Standard Operating Procedure

QB3 BNC

BNC Safety Protocol

I. Purpose

This Standard Operating Procedure (SOP) outlines requirements to be considered by an authorized user of the BNC (Biomolecular Nanotechnology Center) as well as describes the normal operation of the equipment and any hazards that may be encountered during normal operation. Finally, the SOP explains how to minimize any hazards and how to respond in an emergency situation. This document is to be reviewed one year from the date of approval or as conditions warrant, whichever is the shorter time period.

II. Personnel

A. Authorized Personnel: The use of the BNC may be only by authorized personnel who are fully cognizant of all safety issues involved in the operation of such a device. These personnel are to ensure that the equipment is only operated in the manner laid out in this document. To become an authorized user, one must:
   1. Complete MicroFab (Cory Hall) training class.
   2. Read and fully understand the SOP
   3. Receive training on the BNC facility by an authorized user.
   4. Sign the authorized user sheet to affirm that the above steps have been completed.

B. Unauthorized personnel: No unauthorized personnel may enter BNC area during operations unless accompanied by an authorized user. All visitors must be briefed on proper safety protocol and must wear appropriate protective eyewear located on the premises.
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I). Acid Safety
The acid safety section provides information on the proper handling, disposal, storage and use of acids. Specific hazard and incompatibility information is given for both acids and bases used in the clean room.

II). Solvent Safety
The solvent safety section provides information on the proper handling, storage and use of solvents. Specific hazard and incompatibility information is given for common clean room solvents.

III). Disposal of Chemicals
The disposal of chemicals provides information on the proper disposal of chemicals.

IV). Emergency Contact
This section provides a list of names and numbers to call if an accident occurs.

V). Housekeeping and Clean room Etiquette
This section provides instruction for expected clean room behavior including cleaning, labeling, clean room nighttime shut down procedures, morning start up procedures, and guidelines for specific equipment and materials.

VI). Material Data Safety Sheets (MSDS)
This section provides links that give and explain MSDS information.

VII). Clean room Procedures
This section describes gowning procedure for clean room entrance and what materials are and are not clean room compatible.

VIII). Personal Protective Equipment (PPE)
This section describes what should be worn for protection in the clean room and when. The largest section focuses on what gloves are suitable for particular chemicals.

IX). Fire Safety
This section provides basic fire safety information.

X). First Aid
The first aid section describes what should be done when injury occurs in the clean room.

XI). The NFPA Diamond
This section explains what the numbers in each diamond of the NFPA diamond represent and gives other common hazard symbols.

XII). Mechanical Safety
This section contains instructions in regards to machine tools and their use in the BNC.

XIII). Electrical Safety
This section contains information in regards to electrical safety and the handling of equipment with electrical energy.

XIV). Laser Safety
This section contains information in regards to laser safety.
I). Acid Safety
The following is for clean room personnel handling and storing acids:

Section I: Classification and Hazards of Chemicals
Unit 1: Acid Definition and Reference Table

Acids:

1. Are typically soluble in water.
2. Are corrosive.
3. Taste sour.
4. Form salts when mixed with bases.
5. Turn litmus paper red.
6. Burn organic tissues and/or inorganic materials.

Possible acids used in the BNC:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Symbol</th>
<th>Properties</th>
<th>Special Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic</td>
<td>CH₃COOH</td>
<td>Liquid and vapors cause severe burns to skin. Reacts vigorously with oxidizing agents and other acids (particularly nitric). Odor similar to that of strong vinegar.</td>
<td>Incompatible with most other acids. Store alone!</td>
</tr>
<tr>
<td>Chromic</td>
<td>H₂CRO₄</td>
<td>Liquid and vapors cause severe burns to skin. Corrosive to nasal passages. Contains a suspected carcinogen.</td>
<td>Carcinogenic.</td>
</tr>
<tr>
<td>Hydrochloric</td>
<td>HCL</td>
<td>Highly corrosive to skin and mucous membranes. Repeated exposure causes erosion of teeth. Strong chlorine odor detectable at 1-5 PPM.</td>
<td></td>
</tr>
<tr>
<td>Hydrofluoric</td>
<td>HF</td>
<td>Liquid and vapors cause burns that may not be immediately painful or visible. HF attacks glass. HF looks like water and can kill in small amounts. Found in Buffered Oxide Etch (BOE).</td>
<td>Use only plastic containers.</td>
</tr>
<tr>
<td>Nitric</td>
<td>HNO₃</td>
<td>Highly corrosive to skin, mucous membranes and teeth. Highly reactive with acetic acid. Reacts explosively with combustible organic or other oxidizable materials.</td>
<td>Use only glass containers.</td>
</tr>
<tr>
<td>Phosphoric</td>
<td>H₃PO₄</td>
<td>Liquid is highly irritating to skin. Vapors are highly toxic. Contact with most metals causes formation of flammable and explosive hydrogen gas.</td>
<td></td>
</tr>
<tr>
<td>Sulfuric</td>
<td>H₂SO₄</td>
<td>Liquid and vapors are extremely corrosive to skin and mucous membranes. Generates heat upon contact with water. Reacts with acetic acid.</td>
<td>Keep away from water.</td>
</tr>
</tbody>
</table>
Unit 2: Base Definition and Reference Table

Bases:

1. Are typically water soluble.
3. Taste bitter.
4. Form salts when mixed with acids.
5. Turn litmus paper blue.
6. Are corrosive.
7. Burn organic tissues.

Possible bases used in the BNC:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Symbol</th>
<th>Properties</th>
<th>Special Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Hydroxide</td>
<td>NH₄OH</td>
<td>Irritating to skin and mucous membranes. Emits highly toxic vapors when heated.</td>
<td></td>
</tr>
<tr>
<td>Potassium Hydroxide</td>
<td>KOH</td>
<td>Irritating to skin and mucous membranes.</td>
<td></td>
</tr>
<tr>
<td>Sodium Hydroxide</td>
<td>NaOH</td>
<td>Irritating to skin and mucous membranes.</td>
<td></td>
</tr>
</tbody>
</table>

Unit 3: Special Chemical Definition and Reference Table

Special Chemicals:

1. Are not acids or bases.
2. Have similar properties to acids or bases.
3. Are as dangerous as acids or bases.

Possible special chemicals used in the BNC:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Symbol</th>
<th>Properties</th>
<th>Special Precautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Fluoride</td>
<td>NH₄F</td>
<td>Highly toxic and irritating to skin and mucous membranes. Emits toxic vapors when heated or when in contact with acids.</td>
<td></td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>H₂O₂</td>
<td>Strong oxidizing agent. Irritating to skin and mucous membranes. Reacts violently with acids and organic solvents.</td>
<td>Cap with vented cap. Do not boil in open vessels, may cause explosion.</td>
</tr>
</tbody>
</table>
Unit 4: Special Considerations

Hydrofluoric Acid:

1. Hydrofluoric acid (HF) is EXTREMELY dangerous. Be extra attentive when working with HF.
2. HF is colorless and odorless; it looks and smells like water.
3. HF is an ingredient in oxide etches which are used to etch glass. Because of the danger, only trained personnel should pour HF. It should be handled according to MSDS,

HF will:

i) Penetrate skin.
ii) Attack (decalcify) bones.
iii) React with your body’s chemicals to make poisonous salts.

HF may:

i) Kill if more than 5% of the body is exposed.
ii) Kill if ingested or inhaled.
iii) Depending on concentration, not cause pain for up to 24 hours after contact.
iv) Some of the symptoms of HF exposure are:
v) Itching.

1. Red or white discoloration of the skin.
2. Pain within 24 hours after contact.
3. Discoloration under fingernails or toenails.

Sulfuric Acid:

When heating sulfuric acid, a mist will form. The sulfuric acid mist is a known carcinogen. As such, trained personnel should only use sulfuric acid in fume hoods.

In all cases of chemical exposure, report the incident to the lab manager and seek medical attention immediately.
Section II: Handling and Housekeeping

Unit 1: Protective Clothing

When working with acids, bases, or other chemicals, you must wear the proper clothing. The following are the five clothing items that you must wear while working with chemicals.

i) • Safety glasses/goggles: Should completely cover your eye at all times.
ii) • Safety face shield: Wear over the top of any safety glasses or goggles.
iii) • Full-length acid smock: Wear over the clean room clothing.
iv) • Rubber gloves: Wear with a two-inch cuff. This prevents acid from running down your arm. Also, inflate with nitrogen and submerge in water to check for pinhole leaks before using.
v) • Hard leather or other non-porous shoes

Unit 2: Transportation of Chemicals

Transporting One Bottle

i) The chemicals used in the clean room are usually stored in glass or plastic bottles. The best way to transport these chemicals by hand is to carry them in a rubber or plastic bucket. If the bottle breaks or the lid leaks, the chemical will be contained in the bucket.

ii) If a bucket cannot be located, the next best way to transport the chemicals is by grasping the handle with one hand, supporting the bottom of the bottle with the other hand. Carefully carry the bottle in front of you and away from your body.

Transporting More Than One Bottle

i) A chemical cart is to be used if more than one bottle must be transported. The chemical cart is loaded one bottle at a time. Always make sure that the weight is evenly distributed on the cart (this reduces the chance of the cart tipping). Push the cart from behind for better control.
Unit 3: General Handling of Chemicals

Whenever you are working with chemicals, there is danger of spills, splashing, and unwanted chemical reactions occurring.

If you have any question about anything in the lab, talk to your lab PI or BNC director.

**DO:**

i) Use the appropriate size container for the job.
ii) Get help when needed.
iii) Clean containers after use with deionized water.
iv) Work under a fume hood unless you have been told otherwise by the BNC manager/PI.
v) Use a funnel when pouring chemicals into a small container.
vi) Open bottles slowly to avoid spilling and allow vapors to escape.
vii) Know what type of reactions to expect.
viii) Remember to triple-A (AAA): Always Add Acid to water.

**DON'T:**

i) Reuse containers (adverse chemical reaction may occur).
ii) Eat, drink, smoke, or touch any body part before washing your hands when working with chemicals.
iii) Be afraid to ask questions.
iv) Pour leftover chemicals back in its source container, contamination may result.
v) Put your face close to the bottle when pouring.
vi) Puncture cap or lid of any bottle.
vii) Play “mad scientist.” You may kill or injure yourself or others.
Unit 4: Quartz ware

You may find yourself around or involved in cleaning quartz ware. As such, you need to be aware of the dangers associated with degreasing and cleaning.

Degreasing:

You sometimes need to degrease quartz ware before you clean it. You degrease with solvents to remove organic materials that hydrofluoric acid cannot remove. Because acids and solvents react violently, make sure that they cannot come in contact with each other. In particular, DO NOT degrease in the acid sink. Also, make sure all solvents are rinsed off with deionized water before cleaning.

Cleaning:

Clean quartz ware with hydrofluoric acid (HF). Be aware that acids react violently with solvents. Make sure there are NO solvents present on the quartz ware when you clean. Furthermore, DO NOT clean quartz ware in the same sink used for solvents. Know the dangers of hydrofluoric acid—it kills.
Unit 5: Acid Bench Cleanup

A clean acid bench is a safe acid bench. Therefore, the purpose of this section is to give you general guidelines for cleaning up the acid bench. The purpose is not to provide a detailed set of procedures for cleanup; refer to the lab management for detailed cleanup procedures.

The following are the general cleanup checklists:

**Containers Checklist:**

1. Return all chemicals to their proper storage area (See storage requirements on MSDS for incompatibilities).
2. Dispose of any used chemicals (See disposal section in MSDS).
3. Rinse out and dispose of any empty chemical storage bottles.
4. Rinse out all containers you have used (graduated cylinders, beaker, etc.).
5. Put away all the cleaned containers.

**Acid Bench Checklist:**

1. Rinse the acid bench surfaces clean of any chemicals.
2. Rinse the acid bench sink(s) clean of any chemicals.
3. Make sure the bench is dry.

**Clothing Checklist:**

1. Remove and return to their original place:
2. Rubber gloves.
3. Face shield.
4. Acid smock.
Section III: Storage and Disposal

Unit 1: Incompatibles

You must make sure that accidental mixing does not happen between any chemical. In particular, you need to keep the chemicals separate. If you do not, serious chemical reactions may occur. As with any chemical, find someone who is trained to work with these chemicals if you do not have the necessary training, or whenever you are unsure on how to handle, mix, store, or dispose of these chemicals.

Unit 2: Storage

Like proper handling, proper storage of the chemicals will ensure everyone’s safety. Therefore you must make sure to do the following:

1. Store acids and bases in separate cabinets.
2. Keep acids and solvents in different cabinets.
3. Label shelves for quick chemical identification.
4. Make sure that incompatibles are not stored on the same shelf.
5. Keep same shaped bottles on the same shelf to conserve shelf space.
6. Never store chemical containers anywhere except in designated cabinets.

Also, keep in mind that chemicals usually have a shelf life, like food at a grocery store. When a chemical is past its shelf life, notify the lab manager and have a properly trained individual dispose of the chemical.

7. When you need to use the chemicals:

   (a) Take the oldest container whose shelf life has not expired.
   (b) Make sure the container is sealed when you return it.
   (c) Always return the container to its labeled shelf.

Unit 3: Disposal (see Chemical Disposal for additional information)

1. Ask your lab manager where the chemical disposal bottles are located. These bottles are label by the name of the chemical that goes in it.

   • DO NOT use any bottle that is not labeled unless it is a new bottle.

   • DO NOT use any bottle that is labeled with a different chemical’s name.

2. If you are disposing of a chemical in a bottle that is being used for the first time, be sure to label it with that chemical’s name. When the bottles become full, notify the lab manager who will call the chemical disposal unit.
Section IV: Safety
Unit 1: Chemical Spills

Try to prevent spills from happening. When a spill does occur, follow the guidelines below.

(1) If there are fumes, leave and evacuate others immediately.
(2) Do not attempt to wipe up the spill.
(3) Do not dilute the spill.
(4) Block off the area.
(5) Contact one of the following people starting at the top of the list for cleanup:

1. Paul Lum 510-666-3356
2. Thom Opal QB3 EH&S 510-666-3307
3. Patrick Inacio 510-666-3306
4. Your PI xxx-xxx-xxxx
5. Campus EH&S 510 642-3073
Unit 2: First Aid

Always exercise caution when in the lab to prevent accidents. If an accident does happen, your prompt response may mean the difference between life and death. Below are procedures that may save someone’s life.

i) Please take note of where the safety shower and eyewash station are in the clean room.

ii) For any case, call the following contact numbers for medical help:

1. Student Health Center   510-642-6339
2. QB3 EH&S     510-666-3307
3. Campus EH&S  510-642-3073
4. Campus Police    510-642-6760
5. Emergency Room   510-642-3188
6. Paul Lum   510-666-3356

iii) A description of hydrofluoric acid is given in this protocol. This includes symptoms of exposure.

iv) Hydrofluoric Acid burns to the eye

1. Call for medical attention!
2. Immediately rinse exposed eye with water for 5 minutes at the eye wash station.
3. Apply calcium gluconate (1%) solution to the exposed eye.

v) Hydrofluoric Acid burns to the skin

1. Call for medical attention!
2. Immediately get in the shower and wash for 5 minutes.
3. Remove ALL clothing while in the shower.
4. After the shower, have someone massage calcium gluconate (2.5%) gel into exposed area and with gloves.
5. Anyone who has touched the exposed area without gloves must also follow the above procedures.

vi) Inhalation of Chemicals

1. Call for medical attention immediately!
2. Get to fresh air.

vii) General Ingestion of Chemicals

1. Call for medical attention immediately!
2. Unless told otherwise by trained personnel, drink water to dilute the chemical.
viii) **General Chemical Burns to the Eye (Except Hydrofluoric Acid)**

1. Immediately rinse eyes with water for 15 minutes in the eye wash station.
2. Seek medical attention.

ix) **General Chemical Burns to the Skin (Except Hydrofluoric Acid)**

1. Immediately get in the shower and wash exposed area for 15 minutes.
2. Remove all clothing while in the shower.
3. Seek medical attention.

**Unit 3 Material Safety Data Sheets (MSDS)**

Material Safety Data Sheets (MSDS) are pages provided by the chemical manufacturer. They give information about hazards, first aid, etc. concerning that chemical.

Sections may vary from MSDS to MSDS, but the following are the sections generally contained in an MSDS and what is listed under the sections.

1. **Product Identification**: Chemical name, formula, and molecular weight.
2. **Composition**: A list of the ingredients that make up the chemical.
3. **Hazards Identification**: Hazards associated with the chemical.
4. **First Aid Measures**: First aid procedures to perform if exposed.
5. **Fire Fighting Measures**: Procedures for extinguishing chemical fire.
7. **Handling and Storage**: Handling and storage procedures of the chemical.
8. **Exposure Controls/Personal Protection**: What you need to wear to work with the chemical.
9. **Physical and Chemical Properties**: Describes the appearance of the chemical as well as chemical properties such as melting point, density, ph, etc.
10. **Stability and Reactivity**: Incompatibles and conditions when the chemical is stable.
11. **Toxicological Information**: List whether the chemical is carcinogenic or toxic.
12. **Ecological Information**: Environmental considerations.
13. **Disposal Considerations**: Procedures to dispose of the chemical.
14. **Transportation**: How the chemical can be transported.
15. **Other Information**: Miscellaneous information like ratings by NFPA, and NPCA-HMIS for the chemical.
16. **The MSDS sheets for the BNC are located at the following places:**

   1. Inside the front door of the BNC Clean room vestibule.
   2. In the BNC office.
   3. EH&S
## Solvent Safety

The following is to inform BNC users on handling and storing solvents. Possible solvents used in the BNC:

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Abbreviation</th>
<th>Fire Hazard</th>
<th>Toxicity Hazard</th>
<th>TLV ppm</th>
<th>Odor Threshold</th>
<th>Toxic Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetone</td>
<td>ACE</td>
<td>Extreme</td>
<td>Low</td>
<td>750</td>
<td>140 ppm (sweet/fruity)</td>
<td>Irritates eyes, nose and throat; headaches; skin dryness</td>
</tr>
<tr>
<td>Freon</td>
<td>TF</td>
<td>Low</td>
<td>Low</td>
<td>1000</td>
<td>Variable</td>
<td>Dries skin; light headedness</td>
</tr>
<tr>
<td>Isopropyl Alcohol</td>
<td>IPA</td>
<td>Extreme</td>
<td>Low</td>
<td>400</td>
<td>20 ppm (sharp/musty)</td>
<td>Dries skin; irritates eyes, nose and throat; drowsiness</td>
</tr>
<tr>
<td>Methyl Ethylketone</td>
<td>MEK</td>
<td>Extreme</td>
<td>Extreme</td>
<td>200</td>
<td>2-100 ppm (misty)</td>
<td>Irritation of eyes and nose; intoxication, headache, and dizziness</td>
</tr>
<tr>
<td>Ethyl Lactate</td>
<td>Positive Photo Resist</td>
<td>Moderate</td>
<td>Low</td>
<td>None</td>
<td>None (fruity/ester)</td>
<td>Combustible liquid; skin, eye, respiratory irritant; nervous system toxin</td>
</tr>
<tr>
<td>Propylene Glycol Monomethyl Ether Acetate</td>
<td>PGMEA</td>
<td>Moderate</td>
<td>Low</td>
<td>None</td>
<td>Very low (slightly sweet odor)</td>
<td>Irritant; may cause itching, redness and burns to skin; ingestion may cause diarrhea, kidney and liver damage</td>
</tr>
<tr>
<td>N-Methyl-2-Pyrrolidone or M-Pyrol</td>
<td>NMP</td>
<td>Moderate</td>
<td>Extreme</td>
<td>25</td>
<td>Unkown (pungent)</td>
<td>Readily absorbed through intact skin; vapors may cause eye, skin, and nose irritation; eye contact with liquid may cause severe damage</td>
</tr>
<tr>
<td>Trans 1, 2 dichloroethylene</td>
<td>DCE</td>
<td>Extreme</td>
<td>Moderate</td>
<td>200</td>
<td>0.08 ppm (sweet)</td>
<td>Eye irritation; poor coordination, drowsiness, toxic vapors released when heated</td>
</tr>
</tbody>
</table>
Chemical Disposal Guidelines (Adapted from campus EH&S, for a complete copy of the guideline, refer to Office of EH&S website)

I). Introduction

Disposal of chemicals into the sanitary sewer is regulated by federal and state laws and regulations, by the local East Bay Municipal Utility District (EBMUD) Ordinance and by the EBMUD Wastewater Discharge Permit issued to the campus. These laws and regulations prohibit any drain disposal of hazardous wastes and limit the allowable wastewater concentration of a number of specific substances. The University of California, Berkeley (UC Berkeley) is committed to protection of the local community and the environment through strict compliance with these laws and regulations. Discharge of hazardous chemical wastes into the campus sanitary sewer system is prohibited by campus policy (Water Protection Policy, http://campuspol.chance.berkeley.edu/policies/waterprotection.pdf). The range of substances that can be considered hazardous waste is enormous. Indeed, almost any substance is a hazardous waste if it is disposed of in large quantities or in high concentrations. Federal and California laws permit laboratories to drain dispose small amounts of some chemicals in quantities that do not pose a hazard to human health or the environment.

The following guidelines for drain disposal of chemicals at UC Berkeley were developed by the Environmental Management Committee (EMC) together with the Office of Environment Health & Safety (EH&S). These guidelines are based on state law, EBMUD regulations and permits, and on procedures set forth in the National Research Council (NRC) publication "Prudent Practices for Disposal of Chemicals from Laboratories," National Academy Press, Washington D.C., 1983 (Reference 1) and "Prudent Practices for Handling of Hazardous Chemicals in Laboratories," National Academy Press, Washington D.C., 1981 (Reference 2). Drain disposal is permitted by campus policy only within the guidelines set forth in this document.

Notice: EBMUD regularly monitors campus wastewater. Failure to comply with wastewater discharge regulations could lead to fines of up to $25,000 per day and/or restrictions on University water use.

II). Overview of Drain Disposal of Chemicals

Campus interior drains (and several outside drains) are connected to sanitary sewer systems, and their effluent drains to the EBMUD water pollution control plant. Chemicals and some food wastes may be prohibited from drain disposal for a variety of reasons.

Potential Problems at EBMUD Water Pollution Control Plant:

Chemicals and some food wastes may be prohibited from disposal to the water pollution control plant because they:

1. interfere with the biological processes of sewage treatment,
2. are not digested in the sewage treatment process, pass through treatment and are released as pollutants to the air,
3. are released to San Francisco Bay where they are toxic to aquatic organisms or where they accumulate in Bay sediments,
4. concentrate in the sewage treatment sludge, compromising EBMUD's ability to use the sludge for beneficial purposes,
5. cause blockages in sewers that result in sewage backing up into buildings or discharges from manholes where raw sewage could come into contact with humans and the environment.
Potential Problems in Drains and Campus Sewers:

Chemicals and some food wastes may be prohibited from disposal to laboratory drains because they can:
1. create hazards of fire, explosion, or local air pollution or stench,
2. react with other chemicals to form hazardous gases,
3. corrode lab and building plumbing,
4. leak out of old pipes as liquid to pollute campus grounds,
5. escape from sewer pipes as air pollutants,
6. expose plumbers to contact or inhalation hazards.

Campus drains are generally interconnected; substances that go down one sink drain may well come up as a vapor in another. Sinks are usually communal property, and there is a very real hazard of chemicals from two sources contacting one another; the sulfide poured into one drain may contact the acid poured into another with unpleasant consequences for all in the building.

Much of the campus plumbing infrastructure is old and may not be resistant to chemicals placed into the drains. The cost of replacing corroded plumbing can easily exceed the cost of disposal of corrosive chemicals as hazardous waste.

III). Characteristics of Hazardous Wastes

Hazardous wastes are prohibited from discharge. Chemical wastes are hazardous if they are:
1. corrosive
2. reactive
3. ignitable
4. moderately or highly toxic

Drain Disposal of Mixed Wastes (those that are radioactive and are a chemical hazard)
Waste that contains both a radioactive constituent and a chemical of which either is prohibited from drain disposal is called a “mixed waste.” Disposal of mixed waste into the campus sewer system is prohibited. Exceptions to this policy may be granted by case by case action of the campus RSC and the EMC. Production of mixed waste is to be avoided or minimized. When mixed waste is generated, store it in a safe and protected location. Contact EH&S (642-3073) for disposal of mixed waste.

Drain Disposal of Biohazardous Wastes
Disposal of infectious or biohazardous waste, as defined by the California Department of Health Services (CDHS), into the campus sewer system is prohibited. Infectious or biohazardous waste must be handled, stored, treated, and disposed of in accordance with the California Medical Waste Management Act and requirements of Biological Use Authorizations (BUAs).
IV). General Rules for Sanitary Drain Disposal of Non-Radioactive Materials

The following general rules apply to drain disposal of chemicals to sanitary sewers at UC Berkeley. Disposal of chemicals is limited to occasional disposal of small amounts of chemicals, as detailed in the guidelines below. Large scale or continuous disposal of any chemical is permitted only with the written approval of the EMC. (EH&S should be contacted to obtain this approval.)

a. Only water-soluble substances may be disposed of in sinks, toilets, and floor drains. Solutions should be flushed down the drain with an appropriate amount of water. (Residue animal or vegetable fats and oils generated as a result of normal cleaning activities are an exception to the solubility rule. However, significant amounts of these oils and fats (approximately more than a pint) can cause clogging in interior drains and so should be collected and disposed of appropriately (see Appendix V for additional guidance on solubility).

(Note A compound is considered water-soluble if it dissolves to the extent of at least 3%. In general, a soluble substance that contains a substance that is not soluble should not be poured down the drain. However, if the water-insoluble material comprises less than about 2% of the mixture, drain disposal is usually acceptable because the small quantity of water-insoluble material will be well dispersed in the aqueous effluent.)

b. Only acid and basic solutions in the range of pH 5-10 may be disposed of in the sink.

c. Highly toxic, malodorous, or lachrymatory (that is, those that cause strong eye irritation) chemicals shall not be disposed of down the drain.

d. Old, unwanted, or waste chemicals and products must not be poured down the drain as a means of disposal. These materials must be picked up by EH&S personnel.

V). Specific Guidelines For Laboratory Drain Disposal

We divide chemicals into three groups with regard to drain disposal in laboratories:

(1) Class A.
Class A includes chemicals that pose little or no hazard in dilute aqueous solution. These aqueous solutions are suitable for disposal down the drain in quantities of up to about 100 g of solute per laboratory per day (e.g. 100 g of ethanol in one liter of water).

(2) Class B.
Class B includes chemicals of moderate hazard in dilute aqueous solution. These aqueous solutions are suitable for disposal down the drain with excess water in quantities no greater than 1 g of solute per laboratory per day.

(3) Class C.
Class C includes chemicals that may not be drain disposed in any amount except by written approval of the EMC or their delegate. Normally requests for exceptions are made to EH&S Environment, Health and Safety who obtains any necessary additional information and coordinates review by the Committee(s).

Class A chemicals include many simple organic and inorganic compounds, as well as common inorganic chemicals. Included in Class A are most biological metabolites and nontoxic cellular constituents (proteins, nucleic acids, carbohydrates, soluble fats, and their precursors and catabolites). A partial list
of Class A chemicals, derived from State regulations and Appendix K of Reference 2, is provided below in Appendix I.

Class B chemicals include all of the chemicals listed as toxic (T) in the California Code of Regulations Section 22-66261.30 et. seq. that are water soluble, except for those listed as Class A chemicals in Appendix I or Class C chemicals in Appendix III. Class B chemicals also include all inorganic salts listed in reference 2 as "high hazard" in tables 6.1 and 6.2. A partial list of Class B chemicals appears in Appendix II.

Class C chemicals include all chemicals that are not soluble as defined above, chemicals that cause unacceptable concentrations of offensive, toxic or explosive vapors, and chemicals that are toxic or reactive at concentrations below 1 ppm in aqueous solution. Class C chemicals include the chemicals identified in the Main Campus EBMUD Wastewater Discharge Permit "Priority Pollutant Management Plan" Compliance Requirement (Federal Clean Water Act priority pollutants listed in 40 CFR Part 122 Appendix D, Tables II and III). A partial list of Class C chemicals appears in Appendix III.

VI). Hazardous Chemicals That Are Prohibited From Drain Disposal

The following are prohibited from drain disposal.

ORGANIC CHEMICALS
- All alkanes and water-insoluble hydrocarbons, including:
- Mineral spirits
- Stoddard solvent
- Paint stripper (e.g., Jasco)
- Petroleum hydrocarbons
- Naptha
- Solvent based adhesives
- All chlorinated and brominated hydrocarbons solvents, including:
- Methylene chloride (dichloromethane)
- Tetrachloroethylene (perchloroethylene)
- Trichloroethane
- Trichloroethylene
- Chlorofluorocarbons (freons)
- Concentrated acids and bases (pH <5 or >10)
- Latex paint (other than wash-water)
- Oil and grease (e.g., crankcase oil, lube oil, grease (all kinds), vegetable oil, shortening)
- Oil based paint
- Oil based paint solvents
- PCBs (polychlorinated biphenyls)
- EPA Priority Pollutants (See Appendix C)
VII) Accidental Spill Prevention and Emergency Notification

UC Berkeley's EBMUD Wastewater Discharge Permit requires that the campus maintain a Slug Discharge* Prevention and Contingency (SDPC) Plan. The purpose of this SDPC Plan is to eliminate or minimize the potential for an accidental, or slug discharge of any pollutant including laboratory, construction, maintenance, and photoprocessing chemicals which could interfere with EBMUD's Wastewater Treatment Plant.

*Definition of a Slug Discharge
For the purposes of this plan, a slug discharge means any discharge of a non-routine, episodic nature, including but not limited to:
- an accidental spill or a non-customary batch discharge,
- discharges that exceed EBMUD Ordinance 311 limitations,
- hazardous waste discharges, and
- **discharges that are not allowed by these Guidelines for Drain Disposal of Chemicals at UC Berkeley**

Due to the diverse nature of laboratory, shop, construction, and facility operations that use, store, and handle chemicals, the SDPC Plan does not contain specific prevention practices for all campus operations. General best management practices (BMPs) for spill prevention applicable to all chemical use, handling, and storage operations are presented below. These spill prevention measures should be incorporated as standard operating procedures for chemical use operations.

**Measures for containing toxic organic and inorganic pollutants, including solvents, from laboratories, shops, construction and facilities operations:**

General best management practices for slug discharge prevention:
1. avoid open container use of chemicals near sinks and floor drains,
2. where open container use of chemicals near sinks and floor drains is unavoidable, cap or plug sinks and drains during chemical use,
3. store chemicals in tubs, cabinets, bermed or diked areas or in other secondary containment,
4. avoid storing excess quantities of chemicals - order only what you need and dispose of unwanted or expired chemicals through EH&S,
5. secure storage cabinets and shelves to prevent tipping or falling,
6. use proper container restraints,
7. maintain spill containment and clean-up materials nearby, and
8. follow good housekeeping practices - never use sinks to store chemicals.

**Worker training:**
All laboratory, photoprocessing, shop, construction, and facility workers in operations that could cause a slug discharge must be trained in slug discharge prevention and spill reporting. This is accomplished through the Chemical Hygiene Plan and Worker Right-to-Know training and other training implemented by Department Safety Coordinators (DSCs). Drain disposal restrictions and spill discharge notification requirements are also posted through the use of sink stickers, which are required for laboratory, shop, and facility chemical use areas.

If prohibited chemicals or substances enter a sink or drain, immediately notify the Office of EH&S at 642-3073 during business hours or, after hours and weekends, call the University Police Department dispatch by dialing 643-6760 or 911 from a regular phone or 642-3333 from a cell phone.
Upon receiving notification of a chemical release, the Office of EH&S will make the appropriate agency and Campus contacts.

VIII). Appendices

Appendix I - Class A

Class A chemicals are of little or no hazard in dilute aqueous solution. These are aqueous solutions suitable for disposal down the drain with in quantities of up to about 100 g of solute per laboratory per day (e.g. 100 g of ethanol in one liter of water).

Class A chemicals include many simple organic and inorganic compounds, as well as common inorganic chemicals. This includes most normal biological metabolites and nontoxic cellular constituents (proteins, nucleic acids, carbohydrates, soluble fats, and their precursors and catabolites).

This list is illustrative, but cannot include all of the chemicals that do or could fall into Class A; therefore, if you have a question as to the classification of a material contact EH&S.

1. ORGANIC CHEMICALS
Normal biological metabolites and nontoxic cellular constituents (proteins, nucleic acids, carbohydrates, soluble fats, and their precursors and catabolites).

Alcohols
alkanols with fewer than 5 atoms
alkanediols with fewer than 8 atoms
sugars and sugar alcohols
alkoxyalkanols with fewer than 7 carbon atoms
butanol, 1-(n-butyl alcohol)
butanol, 2- (sec-butyl alcohol)
ethanol
ethanol, 2-(2-butoxyethoxy)
ethylene glycol
glycerol
methanol
methyl 1-propanol, 2-(isobutyl alcohol)
methyl 2-butanol, 2-(t-amyl alcohol)
methyl 2-propanol, 2-(tert-buty1 alcohol)
propanol, 1-(n-propyl alcohol)
propanol, 2-(isopropyl alcohol)

Aldehydes
aliphatic aldehydes with fewer than 5 carbon atoms
acetaldehyde
butyraldehyde
formaldehyde
gluteraldehyde
propionaldehyde
Amides

RCONH₂ and RCONHR with fewer than 5 carbon atoms
RCONR₂ with fewer than 11 carbon atoms
formamide
propionamide
methylpropionamide, N-
butanamide

Amines**

aliphatic amines with fewer than 7 carbon atoms
aliphatic diamines with fewer than 7 carbon atoms
benzylamine
butylamine, n-
dimethylamine
dipropylamine
propylamine
pyridine

Carboxylic Acids**

alkanoic acids with fewer than 6 carbon atoms
alcanedioic acids with fewer than 6 carbon atoms
hydroxyalkanoic acids with fewer than 6 carbon atoms
aminoalkanoic acids with fewer than 7 carbon atoms
ammonium, sodium, and potassium salts of the above acid classes with fewer than 21 carbon atoms
acetic acid
citric acid
oxalic acid
potassium binoxalate
propanoic acid
formic acid
sodium acetate
sodium citrate

** Those organic compounds with a disagreeable odor, such as dimethylamine, 1,4 butanediamine,
butyric acids and valeric acids, should be neutralized, and the resulting salt solutions flushed down the
drain, diluted with at least 1000 volumes of water.

Esters

esters with fewer than 5 carbon atoms
ethyl acetate
isopropyl acetate
methyl acetate
methyl formate
methyl propionate
propyl formate, n-

**Ethers**

dioxane, 1,4-
dioxolane
tetrahydrofuran

**Ketones**

ketones with fewer than 6 carbon atoms
acetone (2-propanone)
cyclohexanone
methyl ethyl ketone (2-butanone)
methyl isobutyl ketone
pentanone, 2-

**Nitriles**

acetonitrile
propionitrile

**Sulfonic Acids**

sodium or potassium salts of most are acceptable
## 2. INORGANIC CHEMICALS

This list comprises water-soluble compounds of low toxicity hazard cations and anions. Compounds of any of these ions must be in the range of pH 5 - 10.

<table>
<thead>
<tr>
<th>Cations:</th>
<th>Anions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>aluminum Al$^{3+}$</td>
<td>borate (BO$_3^{3-}$, B$_4$O$_7^{2-}$)</td>
</tr>
<tr>
<td>ammonium NH$^{4+}$</td>
<td>bromide (Br$^-$)</td>
</tr>
<tr>
<td>calcium Ca$^{2+}$</td>
<td>carbonate (CO$_3^{2-}$)</td>
</tr>
<tr>
<td>cesium Cs$^+$</td>
<td>chloride (Cl$^-$)</td>
</tr>
<tr>
<td>hydrogen H$^+$</td>
<td>bisulfite (HSO$_3^-$)</td>
</tr>
<tr>
<td>lithium Li$^+$</td>
<td>hydroxide (OH$^-$)</td>
</tr>
<tr>
<td>magnesium Mg$^{2+}$</td>
<td>oxide (O$^{2-}$)</td>
</tr>
<tr>
<td>potassium K$^+$</td>
<td>iodide (I$^-$)</td>
</tr>
<tr>
<td>sodium Na$^+$</td>
<td>nitrate (NO$_3^-$)</td>
</tr>
<tr>
<td>strontium Sr$^{2+}$</td>
<td>phosphate (PO$_4^{3-}$)</td>
</tr>
<tr>
<td>tin Sn$^{2+}$</td>
<td>sulfate (SO$_4^{2-}$)</td>
</tr>
<tr>
<td>titanium Ti$^{3+}$, Ti$^{4+}$</td>
<td></td>
</tr>
<tr>
<td>zirconium Zr$^{2+}$</td>
<td></td>
</tr>
</tbody>
</table>
3. PROPRIETARY PRODUCTS

Bleach (sodium hypochlorite solution)

Detergents (alkanesulfonates)

Photographic solutions- black and white developers and developer replenishers (No Fixers)

Household ammonia

Alphabetical Lists of Commonly Used Class A Chemicals

**CLASS A Organic**
- acetaldehyde
- acetic acid
- acetone (2-propanone)
- acetonitrile
- benzylamine
- butanamide
- butanol, 1-(n-butyl alcohol)
- butanol, 2-(sec-butyl alcohol)
- butylamine, n-
- butyraldehyde
- citric acid
- cyclohexanone
- dimethylamine
- dioxane, 1,4-
- dioxolane
- dipropylamine
- ethanol
- ethanol, 2-(2-butoxyethoxy)
- ethyl acetate
- ethylene glycol
- formaldehyde
- formamide
- formic acid
- gluteraldehyde
- glycerol
- isopropyl acetate
- methanol
- methyl 1-propanol, 2-(isobutyl alcohol)
- methyl 2- butanol, 2-(t-amyl alcohol)
- methyl 2-propanol, 2-(tert-butyl alcohol)
- methyl acetate
- methyl ethyl ketone (2-butaneone)
- methyl formate

**CLASS A Inorganic**
- ammonium chloride
- ammonium nitrate
- ammonium sulfate
- ammonium thiosulfate
- boric acid
- calcium carbonate
- calcium chloride
- calcium hydroxide
- calcium nitrate
- calcium sulfate
- cesium chloride
- hydrochloric acid (neutralized)
- lithium bromide
- lithium chloride
- magnesium chloride
- magnesium oxide
- magnesium sulfate
- nitric acid (neutralized)
- perchloric acid (neutralized)
- phosphoric acid (neutralized)
- Plaster of Paris (calcium sulfate)
- potassium bicarbonate
- potassium bromide
- potassium carbonate
- potassium chloride
- potassium iodide
- potassium nitrate
- potassium phosphate
- potassium sulfate
- sodium bicarbonate
- sodium borate
- sodium carbonate
- sodium chloride
methyl isobutyl ketone
methylpropionamide, N-methyl propionate
oxalic acid
pentanone, 2-
potassium binoxalate
propanoic acid
propanol, 1-(n-propyl alcohol)
propanol, 2-(isopropyl alcohol)
propionaldehyde
propionamide
propionitrile
propyl formate, n-
propylamine
pyridine
sodium acetate
sodium citrate
tetrahydrofuran

sodium hydroxide (neutralized)
sodium iodide
sodium molybdate
sodium nitrate
sodium phosphate
sodium sulfate
sodium sulfite
sodium thiosulfate
sulfuric acid (neutralized)
Appendix II - Class B

Class B chemicals of moderate hazard in dilute aqueous solutions. These aqueous solutions are suitable for disposal down the drain with excess water in quantities no greater than 1 gram of solute per laboratory per day. The final concentration in wastewater must not exceed 1 ppm after flushing with an appropriate amount of water.

This list is illustrative, but cannot include all of the chemicals that do or could fall into Class B; therefore, if you have a question as to the classification of a material, contact EH&S.

1. ORGANIC CHEMICALS

Commonly used Class B organic chemicals:

- acrylamide
- trypan blue

2. INORGANIC CHEMICALS

<table>
<thead>
<tr>
<th>Cations of the following metals:</th>
<th>Anions and neutral compounds:</th>
</tr>
</thead>
<tbody>
<tr>
<td>barium</td>
<td>aluminum hydride (AlH₄⁻)</td>
</tr>
<tr>
<td>cobalt</td>
<td>amide (NH₂⁻)</td>
</tr>
<tr>
<td>gallium</td>
<td>azide (N₃⁻)</td>
</tr>
<tr>
<td>germanium</td>
<td>borohydride (BH₄⁺)</td>
</tr>
<tr>
<td>hafnium</td>
<td>bromate (BrO₃⁻)</td>
</tr>
<tr>
<td>indium</td>
<td>chlorate (ClO₅⁻)</td>
</tr>
<tr>
<td>iridium</td>
<td>fluoride (F⁻)</td>
</tr>
<tr>
<td>iron</td>
<td>hydride (H⁻)</td>
</tr>
<tr>
<td>manganese</td>
<td>hydroperoxide (O₂H⁺)</td>
</tr>
<tr>
<td>molybdate</td>
<td>hydrosulfide (SH⁻)</td>
</tr>
<tr>
<td>osmium</td>
<td>hypochlorite (OCl⁻)</td>
</tr>
<tr>
<td>platinum</td>
<td>iodate (IO₃⁻)</td>
</tr>
<tr>
<td>rhenium</td>
<td>nitrite (NO₂⁻)</td>
</tr>
<tr>
<td>rhodium</td>
<td>perchlorate (ClO₄⁻)</td>
</tr>
<tr>
<td>ruthenium</td>
<td>permanganate (MnO₄⁻)</td>
</tr>
<tr>
<td>tellurium</td>
<td>peroxide (O₂²⁻)</td>
</tr>
<tr>
<td>tungsten</td>
<td>persulfate (S₂O₈²⁻)</td>
</tr>
<tr>
<td>vanadium</td>
<td>sulfide (S²⁻)</td>
</tr>
</tbody>
</table>
Appendix III - Class C

Class C chemicals are ones that may not be drain disposed in any amount except by written approval of the EMC (or in some cases the RSC). Contact EH&S for assistance in obtaining this approval.

This list is illustrative, but cannot include all of the chemicals that do or could fall into Class C; therefore, if you have a question as to the classification of a material contact EH&S.

1. ORGANIC CHEMICALS

All alkanes and water-insoluble hydrocarbons.
All chlorinated and brominated hydrocarbons.
EPA Priority Pollutants (see list below).
Specific commonly used Class C organic chemicals:
benzene
cyclohexane
ethyl ether
ethidium bromide
hexane
phenol and phenolic compounds
toluene
xylene
ortho-phthalaldehyde (Cidex-OPA)

chlorinated hydrocarbons
chloroform
carbon tetrachloride
methylene chloride (dichloromethane)
PCBs
tetrachloroethylene
trichloroethane
trichloroethylene
chlorofluorocarbons (freons, halons)

2. INORGANIC CHEMICALS

Chemicals containing the following metals and compounds:

  antimony
  arsenic (including arsenate [AsO₃³⁻, AsO₄³⁻] and arsenite [AsO₂⁻])
beryllium
cadmium
chromium (including chromate and dichromate)
copper
cyanides, cyanates (OCN⁻), thiocyanates (SCN⁻)
lead
mercury
nickel
selenium
silver, including photographic fixer
thallium
zinc

Specific commonly used Class C inorganic chemicals:
sodium azide
sodium cyanide
chromium glassware cleaners - chromerge, chromium trioxide/sulfuric acid solutions
"biodegradable" liquid scintillation cocktails

3. EPA PRIORITY POLLUTANTS (40 CFR Part 122 Appendix D, Tables II and III)

TABLE II - ORGANIC TOXIC POLLUTANTS IN EACH OF FOUR FRACTIONS IN ANALYSIS BY
GAS CHROMATOGRAPHY/MASS SPECTROSCOPY (GS/MS)

<table>
<thead>
<tr>
<th>Volatiles</th>
<th>Base/Neutral</th>
<th>Pesticides</th>
</tr>
</thead>
<tbody>
<tr>
<td>1V acrolein</td>
<td>1B acenaphthene</td>
<td>42B N-nitrosodi-n-</td>
</tr>
<tr>
<td>2V acrylonitrile</td>
<td>2B acenaphthylene</td>
<td>propylamine</td>
</tr>
<tr>
<td>3V benzene</td>
<td>3B anthracene</td>
<td>43B N-</td>
</tr>
<tr>
<td>5V bromoform</td>
<td>4B benzidine</td>
<td>nitrosodiphenylamine</td>
</tr>
<tr>
<td>6V carbon tetrachloride</td>
<td>5B benzo(a)anthracene</td>
<td>44B phenanthrene</td>
</tr>
<tr>
<td>7V chlorobenzene</td>
<td>6B benzo(a)pyrene</td>
<td>45B pyrene</td>
</tr>
<tr>
<td>8V</td>
<td>7B 3,4-benzofluoranthene</td>
<td>trichlorobenzene</td>
</tr>
<tr>
<td>chlorodibromomethane</td>
<td>8B benzo(ghi)pyrene</td>
<td></td>
</tr>
<tr>
<td>9V chloroethane</td>
<td>9B benzo(k)fluoranthene</td>
<td></td>
</tr>
<tr>
<td>10V 2-chloroethylvinyl ether</td>
<td>10B bis(2-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>chloroethoxy)methane</td>
<td></td>
</tr>
<tr>
<td>11V chloroform</td>
<td>11B bis(2-chloroethyl)ether</td>
<td></td>
</tr>
<tr>
<td>12V</td>
<td>12B bis(2-</td>
<td>1P aldrin</td>
</tr>
<tr>
<td></td>
<td>chloroethoxy)methane</td>
<td>2P alpha-BHC</td>
</tr>
<tr>
<td>dichlorobromomethane</td>
<td>13B bis(2-</td>
<td>3P beta-BHC</td>
</tr>
<tr>
<td>14V 1,1-dichloroethane</td>
<td>chloroisopropyl)ether</td>
<td>4P gamma-BHC</td>
</tr>
<tr>
<td>15V 1,2-dichloroethane</td>
<td>14B bis(2-</td>
<td>5P delta-BHC</td>
</tr>
<tr>
<td></td>
<td>ethylhexyl)phthalate</td>
<td></td>
</tr>
<tr>
<td>16V 1,1-dichloroethylene</td>
<td>15B 4-bromophenyl phenyl</td>
<td>6P chlordane</td>
</tr>
<tr>
<td>17V 1,2-dichloropropane</td>
<td>16B 4-chlorophenyl phenyl</td>
<td>7P 4,4'-DDT</td>
</tr>
<tr>
<td></td>
<td>ether</td>
<td>8P 4,4'-DDE</td>
</tr>
<tr>
<td>18V 1,3-</td>
<td>17B butylbenzyl phthalate</td>
<td>9P 4,4'-DDD</td>
</tr>
<tr>
<td>dichloropropylene</td>
<td>18B 2-chloronaphthalene</td>
<td>10P dieldrin</td>
</tr>
<tr>
<td>19V ethylbenzene</td>
<td>19B dibenzo(a, h)anthracene</td>
<td>11P alpha-endosulfan</td>
</tr>
<tr>
<td></td>
<td>ether</td>
<td>12P beta-endosulfan</td>
</tr>
<tr>
<td>20V methyl bromide</td>
<td>18B chrysene</td>
<td>13P endosulfan sulfate</td>
</tr>
<tr>
<td>21V methyl chloride</td>
<td>19B dibenzo(a, h)anthracene</td>
<td>14P endrin</td>
</tr>
<tr>
<td></td>
<td>20B 1,2-dichlorobenzene</td>
<td></td>
</tr>
<tr>
<td>22V methylene chloride</td>
<td>21B 1,3-dichlorobenzene</td>
<td>17P heptachlor epoxide</td>
</tr>
<tr>
<td></td>
<td>22B 1,4-dichlorobenzene</td>
<td>18P PCB-1242</td>
</tr>
<tr>
<td>23V 1,1,2,2-</td>
<td>23B 3,3'-dichlorobenzidine</td>
<td>19P PCB-1254</td>
</tr>
<tr>
<td>tetrachloroethane</td>
<td>24B diethyl phthalate</td>
<td>20P PCB-1221</td>
</tr>
<tr>
<td>24V tetrachloroethylene</td>
<td>25B dimethyl phthalate</td>
<td>21P PCB-1232</td>
</tr>
<tr>
<td></td>
<td>26B di-n-butyl phthalate</td>
<td>22P PCB-1248</td>
</tr>
<tr>
<td>25V toluene</td>
<td>27B 2,4-dinitrotoluene</td>
<td>23P PCB-1260</td>
</tr>
<tr>
<td>26V 1,2-trans-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dichloroethylene</td>
<td>27B 2,4-dinitrotoluene</td>
<td>24P PCB-1016</td>
</tr>
<tr>
<td>27V 1,1,1-trichloroethane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28V 1,1,2-trichloroethane</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
29V trichloroethylene
31V vinyl chloride

Acid Compounds
1A 2-chlorophenol
2A 2,4-dichlorophenol
3A 2,4-dimethylphenol
4A 4,6-dinitro-o-cresol
5A 2,4-dinitrophenol
6A 2-nitrophenol
7A 4-nitrophenol
8A p-chloro-m-cresol
9A pentachlorophenol
10A phenol
11A 2,4,6-trichlorophenol

28B 2,6-dinitrotoluene
29B di-n-octyl phthalate
30B 1,2-diphenylhydrazine (as azobenzene)
31B fluroranthenes
32B fluorene
33B hexachlorobenzene
34B hexachlorobutadiene
35B

Other
dioxins- 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD) and others
asbestos

25P toxaphene

TABLE III - OTHER TOXIC POLLUTANTS (METALS AND CYANIDE) AND TOTAL PHENOLS

antimony, Total
arsenic, Total
beryllium, Total
cadmium, Total
chromium, Total
copper, Total
lead, Total
mercury, Total
nickel, Total
selenium, Total
silver, Total
thallium, Total
zinc, Total
cyanide, Total
phenols, Total
## Emergency Contact Numbers:

<table>
<thead>
<tr>
<th>Name</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police, Fire, Emergency Room</td>
<td>911 or 2-3333</td>
</tr>
<tr>
<td>Campus Police</td>
<td>2-6760</td>
</tr>
<tr>
<td>Student Health Center</td>
<td>2-6339</td>
</tr>
<tr>
<td>Paul Lum</td>
<td>6-3356</td>
</tr>
<tr>
<td>QB3 EH&amp;S</td>
<td>6-3307</td>
</tr>
<tr>
<td>Campus EH&amp;S</td>
<td>2-3073</td>
</tr>
</tbody>
</table>
Housekeeping and Clean room Etiquette

A). Cleaning

One of the most effective ways to keep a lab safe and increase productivity is to keep it clean. Pathways should be clear, table tops should be clean, and chemicals should be kept in the proper storage place. It is very frustrating to have to clean an instrument before you use it because someone else left it dirty. Having to search for or make new solutions of chemicals that have not been put away correctly wastes time and chemicals.

Be courteous and clean up your own space. It is your responsibility to clean what you use. Before leaving the clean room, you should also do a quick check of all the areas you worked in to insure you do not inadvertently leave things out of place.
You may want to check for the following:

1. Are there any chemicals, waste, or general garbage that has been left out?
2. Are there any spills that need to be cleaned up?
3. Are all the chemicals you used labeled and in the right place?
4. Are all of your materials stored in your bin?
5. Has all of the equipment you used been cleaned and turned off (if it is supposed to be)?
6. Did you open any gas cylinders that you forgot to close?
7. Is there anything else you may have turned on that you need to turn off?

B). Being the first one in or the last one out

1. If you are the last one in the clean room in the evening make sure you turn off the house vacuum and nitrogen (if it is supposed to be).
2. Check the rest of the clean room equipment and gases to make sure nothing is still on that should be turned off.
3. If you are the first one in the clean room in the morning, the house vacuum and nitrogen will need to be turned on.

C). Equipment that should be turned off

1. Lithography aligners
2. Unused hotplates
3. Microscopes
4. SEM
5. Spinners
6. Machine tools
7. Vacuum pumps (if it is suppose to be)
8. Unused furnaces
D). Labeling

Unlabeled chemicals are significant environmental and health hazards. When you make up a solution, remember to label it. When labeling a solution, you should include the following:

1. Name of the material contained
2. Primary hazard of the material
3. Person responsible for the material
4. Date of filling or preparation

If your name, the substance, and a date are not present on any chemicals left out on the counters (specifically those in glassware), the chemicals will be disposed of. If any chemicals need to be left out on the counters for longer than 48 hours, the label should include the date prepared and the date the solution will be cleaned up. Be courteous and clean up your own chemicals in reasonable time frames.

E). Preparing

Clean room equipment often requires long periods of usage. Be courteous to others who may want to use the same equipment. Before you begin, know what you are going to do and what you need. Proper planning of your tasks saves time, increases safety, and prevents damage to the equipment.

F). Commonsense and Common Courtesy

The most important parts of housekeeping and clean room etiquette are common sense and common courtesy. Lists should not be necessary for much of the behavior expected in the clean room. Obviously, there should be no horseplay in the clean room. If you deplete a squeeze bottle of a frequently used chemical, refill it. If the supply of a chemical is getting low, let the lab manager know so that more may be ordered. Basically, follow the “golden rule” and think about what you are doing.

G). Specific Equipment and Processes

1). HF Etching
   SU-8 can contaminate the hydrofluoric acid etching solution. If you put a wafer with SU-8 in the HF solution, replace the etching solution.

2). Hot Plates
   Hot plates are in high demand. When using a hot plate, be sure your solution will not spill and damage the hot plate. When you are done, promptly clean up the hot plate and remove your materials so that the hot plate is available for others to use.

3). Teaching Lab Aligner
   The aligner should be turned off at night. Whenever the lamp has been turned off, you must wait at least 20 minutes before turning it on again.

4). Piranha
   Piranha is a dangerous mixture. Use it sparingly and only when you need to. When disposing of used piranha, be sure that the mixture has sat for at least 24 hours before putting it in a bottle. When putting waste piranha in a waste container, make sure no heat is produced or reactions are occurring. You still have concentrated sulfuric acid. Do not cap the waste container if gases or heat are being produced. Do not let piranha waste containers sit in the clean room when full.
**MSDS of chemicals used in the BNC**

If you have **questions** on what an MSDS is, what they are for, what they look like, how to read them, or where to find them, this link will answer your questions.

http://www.ilpi.com/msds/faq/parta.html#whatis

If you are simply **looking for MSDS information**, the following link provides over 100 websites with MSDS information

http://www.ilpi.com/msds/index.html
http://www.lib.berkeley.edu/CHEM/safety.html
http://www.ehs.berkeley.edu/healthsafety/msds.html

**MSDS sites for Clean rooms** can be found in the following place

http://www.actiocms.com/chemquik/mainpage.cfm
**Clean Room Procedures**

2) **Gowning**

   a). Before entering the gowning room, make sure you are wearing appropriate attire: Shoes should fully enclose the feet (no sandals, open toe, or sling-back shoes)
   b). Remove outer clothing (i.e., hats, jackets, fuzzy sweaters)
   c). Make sure you have everything you need with you to work in the lab and that it is all clean room-compatible.
   d). When entering the gowning room, obtain a lab coat. Clean coats are available in the gowning room.
   e). Put on the lab coat.
   f). Put the shoe covers over your shoes and fasten the snap.
   g). Put on safety glasses, and plastic gloves.
   h). Raise your hood and make sure all your hair is covered.
   i). Please don't forget to sign in!

   Now you are clean room ready!

3) **Rules and Guidelines for Personal Lab Behavior**

   a). Drinking, eating and gum-chewing are not allowed in any part of the lab.
   b). Full clean room attire must always be worn while in the clean room.
   c). Be discrete in coughing, sneezing, or blowing your nose. If you can, go into the service area or gowning room. At the very least, turn away from the processing area and change your vinyl gloves before commencing processing.
   d). Minimize the amount of materials stored in the lab. All personal items must be labeled with your full name and contact phone number. Storage inside the lab is limited to personal storage bins.

4) **Leaving the lab**

   a). Clean up after yourself. Leave stations neat and ready for the next person to use. Remove personal items from general-use areas after you are done processing.
   b). Any materials you plan on taking out of the lab with you should be bagged to prevent contamination.
   c). In the gowning room: remove your clean room attire from the bottom up:
      1. Booties - Put booties in the appropriate bin.
      2. Lab Coat - Keep the sleeves, main body, and as much of the suit as possible off the floor.
5) **Acceptable Materials in the Clean room**

a) Cleanroom notebooks and cleanroom paper (available in Stock Room Stores.)
b) Wafers and tweezers, in labeled boxes.
c) Pens (preferably ball-point).
d) Materials with smooth, hard surfaces which can be cleaned with alcohol wipes.
e) The following materials are not considered cleanroom-compatible:
   i) Wood pulp-based paper products, which includes regular paper, tissues, cardboard, books, and magazines.
   ii) Styrofoam products.
   iii) Any powders.
   iv) Erasers, pencils, felt-tipped pens (other than Sharpie markers).
   v) Anything that can easily shred or aerosolizes; i.e., anything that may serve as a source of particles.
Personal Protective Equipment (PPE)

1) Lab Coats

Clean room lab coats are intended to keep the clean room clean, not the wearer safe. They do provide an extra layer of protection that may protect against minor spills and splashes. When using corrosive materials, a plastic or rubber apron should be used.

2) Aprons / Acid Smock

Acid aprons provide better protection than the lab coats and can be removed much more quickly. They are recommended when using large volumes chemicals or whenever highly corrosive or toxic materials are being used. Be especially mindful to wear proper protection when heating and mixing chemicals. Remove aprons carefully to prevent any chemicals on them from contaminating other areas.

3) Shoes

In the clean room it is important to protect your feet from chemical spills and dropped objects. The clean room booties do not provide adequate protection. Shoes need to be worn under the booties which are close-toed, close-heeled, and non-porous.

4) Gloves

Gloves are an important piece of safety equipment in the lab, but they reduce dexterity. When working in the lab, it is important to use gloves that are appropriate for the task. There are many different types of gloves with varying resistances. When working with mixtures, choose gloves that are suitable for all of the chemicals in the mixture. If one component in the mixture can penetrate the gloves, it may carry the other components through with it, exposing you to all the chemical hazards in the mixture. Also, be sure to remove your gloves when leaving the clean room to prevent harmful chemicals from being transported to other areas.

5) Eyewear

Safety glasses should be worn in the clean room at all times. These will provide protection against flying objects and some chemical splashes. When working with chemicals, especially when heating or mixing, goggles that seal around the face will provide better protection and prevent damage. Face shields should be worn whenever working with corrosive chemicals.
Selection factors:
(1) wavelength of the laser output
(2) potential of multi-wavelength operation
(3) optical density of eyewear at laser wavelength
(4) visible light transmission requirement
(5) capability of the front surface to produce a specular reflection
(6) field of view provided by eyewear
(7) availability of prescription lenses, or sufficient goggle frame size to permit wearing spectacles inside the goggle
(8) ventilation port to prevent fogging, if full-face fit
(9) provision of side-guards/shields for spectacles
(10) comfort and fitness
(11) effect upon colour vision
(12) absence of irreversible bleaching when filter exposed to high peak irradiances
(13) impact resistance
(14) maximum permissible exposure, radiant exposure or irradiance
(15) radiant exposure or irradiance and the corresponding time factor at which laser safety eyewear damage occurs (penetration), including transient bleaching
**Fire Safety**

Fire is a serious risk anywhere both solvents and electrical equipment are used. The chance of fire is greatly decreased by good housekeeping. Keep rags containing oil, gasoline, alcohol, shellac, paint, varnish, or lacquer in a covered metal container. Keep debris in a designated area away from the building. Sound an alarm if a fire occurs. Alert everyone and then call the fire department. After calling the fire department, make a reasonable effort to contain the fire.

If you try to put out the fire, make sure you can access the escape route at all times. Be aware of any chemicals that may contribute to the fire or explode. If you are unsure whether attempting to put out the fire would be safe, just get out.

**Fire Extinguishers**

When using fire extinguishers, it is important to know the type of fire that is burning and the type of fire extinguisher appropriate for the fire.

Class A – Normal combustibles such as paper, cardboard, plastics, wood, cotton, etc.
Class B – Flammable liquids such as solvents, gasoline, oils, grease, etc.
Class C – Electrical fires
Class D – Combustible metals
Class K – Kitchen fires

* The fire extinguishers near the cleanroom should be BC extinguishers and are adequate for most fires that might occur, but be aware since using an unfit extinguisher could make the problem worse.

**Fire Extinguisher Location Map**

![Fire Extinguisher Location Map](image-url)
First Aid

The main purpose of first aid is to control the life-endangering situation and prevent further injury. For serious accidents, the main responsibility of those in the work area is to get professional help; ignorantly doing the wrong thing can cause further injury.

Cuts

For minor cuts, band-aids are usually sufficient. For larger cuts with significant blood loss, firmly press a clean towel against the wound to slow the bleeding until help arrives. If you are helping someone who has been cut, OSHA requires that you wear gloves and other PPE. Any blood in the lab should be cleaned up using bleach to disinfect.

Minor Chemical Splashes (on person)

Dilute chemical splashes with copious amounts of waters. Generally 15 minutes of rinsing is recommended. For minor splashes that continue to cause irritation, a paste of sodium bicarbonate (baking soda) may be applied. Sodium bicarbonate may also be used to neutralize small acid spills on counter tops and floors. Know the hazards of the chemicals you are working with, and do not hesitate to get professional help. For large spills, get professional help immediately and try to prevent the spread of the spill.

Larger Chemical Spills (on person)

For larger spills of hazardous materials, clothing should be removed and the person should use the emergency showers for rinsing. The following map shows the locations of the emergency showers in the cleanroom.
**Hydrofluoric Acid**

Hydrofluoric acid is particularly hazardous because it is readily absorbed through the skin. Hydrofluoric acid is not easily neutralized and can continue to damage deep layers of tissue under the skin for days after it has been washed off. If concentrated hydrofluoric acid is spilled on just 2% of the body, it can cause death within 24 hours.

If a hydrofluoric acid spill occurs and clothing or skin are splashed, rinse the area for five minutes, massage calcium glutamate cream onto the skin surrounding the splash (if in eyes dilute the cream with water and add as eye drops), and get medical attention. Injections may be necessary for treatment of the burns.

**Burns**

Minor burns should be treated with cold water. If possible immerse burnt tissue in cold water as long as possible. More extensive burns should be covered with a clean cloth until professional help arrives.

**Poisoning**

Determine the cause of poisoning and call for professional help.

**Dizziness**

If a coworker experiences faintness or dizziness, remove them to fresh air and have them sit down. If fainting occurs, get medical attention.

**Shock**

It is important to check for shock when someone is injured. Nausea, shaking, blurring of vision, and paleness are all symptoms of shock. Keep the victim warm, have him/her sit or lie down, and continue to monitor them until help arrives.
The NFPA Diamond

The NFPA diamond is designed to give general hazard information for chemicals. Click on the hazards/colors for the specific hazards represented by the numbers.

**Red: Fire Hazard**
- 0 – Will not burn
- 1 – Must be preheated for ignition; flashpoint above 200°F (93°C)
- 2 – Must be moderately heated for ignition, flashpoint above 100°F (38°C)
- 3 – Ignition may occur under most ambient conditions, flashpoint below 100°F (38°C)
- 4 – Extremely flammable and will readily disperse through air under standard conditions, flashpoint below 73°F (23°C)

**Blue: Health Hazard**
- 0 – Hazard no greater than ordinary material
- 1 – May cause irritation; minimal residual injury
- 2 – Intense or prolonged exposure may cause incapacitation; residual injury may occur if not treated
- 3 – Exposure could cause serious injury even if treated
- 4 – Exposure may cause death

**Yellow: Reactivity Hazard**
- 0 – Stable
- 1 – May become unstable at elevated temperatures and pressures, may be mildly water reactive
- 2 – Unstable; may undergo violent decomposition, but will not detonate. May form explosive mixtures with water
- 3 – Detonates with strong ignition source
- 4 – Readily detonates

**White: Special Hazard**
- OX Strong Oxidizer
- water reactive

Other Symbols Commonly Seen (these are not official NFPA symbols)
- ACID - Indicates an acid
- ALK - Indicates an alkali or base
- COR - Indicates the chemical is corrosive
Additional Symbols

- **radioactive**
- **corrosive**
- **poison**
- **flammable solid**
- **oxidizer**
- **biohazard**
- **irritant**
- **flammable gas or liquid**
- **dangerous when wet**
Mechanical Safety:

Introduction:

Everybody using the Laboratory and Mechanical Workshop facilities has a responsibility to keep them in proper working order and to maintain a safe working environment in the working area.

People working in Laboratory and Workshop should be considerate, have good working attitude and be self-disciplined.

Take care of the facilities being used by you.
Take care of other people working in the area with you.
Take care of your own life!

Any accident or mishap may damage equipment, cause injury or death.

It is important to prevent accident or mishap from happening when operating mechanical equipment.

How?

1) There are general rules and guidelines for you to follow in the Laboratory and Workshop areas.
2) There are also operational manuals and specific rules for every piece of mechanical equipment to be followed by users.
3) Always if you are in doubt, do not attempt to operate by yourself, call for help!

What makes mechanical equipment dangerous?

1) It is because of the Mechanical Movement and Forces.
2) NEVER UNDERESTIMATE THEM!
3) When you are operating a machine or a mechanical apparatus, you should always adopt a defensive attitude and be aware of the source of danger or the likely outcome of each sequence of operation.

Movement of a machine can be dangerous

1) You have to understand what kind of Forces and Mechanical Movement you will be involved with while operating the equipment.
2) To this you need to understand the basic working principles of the equipment or the proper machining processes associated with that particular machine.
Physical Dangers to Remember

Static Force: If a support is not strong enough for an object with increasing weights, it might collapse suddenly.

Pressure: If the safety valve for a pressure vessel e.g. the storage tank of an air compressor, is not working, the pressure will build up to a point it suddenly cause the tank to explode.

Dynamic Force: The magnitude of some dynamic forces is constant but most of them change due to acceleration and deceleration. You should not enter the area covered by the mechanical movement of the equipment.

Vibration: Mechanical vibration is undesirable. It is harmful to the health of the equipment as it may loosen some joints, create additional stresses or induce fatigue. Resonance is even more damaging as the amplitude of vibration increases, it may cause the eventual collapse of the equipment (Remember the Tacoma Bridge). If there is an unusual vibration or noise caused by the mechanical movement, you should immediately stop the machine operation and determine the cause.

Cutting Forces: In the operation of machine tools, forces arising from cutting are unavoidable. Before the operation, you should know the direction of these forces in order to properly clamp your work piece. Incorrect operation of machine tools will cause abnormal behavior of the machine tool and unusual forces may damage it or cause injury to the operator.

Torque: Machine tools operation involves a lot of rotation of the cutting tools or the workplaces. The centrifugal forces of a suddenly broken grinding wheel while in operation cause the broken pieces to fly out in various directions. The torque in drilling may rotate the workplace and the clamping device if it is not securely bolted onto the machine table.

Eye protective Eyewear

In general, protective eyewear should be selected to protect the eye against flying particles or material pieces anticipated while operating the equipment. You should remember that protective eyewear should not be the primary means of protection and the use of engineering controls (such as enclosures and proper tooling) is considered a far important and reliable safeguard than relying on protective eyewear.
Clothing and Personal Protective Equipment:

Clothing should fit snugly to avoid danger of becoming entangled in moving machinery or creating a tripping or stumbling hazard. See Figure below.

![Figure 1-26. Clothing should fit snugly to avoid danger of becoming entangled in moving machinery or creating a tripping or stumbling hazard.]

Recommended safe work clothes include:

- Thick-soled work shoes for protection against sharp objects such as nails. Wear work shoes with safety toes if the job requires. Make sure the soles are oil resistant if the shoes are subject to oils and grease
- Rubber boots for damp locations
- A hat or cap. Wear an approved safety helmet (hard hat) if the job requires

Confine long hair or keep hair trimmed and avoid placing the head in close proximity to rotating machinery. Do not wear jewelry. Gold and silver are excellent conductors of electricity.
**Electrical Safety:**

OSHA and state safety laws have helped to provide safe working areas for electricians. Individuals can work safely on electrical equipment with today's safeguards and recommended work practices. In addition, an understanding of the principles of electricity is gained. Ask managers and your PI when in doubt about a procedure. Report any unsafe conditions, equipment, or work practices as soon as possible.

**Fuses:** Before removing any fuse from a circuit, be sure the switch for the circuit is open or disconnected. When removing fuses, use an approved fuse puller and break contact on the hot side of the circuit first. When replacing fuses, the load side of the electrical circuit should be identified. The fuse on the load side of the circuit should be installed into the fuse clip first, and then followed by the line side.

**GFCIs:** A ground fault circuit interrupter (GFCI) is an electrical device which protects personnel by detecting potentially hazardous ground faults and quickly disconnecting power from the circuit. A potentially dangerous ground fault is any amount of current above the level that may deliver a dangerous shock. Any current over 8 mA is considered potentially dangerous depending on the path the current takes, the amount of time exposed to the shock, and the physical condition of the person receiving the shock.

Therefore, GFCIs are required in such places as dwellings, hotels, motels, construction sites, marinas, receptacles near swimming pools and hot tubs, underwater lighting, fountains, and other areas in which a person may experience a ground fault.

A GFCI compares the amount of current in the ungrounded (hot) conductor with the amount of current in the neutral conductor. If the current in the neutral conductor becomes less than the current in the hot conductor, a ground fault condition exists. The amount of current that is missing is returned to the source by some path other than the intended path (fault current). A fault current as low as 4 mA to 6 mA activates the GFCI and interrupts the circuit. Once activated, the fault condition is cleared and the GFCI manually resets before power may be restored to the circuit.

![GFCI circuit diagram](image)

**Figure 1-22.** A GFCI compares the amount of current in the ungrounded (hot) conductor with the amount of current in the neutral conductor.

GFCI protection may be installed at different locations within a circuit. Direct-wired GFCI receptacles provide a ground fault protection at the point of installation. GFCI receptacles may also be connected to provide GFCI protection at all other receptacles installed downstream on the same circuit. GFCI CBs,
when installed in a load center or panel board, provide GFCI protection and conventional circuit over current protection for all branch-circuit components connected to the CB.

Plug-in GFCIs provide ground fault protection for devices plugged into them. These plug-in devices are often used by personnel working with power tools in an area that does not include GFCI receptacles.
**Electrical Shock:**

Strange as it may seem, most fatal electrical shocks happen to people who should know better. Here is some electro-medical facts that should make you think twice before taking chances.

It's not the voltage but the current that kills. People have been killed by 100 volts AC in the home and with as little as 42 volts DC. The real measure of a shock's intensity lies in the amount of current (in milliamperes) forced through the body. Any electrical device used on a house wiring circuit can, under certain conditions, transmit a fatal amount of current.

Currents between 100 and 200 milliamperes (0.1 ampere and 0.2 ampere) are fatal. Anything in the neighborhood of 10 milliamperes (0.01) is capable of producing painful to severe shock.

<table>
<thead>
<tr>
<th>Readings</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe Current Values</td>
<td></td>
</tr>
<tr>
<td>1 mA or less</td>
<td>Causes no sensation - not felt.</td>
</tr>
<tr>
<td>1 mA to 8 mA</td>
<td>Sensation of shock, not painful; Individual can let go at will since muscular control is not lost.</td>
</tr>
<tr>
<td>Unsafe current values</td>
<td></td>
</tr>
<tr>
<td>8 mA to 15 mA</td>
<td>Painful shock; individual can let go at will since muscular control is not lost.</td>
</tr>
<tr>
<td>15 mA to 20 mA</td>
<td>Painful shock; control of adjacent muscles lost; victim can not let go.</td>
</tr>
<tr>
<td>50 mA to 100 mA</td>
<td>Ventricular fibrillation - a heart condition that can result in death - is possible.</td>
</tr>
<tr>
<td>100 mA to 200 mA</td>
<td>Ventricular fibrillation occurs.</td>
</tr>
<tr>
<td>200 mA and over</td>
<td>Severe burns, severe muscular contractions - so severe that chest muscles clamp the heart and stop it for the duration of the shock. (This prevents ventricular fibrillation).</td>
</tr>
</tbody>
</table>

As the current rises, the shock becomes more severe. Below 20 milliamperes, breathing becomes labored; it ceases completely even at values below 75 milliamperes. As the current approaches 100 milliamperes ventricular fibrillation occurs. This is an uncoordinated twitching of the walls of the heart's ventricles. Since you don't know how much current went through the body, it is necessary to perform artificial respiration to try to get the person breathing again; or if the heart is not beating, cardio pulmonary resuscitation (CPR) is necessary.
Electrical shock occurs when a person comes in contact with two conductors of a circuit or when the body becomes part of the electrical circuit. In either case, a severe shock can cause the heart and lungs to stop functioning. Also, severe burns may occur where current enters and exits the body.

Prevention is the best medicine for electrical shock. *Respect all voltages*, have a knowledge of the principles of electricity, and follow safe work procedures. *Do not take chances*. All electricians should be encouraged to take a basic course in CPR (cardiopulmonary resuscitation) so they can aid a coworker in emergency situations.

Always make sure portable electric tools are in safe operating condition. Make sure there is a third wire on the plug for grounding in case of shorts. The fault current should flow through the third wire to ground instead of through the operator's body to ground if electric power tools are grounded and if an insulation breakdown occurs.

**First Aid for Electrical Shock:**

Shock is a common occupational hazard associated with working with electricity. A person who has stopped breathing is not necessarily dead but is in immediate danger. Life is dependent on oxygen, which is breathed into the lungs and then carried by the blood to every body cell. Since body cells cannot store oxygen and since the blood can hold only a limited amount (and only for a short time), death will surely result from continued lack of breathing.

However, the heart may continue to beat for some time after breathing has stopped, and the blood may still be circulated to the body cells. Since the blood will, for a short time, contain a small supply of oxygen, the body cells will not die immediately. For a very few minutes, there is some chance that the person's life may be saved.

The process by which a person who has stopped breathing can be saved is called artificial ventilation (respiration). The purpose of artificial respiration is to force air out of the lungs and into the lungs, in rhythmic alternation, until natural breathing is reestablished. Records show that seven out of ten victims of electric shock were revived when artificial respiration was started in less than three minutes. After three minutes, the chances of revival decrease rapidly.

Artificial ventilation should be given only when the breathing has stopped. *Do not give artificial ventilation to any person who is breathing naturally*. You should not assume that an individual who is unconscious due to electrical shock has stopped breathing. To tell if someone suffering from an electrical shock is breathing, place your hands on the person's sides at the level of the lowest ribs. If the victim is breathing, you will usually be able to feel movement.

Once it has been determined that breathing has stopped, the person nearest the victim should start the artificial ventilation without delay and send others for assistance and medical aid. The only logical, permissible delay is that required to free the victim from contact with the electricity in the quickest, safest way. This step, while it must be taken quickly, must be done with great care; otherwise, there may be two victims instead of one.

In the case of portable electric tools, lights, appliances, equipment, or portable outlet extensions, the victim should be freed from contact with the electricity by turning off the supply switch or by removing
the plug from its receptacle. If the switch or receptacle cannot be quickly located, the suspected electrical device may be pulled free of the victim. Other persons arriving on the scene must be clearly warned not to touch the suspected equipment until it is de-energized.

The injured person should be pulled free of contact with stationary equipment (such as a bus bar) if the equipment cannot be quickly deenergized or if the survival of others relies on the electricity and prevents immediate shutdown of the circuits. This can be done quickly and easily by carefully applying the following procedures:
Protect yourself with dry insulating material.

Use a dry board, belt, clothing, or other available nonconductive material to free the victim from electrical contact. Do NOT touch the victim until the source of electricity has been removed.

Once the victim has been removed from the electrical source, it should be determined whether the person is breathing. If the person is not breathing, a method of artificial respiration is used.

**Cardiopulmonary Resuscitation (CPR):**

Sometimes victims of electrical shock suffer cardiac arrest or heart stoppage as well as loss of breathing. Artificial ventilation alone is not enough in cases where the heart has stopped. A technique known as CPR has been developed to provide aid to a person who has stopped breathing and suffered a cardiac arrest. Because you are working with electricity, the risk of electrical shock is higher than in other occupations. You should, at the earliest opportunity, take a course to learn the latest techniques used in CPR. The techniques are relatively easy to learn and are taught in courses available through the American Red Cross.

*Note:* A heart that is in fibrillation cannot be corrected by closed chest cardiac massage. A special device called a defibrillator is available in some medical facilities and ambulance services.

**Lockout/Tagout:**

Electrical power must be removed when electrical equipment is inspected, serviced, or repaired. To ensure the safety of personnel working with the equipment, power is removed and the equipment must be locked out and tagged out.

Per OSHA standards, equipment is locked out and tagged out before any preventive maintenance or servicing is performed. Lockout is the process of removing the source of electrical power and installing a lock which prevents the power from being turned ON. Tagout is the process of placing a danger tag on the source of electrical power which indicates that the equipment may not be operated until the danger tag is removed. See Figure below.

A danger tag has the same importance and purpose as a lock and is used alone only when a lock does not fit the disconnect device. The danger tag shall be attached at the disconnect device with a tag tie or equivalent and shall have space for the worker's name, craft, and other required information. A danger tag must withstand the elements and expected atmosphere for as long as the tag remains in place. A lockout/tagout is used when:

1. Servicing electrical equipment that does not require power to be ON to perform the service
2. Removing or bypassing a machine guard or other safety device
3. The possibility exists of being injured or caught in moving machinery
4. Clearing jammed equipment
5. The danger exists of being injured if equipment power is turned ON

![Image]

Figure 1-23.
Equipment must be locked out and tagged out before preventive maintenance or servicing is performed.

Lockouts and tagouts do not by themselves remove power from a circuit. An approved procedure is followed when applying a lockout/tagout. Lockouts and tagouts are attached only after the equipment is turned OFF and tested to ensure that power is OFF. The lockout/tagout procedure is required for the safety of workers due to modern equipment hazards. OSHA provides a standard procedure for equipment lockout/tagout. OSHA's procedure is:

1. Prepare for machinery shutdown.
2. Machinery or equipment shutdown.
3. Machinery or equipment isolation.
4. Lockout or tagout application.
5. Release of stored energy.
6. Verification of isolation.

A lockout/tagout shall not be removed by any person other than the person that installed it, except in an emergency. In an emergency, the lockout/tagout may be removed only by authorized personnel. The authorized personnel shall follow approved procedures. A list of company rules and procedures are given to any person that may use a lockout/tagout. Always remember:

1. Use a lockout and tagout when possible
2. Use a tagout when a lockout is impractical. A tagout is used alone only when a lock does not fit the disconnect device
3. Use a multiple lockout when individual employee lockout of equipment is impractical
4. Notify all employees affected before using a lockout/tagout
5. Remove all power sources including primary and secondary
6. Measure for voltage using a voltmeter to ensure that power is OFF
Lockout Devices:

Lockout devices are lightweight enclosures that allow the lockout of standard control devices. Lockout devices are available in various shapes and sizes that allow for the lockout of ball valves, gate valves, and electrical equipment such as plugs, disconnects, etc.

Lockout devices resist chemicals, cracking, abrasion, and temperature changes. They are available in colors to match ANSI pipe colors. Lockout devices are sized to fit standard industry control device sizes. See Figure below.

Lockout devices are available in various shapes and sizes that allow for the lockout of standard control devices.

Locks used to lock out a device may be color coded and individually keyed. The locks are rust-resistant and are available with various size shackles.

Danger tags provide additional lockout and warning information. Various danger tags are available. Danger tags may include warnings such as "Do Not Start," "Do Not Operate," or may provide space to enter worker, date, and lockout reason information. Tag ties must be strong enough to prevent accidental removal and must be self-locking and non-reusable.

Lockout/tagout kits are also available. A lockout/tagout kit contains items required to comply with the OSHA lockout/tagout standards. Lockout/tagout kits contain reusable danger tags, tag ties, multiple lockouts, locks, magnetic signs, and information on lockout/tagout procedures. See Figure 1-25. Be sure the source of electricity remains open or disconnected when returning to work whenever leaving a job for any reason or whenever the job cannot be completed the same day.

Lockout/tagout kits comply with OSHA lockout/tagout standards.
Laser Safety:

Basic Laser Safety - Introduction

All lasers and laser light show systems have intrinsic dangers - even laser pointers! Observation of basic laser safety rules and the specific safety regulations of the jurisdiction in which you operate are essential.

We can NOT hope to review laser safety regulations on a jurisdiction by jurisdiction basis - there is just not enough space. Instead we will focus on some general safety information that applies across the board. If you do need specific safety information for a particular jurisdiction, contact the authorities in your area or the embassy for the country in question and ask.

Basic Laser Safety Information:

- **Eye hazards** such as retinal or cornea burns
- **Skin hazards** such as burns
- **Electrical hazards** from high voltage equipment
- **Fire and flood** hazards.

More detailed Laser Safety information:

- [Laserist Introduction](#)
- [Laser Safety Archives](#) - articles, papers and links
- [Laser Safety Regulations](#) - links to safety authorities
- [Laser Safety Links](#) - selected off-site safety links

Laser Hazards

A laser can be considered as a highly collimated source of extremely intense electromagnetic radiation that is defined by three characteristics: monochromatic, directional and coherent. Due to the temporal and spatial coherence of the laser beam it can be considered as a point source of phenomenal brightness than can easily exceed the brightness of the sun. Lasers are a more directional light source than any other common fixture such as stage lights or a follow-spot. The higher the optical output power of the laser, the greater the potential hazard.

Classification of lasers

We have not classified lasers by class or output power, nor have we made mention of any hazard...
labels or warning signs that may be required. This is because the classification of lasers and labels/signage varies by jurisdiction. Check with your local authorities as to the classification of your system(s) and any labels or signage that may be required.

**Audience Scanning**

In enlightened jurisdictions where audience scanning is permitted, as the laser operator you must take all precautions to make sure the audience scanning effects are intrinsically safe. The power of the effects used must meet the exposure levels permitted in your area. Audience scanning is a big responsibility as you could ruin hundreds of people's vision.

*RETINAL INJURY IS PERMANENT*
Basic Laser Safety - Eye and Skin Hazards

The part of the human body that is most sensitive to light and can most easily be damaged by lasers is the human eye. Common sense precautions such as not shining a laser into your own, or anyone else's eyes, will help prevent vision loss from laser exposure.

Eye Hazards

The major danger of laser light shows is hazards from beams entering the eye since this is the organ most sensitive to light. The simplest way to explain this is to say, "just as a magnifying glass can be used to focus the sun and burn wood, the lens in the human eye focuses the laser beam into a tiny spot than can burn the retina".

Lasers in the visible and near infrared range of the spectrum have the greatest potential for retinal injury, as the cornea and lens are transparent to these wavelengths and the lens can thus focus the laser energy onto the retina. The maximum transmission by the cornea and lens, and the maximum absorption of laser energy in the retina occurs in the range from 550 nM to 400 nM. Argon and YAG lasers operate in this range clearly making them the most hazardous lasers. Wavelengths of less than 550 nM can cause a photochemical injury similar to sunburn. Photochemical effects are cumulative and result from long exposures (over 10 seconds) to diffuse or scattered light.

Laser damage and retinal burns can occur when a laser beam enters the human eye. Lasers are a 'point source' of light much like the sun thus the eye focuses on infinity when viewing lasers especially in a darkened space where no other light sources are present. Laser beams are almost parallel thus the lens of the human eye will focus them down to a small spot. A laser beam with low divergence entering the eye can be focused down to a spot 10 to 20 microns in diameter.

The laws of thermodynamics do not limit the power of lasers. The second law states that the temperature of a surface heated by a beam from a thermal source of radiation cannot exceed the temperature of the source beam. The laser is a non-thermal source and is able to generate temperatures far greater than it's own. A 30 mW laser operating at room temperature is thus capable of producing enough energy (when focused) to instantly burn through paper!

Due to the law of the conservation of energy, the energy density (measure of energy per unit of area) of the laser beam increases as the spot size decreases. This means that the energy of a laser beam can be intensified up to 100,000 times by the focusing action of the eye. A one watt laser beam when focused down to a small spot can produce temperatures higher than the surface temperature of the sun! Thus even a low power laser in the milliwatt range can cause a burn if focused directly onto the retina.

NEVER point a laser, even a laser pointer, at someone's eyes no matter how low the power of the laser.
Structure of the eye

The part of the eye that provides the most acute vision is the Fovea Centralis (also called the Macula Lutea). This is a relatively small area of the retina (3 to 4%) that provides the most detailed and acute vision as well as your colour perception. This is why you move your eyes when you read or when you look as something; the image has to be focused on the fovea for detailed perception. The balance of the retina can perceive light, and movement but not detailed images (peripheral vision).

If a laser burn occurs on the Fovea, you can lose most of your fine (reading and working) vision in an instant. If a laser burn occurs in the peripheral vision it may produce little or no effect on fine vision. Repeated retinal burns can lead to blindness.

Fortunately the eye has a self defense mechanism, the blink or aversion response. When a bright light hits the eye it tends to blink or turn away from the light source (aversion). This MAY defend the eye from damage where very lower power lasers are involved but cannot help where higher power lasers are concerned. By the time the eye reacts, the damage is already done. Due to the focusing effect discussed above, a one watt laser beam entering the eye can be focused to 100,000 watts per square centimeter of power at the retina.

Eye damage can also occur when laser beams are scanned across the eye even for very brief periods. The amount of exposure is difficult to estimate as 'dwell' or 'transit' time must be taken into account in your calculations. For example a 1 mW laser illuminating a 7 mm aperture (the average size of the dark adapted iris) for one second is the equivalent of a 10 mW laser illuminating the same 7 mm aperture for 1/10 of a second.

The international laser safety standard, IEC-825, defines a short exposure as 2.5 mW per square centimeter. Each jurisdiction has its own maximum exposure levels for laser radiation. You should consult with your local regulatory authorities and get their official methodology and formula(s) for calculating the MPE (Maximum Permissible Exposure).

Symptoms of a laser burn in the eye include a headache shortly after exposure, excessive watering of the eyes, and sudden appearance of many 'floaters' in your vision. Floaters are those swirling distortions that occur randomly in normal vision most often after a blink or when you have had your eyes closed for a couple of seconds. Floaters are caused by dead cell tissues that detach from the retina and choroid and
float in the Vitreous Humour. Ophthalmologists often dismiss minor laser injuries as floaters due to the very difficult task of detecting minor retinal injuries.

**Skin Hazards**

Exposure of the skin to high power laser beams (1 or more watts) can cause burns. At the under five watt level, the heat from the laser beam will cause a flinch reaction before any serious damage occurs. The sensation is similar to touching any hot object, you tend to pull your hand away or drop it before any major damage occurs.

With higher power lasers, a burn can occur even though the flinch reaction may rapidly pull the affected skin out of the beam. These burns can be quite painful as the affected skin can be cooked and forms a hard lesion which takes ages to heal.
Basic Laser Safety - Electrical, Fire and Flood Hazards

When working around or experimenting with lasers, one should be aware that there are electrical, fire and flood hazards associated with even low power lasers.

**Electrical hazards**

Most medium and high power lasers operate on 220 or even higher AC voltages; draw lots of current and frequently use multi-phase electrical connections. The power supply (exciter) for the laser typically doubles or even triples the line voltages before feeding them to the laser head where lethal voltages can be present. An average of two people per year die from laser electrocution.

If it become necessary to open the power supply to diagnose or correct problems, you should insure that the main power has been disconnected at the breaker or disconnect switch. With the cabinet of the laser head or exciter open, terminals carrying lethal voltages may be exposed. In some systems large electrolytic capacitors are used for smoothing DC voltages. Even with 'bleed' resistors these can take several minutes to discharge fully and should be treated with caution and possibly discharged manually before working on the system.

Even small HeNe lasers of the type found in school science labs operate at very high voltages. While the power supplies typically don't deliver enough amperage to kill you, they will deliver a very nasty jolt that could cause heart palpitations. The jolt could also cause one to drop and smash the laser. Before connecting the laser to the power supply, insure that the AC power is turned off.

Most laser tubes act as a type of capacitor called a "Leaden Jar". They can store a charge for some hours even after the power has been turned off. When disconnecting small HeNe lasers from their power supplies, be careful not to come in contact with the pins on the Alden connector. You should short those together briefly on an un-insulated strip of metal to discharge the tube before handling the connector. Larger laser tubes, such as Argon of Krypton lasers should be disconnected from the power supply and the leads to the tubes shorted briefly at the connector before doing any work on or around the tube.

**HIGH VOLTAGES CAN KILL YOU !!**

An additional electrical hazard exists where water cooling of the power supply (exciter) is used. Minor leaks in the water cooling pipes can cause high voltages to short to the water or case of the unit both of which are usually at ground potential.

In high humidity conditions, condensation can form on the water cooled parts inside the laser power supply. In combination with dust and residue in the power supply, the condensation can form a conductive path shorting components and causing an explosion. Condensation on water pipes and fittings inside the laser head can also drip onto vital components causing problems. Puddles of water on the floor are also a hazard when working with the high voltages present in laser equipment.
Fire and flood hazards

High power laser beams deflected onto flammable materials can cause ignition and fires. A 10 watt laser will drill a hole in cinder block (when focused). Almost any material except metal is a potential fire hazard, especially wood and drapes (flameproof drapes make little difference). Nylon or rayon clothing is especially bad for burns as the plastic fabric melts and can cling to your skin increasing the burn duration and intensity.

You should be aware of beam path positions and avoid directing high power beams at dry bushes, drapes or other flammable surfaces. Watch out for beams when you are around the projector so as to avoid burning holes in your clothing and setting fire to your fashions.

Hoses connections at the water feed and the hoses themselves can leak. Water cooled system can also leak in unexpected places inside the equipment causing flooding and water damage. A further hazard exists if there is a pool of water or a damp area on the floor as it provides a good ground for an electrical discharge through your body. When working around laser it is best to wear shoes that have insulated soles.