining a speed of over 30 miles per hour in a fraction of a second after venting from the broken cylinder connection.

9.7.1 Basic Safety:

- Select the least hazardous gases that will work for a given application.
- Purchase only the necessary quantities.
- Select gases with returnable containers.
- When receiving gas cylinders:
 - Check for leaks
 - Visually inspect the cylinder for damage
 - Ensure the valve cover and shipping cap is on and secured tightly
 - Check for proper labeling
 - If a cylinder is damaged, in poor condition, leaking, or the contents are unknown, contact your cylinder vendor. Have the vendor return the damaged cylinder to the manufacturer.
- Wear appropriate foot protection when engaged in moving or transporting cylinders:
 - Sturdy shoes are a minimum.
 - Steel toed shoes if required by your supervisor, instructor, or department.
 - Proper personal protective clothing and equipment shall be worn.
 - Always have an appropriate *Material Safety Data Sheet (MSDS)* available and be familiar with the health, flammability, and reactivity hazards for the particular gas.

9.7.2 Cylinder Markings:

- Cylinders must be properly labeled, including the gas identity and appropriate hazards (e.g., health, flammability, reactivity).
- Cylinders have several stamped markings:
 - ~ The top mark is either a DOT or an ICC marking indicating pertinent regulations for that cylinder.
 - ~ The second mark is the serial number. Under the serial number is the symbol of the manufacturer, user, or purchaser.
 - ~ The remaining marks the numbers represent the date of manufacture, and retest date (month and year). A (+) sign indicates the cylinder may be 10% overcharged, and a star indicates a ten-year test interval.

9.7.3 Cylinder Storage:

- Cylinders should be stored in compatible groups:
 - ~ Flammables from oxidizers
 - ~ Corrosives from flammables
 - ~ Full cylinders from empties
 - ~ *Empty cylinders should be clearly marked and stored as carefully as those that are full because residual gas may be present.*
 - ~ All cylinders from corrosive vapors.

- Store cylinders in an upright position.
- **Keep oxygen cylinders a minimum of twenty feet from flammable gas cylinders or combustible materials.** If this cannot be done, separation by a non-combustible barrier at least 5 feet high having a fire-rating of at least one-half hour is required.
- **Compressed gas cylinders should be secured firmly at all times at two points (where possible).** A clamp and belt or chain, securing the cylinder between "waist" and "shoulder" to a wall, are generally suitable for this purpose.
- Cylinders should be individually secured; using a single restraint strap around a number of cylinders is often not effective
 - ~ Keep valve protective caps in place when the cylinder is not in use.
 - ~ Mark empty cylinders EMPTY or MT.
 - ~ Keep valves closed on empty cylinders.
 - ~ Cylinders must be kept away from sources of heat.
 - ~ Cylinders must be kept away from electrical wiring where the cylinder could become part of the circuit.
 - ~ Store cylinders in well-ventilated areas designated and marked only for cylinders.

9.7.4 Moving Cylinders:

- Use a cylinder cart and secure cylinders with a chain.
- Don't use the protective valve caps for moving or lifting cylinders.
- Don't drop cylinders, permit them to strike each other, or be handled roughly.
- Unless cylinders are secured on a special cart, regulators shall be removed, valves closed and protective valve caps in place before cylinders are moved.

9.7.5 Cylinder Use:

- Be sure all connections are tight. Use soapy water to locate leaks.
- Keep cylinders valves, regulators, couplings, hose and apparatus clean and free of oil and grease.
- Keep cylinders away from open flames and sources of heat.
- Safety devices and valves shall not be tampered with, nor repairs attempted.
- Use flashback arrestors and reverse-flow check valves to prevent flashback when using oxy-fuel systems.
- Regulators shall be removed when moving cylinders, when work is completed, and when cylinders are empty.
- Cylinders shall be used and stored in an upright position.
- The cylinder valve should always be opened slowly. Always stand away from the face and back of the gauge when opening the cylinder valve.
- When a special wrench is required to open a cylinder or manifold valve, the wrench shall be left in place on the valve stem when in use; this precaution is taken so the gas supply can be shut off quickly in case of an emergency; and that nothing shall be placed on top of a cylinder that may damage the safety device or interfere with the quick closing of the valve.
- Fire extinguishing equipment should be readily available when combustible materials can be exposed to welding or cutting operations using compressed cylinder gases.

9.7.6 Things Not To Do:

- Never roll a cylinder to move it.
- Never carry a cylinder by the valve.
- Never leave an open cylinder unattended.
- Never leave a cylinder unsecured.
- Never force improper attachments on to the wrong cylinder.
- Never grease or oil the regulator, valve, or fittings of an oxygen cylinder.
- Never refill a cylinder.
- Never use a flame to locate gas leaks.
- Never attempt to mix gases in a cylinder.
- Never discard pressurized cylinders in the normal trash.

9.8 Vacuum System Safety

<http://www.ehs.berkeley.edu/pubs/factsheets/71vacuumsystems.pdf>

10. SHOP SAFETY

Shops are characterized by noise, machine tools, heavy machinery repair, heavy material handling equipment, fabrication, welding, and other similar activities. Room 1140 of Etcheverry Hall is considered a shop (as well as a laboratory). The Thermal-Hydraulics laboratory (4168 Etcheverry) is also considered to be a shop. The UC Berkeley Code of Safe Shop Work Practices applies to shops

Table 8. Code of Safe Shop Practice.

10.1 Safety training

Training for students is provided by the ME Student Machine Shop. Specific additional training is required to drive forklifts, use fall protection apparatus, wear respiratory protection or use overhead cranes. General shop safety training should be provided by a faculty member, lab safety contact, or staff member at the beginning of a new assignment or when a new hazard is introduced into the workplace.

10.2 Mechanical Safety

When using compressed air, use only approved nozzles and never direct the air towards any person.

Guards on machinery must be in place during operation.

Exercise care when working with or near hydraulically- or pneumatically-driven equipment. Sudden or unexpected motion can inflict serious injury.

10.3 Crane Safety

Crane Lift Policy: Cal-OSHA regulates the use and operation of cranes and other hoisting equipment. EH&S has specific procedures for the use of cranes on campus. EH&S serves as a special consultant to lab managers in complying with Cal-OSHA regulations and EH&S

procedures. The lab manager is responsible for determining the time of the lift and lift location. The lab manager is also responsible for selecting an appropriate crane company to comply with equipment permitting and operator certification. EH&S and the lab manager will cooperatively pre-arrange the path of travel, operational area, pedestrian and traffic control and any required outages or notifications. Edward Morse and Dan Essley have been certified as a crane lift operators for Nuclear Engineering. Consult them for information regarding the cranes in 1140 Etchevery including how to obtain crane safety certification.

11. CHEMICAL SAFETY

11.1 Chemical Hygiene Plan

<http://ehs.berkeley.edu/healthsafety/chp.html>

11.2 Storage

Make sure all chemicals are clearly and currently labeled with the substance name, concentration, date, and name of the individual responsible.

Arrange storage by chemical compatibility. Useful information on chemical compatibility can be found in Dangerous Properties of Industrial Materials, by N.I. Sax, the Merck Index, and the Aldrich Chemical Catalog.

Comply with fire regulations concerning storage quantities, types of approved containers and cabinets, proper labeling, etc. If uncertain about regulations, contact the building coordinator or EH&S (2-3073).

All pressurized containers (e.g. gas cylinders) will be moved and installed only by staff personnel.

Use volatile and flammable compounds only in a fume hood. Procedures that produce aerosols should be performed in a hood to prevent inhalation of hazardous material.

State law requires that the University maintain a complete chemical inventory as part of a Hazardous Materials Management Program. All labs must submit a chemical inventory to the Building Manager and update it annually.

Never eat or drink and do not store food in laboratories.

11.3 EXCEPTIONALLY HAZARDOUS CHEMICALS (EHC)

The following list, although not exhaustive, cites some chemicals that are especially hazardous. Read bottle labels and research the hazards and proper handling procedures of the compounds that you use. Particularly hazardous substances may require campus registration and approval. Such material includes radioactive, reproductive toxins, acutely toxic chemicals, biohazardous, and regulated carcinogens. Check with EH&S (2-3073), DSC or Safety Committee if in doubt about approval requirements for a substance. Laboratories planning to use EHC should prepare SOP before the first use of the chemical.

Table 9. Some Hazardous Chemicals

Common Chemical	Properties
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Name	
Ether	Extremely flammable. May form highly explosive peroxides when stored with air (especially true of anhydrous ether). Date ether container when received and when opened. Be very careful when handling old ether containers as peroxides may decompose explosively.
Nitric Acid	Gases are given off by heating HNO ₃ or whenever HNO ₃ reacts with organic compounds (also some present at room temperature). Inhalation can cause fatal pulmonary edema which may show up within 6-24 hours.
Nitrogen Oxides (except nitrous)	Gases are given off by heating HNO ₃ or whenever HNO ₃ reacts with organic compounds (also some present at room temperature). Inhalation can cause fatal pulmonary edema which may show up within 6-24 hours. Since the bases are not so water-soluble as to be immediately irritating in the upper respiratory tract, a considerable amount may be inhaled before it is noticed. Anyone exposed should remain under observation for 48 hours.
Mercury	Spills can be a hazard because Hg is very difficult to clean up completely. It clings to many kinds of surfaces. EH&S can monitor airborne Hg level before and after clean-up. Fumes are neuro-toxic. Heat can increase airborne concentration. Use special Mercury vacuum for clean-up.

11.4 MSDS (Material Safety Data Sheets)

Thousands of Material Safety Data Sheets ([MSDSs](#)) are now available electronically over the Internet. The primary MSDS databases below are for University of California faculty, staff and students only. Additional general and specific MSDS database sites are also listed. The web sites may be searched by chemical name, manufacturer name, or CAS. To access this UC MSDS database you must be connected through a recognized UC campus computer. To learn how to understand an MSDS, read the EH&S MSDS Fact Sheet (How to Read and Understand an MSDS).

An MSDS describes the hazards of a material and provides information on how the material can be safely handled, used, and stored. The HCS regulation specifies the type of information that must be included but leaves the format of the document up to the discretion of the author. Consequently you will find MSDS organized in many different ways.

Before attempting to work with a chemical you are unfamiliar with, be sure to read its MSDS. Consult with your supervisor, the DSC or the Office of Environment, Health & Safety (EH&S) if you have specific questions concerning MSDSs or the chemicals in your work area.

MSDS, of course, do not contain all the information on a chemical. They are designed to give information about exposures resulting from customary and reasonably foreseeable occupational use, misuse, handling, and storage. For complete information, make sure you also use labels, technical bulletins, and other communications.

The University of California's Offices of Environment, Health & Safety have combined efforts and resources to create a source for Material Safety Data Sheets and chemical safety information. This search engine will be growing as UC routinely adds major chemical vendors into its integrated database.

Material Safety Data Sheets: <http://www.ucmsds.com>

Chemical Hazard Information: <http://www.tomescps.com>

Additional Info: <http://www.cchem.berkeley.edu/cchasp/?q=section8>

Additional MSDS and Chemical Hazard Sites are located at:
<http://www.ehs.berkeley.edu/whatwedo/healthsafety/msds.html>

11.5 How to Read and Understand an MSDS

Although they may vary in appearance and length, MSDSs are required to have nine sections, which explain the proper ways to use, handle, and store chemicals in your work area. A description of the kinds of information each section contains follows:

1. Chemical Identification

This section includes the chemical name, trade name, chemical formula and the chemical manufacturer's name, address and emergency phone number.

2. Hazardous Ingredients

This section lists any hazardous ingredients found within the chemical. In this section you might also see the terms TLV (Threshold Limit Value) and PEL (Permissible Exposure Limit). Both terms are used to express the highest airborne concentrations of a chemical to which most persons can safely be exposed during a normal workday. The CAS (Chemical Abstract Service) numbers listed in this section identify specific chemicals according to information published by the American Chemical Society.

3. Physical Data

This section lists important physical properties of the chemical such as its boiling point, vapor density, percent volatile, appearance, and color. This information helps determine the degree of hazard associated with the chemical in different work environments. For example, vapor density describes the weight of a vapor relative to an equal volume of air (air=1). If a chemical has a vapor density greater than 1, its vapor will be heavier than air and tend to fall and concentrate near the floor.

4. Fire and Explosion Data

This section helps you determine the chemical's flash point, which is the temperature at which a chemical will release enough flammable vapors to ignite. Chemicals that ignite at or below 100degF are classified as flammable. In addition, this section usually lists the chemical's upper and lower flammability limits, proper types of extinguishing media required to safely extinguish the fire (example: carbon dioxide, water, foam, etc.), special fire fighting procedures, and any unusual fire or explosion hazards.

5. Health Hazard Data

This section describes health effects associated with overexposure to the chemical through ingestion, inhalation, and skin or eye contact. The information may include the acute (immediate) and chronic (long-term) effects of overexposure to the chemical, whether the chemical is a known carcinogen (cancer-causing agent), emergency and first aid procedures to follow in case of overexposure, and medical conditions that may be aggravated upon contact with the chemical.

6. Reactivity Data

The information in this section helps you determine if the chemical will react with other chemicals or under certain conditions. Chemical that are reactive (unstable) may explode, burn,

or release toxic substances under certain conditions. This section usually tells you if the chemical is stable or unstable and lists any chemicals or substances that might be incompatible with the chemical.

7. Spill or Leak Procedures

This section lists the procedures to follow when a chemical is accidentally released or spilled. It will also cover types of clean-up and protective equipment needed to safely contain or clean up a spill as well as proper ways to dispose of the chemical.

8. Special Protection Information

This section lists the personal protective equipment (respirators, gloves, eye protection, etc.) and other precautions the manufacturer recommends for work with the chemical. Remember, there are various types of protective equipment that are specially designed for certain tasks. Consult your supervisor and/or EH&S to ensure you are using the correct type for the work you are performing.

9. Special Precautions

The last section usually discusses special precautions to be taken during handling and storage of the chemical. Also, this section will usually discuss any other health and safety concerns that have not been mentioned elsewhere in the MSDS.

11.6 How to Get MSDSs

The California Hazard Communication Standard requires that MSDSs be available to all employees during all shifts. If your work area does not have MSDSs for the chemicals that you use, contact the manufacturer or EH&S to request a copy. (When you purchase a new chemical, send a copy of its MSDS to EH&S for the campus master file.) In addition, you can obtain MSDSs through the EH&S web site at <http://ehs.berkeley.edu/hs/267-material-safety-data-sheets-msds.html>

12. WASTE DISPOSAL

State and federal laws regulate the disposal of many kinds of waste, and there are new restrictions on what may be put in public landfill or poured down the drain.

Many laboratory chemicals that seem non-hazardous are in fact regulated by the EPA or the California Department of Health Services. Therefore, unless you are absolutely sure that a chemical is not classified as hazardous, do not put it down the drain or into the building trash. Package it for pickup and hazard determination by EH&S, or consult EH&S before disposing of it. Call 2-3073 for more information.

Moreover, all chemicals listed on the laboratory inventories should be disposed of through the Hazardous Waste Program organized by EH&S. Information about the HWP can be found at the EH&S website.

MEDICAL WASTE: Questions about medical waste should be directed to EH&S (2-3073). "Medical waste" is defined as: any waste containing "INFECTIOUS AGENTS" with evidence of human pathogenicity (e.g., arthropods, bacteria, fungi, helminthes, prions, protozoa and viruses); all **SHARP WASTE** (i.e., ALL scalpels, razor blades, syringes and syringe needles, AND

any glass or sharp devices which are contaminated with infectious or biohazardous waste); any fluid HUMAN BLOOD and blood products; all human anatomical remains.

12.1 Drain Disposal:

CAMPUS POLICY PROHIBITS THE DRAIN DISPOSAL OF HAZARDOUS WASTES OR ANY MATERIAL CAUSING VIOLATION OF EAST BAY MUNICIPAL UTILITY DISTRICT (EBMUD) WASTEWATER DISCHARGE PERMIT LIMITATIONS.

All hazardous and chemical wastes must be packaged for pickup and disposal by EH&S. Absolutely no carcinogenic, hazardous, or biohazardous waste is to go down the drain. A waste is considered hazardous if it is flammable, corrosive, reactive, toxic, or contains heavy metals. Failure to comply with EBMUD requirements for campus drain disposal can lead to substantial fines or restrictions on laboratory water use.

What **CANNOT** Go Down the Drain:

solutions containing any heavy metals	poisons
organic solvents	strong acids and bases
photographic fixer	motor oil
chromic acid	glass washing solutions
sulfuric acid	waste paint
radioactive wastes	paint thinner
biohazardous wastes	methanol

What **CAN** go down the drain

sugar and non-hazardous protein solutions
liquid detergents
SOME DILUTE ACIDS AND BASES, (pH<10 or pH>5.5)
liquid non-medical waste which has been neutralized/decontaminated with bleach to a final concentration of 1%
photo developer (pH <10)

12.2 BUILDING TRASH

Only non-hazardous materials are allowed in building trash containers. Disposal of hazardous chemicals or medical waste in the building trash is strictly prohibited.

What CAN go into Building Trash

-- sugars and some salts

- powdered detergent
- non-hazardous proteins
- sand and clay
- BROKEN OR WASTE GLASSWARE (put in cardboard box, tape box closed, label it "Broken Glassware", and leave for pickup by custodians)

What must be packaged for EH&S Pickup

- all hazardous lab chemicals
- unused copy machine toner
- photographic chemicals
- pesticides
- paint and paint thinners
- waste solvents
- waste oil
- liquid paper white-out
- batteries
- empty containers with chemical residue
- hazardous household chemicals

12.3 HAZARDOUS WASTE DISPOSAL PROCEDURES

How to Request EH&S Pickups for Waste: Complete a waste disposal information card through the EH&S HWP website. Similarly, Phil Hayes (642-8800) at EH&S can help coordinate waste disposal pickups. Waste pickups typically only occur once a month as Etcheverry Hall is not part of the main campus, so be considerate of lead times and scheduling for chemical disposals.

Minor Chemical or Radioactive Spill (i.e., spill involves no immediate health hazard)

Contain spill.

Delineate contaminated area at once, cover shoes, and keep all persons away.

Call EH&S immediately (2-3073). Stay in the area until EH&S arrives. (After 5:00 p.m., call Campus Police, 2-6760).

Do not attempt decontamination except as expressly directed by EH&S.

All students and staff employees that work with hazardous chemicals are required by state law to complete the *Hazardous Spill Response* training course each year. Like most safety training courses, this training course can be found through the UC Learning website. For more information, contact your lab safety representative or the Department Safety Officer.

Major Contamination (i.e., spill involves potential health hazard)

Vacate the immediate area, leaving behind clothing and other articles which may be contaminated, and remain in the vicinity.

Keep all persons out of the area, except monitoring and rescue teams.

Call EH&S immediately (2-3073) (after hours dial 2-6760) or the Campus Police Emergency Line (2-3333). Stay in the adjacent area until EH&S arrives.

Do not attempt decontamination unless expressly directed to do so by EH&S.

13. RADIATION SAFETY

The Department of Nuclear Engineering handles all radioactive materials and radiation-producing machines in accordance with policies and standards set forth by the Campus license, the Berkeley Campus Radiation Safety Manual, and the regulations of the governmental agencies involved. The Office of Radiation Safety has the responsibility to ensure that work with radioactive materials and radiation-producing machines is conducted in such a manner as to protect health, minimize danger to life and property and to keep radiation exposure to all personnel as low as is reasonably achievable (ALARA). The Berkeley Campus Radiation Safety Manual may be viewed in its entirety at:

<http://www.ehs.berkeley.edu/images/ehs/radsafe/rsm2010.pdf>

A copy of the Radiation Safety Manual shall be kept at all times in the laboratories where radioactive material or radiation-producing machines are used to serve as a reference for persons engaged in a project involving radioactive material or working under the Radiation Use Authorization.

Training and Information

All individuals working with radioactive sources or radiation producing machines are required to be listed on a Radioactive Use Authorization (RUA) form.

Anyone using sealed radioactive sources or radiation producing machines is required to complete an online training course that can be found through the UC Learning center.

Those that are using unsealed radioactive sources are required to attend a four-hour in-person training course offered monthly by EH&S. More information can be found through the EH&S website or the Department Safety Officer.

Additional material that is required reading for radiation source users and radiation producing machine users is found under:

<http://www.ehs.berkeley.edu/rs/129-radiation-safety-forms-and-additional-resources.html>

[Handbook for Safe Use of Radioisotopes \(PDF\)](#)

[Instruction Concerning Prenatal Radiation Exposure \(PDF\)](#)

[Radiation Producing Machines Safety Procedures \(Poster - PDF\)](#)

[Radiation Safety Logbook \(PDF\)](#)

[Radiation Safety Manual \(PDF\)](#)

[Radioisotope Safety Procedures \(Poster - PDF\)](#)

[Notice To All Personnel Whose Work Involves Exposure To Ionizing Radiation](#)

13.1 RADIATION PHYSICS

Basic Review

The atom is made up of a nucleus of protons and neutrons, surrounded by a cloud of electrons. The number of protons and electrons determine the chemical nature of the atom. The number of neutrons determines if the atom is stable or radioactive.

All isotopes of a particular element have the same atomic number (number of protons) but different atomic mass (number of neutrons). Because all isotopes of an element have the same atomic number, their chemical nature is identical. However, the radioactive nature of the isotopes varies.

Unstable (or radioactive) isotopes emit energetic particles and/or electromagnetic (EM) radiation in the form of photons. All radioactive isotopes eventually decay to stable isotopes. Stable isotopes can be made radioactive (activated) by bombardment with energetic protons in particle accelerators or neutrons in nuclear reactors.

Radioactive decay is a disintegration process by which a radioactive isotope radiates energy in order to become a stable isotope.

Radioactive decay is random when observed for short periods. Only by observing over long periods of time does a regular pattern emerge. This pattern of decay we call the physical half-life.

The half-life is defined as the time required for half of the atoms of a particular isotope to decay. The value of the half-life is specific to the isotope and may vary from microseconds to millions of years.

The half-life is physically fixed and well characterized for each isotope, and can be used to perform decay calculations.

As a general rule, whenever an isotope has undergone 10 half-lives, enough atoms will have decayed to make the radiation field emitted indistinguishable from the "background" level, however, with large sources, a hazard may still be present.

13.2 Types of Radiation and Characteristics

EM radiations (photons) differ in frequency, wavelength and energy. The EM spectrum diagram below shows the break point between ionizing radiation and non-ionizing radiation. This training program will discuss only ionizing radiation. By definition, ionizing radiation has sufficient energy to disrupt the structure of an atom, causing the formation of charged ion pairs. These ions can cause chemical changes (damage) in human tissue.

Ionizing radiation falls into two categories: directly ionizing and indirectly ionizing. Ionizing radiation emitted may be photons (EM) or particles.

Alpha radiation is directly ionizing. Alpha particles are Helium nuclei consisting of two protons and two neutrons. They have a charge of +2, a mass of 4 AU (atomic units), and are very energetic, on the order of 3 to 5 MeV (million electron volts; particle energy is measured in the eV or electron volt).

The large charge and great mass makes them readily interact with matter, giving them a short range (a few centimeters in air and a few microns in tissue). They are of no concern as an

external radiation hazard, but can be a hazard if alpha emitting isotopes enter the body through surface contamination or inhalation.

Beta particles are directly ionizing energetic electrons emitted from the nucleus of the atom as a spectrum of energies. The average energy of the betas emitted from the nucleus is about 1/3 of the maximum energy beta emitted; the remainder of the energy is transferred to a neutrino. The mass of the beta is 1/1800 of an AU and it has a charge of + (positron) or - 1 (electron, negatron). The range of a beta is dependent on its energy and the material it is traveling in. For example, a P-32 beta has a range in air of about 7 meters.

Bremsstrahlung (x-rays) and gamma rays are photons with no mass or charge. Photons are emitted at a discrete energy that depends on the isotope. They are indirectly ionizing EM radiations with no charge or mass. Photons interact with matter, transferring their energy to directly ionizing particles.

The range of EM radiation is theoretically infinite, however in practice, interaction with matter will gradually transfer all the energy to directly ionizing particulate radiation. Depending on the energy of the photon, a half-value layer may be determined for a specific shielding material that defines the thickness required to reduce the radiation field intensity by one half.

Neutrons are indirectly ionizing particles with no charge, but with a mass of 1 AU. They are produced only in particle accelerators, nuclear reactors, and isotopic neutron generators. The energy of the neutron is dependent on its source, and neutrons may be found as a spectrum of energies. They are most efficiently shielded by elastic scattering using with low Z materials (containing hydrogen) such as water or borated polyethylene.

13.3 Radiation Interaction with Matter and Attenuation (Shielding)

Radiation shielding is a matter of attenuation. Particles or EM radiation deposit energy in the shielding material and are thereby attenuated. Energy deposited in the shield is energy that is not available to be absorbed in tissue. Thus shielding reduces the radiation hazard.

The ranges of various particulate radiations are well known. These values can be used to determine the type and thickness of material required to reduce or stop particulate radiation. Alpha particles, due to their mass and charge, readily interact with matter and are stopped by a single sheet of notebook paper.

Low Z materials should be used to shield beta particles. For example: all P-32 betas will be attenuated in 0.8 cm. of Lucite. In general, 1.0 cm. of Lucite is sufficient to absorb any beta radiation. The slowing down of beta particles (or electrons produced by x-ray machines) produces characteristic photons and x-radiations called Bremsstrahlung. Note: Machine produced electrons are emitted from the orbital electron shells and are generally indistinguishable from beta particles emitted from the nucleus.

Using high Z materials to shield betas results in Bremsstrahlung production, replacing the beta hazard with an x-ray hazard. Therefore Lucite (Plexiglas) is preferred for high energy beta shielding.

Shielding is accomplished by use of enough material to reduce the radiation field to a safe level (exposure rate). The thickness of shielding is commonly specified in half-value layers. A half-

value layer is the thickness of a material necessary to reduce the radiation intensity by 50%. Lead, concrete, or steel are the best shielding materials for photons.

13.4 RADIATION UNITS

The Curie (Ci) is the historical unit of radioactivity. It is equal to 3.7×10^{10} (nuclear) transformations per second (s^{-1}) or 2.22×10^{12} disintegrations m^{-1} . This corresponds to the activity in one gram of 226-Ra. The international unit used is the Becquerel (Bq) that is equal to 1 transformation s^{-1} .

Because the range of activity encountered in Nuclear Engineering applications can vary over more than 20 orders of magnitude, we often use prefixes to define levels of activity. Examples of these prefixes follow:

a	atto	10^{-18}		0.000000000000000001
f	femto	10^{-15}		0.000000000000001
p	pico	10^{-12}	trillionth	0.000000000001
n	nano	10^{-9}	billionth	0.000000001
μ	micro	10^{-6}	millionth	0.000001
m	milli	10^{-3}	thousandth	0.001
c	centi	10^{-2}	hundredth	0.01
k	kilo	10^3	thousandth	1,000
M	mega	10^6	millionth	1,000,000
G	giga	10^9	billionth	1,000,000,000
T	tera	10^{12}	trillionth	1,000,000,000,000
P	peta	10^{15}	million billionth	1,000,000,000,000,000
E	exa	10^{18}	billion billionth	1,000,000,000,000,000,000

The Roentgen (R) is the unit of radiation exposure (ionization in air). Geiger counters are commonly calibrated to express measurements in the units of R (or mR)

The rad (Radiation Absorbed Dose) and Gy (the Gray is equal to 100 Rads) are the units of absorbed energy dose. The Rad is most often used in physical dosimetry and medical applications.

The rem (Roentgen Equivalent Man) and Sv (the Sievert is equal to 100 rem) are indexes of biological harm relating the damage done by various energetic particles and EM radiations. The rem is also called the unit of risk. Dosimetry reports (reports of absorbed dose) are always expressed in rem or submultiples thereof (millirem)

QFs (quality factors) are used to relate the RBE (relative biological effectiveness) of different types of radiation. $\text{Rad (or R)} \times \text{QF} = \text{rem}$. Quality factors are as follows: 1 for beta, gamma, and x-rays, 10 for neutrons, and 20 for alpha particles. Quality factors are defined by various regulatory agencies based on ICRP and ICRU reports.

Radiation exposure field measurements are expressed in mR/hr dose rates.

DETECTION AND MEASUREMENT

Ionizing radiation is not detectable with any of the human senses. Radiation survey instruments are therefore used to determine the presence of radiation fields.

Geiger Mueller (or GM) detectors are the most common type of survey instrument. They detect and count the rate of ion pairs formed when beta, gamma or x-ray radiation cause ionizations in the gas in the detector. GM survey meters display in units of mR/hr or cpm. See the diagram in the Appendix.

The accuracy of GM survey meters depends on several factors, including the match between energy of the radiation being measured and the energy of the source used for calibration. They are used to detect betas and gamma photons. GM METERS WILL NOT DETECT THE LOW ENERGY BETAS PRODUCED BY TRITIUM.

Solid scintillator detectors utilize a solid NaI crystal with a photo multiplier tube. These Instruments are most useful in detecting gamma radiation. The thickness of the NaI crystal determines the energy efficiency of the detector. Thin crystals are used to detect low energy gammas like I-125. Thicker crystals are very sensitive for higher energy photons.

Liquid scintillation counting (or LSC) uses photo multiplier tubes to amplify light produced by a radioactive sample immersed in a vial of liquid scintillation cocktail. An LSC is used to count swipe samples for contamination. The LSC is most effective for counting low energy beta emitters such as carbon-14 and hydrogen-3 (tritium) used in nuclear research.

Radiation detection methods vary in counting efficiency for various isotopes. Counts per minute (cpm) are not the same as disintegrations per minute (dpm), but rather relate to one another as: $\text{cpm}/\text{efficiency} = \text{dpm}$.

Counting statistics are important in interpreting LSC results. The higher the count rate, the greater the accuracy and confidence of the count. A background count performed on a control blank vial is essential in interpreting results.

13.5 RADIATION BIOLOGY

13.5.1 Natural Background and Man Made Radiation Doses

Each of us receives about 300 millirem year⁻¹ from natural sources. These include solar cosmic radiation, radon (gases) from soils, and internal dose from K-40.

We also receive about 70 millirem from man-made sources, primarily from medical applications. Your altitude above sea level and the location and construction materials in your home can also influence your background dose. For example: In Denver, the background dose is about twice the dose in San Francisco.

13.5.2 Internal verses External Exposure

External exposure is the passage of particulate or EM radiation into tissue from outside the body. Internal exposure results from isotopes that have been deposited inside the body. Internal deposition can only result from one of the four entry pathways: ingestion, inhalation, absorption through the skin and skin punctures.

The biological half-life of any deposited isotope is determined by its residence time in the body, and varies with the chemical nature of the element.

The effective half-life is determined by the relationship between the biological half-life and the physical half-life. The effective half-life is used in calculating the absorbed dose to tissue from a deposited isotope.

13.5.3 Acute versus Chronic Doses and Effects

Chronic radiation doses are received over many years. The biological effects of chronic whole body doses up to regulatory limits (150 rem over 30 years) have proven undetectable and may not exist.

Acute radiation doses are received in a few hours. The biological effects of acute whole body doses under 10 rem have proven undetectable and may not exist. At acute doses of 10 to 75 rem, temporary changes in blood cell chromosomes have been observed.

At acute doses of 75 to 300 rem biological effects include erythema (skin reddening), and acute radiation syndrome (ARS - loss of hair, nausea, dehydration and possible death) have been observed. The LD 50/30 for humans (the lethal dose for 50% of a population exposed within 30 days without medical treatment) is 300 to 350 rem.

At an acute dose of 550 rem, 99% of those exposed may die.

13.5.4 Somatic versus Genetic Effects

Somatic effects occur in the person receiving the radiation dose. Somatic effects can be caused by acute or chronic exposure. Cancer is a somatic effect identified with radiation exposure.

Genetic effects occur in the descendants of the person receiving the radiation dose. Genetic effects can be caused by acute or chronic exposure. Mental retardation is a genetic effect identified with radiation exposure.

The BEIR VII (Biological Effects of Ionizing Radiation) report (2006) from the National Academy of Sciences uses information from several radiation exposure cohorts (such as the Hiroshima and Nagasaki atomic bomb survivors) to estimate somatic and genetic effects of radiation exposure.

It is estimated that the normal lifetime probability of cancer induction is about 25% from causes other than radiation exposure. The BEIR VII report estimates that the probability of additional cancer risk is about 0.08% rem⁻¹ for continuous lifetime exposure. Alternately stated, this is $\sim 8 \times 10^{-4}$ risk rem⁻¹.

The BEIR V report (1990), estimated the increased risk of mental retardation at 0.4% rem⁻¹ of fetal exposure during the 8 to 15 week segment of the gestation period.

13.5.5 Radiation Risk Models and the ALARA Concept

Because of the uncertainty of human health effects at low radiation doses, a number of dose/response models have been proposed. The linear model of dose response assumes a direct relationship between radiation dose and effects down to zero exposure. The quadratic model indicates there may be limited risk present at low doses.

The threshold model assumes a "threshold" dose of about 10 rem must be received in order to see any effects.

Most experts and regulators agree that the linear model presents the safest assumption of the risk relationship for radiation exposure. This view drives the ALARA concept - keeping radiation exposures As Low As Reasonably Achievable.

13.5.6 Risk versus Benefit

While there are no unique risks associated with radiation exposure, it is well understood that there are substantial benefits resulting from radiation use. In the appendix of this document, *Table 9. Estimated Loss of Life Expectancy Due to Various Causes*, compares risks from radiation exposure as compared to "acceptable" risks in modern life. This table rates radiation exposure as a limited risk compared to the risk of driving a car, smoking, swimming, etc.

13.5.7 ALLOWED OCCUPATIONAL AND NON-OCCUPATIONAL RADIATION DOSES

The allowed Total Effective Dose Equivalents (TEDEs) are published in Title 17, CCR (California Code of Regulations). The TEDE is a risk-based limit. The TEDEs includes both the external dose (from dosimeters) and internal dose (from bioassay): The UC Berkeley Radiation Safety Manual imposes lower limits (10% of the limits set by the CCR).

The occupational (whole body) TEDE for radiation workers is not allowed to exceed 5,000 millirem/year (500 mR/year for UC radiation workers).

The (shallow) dose to the skin of the whole body is not allowed to exceed 50,000 millirem/year (5,000 mR/year for UC radiation workers).

The dose to the extremities (hands and forearms, feet and ankles) is not allowed to exceed 50,000 millirem/year (5,000 mR/year for UC radiation workers).

The dose to the lens of the eye is not allowed to exceed 15,000 millirem/year (1,500 mR/year for UC radiation workers).

The dose to any individual organ is not allowed to exceed 50,000 millirem/year.

The fetal TEDE is not allowed to exceed 500 millirem during the 9-month gestation period.

The (whole body) TEDE for the general population is not allowed to exceed 100 millirem/year.

Limits for minors working with special authorization are 10% of the limit for adult workers.

13.5.8 RADIATION CONTROL METHODOLOGY

A) The ALARA Concept

Simply stated, the ALARA concept is the practice of maintaining radiation exposures to levels As Low As Reasonably Achievable. This philosophy is the basis of modern radiation protection.

Administrative guidelines are dose equivalent recommendations adopted by the Radiation Safety Committee (RSC) for all UC Berkeley personnel. These guidelines should not be exceeded in routine operations without prior RSC approval. The administrative guidelines are not intended to be absolute limits, but to provide guidelines for keeping exposures ALARA. The guidelines are 10% of the above limits. Limits for minors with special authorization are 5% of UC Berkeley administrative guideline for adult workers. The UCB Campus RSO investigates any exposures above the UC Berkeley administrative guideline value.

B) Limiting External Radiation Exposure

The three basic elements to be considered in an external radiation protection program are time, distance, and shielding.

Radiation field measurements are always expressed as a rate, i.e. millirem/hr (or cpm). The amount of time spent in a radiation field should be kept to the minimum required to perform the task.

EM radiation follows the inverse square law. The intensity of the radiation field decreases with the inverse square of the distance from the source. For example, standing twice as far from a source will reduce the radiation field intensity to 1/4 of the original intensity.

Maintain the maximum distance possible from EM radiation sources that will still allow the work to be done. From a point source (such as a vial), a distance of a few centimeters will greatly reduce the dose to the extremities. Particulate radiations (alpha, beta and neutrons) obey the inverse square law but also have finite absorption ranges. While it is appropriate to maintain the maximum distance possible from particulate radiation sources, shielding is more effective in reducing dose. For particulate radiation, use a thickness of shielding at least 10% greater than the particle range in the shielding material.

Shielding is used to reduce field intensity by attenuating the energy of the radiation. Always use the appropriate shielding for the isotope being used.

C) Preventing Internal Radiation Exposure

Radioactive material (RAM) contamination is defined as: RAM dispersed in materials or places where it is unwanted.

Contamination may enter the body through four routes (or paths) of intake. These are: ingestion, inhalation, skin absorption, and through skin punctures.

Contamination control measures are used with all unsealed isotopes to prevent deposition of the isotope in the body.

Personal Protective Equipment (PPE) - Is used to prevent contamination of skin or clothing. PPE is required when handling unsealed RAM.

Lab coat - With sleeves long enough to cover the arms to the wrists, and long enough to cover the torso to the thighs. Wear with the closures fastened. Wear to protect the arms and torso.

Eye Protection - Worn to protect the eyes from splashes of radioactive and other hazardous materials.

Close Toed Shoes, Long Pants or a Long Dress - Worn to protect the feet and legs from splashes.

Disposable Gloves - Worn to protect the skin of the hands and wrists. Most effective if two pairs are worn at a time. Change the outer pair frequently.

Appropriate Bench Coverings - Used to prevent contamination of benches and hood surfaces.

Plastic Backed Disposable Paper - Defines and protects the RAM work area. "CAUTION - RAM" tape is used to secure the paper in place with the plastic side down. Replaced whenever damaged or contaminated.

Containment Trays - These shallow trays are used to contain RAM spills. They are available with disposable plastic liners to insure ease of decontamination.

Double Containment - Is the use of secondary containers (of sufficient volume) to contain all of the liquid should a RAM spill occur.

Liquid Waste Storage Cans - Used to store liquid radioactive waste, these metal cans are available from the campus storehouse.

Transport Containers - Usually a deep plastic tray with a snap-fitting lid. Used to contain RAM being transported between laboratories.

Use of Disposables - It may be preferable to use disposable plastic pipette tips, petri dishes, centrifuge tubes, etc. to prevent problems associated with the decontamination of glassware. Will adversely affect the minimization of radioactive waste generation in the lab.

Appropriate Handling Tools - Serve the dual purpose of reducing hand contamination while reducing extremity dose. Includes tweezers, forceps, tongs, and shielded containers.

Laboratory Hygiene - Restrict eating, drinking, and use of cosmetics to areas at least 1 meter distant from RAM use or storage. Food and drink cannot be stored in refrigerators, freezers or cold rooms used for RAM storage. The best practice is to isolate food and RAM to separate rooms.

Trial Runs - Contamination can be prevented during experimental procedures by performing trial runs first with non-radioactive materials. Colored water works well because "contaminated" droplets show up easily.

Marking and Labeling - An essential contamination control measure. ALL RAM USE AREAS, EQUIPMENT, AND STORAGE CONTAINERS MUST BE MARKED WITH THE RADIATION TRIFOIL SYMBOL. Failure to mark RAM with the trefoil symbol is the most common cause of contamination spread.

Contamination Monitoring Methods - Radiation monitoring is required whenever RAM is being used. Failure to use these methods often result in a spread of contamination.

Survey Meter Monitoring - With the exception of tritium, virtually all beta and gamma emitters can be detected with a GM (Geiger Mueller) survey meter. GM survey meters are used to determine the rough location and gross nature of contamination. The appropriate GM survey method is to position the

probe surface 1 to 2 cm above the suspected surface and then slowly "paint" the area, listening for variations in the click rate.

Wipe monitoring - This method is used with all isotopes, and is the only reliable method for quantitative determination of contamination levels. Contamination levels are normally expressed in cpm/100 cm². Wipe methods involve wiping a surface with a swipe material (filter paper or Q-tips are favorites) and then counting the wipe in the LSC. A background (uncontaminated) wipe is counted as a blank control.

Record Keeping - Documentation is maintained on all surveys performed. The wipe analysis data is related to a survey map by means of numbers so that areas found to be contaminated can be identified and decontaminated. Records should be maintained until the RUA is terminated. The records should then be returned to UC EH&S.

Decontamination - Decontamination of equipment or skin can be performed with simple soap and water washing. Decontaminate in a sink marked for RAM release to the sanitary sewer.

Emergencies - Report personnel or floor contamination incidents to EH&S-ORS immediately. Isolate any RAM spill area to prevent the spread of contamination. Keep all involved personnel near the area until an ORS staff member responds to assist you. THE MOST IMPORTANT THING TO REMEMBER ABOUT A CONTAMINATION EMERGENCY IS TO CALL ORS RIGHT AWAY. The ORS office number is 2-3073. After hours call 911 and ask for UCB ORS.

D) Dosimetry

Dosimeters are small wearable devices that monitor and record your radiation dose. Your RUA may not require dosimetry.

Assigned dosimeters must be worn whenever in the presence of RAM or Radiation Producing Machines. Store dosimeters in an uncontaminated area free from radiation fields when they are not being worn.

Dosimeters must be exchanged on a timely basis. Report lost or contaminated dosimeters to ORS as soon as possible.

E) Radioisotope Handling Methods

Detailed information on handling specific isotopes can be found in "The Handbook for Safe Use of Radioisotopes" which appears as an appendix to the campus "Radiation Safety Manual."

F) Posting and labeling of Radiation Use Locations

Controlled areas are designated by a RAM Area sign. Uncontrolled areas cannot exceed a whole body dose rate of 2.0 mR/hr, 100 mR/week, or 500 mR/yr.

Posted Radiation Areas may have whole body dose rates between 5 and 100 mR/hr. High Radiation Areas may have whole body dose rates between 100 and 5,000 mR/hr.

VII) UCB RADIATION SAFETY PROGRAM DOCUMENTS

You should read and be familiar with the documents in items A through E below. These documents define and explain the UCB Radiation Safety Program. If you are interested in the California regulations, copies of the Title 17, California Radiation Control Regulations and the UCB Radioactive Materials

License are available for review at the Office of Radiation Safety (ORS), 3rd Floor University Hall (3-8414) or from the DSC.

A) A copy of the campus Radiation Safety Manual is available from your Principle Investigator (PI) or Lab Contact. This document gives instructions on how to obtain, modify or terminate a RUA. In the back of the manual is a copy of the Handbook for the Safe Use of Radioisotopes. This handbook gives specific information on precautions used in handling I-¹²⁵, P-³², C-¹⁴, S-³⁵ and H-³.

B) The laboratories RUA (Radiation Use Authorization) document should be posted in your work area. This document gives detailed information on the isotope(s) and activity of RAM authorized, the persons allowed to use the RAM, and the specific safety precautions required for their use.

C) A copy of the campus [Radiation Safety Logbook](#) is available from your Principle Investigator (PI) Lab Contact or from EH&S web site. The logbook gives specific information on the UCB Radiation Safety Program.

D) The Radiation Safety Procedure Poster (yellow poster) should be found posted in all areas designated on the RUA. The poster covers the basics of using RAM at UCB.

E) The Notice to Employees should be found posted in a conspicuous location in all buildings in which RAM is used. The poster covers the rights and responsibilities of RAM users under California law.

14. LASER SAFETY

UCB Laser Safety Operation Guidelines

- 1) Intrabeam viewing of laser beams is not allowed on campus.
- 2) Never look directly into any laser beam for any reason.
- 3) Enclose the laser beam path whenever possible.
- 4) Use appropriate laser protective eyewear for all laser beam alignments (see below).
- 5) Restrict unauthorized access to laser facilities.
- 6) Do not operate lasers at sitting or standing eye level.
- 7) Shield all laser light pumping sources.
- 8) Remove all reflective or combustible materials from the beam path.
- 9) Use diffuse (non-reflective) beam stops, barriers and enclosures.
- 10) Use low beam power (or an alignment laser) for alignments.
- 11) Remove all keys from interlocks when the laser is not in operation.
- 12) Alert persons in the area when the beam is operating.
- 13) Be aware of and protect users from all non-beam hazards.
- 14) Never override any laser system safety interlock.

14.1 Administration Guidelines

- 1) Mark all laser facility entrances with an ANSI laser hazard sign.
- 2) Complete, sign, and return a laser safety training certificate to ORS.
- 3) Report all accidents or suspected eye injuries to ORS.
- 4) Eye exams may be required for Class 3b and 4 laser users.
- 5) Inform ORS of any transfer or sale of lasers.
- 6) Laser facilities are inspected periodically by ORS.
- 7) Inform ORS of any new, modified or relocated lasers.
- 8) Call EH&S 2-3073 any time you need laser safety assistance.

14.2 Laser Protective Eyewear for Alignments

Even if you are wearing laser protective eyewear, never look directly into any laser beam. Intrabeam viewing of lasers is not allowed except with the direct permission of the Laser Safety Committee. Contact the Laser Safety Officer if you feel that aligning your laser requires intrabeam viewing.

The LUR document for each laser indicates if laser protective eyewear is required for alignment or use of the laser. If laser protective eyewear is required, the LUR specifies the OD (optical density) at the laser wavelength(s) being used. The OD specified is the minimum OD sufficient to protect the user against a momentary intrabeam or specular reflection exposure.

For visible lasers, the minimum OD required to protect the user against intrabeam viewing should allow the viewing of a diffuse spot on a light colored surface. If the laser protective eyewear has an OD much larger than the specified minimum OD, it may be impossible to properly view a diffuse beam spot (or even see properly in the laser facility).

In some instances (visible lasers from 400 - 450 nm and 650 - 700 nm), it may be preferable to reduce the OD below the specified intrabeam minimum OD to better view a diffuse spot. Reducing the OD by 1 or 2 should substantially improve viewing while still offering adequate eye protection (the intrabeam OD has a X10 safety margin calculated into the value which includes the human aversion (blink) response). Reducing the specified OD by a number greater than 2 may reduce the protection factor enough to allow eye injury should a specular reflection be viewed accidentally.

For invisible lasers, the minimum OD for intrabeam viewing should not be reduced, as OD reduction will not aid in viewing the beam. Instead, the laser protective eyewear should be chosen to allow the wavelength produced by the viewing aid to be transmitted while absorbing the invisible beam. For example: a Nd:YAG beam at 1064 nm is being aligned with the use of an IR sensing card which absorbs some of the 1064 nm radiation and emits radiation at 550 nm. The calculated intrabeam OD for the Nd:YAG is 6.0. A good choice for laser protective eyewear would be a goggle with a UVEX type O6 filter (an OD of 8+ at 1064 nm and an OD of less than 1 at 400 to 700 nm). This goggle has a visible light transmission of 70% and should allow the diffuse spot to be easily viewed while giving excellent protection from the invisible Nd:YAG beam. NOTE: This eyewear would obviously not be a good choice if the Nd:YAG beam was frequency doubled to 532 nm.

All laser protective eyewear should have a visible light transmission (VLT) sufficient to allow safe operation in the laser facility. ORS recommends a VLT of at least 35%. Laser protective eyewear with a low VLT will generally not be worn by users and so cannot provide any protection.

If you have additional questions on laser protective eyewear or any other laser safety issue, please contact ORS at 643-8414.

15. REPORTING HAZARDS

Hazard Report Forms are available outside Rm. 4108 Etcheverry Hall. The Department Safety Committee will investigate promptly and arrange for whatever corrective action may be necessary. In the event of an imminent hazard which cannot be corrected immediately, the safety committee chair or building manager will arrange to post warning notices or limit access to the area.

15.1 ENSURING COMPLIANCE WITH THE IIPP

Every department employee has the responsibility to comply with all applicable regulations, campus policy, and departmental safety procedures. Adherence to the requirements of the IIPP should be included in each assessment of job performance. Outstanding performance in maintenance of a safe and healthful work environment will be noted in performance evaluations.

Standard progressive disciplinary measures in accordance with the applicable personnel policy or labor contract will result when employees fail to comply with applicable regulations, campus policy, and/or departmental safety procedures. Employees will be given ample opportunity to correct unsafe behavior. Repeated failure to comply, or willful and intentional non-compliance, may result in disciplinary measures up to and including termination.

Employees will not be discriminated against for work-related injuries or illnesses, and injuries will not be included in assessments of job performance, unless they were a result of an act violating established safety procedures or otherwise improper behavior.

Table 5 Campus Resources

A number of University programs and service organizations have been established to address injury and illness prevention and to maintain and promote a safe and healthful work environment for the campus community. A list is provided below:

Office of Emergency Preparedness - For information on disaster preparedness
642-9036 <http://oep.berkeley.edu/>

Office of Environment, Health & Safety - For information on various safety topics, including hazard evaluations and employee training
642-3073 <http://www.ehs.berkeley.edu>

Office of Radiation Safety - For information on radioactive materials and lasers
643-8414 <http://ehs.berkeley.edu/radsafety.html>

Office of Risk Management - For safety issues that may generate lawsuits against the University
642-5141 <http://fbs.berkeley.edu/RISK/>

Student Ombuds Office - Assistance for Students and Postdoctoral Appointees in dealing with supervisory issues
642-5754 <http://students.berkeley.edu/Ombuds/>

Office of the Ombudsperson for Staff- Assistance for staff employees in dealing with supervisory issues
642-7823 <http://stfombuds.berkeley.edu/>

Personnel Office - For information on personnel policies and labor contracts
642-9046 <http://hrweb.berkeley.edu>

Physical Plant - Campus Services - For installation and repair of facility safety equipment
642-1032 <http://physicalplant.berkeley.edu/>

Student Life Advising Services - Assistance for student employees
642-7224 <http://slas.berkeley.edu/>

The Chancellor's Office - For information on campus policies
642-2331 <http://office.chancellor.berkeley.edu/index.shtml>

UC Police Department - For information on personal security at the workplace
642-6760 <http://publicsafety.berkeley.edu/> <http://police.berkeley.edu/>

University Health Services - For assistance on various topics, including psychological counseling, medical evaluations and treatment, ergonomic issues, worksite wellness, and Workers' Compensation programs
642-2000 <http://www.uhs.berkeley.edu>

Table 6. Nuclear Engineering Standard Operating Procedures

Corresponding Procedure	Procedure Title
NE-SAFETY-SOP-001	Handling DOWTHERM
NE-SAFETY-SOP-002	Handling Lead
NE-SAFETY-SOP-003	Cryogenic Liquid Handling
NE-SAFETY-SOP-004	Hot Work (open flame or welding)
NE-SAFETY-SOP-005	Hot Work (electrical or fuel gas installation)
NE-SAFETY-SOP-006	Work at Elevated Locations
NE-SAFETY-SOP-007	General Chemical Use
NE-SAFETY-SOP-008	Corrosives
NE-SAFETY-SOP-009	Compressed Gases

Table 7. Conversion Table (Curie to Becquerel)

Curies	Becquerel		Bq	Curie
2.7×10^{-11}	1		1 Gbq	0.03
1.0×10^{-10}	3.7		2 GBq	0.05
2.7×10^{-10}	10		5 GBq	0.14
1.0×10^{-9}	37		10 GBq	0.27
2.7×10^{-9}	100		20 GBq	0.54
1.0×10^{-8}	370		50 GBq	1.35
2.7×10^{-8}	1,000	1 kilo Bq	100 GBq	2.7
1.0×10^{-7}	3,700	3.7 kilo Bq	200 GBq	5
2.7×10^{-7}	10,000	10 kilo Bq	500 GBq	13
1.0×10^{-6}	37,000	37 kilo Bq	1 Tbq	27
2.7×10^{-6}	100,000	100 kilo Bq	2 TBq	54
1.0×10^{-5}	370,000	370 kilo Bq	5 TBq	135
2.7×10^{-5}	1,000,000	1 mega Bq	10 TBq	270
1.0×10^{-4}	3,700,000	3.7 mega Bq	20 TBq	540
0.1	3.7×10^9	3.7 giga Bq	2 PBq	54,000
0	1×10^{10}	10 giga Bq	5 PBq	135,000
1	3.7×10^{10}	37 giga Bq	10 PBq	270,000
2.7	1×10^{11}	100 giga Bq	20 PBq	540,000
10	3.7×10^{11}	370 giga Bq	50 PBq	1,350,000
27	1×10^{12}	1 tera Bq	100 PBq	2,700,000
100	3.7×10^{12}	3.7 tera Bq	200 PBq	5,400,000
270	1×10^{13}	10 tera Bq	500 PBq	13,500,000
1,000	3.7×10^{13}	37 tera Bq	1 EBq	27,000,000
2,700	1×10^{14}	100 tera Bq		
10,000	3.7×10^{14}	370 tera Bq		
27,000	1×10^{15}	1 peta Bq		

Table 8. Code of Safe Shop Practice

1. This is a guide to be observed by all who enter or work in university shop areas. Any deviations, observed or perceived, should be immediately reported to supervisory personnel.
2. Shop supervisors will ensure shop user compliance with university policies and rules, and applicable Cal/OSHA regulations.
3. A written Job Safety Analysis (JSA) document will be developed by personnel who actually perform the operation for each shop operation (and/or machines/equipment) deemed potentially hazardous by the supervisor in the absence of a printed operating manual for the equipment. Such documents will be reviewed and updated, as necessary, by the supervisor with input from personnel who actually perform the operation.
4. All shop employees will attend at least monthly safety meetings to review safety topics, rules, practices, and procedures, as well as shop-specific JSA's.
5. Anyone known to be under the influence of drugs or intoxicating substances that impair the employee's ability to safely perform the assigned duties will not be allowed in the shop while in that condition.
6. No one will knowingly be permitted or required to work while their ability or alertness is so impaired by fatigue, illness, or other causes that it might unnecessarily expose that employee or others to injury.
7. Horseplay, scuffling, and other acts that tend to have an adverse influence on the safety or well being of the shop users are prohibited.
8. Work will be well planned to prevent injuries in the handling of materials and in working together with equipment.
9. Shop users will be instructed to ensure that all guards and other protective devices are in their proper places and are adjusted, and that they must report deficiencies promptly to the shop supervisor.
10. Employees will not handle or tamper with any electrical equipment, machinery, utilities, or systems in a manner outside of the scope of their duties, unless they have received instructions from their shop supervisor.
11. All injuries must be reported promptly to the shop supervisor.
12. Inappropriate footwear including open-toed shoes or shoes with thin or badly worn soles are prohibited.
13. Shop users are required to wear long pants while working with shop equipment and tools.

14. Appropriate protective eyewear will be worn properly when working with or near tools, equipment, or chemicals that can cause an eye injury from flying material or splashes.
15. Materials, tools, or other objects may not be thrown nor be allowed to fall from elevated locations or structures.

* "Users" includes shop employees and authorized faculty, students, and guests.

Figure 1. SOP Template

Section 1 — Process	List the process or type of process involving hazardous chemicals - for example, "atomic absorption spectroscopy for heavy metals." Include any unique equipment used. If the term "process" does not apply, proceed to Section 2.
Section 2 —Hazardous Chemicals Involved	List the hazardous chemicals (or class of chemicals) involved, including any hazardous products or by-products. Material Safety Data Sheets (MSDSs) for highly reactive or unstable chemicals should be on hand; MSDSs for all chemicals should be readily accessible. MSDSs for most chemicals are available through the EH&S web site or through the chemical manufacturer.
Section 3—Potential Hazards	Describe the potential dangers for each hazardous chemical or each element of the hazardous process or procedure. Include physical, health, and environmental hazards. To find hazard information, look up the MSDSs (available from the EH&S web site or from chemical manufacturers) or look online for other sources. In addition, the Sigma-Aldrich website, has technical bulletins that provide detailed information about various processes, equipment and classes of chemicals.
Section 4—Approvals Required	List the circumstances under which a particular laboratory operation, procedure, or activity requires prior approval from the Principal Investigator (PI), laboratory supervisor, or other personnel.
Section 5—Designated Area	Consider establishing a designated area for this operation within the laboratory. A fume hood, portion of the laboratory, or the entire laboratory may be the designated area.
Section 6—Special Handling Procedures and Storage Requirements	Describe special handling procedures and storage requirements including, (but not limited to): specific laboratory techniques; ventilation requirements; temperature controls; chemical incompatibilities; special containment devices; and access restrictions. If applicable, describe safe methods to transport the chemicals.
Section 7—Personal Protective Equipment (PPE)	List the PPE required for each activity or chemical. PPE includes gloves, laboratory coats, safety glasses, goggles, face shields, and respirators. If applicable, indicate the type of PPE (e.g., gloves, splash protection) needed for each phase of a process. For help with PPE selection or to determine if respirator use may be necessary, contact DSC or Safety Committee.
Section 8— Engineering/Ventilation Controls	List any engineering controls used. An engineering hazard control is generally defined as equipment or physical infrastructure that reduces or removes hazards from the laboratory. It can include specifically selected and arranged experimental equipment. Common engineering controls include the fume hood, glove box, biosafety cabinet and laser interlock.
Section 9—Spill and Accident Procedures	Describe procedures for handling potential emergencies related to this chemical or process such as accidental releases to the sanitary sewer, spills, fires, chemical burns to skin or eyes, shattered glassware, etc. Note the location of emergency equipment such as spill kits, emergency eyewash/showers, fire extinguishers, etc. Take care to describe any special procedures for dealing with personal exposures (e.g., calcium gluconate should be used for HF exposures). Identify the location of emergency response phone numbers and emergency contact phone

	numbers. Emergency situations can affect your ability to think clearly. It is important that everyone feel confident in their understanding of proper emergency procedures, including nearby lab members whose work may not be related to this SOP but who may need to respond in an emergency.
Section 10 —Waste Disposal	Describe any unique waste disposal procedures for the chemicals.
Section 11— Decontamination	Discuss any appropriate decontamination procedures for equipment, glassware, and clothing. Where applicable, include controlled areas (e.g., fume hoods, glove boxes) in the text.
Section 12 — Process Steps (Optional)	This section is useful for particularly complex or multi-step processes. List each step of the process or procedure chronologically on the left side of the SOP Template page. On the right side of the page and directly across from the corresponding process steps, list precautionary safety measures to be taken, including the use of specific laboratory techniques and PPE. If possible, describe indicators (visual or otherwise), which show whether the reaction, equipment, etc. is working safely as intended or that a hazardous situation may be developing.

Figure 2. Job Hazard Analysis Template .

Job Hazard Analysis Safety Information for the University of California, Berkeley		
NUCLEAR ENGINEERING BRAZING SAFETY		
TASK	HAZARDS	CONTROLS
Prepare for brazing.	Inhalation of fumes	Turn on exhaust fan or work in well-ventilated area.
	Flashing	Wear goggles or dark tinted safety glasses.
	Sparks	Wear, gloves, work shoes as specified on hot work permit.
Set gauges, turn on gas cylinders.	Pinching fingers and hands	Avoid pinch points
Clean tip, make sure hose valves are tight, unwrap hoses.	Pinching fingers	Avoid pinch points.
	Tripping	Keep hoses untangled and free from feet.
Use striker to light torch	Burning fingers, hands body; flashing	Wear, gloves, work shoes as specified on hot work permit.
Apply flame to material.	Flashing, sparks, splatter	Wear, gloves, work shoes as specified on hot work permit.
Allow material to cool on workbench.	Burn to hands or fingers	Wear gloves. Chalk mark welded area "Hot.", or place a sign if items will be unattended while cooling
Required Training: Review Hot Work Permit and Hot Work SOP	Required Personal Protective Equipment (PPE): Wear, gloves, work shoes as specified on hot work permit.	
Other Information: Contributors: Created:	EH&S Fact Sheets on "Welding and Cutting, Fire Prevention and Suppression Procedures" Nuclear Engineering, Thermal Hydraulics Lab 9-1-2010, C Sherman	

Table 9. Estimated Loss of Life Expectancy Due to Various Causes

Cause	Days	Cause	Days
Cigarette smoking (male)	2250	Job with radiation exposure	40
Heart disease	2100	Falls	39
Being 30% overweight	1300	Accidents to Pedestrians	37
Being a coal miner	1100	Safest job (accidents)	30
Cancer	980	Fire (burns)	27
Being 20% Overweight	900	Generation of energy	24
Cigarette smoking (female)	800	Illicit drugs (U.S. average)	18
Stroke	520	Poison (solid, liquid)	17
Living in unfavorable state	500	Suffocation	13
Cigar smoking	330	Firearms accidents	11
Dangerous job (accidents)	300	Natural radiation	8
Pipe smoking	220	Poisonous gases	7
Increasing food intake 100 calories/day	210	Medical X rays	6
Motor vehicle accidents	207	Coffee	6
Pneumonia (influenza)	141	Oral contraceptives	5
Alcohol (U.S. average)	130	Accidents to bicycles	5
Accidents in home	95	All catastrophes combined	3.5
Suicide	95	Diet drinks	2
Diabetes	95	Reactor accidents (UCS)	2*
Being murdered (homicide)	90	Reactor accidents (NRC)	0.02*
Legal drug misuse	90	PAP test	-4
Average job (accidents)	74	Smoke alarm in home	-10
Drowning	41	Air bags in car	-50
		Mobile coronary care units	-125

Source: Adapted from Cohen, B. and Lee, I. "A Catalog of Risks." *Health Physics*, 36, June, 1979, 707-722.

Notes: (*) These items assume that all U.S. power is nuclear. UCS stands for the Union of Concerned Scientists, a leading critic of nuclear power. NRC stands for the U.S. Nuclear Regulatory Commission. Adapted from P. Sandman, <http://www.psandman.com/articles/cma-appb.htm#B-1>

Table 10. Read and Sign ACKNOWLEDGMENT FORM for Shop Users

I have read and understand both the UC Berkeley Code of Safe Shop Work Practices and the UC Berkeley Shop Safety Manual.

_____ Print Name	_____ Signature	_____ Date
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