Chemical Hygiene Plan

I. Policy

The purpose of the Chemical Hygiene Plan (CHP) is to outline laboratory work practices and procedures which are necessary to ensure that members of the university community are protected from health hazards associated with chemicals with which they work.

II. Authority

The Chemical Hygiene Plan, required to comply with provisions of California Code of Regulations (CCR), Title 8, Section 5191 et al:

A. Standard Operating Procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals CCR Title 8 §5191(b)(2)(e).

B. Criteria that the university will use to determine and implement control measures to reduce laboratory worker exposures to hazardous chemicals including engineering controls, the use of personnel protective equipment and hygiene practices.

C. A requirement that fume hoods and other protective equipment are functioning properly.

D. Provisions for laboratory worker information and training.

E. The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the Principal Investigator, who will be defined hereon as an individual who supervises others in any laboratory setting.

F. Provisions for medical consultation and medical examination.

G. Designation of personnel responsible for implementation of the Chemical Hygiene Plan, including the assignment of a Chemical Hygiene Officer.

H. Provisions for additional laboratory worker protection for work with particularly hazardous substances.

III. Scope

CCR Title 8, Section 5191 defines a laboratory as a facility where “laboratory use of hazardous chemicals” occurs. It is a workplace where relatively small quantities of

hazardous chemicals are used on a non-production basis, and is a facility which meets the following conditions:

A. Multiple chemical procedures or chemicals are used;

B. The procedures are not, and do not simulate, production processes;

C. Chemical manipulations are performed;

D. The potential for laboratory worker exposure to hazardous chemicals is minimized by the use of protective laboratory practices and equipment.

CCR Title 8, Section 5191 defines a hazardous chemical for which there is statistically significant evidence, based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which action on the haematopoietic systems, and agents which damage the lungs, skins, eyes, or mucous membranes.

Each laboratory will develop all procedures necessary to protect laboratory worker health and safety. The following chapters provide a recommended set of minimum procedures and guidelines for protecting persons working in a laboratory environment, and may assist individual laboratories in developing laboratory-specific standard operating procedures.

For the purpose of this manual, a laboratory worker could mean a Principal Investigator, course or laboratory instructor, faculty member, technician, laboratory assistant, teaching assistant, research assistant or student.

IV. Definitions

ANSI – American National Standards Institute

CCR – California Code of Regulations

CHP – Chemical Hygiene Plan

Cal-OSHA – California Occupational Safety and Health Administration

EPA – Federal Environmental Protection Agency

NFPA – National Fire Protection Association

OSHA – Federal Occupational Safety and Health Administration

PEL – Permissible Exposure Limit

V. Accountability

A. California State University, Fullerton

1. Keep records of laboratory worker exposures to hazardous chemicals including measurements made to monitor exposures, medical consultation and examination and written opinions;

2. Provide laboratory workers with general training and information regarding chemical and physical hazards;

3. Provide laboratory workers with access to medical consultation and examinations at no cost if laboratory worker develops signs or symptoms of exposure, the action level or PEL is routinely exceeded (see f), or if a spill, leak, or explosion occurs that increases the likelihood of exposure.

4. Provide laboratory workers with respirators when necessary;

5. Make SDSs accessible to laboratory workers;

6. Measure the concentration of the chemical in the air, if there is reason to believe that an action level or PEL has been exceeded for any chemical for which a substance-specific standard has been established;

7. Notify all laboratory workers of the results of the measurements and implement procedures to lower the level below the PEL or action level, if the level measured is greater than the PEL or action level;

8. Identify and establish "Controlled Work Area(s)" in the laboratory for work with select carcinogens, reproductive toxins, or acute toxins that are highly toxic.

B. Chemical Hygiene Officer, Environmental Health and Safety (EHS)

1. Chemical Hygiene Officer develops and updates the Chemical Hygiene Plan and appropriate policies and practices;

2. Chemical Hygiene Officer provides technical assistance in complying with the Chemical Hygiene Plan and answers safety questions for laboratory workers;

3. Chemical Hygiene Officer assists Principal Investigators in developing appropriate safety precautions for new projects and procedures;

4. Monitors collection and disposal of spent and hazardous chemical wastes;

5. Keeps current on federal, state and local legislation and regulations concerning chemicals;

6. Chemical Hygiene Officer ensures that laboratory workers comply with the Chemical Hygiene Plan;

7. Ensures that appropriate personal protective equipment is available as needed;

8. Monitors proper functioning of protective equipment such as fume hoods and arranges for prompt repairs as needed;

9. Chemical Hygiene Officer performs regular chemical hygiene and housekeeping inspections;

10. Performs routine inspections of emergency equipment;

11. Gathers and maintains manufacturers' Safety Data Sheets (SDS), and assures that the current web-based Safety Data Sheet site(s) are established and operable on the desktop of at least one laboratory computer;

12. Assists in the development and implementation of a labeling program for chemicals;

13. Assists in determining when a complaint of possible over-exposure is reasonable and should be referred for medical consultation;

14. Assists in determining when an exposure assessment is appropriate;

15. Assists in conducting "Exposure Assessments;"

16. Chemical Hygiene Officer reviews chemical inventory to determine which chemicals are carcinogens as designated in CCR General Industry Safety Orders Group 16; Control of Hazardous Substances; Article 110. Regulated Carcinogens Section 5209;

17. EHS maintains campus' chemical inventory.

C. Principal Investigator, Course or Laboratory Instructor

The Supervisor's duties, as defined in the Cal-OSHA Laboratory Standard and the Chemical Hygiene Plan, are the responsibility of the Principal Investigator. For laboratories with no Principal Investigator, the Supervisor's duties are assumed by the person with authority over all laboratory functions, such as course or laboratory instructor.

The primary responsibility of the supervisor is to institute the Chemical Hygiene Plan and ensure compliance with the Cal-OSHA Laboratory Standard within their respective laboratories. The duties include the following:

1. Ensure that all work is conducted in accordance with the Chemical Hygiene Plan;

2. Define the location of "Controlled Work Areas" where toxic substances and potential carcinogens will be used, and ensure that the inventory of these substances is properly maintained;

3. Obtain, review, and approve standard operating procedures, detailing all aspects of proposed research activities that involve hazardous agents;

4. Prepare a Standard Operating Procedure (SOP) for every experimental procedure. The SOP shall include a description of any alternate procedure and an assessment of alternate controls that could be used;

5. Define hazardous operations, designating safe practices, and selecting protective equipment;

6. Ensure that laboratory workers receive instructions and training in safe work practices, use of personal protective equipment, and in procedures for dealing with accidents involving toxic substances; also training specific to hazards in those areas supervised by them.

7. Ensure that all personnel obtain the medical examinations and protective equipment necessary for the safe performance of their job;

8. Monitor the safety performance of laboratory workers to ensure the required safety practices and techniques are being employed;

9. Arrange with Chemical Hygiene Officer or EHS for workplace air samples, swipes, or other tests to determine the amount and nature of airborne and/or surface contamination, inform employees of the results, and use data to aid in the evaluation and maintenance of appropriate laboratory conditions;

10. Assist the Chemical Hygiene Officer, Radiation Safety Officer, Biohazard Safety Officer, and EHS personnel when necessary;

11. Conduct informal laboratory inspections on a timely basis consistent with the type or degree of hazard to ensure compliance with existing laboratory SOPs;

12. Prepare emergency procedures for dealing with accidents that may result in the unexpected exposure of personnel, or the environment, to a toxic substance;

13. Investigate accidents and report them to the Chemical Hygiene Officer. Include procedures that will minimize the repetition of that type of accident;

14. Report to the Chemical Hygiene Officer incidents that (1) cause personnel to be seriously exposed to hazardous chemicals or materials, such as through skin penetration, ingestion of a chemical, or probable inhalation of a chemical, or that (2) constitute a danger of environmental contamination;

15. Ensure that action is taken to correct work practices and conditions that may result in the release of toxic chemicals;

16. Ensure proper disposal of unwanted and/or hazardous chemicals and materials through appropriate office;

17. Document and maintain compliance with all local, state, and federal regulatory requirements;

18. Make copies of the approved safety plan available to the laboratory staff;

19. Performs regular chemical hygiene and housekeeping inspections;

20. Develops and implements a labeling program within the laboratory.

D. Technicians, Laboratory Assistants, Teaching Assistants, Students

1. Understand and comply with the procedures outlined in the Chemical Hygiene Plan;

2. Understand and comply with all Standard Operating Procedures;

3. Understand and comply with all training received;

4. Understand the function and proper use of all personal protective equipment. Wear personal protective equipment when mandated or necessary.

5. Report, in writing, to your Principal Investigator/Course or Laboratory Instructor any significant problems arising from the implementation of the Standard Operating Procedures;

6. Report to your Principal Investigator/Course or Laboratory Instructor all facts pertaining to every accident that results in the exposure to toxic chemicals, and any action or condition that may exist that could result in any accident;

7. Contact your Principal Investigator/Course or Laboratory Instructor, and/or the Chemical Hygiene Officer if any of the above procedures are not clearly understood.

E. Responsibilities of All Personnel Using Hazardous Chemicals

Each person working with or around chemicals, having been trained, is responsible for remaining aware of the hazards of those materials and handling those chemicals in a safe manner. Each person is responsible for knowing how to handle a hazardous chemical safely according to its types of hazards. If that person is unsure of a hazard or safety procedure, ASK UNTIL YOU KNOW FOR SURE!

Everyone shares the responsibility to ensure that all containers of chemicals are properly labeled with the identity of the chemical and its hazards.

REMEMBER: NO AMOUNT OF INSURANCE CAN CURE BLINDNESS OR RESURRECT THE DEAD! SO BE RESPONSIBLE FOR YOUR OWN WELL-BEING.

F. Lab Visitors

Visitors to research labs must be supervised at all times. Entry of visitors will not be allowed during operations with hazardous materials or equipment.

Children under the age of 18 are not allowed in any of the research labs. Exceptions to this are participants in special programs which have prior approval from the Department Chair and require advance notification of the Chemical Hygiene Officer.

VI. Program

There are three important attitudes to assume while working:

BE AWARE	Know the hazards before you begin your experiment. At minimum, read the label and Safety Data Sheet.
BE PREPARED	Answer the following questions: What's the worst thing that can go wrong? What should I do to be prepared for it?
BE PROTECTED	Know the practices and equipment that can minimize your exposure to the hazards of your work?

A. General Safety Guidelines:

1. Working alone is fundamentally unsafe. Someone should be working with you. If the "buddy system" is not possible then someone should be aware of the solitary worker and check on him/her at regular intervals;

2. Wear appropriate eye protection at all times. Contact lenses can absorb chemicals and trap them against your eyes. Glasses, not contact lenses should be worn; however, normal prescription glasses are not protective eye wear;

3. When working with flammable chemicals, be certain there are no sources of ignition near enough to cause a fire or explosion in the event of a vapor release or liquid spill;

4. Use shields for protection whenever an explosion or implosion might occur;

5. Don't underestimate the risks of materials you use. Find out the facts, and protect yourself. Be aware of the chemical hazards, as determined from the SDS and other appropriate references;

6. Use proper protective equipment every time you use the materials. Make sure the equipment is not damaged and that you know how to use it;

7. Know the location, and proper use of emergency equipment, and be familiar with procedures. Clean up spills immediately. Emergency Response Procedures should be posted next to the telephone in each laboratory;

8. Don't use equipment unless you know how to use it properly, and use it only for its intended purpose;

9. Minimize all chemical exposures. Avoid all skin contact with chemicals. Wear gloves appropriate for the material;

10. Assume a mixture (or substance of unknown toxicity) is more hazardous than its components;

11. Keep chemicals in labeled containers;

12. Use chemicals in a chemical fume hood, and know how to use the hood properly. Never use highly toxic agents, carcinogens, or reproductive toxins outside the hood. The room and hood should be labeled as a "Controlled Work Area" if these chemicals are in use;

13. Your ventilation system will work more efficiently with the laboratory doors closed;

14. Dispose of cracked or broken glassware immediately. Lubricate glassware with water or glycerol when appropriate, such as when fitting glass tubing through a rubber stopper. Protect your hands with a towel when inserting or attaching glassware;

15. Unattended Operations - An experiment is unattended if there is no one immediately present who fully understands the operation and shutdown procedure to be taken in the event of an emergency. These circumstances require special precautions:

    a. Unattended procedures that could result in fire or explosion should be equipped with the necessary automatic shutdown control. Examples of mishaps that can occur during unattended operations include loss of cooling water, overheating, flooding, etc.;

    b. Post warning signs for radioactive, chemical, biological, flammable, reactive, explosive hazards, and any other hazards;

c. Use necessary shields and barriers to contain splashes, explosions, or other releases;

d. Leave lights on and doors closed and locked while absent;

e. Be aware that as the need for water for cooling decreases late in the day or at night, water surges may result because of excess water pressure in the few areas that are using it.

B. Personal Hygiene

1. In the event of skin contact with a chemical rinse the affected area with a neutralizing solution in the case of contact with a strong acid or caustic and/or with copious amounts of water;

2. When handling chemicals used appropriate fume hoods to avoid inhalation of chemicals; do not smell or taste chemicals, for identification;

3. NEVER mouth pipette anything, or use mouth suction to start a siphon;

4. Always wash your hands with soap and water just before leaving the laboratory, and wash your face prior to eating, drinking, smoking, using the restroom, applying cosmetics, or inserting contact lenses;

5. Never eat, drink, smoke, chew gum, bite fingernails, apply cosmetics, or insert contact lenses in a laboratory, and, once removed from the laboratory, only after you have washed your hands;

6. Never bring food, cigarettes, chewing gum, beverages, or food containers into a laboratory. They can absorb chemicals;

7. Never store food in refrigerators/freezers that are approved for chemical, radiation, or biohazards use.

C. Protective Clothing and Equipment

1. Eye protection worn when working with chemicals should meet the requirements of ANSI;

2. Eye protection should include a face shield when the chemical hazard warrants it;

3. When working with corrosive liquids, wear gloves made of a material that is resistant to permeation by the corrosive chemical (use manufacturer's published permeation chart). Test the glove by air inflation (do not inflate by mouth) for the absence of pin-hole leaks;

4. When working with corrosive chemicals, wear a rubberized laboratory apron;

5. Lab coats should be worn and buttoned at all times while in the laboratory. The lab coat should be removed when you leave the laboratory and, immediately, if it becomes contaminated;

6. Protect your skin and feet with adequate clothing and footwear. Shorts or short skirts should not be worn in the laboratory without a lab coat. Open-toed shoes or sandals, or shoes without firm footing shall not be worn in the laboratory; appropriate footwear shall protect the whole foot.

7. Remove protective clothing when you leave the laboratory;

8. Confine hair and loose clothing while in the laboratory;

9. When working with allergenic, sensitizing, or toxic chemicals, wear gloves made of material known to be or tested and found to be resistant to permeation by the chemical and tested for the absence of pin holes;

10. Whenever exposure by inhalation is likely to exceed the threshold limits described in SDSs, use a fume hood. If this is not possible, a proper respirator must be worn. You must be enrolled in the Respiratory Protection Program to wear a respirator, which requires annual training, medical evaluation, and fit testing. To become certified to wear a respirator contact EHS at 657-278-7233;

11. Carefully inspect all protective equipment before using. Do not use defective equipment.

D. Housekeeping

1. Clear access MUST be available to ALL emergency equipment, eye washes, safety showers, fire extinguishers, circuit breakers, fire pull boxes, emergency spill equipment and exits should never be blocked by anything, not even a temporarily parked cart;

2. All chemical containers must be labeled with at least the identity of the contents and the hazards those contents present to users;

3. Keep all work areas, especially laboratory benches, clear of clutter;

4. Keep all aisles, hallways, exits, and stairs clear of all chemicals;

5. All chemicals should be placed in their assigned storage areas at the end of each workday;

6. At the end of each workday, the contents of all unlabeled containers are to be considered as either spent chemical material and will be classified by the CHO as a waste based on qualitative testing performed in the Chemical Storage Area or a hazardous waste based on knowledge of the PI, graduate student/undergraduate student;

7. Spent or chemical waste material should be properly labeled and kept in their proper containers;

8. Promptly clean up all spills; properly dispose of the spilled chemicals and clean up all materials;

9. All working surfaces and floors should be cleaned regularly. Bench tops should be cleaned at the end of a particular operation or experiment or at the end of each workday;

10. No chemicals are to be stored in aisles or stairwells, on desks or laboratory benches, on floors or in hallways;

11. Extraneous materials should not be stored in a fume hood because it can interfere with the air flow and jeopardize the safe operation of the hood;

12. Chemicals should be stored in an Earthquake Safe manner: in closed cabinets or on lipped or retaining wired shelves.

E. Prior Approval

Each laboratory Principal Investigator/Course or Laboratory Instructor should identify activities which (due to potential hazard) require prior approval by them or safety personnel and should inform technicians, laboratory assistants, teaching assistants, researchers, and students of the necessary approval procedures. EHS can assist as a resource providing information to help minimize hazards and identify activities which require prior approval. The following guidelines are offered to assist in that decision making process:

Prior approval needs to be considered when:

1. There is a new procedure, process or test, even if it is very similar to older practices;

2. It is likely that toxic limit concentrations could be exceeded or that other harm is likely;

3. There is a change in a procedure, process or test, even if it is very similar to older practices. "Change in a procedures, process or test" means:

    a. There is a substantial increase or decrease in the amount of one or more chemicals used;

    b. There is a substitution or deletion of any of the chemicals in a procedure;

    c. There is any change in other conditions under which the procedure is being conducted;

4. There is a change in location of the procedure, process, or test;

5. There is a failure of any of the equipment used in the process, especially of safeguards such as fume hoods, power supplies, or clamp apparatus;

6. There are unexpected results; members of the laboratory staff become ill, suspect that they or others have been exposed, or otherwise suspect a failure of any safeguards.

Any new procedures should be subjected to considerable review. Not only from a scientific standpoint, but also to assure that all safety considerations are in place prior to implementation.

F. Spills and Accidents

Spills of toxic substances or accidents involving any hazardous chemical or substance should be resolved quickly according to the Emergency Response Procedures and the following Spills Accident Procedures. Always notify your supervisor and appropriate emergency personnel immediately.

1. Chemical Spills

Notes and Precautions: The range and quantity of hazardous chemicals used in laboratories require preplanning to respond safely to chemical spills. The cleanup of a chemical spill should only be done by knowledgeable and experienced personnel. Spill cleanup instructions are available from EHS. A minor chemical spill is one that the laboratory staff is capable of handling safely without the assistance of safety and emergency personnel. All other chemical spills are considered major.

a. Minor Chemical Spill

i. Alert people in immediate area of spill.

ii. Call EHS at 657-278-7233. After hours dial 911.

iii. Wear protective equipment, including safety goggles, gloves, and long-sleeve lab coat.

iv. Avoid breathing vapors from spill.

v. Confine spill to small area.

vi. Neutralize or absorb the spilled chemical with the proper spill cleanup materials. Collect residue, place in container, and dispose of it in accordance with hazardous waste procedures.

vii. Clean spill area with water.

b. Major Chemical Spill

i. Attend to injured or contaminated persons and remove them from exposure, if you can do so safely without endangering yourself.

ii. Alert people in the laboratory to evacuate.

iii. If spilled materials is flammable, turn off ignition and heat sources.

iv. Call EHS at 657-278-7233. After hours dial 911.

v. Close doors to affected area.

vi. Have person knowledgeable of incident and laboratory assist emergency personnel.

2. Biological Spill

Note and Precautions: Biological spills can generate aerosols that can be dispersed in the air throughout the laboratory. These spills are very serious if they involve microorganisms that require Biosafety Level 3 (BSL3) containment, since most of these agents have the potential for transmitting disease by infectious aerosols. To reduce the risk of inhalation exposure in such an incident, occupants should hold their breath and leave the laboratory immediately. The laboratory should not be reentered to decontaminate and clean up the spill for at least 30 minutes. Appropriate protective equipment is particularly important in decontaminating spills involving microorganisms. This equipment includes lab coat with long-sleeves, disposable gloves, disposable shoe covers, if appropriate, and safety goggles and mask. Use of this equipment will prevent contact with contaminated surfaces and protect mucous membranes from exposure to splattered materials. For further precautions involving biohazards, refer to the Biosafety Manual available from EHS.

a. Spill Involving a Microorganism Requiring Biosafety Level 1 Containment

i. Wear disposable gloves.

ii. Soak paper towels in disinfectant and place over spill area.

iii. Place towels in plastic bag for disposal.

iv. Clean spill area with fresh towels soaked in disinfectant.

b. Spill Involving a Microorganism Requiring Biosafety Level 2 Containment

i. Alert people in immediate area of spill.

ii. Put on protective equipment.

iii. Cover spill with paper towels or other absorbent materials.

iv. Carefully pour a freshly prepared 1 in 10 dilution of household bleach around the edges of the spill and then into the spill. Avoid splashing.

v. Allow a 20-minute contact period.

vi. Use paper towels to wipe up the spill, working from the edges into the center.

vii. Clean spill area with fresh towels soaked in disinfectant.

viii. Place towels in a plastic bag and decontaminate in an autoclave.

c. Spill Involving an Unknown Microorganism

i. Attend to injured or contaminated persons and remove them from exposure, if you can do so safely without endangering yourself.

ii. Alert people in the laboratory to evacuate.

iii. Close doors to affected area.

iv. Call EHS at 657-278-7233. After hours dial 911.

v. Have person knowledgeable of incident and laboratory assist emergency personnel.

3. Radiation Spill

Notes and Precautions: Spreading of radiation beyond the spill area can easily occur by the movement of personnel involved in the spill or cleanup effort. Prevent spread by confining movement of personnel until they have been monitored and found free of contamination. A minor radiation spill can be managed by laboratory personnel/staff. The Radiation Safety Officer and EHS must be notified for all radiation spills.

a. Minor Radiation Spill

i. Alert people in immediate area of spill.

ii. Immediately notify the Radiation Safety Officer.

iii. Wear protective equipment, including safety goggles, disposable gloves, shoe covers, and long-sleeve lab coat.

iv. Place absorbent paper towels over liquid spill. Place towels dampened with water over spills of solid materials.

v. Using forceps, place towels in plastic bag. Dispose in radiation waste containers.

vi. Monitor area, hands, and shoes for contamination with an appropriate survey meter or method. Repeat cleanup until contamination is no longer detected.

b. Major Radiation Spill or any isotope of Iodine Spill

i. Attend to injured or contaminated persons and remove them from exposure if you can do so safely without endangering yourself.

ii. Alert people in the laboratory to evacuate.

iii. Have potentially contaminated personnel stay in one area until they have been monitored and shown to be free of contamination.

iv. Call the EHS at 657-278-7233. After hours dial 911.

v. Close doors and prevent entrance into affected area.

vi. Have person knowledgeable of incident and laboratory assist emergency personnel.

G. Spent/Hazardous Waste Chemical Guidelines

1. Spent/Waste Chemical Disposal Procedures

a. Whenever possible, the container of the original material should be used for the spent/waste chemical material (exception: can with plastic pour spouts);

b. The outside of the container must be completely clean;

c. Containers must have a screw cap or lid which is leak-proof. Secure loose screw tops with strong tape. Do not use caps of foil, corks, or glass stoppers;

d. Give special attention to containers of carcinogens, mutagens, and teratogens. Tape all caps, double-bag, and seal in airtight plastic;

e. Store corrosives in glass containers (exception: hydrofluoric acid and other glass-reactive chemicals, such as potassium hydroxide and sodium hydroxide);

f. Do not mix acids;

g. Store flammable and other spent/waste solvents in either glass containers or nonmetallic safety disposal containers;

h. Halogenated and non-halogenated compounds must be separated from one another;

i. Whenever possible, do not dispose of spent or waste chemicals in partially-filled containers. Disposal costs are based on the size of the container or drum, not the contents;

j. Refer to EHS and this Plan for information on chemical incompatibility. Segregate incompatible spent chemicals/waste to prevent accidental combinations;

k. Spent/Waste chemicals will be collected only if the containers have been properly sealed and labeled. Label containers with the CHEMICAL NAME, not structure, formula, or an abbreviation.

l. Identify mixtures (for every component) by percent or volume composition;

m. Completely remove, cross-out, or cover over any chemical information that does not pertain to the spent chemical/waste chemical in the container;

n. Carefully label all chemicals in use to reduce generating unknown waste. Disposal of unknown waste requires extensive laboratory testing, which is very expensive;

o. To obtain more information, or to request pick-up of spent chemical or hazardous waste contact EHS.

2. Guidelines For Waste Reduction

Plan a procedure to collect spent hazardous chemicals for disposal before you start on a project. Properly label each collection container with the name of each chemicals placed into the container. It is the responsibility of each department, group, or experimenter to identify the spent chemical/hazardous waste chemical properly before disposal; inadvertent mixing of incompatible chemicals could have serious consequences.

Protection of the environment makes the disposal of large quantities of hazardous chemical liquids and solids a costly problem. It is in everyone's best interest to keep quantities of chemical waste to a minimum.

The following suggestions may help:

a. Order only the amount of chemical you need for your project or experiment even if you can get twice as much for the same money;

b. Use only the amount of chemicals that are needed for conclusive results;

c. Avoid long term storage (over one year) of excess chemical, particularly if it is an extremely toxic or flammable chemical, just because you may want it in the future;

d. Before disposing of unwanted, unopened, uncontaminated chemicals, check with others in your department who may be able to use them;

e. On termination of a research project or completion of a thesis, all unused chemicals to be kept by the laboratory must be labeled;

f. Make sure all samples and products to be disposed of are properly identified, labeled with its chemical name and placed in correct containers. Do not leave them for others to clean up after you.

H. Receipt, Check-In, and Delivery/Transportation of Hazardous Materials or Chemicals

Serious accidents may occur if hazardous chemicals, etiological (disease-causing) agents, radioactive materials, carcinogens, compressed gas cylinders, and other materials are not handled, transported and shipped in accordance with safe practices.

1. Checking-in Hazardous Materials or Chemicals

The most important aspect of checking-in hazardous materials or chemicals should be to verify that the integrity of the container(s) is intact.

a. Shipping Container(s)

Make sure the outside shipping container(s) (cardboard, wood, metal cans, etc.) has not been damaged. Check for stains resulting from leakage inside. Check for evidence of crushing that might damage the hazardous material or chemical container(s) inside. Note any unusual odors that could indicate leakage.

b. Packing Material(s)

Check inside packing material(s) (secondary cardboard containers, plastic bags or wrapping, vermiculite, etc.) to make sure that they are intact. Check for tears in the plastic. Check for leakage or odors in the vermiculite. Examine secondary container(s) for damage. Check for stains resulting from leakage inside.

c. Hazardous Materials or Chemical Container(s)

Check the hazardous material or chemical container(s) (glass bottle or jar, plastic bottle or jar, can, etc.) for breakage or cracks. Check the cap for cracks, deterioration, or dried or wet residue. Check for unusual odors. Make sure the hazardous material or chemical container(s) are not damaged in any way.

If any evidence of damage, breakage, leakage, etc. is found, isolate the shipping container(s), preferably in a fume hood if available, then call EHS for assistance at extension 657-278-7233 (x. 7233).

2. Transporting Hazardous Materials

Guidelines have been developed regarding the transport of hazardous chemicals such as acids and corrosive liquids, flammable solids and liquids, toxic chemicals, oxidizers and reactive chemicals (including spent chemical and hazardous waste), from one room to another within a building or from building to building. The guides require: (1) using a proper container, (2) utilizing a proper transporting device, or (3) limiting the size and quantity transported. Other hazardous chemicals, such as compressed gas cylinders, biohazards, radioactive materials, carcinogenic compounds, etc., require special precautions. D.O.T. shipping boxes are available from EHS for safe transporting of hazardous materials.

a. Glass Bottles

i. The transport of large glass bottles (one gallon or larger) by hand shall be done in a proper carrier. Acceptable carriers include a plastic acid or bottle carrier, styrofoam casing, or appropriate cardboard box, wooden crate, etc. In general, depending on the hazard, a single glass bottle of one quart or less may be carried by hand, except inside an elevator.

ii. Whenever more than one glass bottle of any size is being transported, it is necessary that measures be taken to prevent the glass bottles from contacting each other. Such devices as cardboard boxes with dividers, styrofoam cases with compartments, or the use of a vermiculite filler is appropriate.

iii. If a cart is employed to transport glass bottles within a building, precaution must be taken to prevent the glass bottles from contacting each other and/or falling off the cart. Glass bottles shall not be placed loosely on a cart unless the cart is specially designed to accommodate the bottles, or the bottles are in protective containers, such as described above. The cart shall have an adequate lip to prevent packages from slipping off the cart.

iv. Anytime glass bottles are to be transported from building to building, additional precaution must be taken. The cart used should have larger wheels (4" minimum), preferable of a pneumatic type. The cart should have at least a 3" lip and all bottles should be transported in some type of protective container, such as described above.

v. Transport within elevators always requires an acceptable carrier as described above.

b. Plastic Coated Bottles/Metal Cans/Safety Cans

i. The hand-carrying of these kinds of containers is permitted since the integrity of the container is far superior to that of the glass bottle. If any of these containers are involved in an accident, it is not likely that the entire contents of the container would be immediately spilled or splashed about. There also would be little or no glass fragments.

ii. Whenever more than two of these containers are being transported, an additional carrying device, such as an appropriate cardboard box or a wheeled cart with a lip should be employed. Follow the precaution given for the type of cart as outlined above.

c. Cardboard Cartons, Crates, Boxes Containing Chemicals Bottles

When transporting chemicals in their original shipping packages, normal transporting methods may be used, such as push carts and dollies. If these containers must be transported on outdoor paths, the precautions listed above for bottles shall be followed, unless the packages can be adequately secured to the cart or the dolly.

d. Chemical Ordering Do's and Don'ts

i. When available, order chemicals in plastic coated bottles.

ii. When available, order flammable liquids in MCB SAF-T-CAN (glass bottles inside metal can).

iii. Do not order more of one chemical than you will utilize in normal operations. Overstocking to save money on large quantities creates many other problems, such as exceeding the permissible amount of flammable liquids in a lab, or increasing the possibility of the chemicals getting old before they are consumed. Old chemicals may become hazardous due to aging, and disposal is always costly. If the overstock is not used it will likely have to be shipped off as waste at extra cost to the campus.

e. Biohazard Transport

Transport of biohazards to other labs or facilities requires suitable enclosed containers. Contact EHS for assistance if a biohazard (or suspected biohazard) is delivered to your area.

f. Cylinder Transport

Whenever compressed gas cylinders are moved, caps must be placed over the valves and suitable carts with securing devices used. Cylinders have to be secured to the bench or wall of labs at all times. Free-standing cylinders, or cylinders moved without a cart, may become "unguided missiles" if they fall and the valve stem is broken.

g. Transporting of Radioactive Materials

Transportation of all radioactive materials/waste must be performed under the supervision of the Radiation Safety Officer. Contact EHS for assistance at 657-278-7233.

h. Transport of Chemical Carcinogens

Personnel utilizing carcinogens or suspect carcinogens should be aware of the hazards involved in transporting these chemicals. The risk can be reduced by using sealed containers, such as plastic bags which are large enough to contain the material if spillage or breakage occurs. The sealed bags shall then be placed in an airtight can, such as a paint can. A warning label shall identify the substance, its carcinogenicity (use "Caution -- Cancer Suspect Agent"), and the quantity, with the researcher's name and department. This procedure is the NCI recommended practice not only for transport, but also for storage of such materials. Please refer to Chemical Hygiene Plan for more information on proper handling and storage of carcinogens.

i. Finally, never utilize a private vehicle for transporting a hazardous materials. Always consult EHS if in doubt as to safe procedures.

I. Protocol-Specific Safety Procedures

All laboratory procedures must contain a description of specific safety practices which have been prepared by a Principal Investigator or Laboratory/Course Instructor and incorporates the applicable precautions described in this section. Laboratory workers should read and understand these practices before commencing a procedure. No amount of written precautions can substitute for procedure specific advice from your Principal Investigator, laboratory or course instructor. Therefore, before starting a procedure always meet with your supervisor.

1. Procedures for Toxic Chemicals

The SDSs for many of the chemicals used in the laboratory will state recommended limit or OSHA-mandated limits, or both, as guidelines for exposure. Typical limits are threshold limits values (TLV), permissible exposure limit (PEL), and action levels. When such limits are stated, they will be used to assist the Chemical Hygiene Officer in determining the safety precautions, control measures, and safety apparel that apply when working with toxic chemicals.

a. When a TLV or PEL value is less than 50 ppm or 100 mg/m^3, the user of the chemical must use it in an operating fume hood, glove box, vacuum line, or similar device, which is equipped with appropriate traps and/or scrubbers. If none are available, no work should be performed using that chemical;

b. If a TLV, PEL, or comparable value is not available for that substance, the animal or human median inhalation lethal concentration information, LC50, will be assessed. If that value is less than 200 ppm or 2000 mg/m^3 (when administered continuously for one hour or less), then the chemical must be used in an operating fume hood, glove box, vacuum line or similar device, which is equipped with appropriate traps and/or scrubbers. If none are available, no work should be performed using that chemical;

c. Whenever laboratory handling of toxic substances with moderate or greater vapor pressures will be likely to exceed air concentration limits, laboratory work with such liquids and solids will be conducted in a fume hood, glove box, vacuum line, or similar device, which is equipped with appropriate traps and/or scrubbers. If none are available, no work should be performed using that chemical.

2. Procedures for Flammable Chemicals

In general, the flammability of a chemical is determined by its flash point, the lowest temperature at which an ignition source can cause the chemical to ignite momentarily under certain controlled conditions.

a. Chemicals with a flash point below 200°F (93.3°C) will be considered "fire-hazard chemicals";

b. OSHA standards and the National Fire Protection Association (NFPA) guidelines on when a chemical is considered flammable apply to the use of flammable chemicals in the laboratory. In all work with fire-hazard chemicals, follow the requirements of 29 CFR, sub-parts H and L; NFPA Manual 30, "Flammable and Combustible Liquids Code"; and NFPA Manual 45, "Fire Protection for Laboratories Using Chemicals";

c. Fire-hazard chemicals should be stored in a flammable-solvent storage area or in storage cabinets designed for flammable chemicals;

d. Fire-hazard chemicals should be used only in vented hoods and away from sources of ignition.

3. Procedures for Reactive Chemicals

The most complete and reliable reference on chemical reactivity is found in the current edition of "Handbook of Reactive Chemical Hazards" by L. Bretherick, published by Butterworth-Heinemann, 1990. Reactivity information is sometimes given in manufacturer's SDSs and on labels. Guidelines on which chemicals are reactive can be found in regulations published by the Department of Transportation (DOT) in 49 CFR and by the Environmental Protection Agency (EPA) in 40 CFR. Also see NFPA Manual 325M, "Fire Hazard Properties of Flammable Liquids, Gases, Volatile Solids"; Manual 49, "Hazardous Chemicals Data"; and Manual 491M, "Manual of Hazardous Chemical Reactions".

a. A reactive chemical is one that meets any of the following:

i. Is described as such in Bretherick or the SDS;

ii. Is ranked by the NFPA as 3 or 4 for reactivity;

iii. Is identified by the DOT as:

a. An oxidizer;

b. An organic peroxide; or

c. An explosive, Class A, B, or C.

iv. Fits the EPA definition of reactive in 40 CFR 261.23;

v. Fits the OSHA definition of unstable in 29 CFR 1910.1450; or

vi. Is known or found to be reactive with other substances.

b. Handle reactive chemicals with all proper safety precautions, including segregation in storage and prohibition on mixing even small quantities with other chemicals without prior approval and appropriate personal protection and precautions.

4. Procedures for Corrosive Chemicals and Contact-Hazard Chemicals

Corrosivity, allergenic, and sensitizer information is sometimes given in manufacturer's SDSs and on labels. Also, guidelines on which chemicals are corrosive can be found in other OSHA standards and in regulation published by DOT in 49 CFR and the EPA in 40 CFR.

a. A corrosive chemical is one that meets any of the following:

i. Fits OSHA definition of corrosive in Appendix A of 29 CFR 1910.1200;

ii. Fits the EPA definition of corrosive in 40 CFR 261.22 (has a pH greater than 12 or less than 2.5); or

iii. Is known or found to be corrosive to living tissue.

b. Handle corrosive chemicals with all proper safety precautions, including wearing both safety goggles and a face shield, gloves tested for absence of pin holes and known to be resistant to permeation or penetration, a laboratory coat and a rubberized apron.

c. A contact-hazard chemical is an allergen or sensitizer when it meets any of the following:

i. Identified or described in the SDS or on the label;

ii. Identified or described in the medical or industrial hygiene literature; or

iii. Is known or found to be an allergen or sensitizer.

5. Procedures for Compressed Gases

Compressed gas cylinders may have many hazards. They often contain materials which are toxic or highly flammable. If mishandled or if they fall over, they can become "unguided missiles" with enough explosive force to penetrate a concrete wall. If they tip over, they can fall on other equipment, stored chemicals, or on nearby personnel.

Corrosive compressed gases constitute another hazard. If they are stored for a lengthy period of time after use, the corrosive nature of the material may

affect the valves. Therefore, corrosive compressed gases should not be stored for more than six months.

a. Guidelines for transportation and storage of compressed gas cylinders:

   i. Make sure the valve cap is securely in place before moving any cylinder.

   ii. Transport cylinders on a designated wheeled cart (designed for the specific task), carefully secured (by a chain) in an upright position to prevent them from falling.

   iii. Make sure the label is legible and secured to the cylinder (use packaging tape if necessary to prevent it from falling off).

   iv. Do not leave a cylinder unattended in a corridor for more than a few minutes.

   v. Never move a cylinder by rolling it across the floor.

   vi. Never drop cylinders or bang them against each other or another object.

   vii. When a cylinder is not in use, make sure the valve cap is securely in place.

   viii. Whether in use or in storage, all cylinders must be double strapped or double chained in an upright position, according to Fire Marshal requirements. For assistance with the double strapping requirement, contact EHS at 657-278-7233.

b. Leaks

   i. Report all suspected leaks immediately - if the material in the cylinder is highly toxic, evacuate everyone from the area - call EHS at 657-278-7233, Public Safety at 657-278-2515, or in an extreme emergency call 911.

   ii. Leaking cylinders should be put in or near a fume hood, if possible.

c. Disposal

   i. Empty cylinders should be labeled "empty" and returned to the appropriate area or vendor for refill or disposal.

   ii. Empty lecture bottles may be returned to the manufacture or vendor, contact EHS at 657-278-7233 for assistance.

iii. Any suspected "unknown" cylinders should be reported to EHS at 657-278-7233.

iv. Always leave at least 25 psi in all "empty" cylinders to prevent contamination and the formation of explosive materials.

J. Control Measures and Equipment

1. Ventilation

Many laboratory workers depend on fume hoods to protect themselves from the potentially dangerous fumes of the chemicals they must use. Fume hoods prevent or minimize the escape of contaminants from the hood into the laboratory. A fume hood may also minimize the potential for fire or explosion from vapors of flammable chemicals. Successful performance of the fume hood depends primarily on adequate and even velocity of air moving through the hood. This is adversely affected by cross drafts, thermal load and obstruction of the hood sash and rear intake baffles. As fume hoods are designed to operate most effectively with room doors closed, proper venting may not be guaranteed with the room doors open. To allow for adequate protection, the hood user must avoid work practices and procedures that interfere with hood performance. Hazardous operations involving toxic and explosive chemicals, pathogenic microorganisms, or radioisotopes in certain forms, must be performed within these enclosures. The exhaust systems are a prime safety feature for the laboratory and serve four major functions:

a. Confining hazardous contaminants and preventing their coming into contact with persons working in the laboratory;

b. Transporting these hazardous materials to a point where they may be discharged safely into the atmosphere;

c. Sufficiently diluting toxic chemicals to prevent pollution of the atmosphere. Ventilation used for work with highly pathogenic microorganisms or certain radioactive particles should be fitted with filters to entrap these particles and prevent their discharge;

d. Providing sufficient air movement within the enclosure so that flammable vapor concentrations will be reduced below their lower explosive limits.

For adequate containment, the linear velocity of air moving into the hood at the face should be at least 100 feet per minute (fpm) at the working sash height. The hoods are surveyed annually and the face velocity and optimum working sash height will be labeled on each hood.

2. Fume Hood Safety Procedures

a. Use all toxic chemicals inside the hood, but do not use the hood as a storage cabinet;

b. Operate hood at proper sash height, as marked on the hood;

c. Work at least six inches in from the plane of the sash. Keep all chemicals and equipment behind this line during every experiment;

d. Only equipment necessary to conduct the experiment should be in the hood;

e. Use equipment with legs to raise it off the work surface and allow even airflow;

f. Eliminate clutter and storage;

g. Minimize pedestrian traffic in front of the hood;

h. Know the toxic properties of the chemicals with which you are working. Be familiar with the signs and symptoms of exposure;

i. Never put your head inside an operating fume hood to check an experiment. The plane of the sash is the barrier between contaminated and uncontaminated air;

j. Position fans and air conditioners so that air flow is directed away from the hood;

k. Note the date that the hood was last checked. It should be checked annually. If the date is overdue, please notify EHS at 657-278-7233;

l. Work with the sash in the lowest position possible for added protection while an experiment is in progress;

m. Do not clutter your hood with bottles or equipment. Keep it clean and clear. Only materials actively in use should be in the fume hood. This will provide optimal containment and reduce risk of extraneous chemicals being involved in fire or explosions which may occur in the hood;

n. Clean the grill along the bottom slot of the hood regularly so it does not become clogged with papers and dirt;

o. Do not dismantle or modify the physical structure of your hood or exhaust system;

p. Report any suspected fume hood malfunctions to EHS at 657-278-7233

q. Keep only the amount of materials necessary for the experiment inside the hood, using the smallest possible amount of materials in any reaction;

r. If small amounts of chemicals or reagents must be stored in the hood, equip the hood with perforated shelves installed on the side walls;

s. If large equipment must be used or stored in the hood, place the equipment on blocks or risers to raise it at least two inches above the counter top. This will allow the air to flow beneath the equipment;

t. Gas cylinders which are not needed for the current experiment should be stored away from the front of the hood;

u. Close the sash completely whenever the hood is on and is not being used;

v. All electrical components should be mounted outside of the hood to avoid sparks which may ignite a flammable or explosive chemical;

w. Never operate a hood unless there is some indication that the exhaust fan is on and operating;

x. The hood is not a substitute for other types of personal protective equipment. Wear gloves, aprons, lab coat, safety glasses, etc. as appropriate;

y. Keep the sash clean and clear;

z. Clean all residue from the hood chamber after each use.

Special fume hoods or ventilated safety cabinets may be required for certain hazards, such as perchloric acid, biohazards, chemical carcinogens and radioactive substances. If you have questions about these contact EHS at 657-278-7233 and refer to the Biosafety Manual or the Radiation Safety Manual.

3. Safety Cans

a. Fire-hazard chemicals in quantities greater than one liter should be kept in metal safety cans designated for such storage. The safety cans should be used only as recommended by the manufacturer;

b. Never disable the spring-loaded closure;

c. Always keep the flame-arrester screen in place; replace it if it is punctured or damaged;

d. Always use proper ground-straps;

e. Store all safety cans in an appropriate well-ventilated flammables storage area.

4. Flammable Storage Cabinets

a. Cabinets designed for the storage of flammable materials should be properly used and maintained. Read and follow the manufacturer's instructions;

b. Cabinets should be vented to fume hoods when necessary;

c. Store only compatible materials inside a flammable storage cabinet;

d. Do not store paper or cardboard or other combustible packaging material in a flammable-liquid storage cabinet;

e. The manufacturer establishes quantity limits for various sizes of flammable-liquid storage cabinets; do not overload a flammable storage cabinet.

5. Corrosive Storage Cabinets

a. Cabinets designed for the storage of corrosive materials should be properly used and maintained. Read and follow the manufacturer's instructions.

b. Store only compatible materials inside a corrosive storage cabinet.

i. Segregate acids from bases and active metals;

ii. Segregate oxidizing acids from organic acids (see table below), flammables, and combustibles;

Strong Oxidizing Acids	Organic Acids
Chromic acids	Acetic acid
Hydrobromic acid	Benzoic acid
Iodic acid	Formic acid
Nitric acid	Phenol
Perchloric acid	Trichloroacetic acid
Sulfuric acid	Propionic acid
	Sulfamic acid
	Sulfanilic acid

iii. Store solutions of inorganic hydroxides in polyethylene containers (never in glass) (examples: ammonium hydroxide, potassium hydroxide sodium hydroxide).

iv. Store oxidizers away from organic compounds, flammables, combustibles, and oxidizable compounds (see table below).

Segregate oxidizers from reducing agents such as zinc, alkaline metals and formic acid. Store in glass containers, but do not cap with cork or rubber stopper.

Some Common Oxidizers	
Ammonium dichromate	Ammonium perchlorate
Ammonium persulfate	Benzyl peroxide
Bromates, salts of	Calcium hypochlorite
Cerric sulfate	Chlorates, salts of
Chromium trioxide	Ferric trioxide
Ferric chloride	Iodates, salts of
Iodine	Magnesium perchlorate
Magnesium dioxide	Nitrates, salts of
Periodic acid	Potassium dichromate
Peroxides, salts of	Potassium permanganate
Potassium ferricyanide	Sodium chlorite
Sodium bismuthate	Sodium nitrite
Sodium dichromate	Sulfates, salts of
Sodium perborate	

c. Do not store paper or cardboard or other combustible materials near oxidizing acids in a corrosive material storage cabinet;

d. The manufacturer establishes quantity limits for various sizes of corrosive material storage cabinets; do not overload a corrosive storage cabinet.

6. Eye Washes and Safety Showers

a. All laboratories should be equipped with eye washes and safety showers. These must be located so they can be quickly reached from any point in the laboratory (ANSI Z 358.1, Title 8 sections 5162 & 5191, 29CFR 1910.1450);

b. The function of eye washes and safety showers is checked at regular intervals by EHS. Copies of the Preventative Maintenance Records are maintained by EHS. Promptly notify EHS at 657-278-7233 of any eye wash or safety shower malfunction or need for repair;

c. Be sure that access to eye washes and safety showers is not restricted or blocked by temporary storage of objects or in any other way;

d. For chemical splashes in the eye(s), complete irrigation is indicated with continuous flushing for 15 to 20 minutes. Immediately flush the eye with copious amounts of water. Hold the eye open to wash thoroughly behind the eyelids. The injured person must be given prompt medical attention, regardless of the severity of the injury.

e. For chemical splashes to the body, “flush-strip-flush.” Begin flushing with water while stripping clothes off, and continue flushing for at least 15 minutes. The water in the safety showers is not heated, so assistance may be needed to keep the exposed person in the water.

7. Protective Apparel

Appropriate attire helps protect laboratory workers from hazards commonly found in a laboratory environment. To supplement street clothing, protective apparel and equipment are called for during certain operations involving hazardous substances. (See checklist which follows.)

Personnel working in the laboratory should be clad in appropriate street wear which affords an acceptable base on which to add appropriate items of protective clothing and equipment.

a. Full shoes are required. No open-toed sandals or bare feet are allowed;

b. Hair below the neckline should be secured whenever the laboratory utilizes power tools or flames. Loose long sleeves, jewelry, or other dangling or loose apparel should not be worn when using these devices, or when they constitute a danger of overturning glassware containing hazardous chemicals;

c. Protective eye wear and face wear must be worn;

d. Lab coats and/or chemical aprons are worn as necessary to protect the body. Similarly, appropriate gloves are worn as the hazard requires.

Personal Protective Equipment Checklist

I. General

1. Be constantly aware of exposure hazards in the laboratory.
2. Develop a positive attitude toward the use of safety equipment.

II. Hand and Face Protection

Hazards	Protective Equipment
Glass Burns Splashing Spilling	Protective Shields Gloves: Asbestos - for handling hot objects or cryogenics Leather - for working with glass Heavy Rubber - corrosive chemicals Light Rubber - where finger dexterity is required Moleskin Mitts - for heavy duty; for work with sodium hydrocarbons Plastic Coated - for handling organic solvents and chlorinated hydrocarbons

III. Eye and Face Protection

Hazards	Protective Equipment
Splashing and spills	Safety glasses, goggles
Toxic fumes and gases	Face shields, fume hoods
Ruptures and explosions	Hoods, shatter proof glass or plastic shields

IV. Respiratory Protection

Treat every chemical as toxic; odor is not a dependable guide

Hazards	Protective Equipment
Gaseous chemicals	Hoods or local exhaust
Fumes from reactions	Chemical-cartridge respirators
Harmful dust	Self-contained breathing apparatus and filter respirators

V. Body Protection

Hazards	Protective Equipment
Explosion	Protective Shields
Fumes and gases	Hoods
Spills and splashes	Aprons, coats: Rubber, plastic for mild acids, water and alkalis Natural rubber for strong acids or alkalis Synthetic rubber for solvents Insulated glass fiber for flames

8. Respirators

a. Laboratory workers should wear respirators whenever it is possible that 1) engineering controls or work practices are or could become inadequate and/or 2) laboratory workers might be exposed to vapor or particulate concentrations greater than the PEL, action level, TLV or similar limit.

b. The requirements of the California Code of Regulations, Subchapter 7. General Industry Safety Orders, Group 16. Control of Hazardous Substances, Article 107. Dusts, Fumes, Mists, Vapors and Gases §5144. Respiratory Protection. should be followed, including:

i. Written standard operating procedures governing the selection and use of respirators;

ii. All laboratory workers who are likely to need to use respirators must be trained in their proper use, inspection, and maintenance.

EHS will provide guidance in identifying laboratory workers and classes in which respiratory protection is advised or required and will coordinate with users about procedures for the selection, purchase, and training of approved respiratory protection for laboratory workers.

Refer to the Respiratory Protection Program and the EHS office.

9. Vapor Detection

Do not use odor as a means of determining that inhalation exposure limits are or are not exceeded. Whenever there is any reason to suspect that a toxic chemical inhalation limit might be exceeded, whether or not a suspicious odor is noticed, notify the Principal Investigator and EHS at 657-278-7233.

K. Special Procedures for Carcinogens, Biohazards, Reproductive Toxins, Toxins, Substances that have a High Degree of Acute Toxicity, and Chemicals of Unknown Toxicity

1. Follow the procedure described in this section when performing laboratory work with any select carcinogen, biohazard, reproductive toxin, toxin, substance that has a high degree of acute toxicity, or a chemical whose toxic properties are unknown, or when using or handling amounts which would pose any threat to human health or life. Guidance for determining when to apply these procedures should be obtained by consulting SDSs or specific references available in EHS. Also, note that mixed hazards can occur in the laboratory that require special procedures based on a hazard-priority. EHS can assist with mixed hazard safety precautions.

a. Carcinogens are any substances defined as such in Subchapter 7. General Industry Safety Orders, Group 16: Control of Hazardous Substances, Article 110: Regulated Carcinogens, Section 5209. Carcinogens or any other substances described as such in the applicable SDS. Carcinogens are materials which have been causally associated with the development of cancer in humans or animals. These materials may cause no immediate adverse effects, but repeated or prolonged exposures may result in later development of cancer, often after a latency period of 10 to 30 years. Known carcinogens have been associated with cancer in human studies. Probable and suspected carcinogens have induced cancer in animal systems and/or short term bioassays. Any of these materials should be treated with care. In most cases, the reason chemicals are on the suspect or probable list is lack of human data, not negative findings. Since the majority of carcinogens also are mutagens (alter the genetic structure), it is believed that even extremely low doses are capable of increasing the risk of cancer, and as a result, no dose can be called acceptable (a zero threshold). Therefore, while Permissible Exposure Levels (PELS) have been established for toxic materials, for carcinogens, the Lowest Possible Exposure is the standard.

b. Reproductive toxins are any substances described as such in the applicable SDS. Reproductive toxins are materials which can harm the offspring of the exposed worker, or cause difficulty in attaining pregnancy, for instance, by lowering sperm count. Reproductive toxins have been identified for both men and women. They may be toxic or mutagenic to offspring (teratogenic), or cause dysfunction or other effects on reproductive organs. Approximately 5000 chemicals have been identified as animal or human reproductive toxins. Examples of known reproductive toxins are lead and ethylene oxide.

c. Acutely toxic chemicals are any substances for which the LD50 data described in the applicable SDS cause the substances to be classified as a highly or acutely toxic chemical. Acutely toxic chemicals include corrosives, poisons, asphyxiants, anesthetics, and irritants. Corrosives are acids, bases, oxidizers and dehydrating agents. They will destroy cells on contact. Poisons interfere with vital body processes. Cyanide, arsenic, acrylamide, chromates, fluorides, and methyl butyl ketone are all commonly used poisons. Asphyxiants interfere with either the supply or availability of oxygen to the lungs. Nitrogen, argon, helium, and nitrous oxide are asphyxiants at high concentrations; while carbon monoxide and cyanide will interfere with oxygen uptake in the body, causing suffocation. Many solvents are anesthetics, which depress the central nervous system. Irritants cause immediate pain or reddening on contact with skin. They may affect the respiratory system, skin, and/or eyes.

d. Chronic toxins are materials which cause health effects long after exposures, often from repeated or long time exposures. These effects may include organ damage, such as decreased lung function or kidney failure, or cancer.

e. Sensitizers are materials which produce allergies from exposures. Often these are not immediate, but show up after repeated exposure. Dermatitis, eye irritation, and respiratory allergy or asthma are common results of exposure to sensitizers.

2. Provisions for work with hazardous substances

Several groups of substances fall under specific categories--either by hazardous effects to humans (such as carcinogens or reproductive toxins) or by hazardous properties (such as corrosive or explosion hazards). More stringent work practices and sometimes specific precautions are appropriate when working with these types of chemicals. In general, when working with these particularly hazardous chemicals, you must:

a. Before beginning work, consult the SDS for exposure and emergency information. This information is available EHS;

b. Work in a fume hood and/or Controlled Work Area. This area should be visibly labeled with a sign ("CONTROLLED WORK AREA: CARCINOGENS, REPRODUCTIVE TOXINS, ACUTELY TOXIC CHEMICAL, EXPLOSIVE, etc. IN USE"). NOTE: If ALL manipulation of the chemical can be performed in the chemical fume hood, you may consider the hood to be a Controlled Work Area;

c. Label ALL containers with contents, date, and hazardous properties;

d. You should wear appropriate protective equipment, including gloves, lab coat or other skin protective covering, and face/eye protection;

e. Traffic through the immediate area should be limited;

f. Work only in a fume hood or glove box, or other appropriate system to avoid inhalation exposure;

g. After working with these chemicals return them to secure storage immediately, and decontaminate the work surfaces. Immediately label all spent chemicals or waste chemicals with the corresponding chemical classification (e.g.; CARCINOGEN).

These chemicals may be classified under those requiring prior approval, so check with your Principal Investigator or the Chemical Hygiene Officer before beginning work with these chemicals.

If work entails laboratory animals as well as carcinogens, personal protection should be worn at all times. Personal protective equipment should include shoe covers, jump suit, double gloves, and respiratory protection. Minimize the creation of aerosol exposure to carcinogens. Administer carcinogenic substances by gavage if possible. Decontaminate entire work area and all affected items as soon as work is completed.

3. Procedures for working with reproductive toxins

Since there are at least 5000 chemicals which are considered reproductive toxins, and anyone of childbearing age, male or female, may be affected, one should always consult an SDS or current source of toxicity data for reproductive toxicity of a substance before working with it. This information is available in EHS. Containers of known reproductive toxins should be clearly labeled and used only in a designated Controlled Work Area, designated as such by labels. For chemicals which are teratogens, pregnant women should exercise extreme care, and consult an appropriate authority (Chemical Hygiene Officer or Biological Safety Officer) for advice before using, and should exercise extreme care when working to avoid spills and splashes. As with carcinogens, any work with a reproductive toxin should be well thought out and carried out to avoid exposure.

4. Procedures for working with substances of moderately chronic or high acute toxicity

Work with acutely toxic materials must be conducted in a designated, Controlled Work Area. Consult an SDS or other source of information before working with any substance you know or suspect is hazardous. This information is available in EHS. Determine the route(s) of exposure and the signs and symptoms of exposure. Also look for any emergency or fire information. If your work entails a substance of unknown toxicity, assume it is hazardous and proceed accordingly. For any substance, determine how you could be exposed and what to do in case of a spill, fire, emergency, explosion, etc. before beginning work.

5. Labeling requirements

Any area where Hazardous Substances are used or stored must be labeled. If the Laboratory is the Controlled Work Area for work with carcinogens, reproductive hazards, and acutely toxic materials, the door should be clearly labeled. Labels may be obtained from EHS. Label ALL containers with contents, date, hazardous properties.

Chemical Storage Cabinets must be labeled with appropriate warnings - for example, Flammable Liquids Only, Acid Only, Bases Only, etc. Refrigerators and freezers should be labeled, as well as hoods or other specific areas designated for work with hazardous substances.

Where acids are in use, the "ACID - Goggles And Rubber Gloves Must Be Worn In This Area" sign must be visible.

If carcinogens are used, the "Caution Carcinogens In Use" sign must be posted.

Similarly, any other special hazards posed, i.e. sensitizers, reproductive and other toxins, should be clearly posted with warning signs of materials in use.

6. Controlled Work Areas

A Controlled Work Area is defined as a hood, glove box, containment cabinet, portion of a laboratory, or an entire laboratory room designated as the only area where work with quantities of the hazardous substances shall be conducted.

a. Controlled Work Areas shall be posted and their boundaries clearly marked. Only those persons trained to work with these hazardous substance will work with those substances in a Controlled Work Area;

b. Use the smallest amount of a hazardous substance that is consistent with the requirements of the work to be done;

c. Use of high-efficiency particulate air (HEPA) filters, high-efficiency scrubber systems, chemical deactivating traps, or liquid disinfectant traps are recommended when feasible;

d. Controlled Work Areas should be decontaminated when work is completed;

e. Spent chemicals and chemical wastes generated in a Controlled Work Area should be prepared for disposal in accordance with specific disposal procedures consistent with the Resource Conservation and Recovery Act (RCRA), Biosafety Manual, and as designated by the Hazardous Waste Technologist;

f. Those substances defined as hazardous substances should be stored or locked in enclosed spaces segregated from other chemicals;

g. Jewelry should not be worn when working in a Controlled Work Area because of the difficulty of decontamination;

h. Wear long-sleeved lab coat and gloves known to resist permeation by the substances to be used when working in a Controlled Work Area.

7. Closed System Protection

All work involving Carcinogens, Biohazards, Reproductive Toxins, Toxins, Substances of Acute Toxicity, and Chemicals of Unknown Toxicity must be done in specially equipped closed systems to reduce the risk of laboratory worker exposure to the vapors. These closed systems include fume hoods, gloves boxes, containment cabinets or similar devices. The exhaust air from these devices should be treated by filtration, reaction, absorption, adsorption, electrostatic precipitations or incineration, when feasible. The need for a type of primary containment equipment should be a joint determination made by the Principal Investigator/laboratory or course instructor and the laboratory worker after consulting with EHS for applicable SDSs and references. Treatment systems that remove the above described hazardous substances from the exhaust air should be operated in a manner that permits maintenance without direct contact with the hazardous substances. All exhaust air from other primary containment equipment should be discharged to the outdoors so that the possibility of entry into the building's air supply is minimized.

8. Protection of Vacuum Systems

Each vacuum service, including water aspirators, should be protected with adsorbents, liquid trays and/or a HEPA filter to prevent entry of any hazardous substance described into the system. When using a volatile hazardous substance described above, a separate vacuum pump should be used. This device should be placed within or vented into an appropriate fume hood. When feasible, high efficiency scrubber systems can be used.

9. Handling Contaminated Waste Waters

Prior to the start of any laboratory activity involving the above described hazardous substances plans for the handling and ultimate disposal of contaminated wastes, waste waters and surplus amounts of the hazardous substances should be completed. The Principal Investigator or laboratory or course instructors with EHS should determine the best methods available for handling and disposal of wastes that are in compliance with all Federal, State and other Local regulations. Primarily, all rinse water and other waste waters contaminated with the above described hazardous substances must be collected for disposal.

10. Personal Hygiene

Laboratory workers using hazardous substances shall take extra precautions in maintaining good personal hygiene. All laboratory workers should wash their hands immediately after completion of any procedure in which a hazardous substance has been used and when they leave the laboratory. Immediately after an exposure to one of these hazardous substances, personnel should wash or, if appropriate shower the affected area.

11. Prohibited Items and Activities

The precautions against eating, drinking, smoking, chewing of gum or tobacco, application of cosmetics or storage of utensils, food, or food containers must be strictly enforced in laboratories that use a Controlled Work Area or are Controlled Work Areas or use or store hazardous substances.

12. Protective Apparel

Persons working in a Controlled Work Area should not wear any personal items such as jewelry which might be lost if decontamination is not possible. Laboratory clothing that protects street clothing, such as a fully fastened laboratory coat or a disposable jump suit, should be worn in any work area in which the above described hazardous substances are being used. When possible, disposable clothing should be used. Protective clothing used in a Controlled Work Area should not be worn outside of the work area. Clothing overtly contaminated should be removed immediately and disposed of or decontaminated prior to laundering. When clothing decontamination methods are unknown or too difficult, disposable clothing is recommended. Gloves which are appropriate to the task and hazardous substances in use should be worn at all times to prevent skin contact with the hazardous substances. Disposable gloves should be discarded after each use and immediately after overt contact with hazardous substances. Devices to provide appropriate eye protection should be worn at all times while in the laboratory. The type of eye protection used will depend upon the hazard presented by the operation and/or hazardous substance in use.

13. Additional Precautions

Working quantities of above described hazardous substances present in the Controlled Work Area should be kept to a minimum. Quantities should be restricted to amounts only necessary for the procedure or operation at the time. Purchases of the hazardous substances should be restricted to minimal amounts necessary to prevent uninterrupted work. This does not apply to amounts stored in a specific storage area or cabinet that is located within the laboratory work area, but quantities should be kept as small as reasonable for safety and inventory tracking requirements. Storage vessels or cabinets must labeled with the appropriate warning. EHS can assist with recommendations for amounts to be purchased and with labeling requirements.

L. Criteria to Determine and Implement Controls to Reduce Exposures

Each laboratory determines its criteria for requiring the use of personal protective equipment, specific hygiene practices, and other control practices to reduce laboratory worker exposure to hazardous chemicals. According to accepted industrial hygiene practice, however, substitution with a non-hazardous chemical or procedure is the preferred method to reduce employee exposure to hazardous chemicals. If

there is no suitable substitution, engineering controls in the laboratory are the primary measure to reduce exposure. The chemical fume hood and local exhaust ventilation are the most common engineering controls in the laboratory.

When a substitution or engineering or administrative controls are infeasible or incomplete, use of personal protective equipment sometimes is necessary. The Personal Protective Equipment Checklist provides recommendations that may be useful to laboratories in selecting personal protective equipment. For assistance in determining if a respirator is needed for laboratory work, contact EHS.

EHS is available to evaluate safety procedures prior to start up, to investigate all suspected overexposures to hazardous substances, to recommend safer work practices or engineering controls, and to provide necessary information and training.

The following sections examine criteria and guidelines which can be used to determine the use of control measures and personal protective equipment. It should be remembered that the SDS is the best reference for determining control measures and PPE.

1. Exposure Guidelines

   Most hazardous chemicals used in laboratory work have some guidelines for exposure, such as Threshold Limit Values (TLV) or Permissible Exposure Limits (PEL). When such values exist, they will be used to assist the Chemical Hygiene Officer, Principal Investigator, and laboratory instructor in determining proper safety precautions, including control measures and personal protective equipment.

   When TLV or PEL values exist and are low, the user of the chemical must use it in an operating fume hood or if a fume hood is not available, a respirator will be used in accordance with the "Respiratory Protection Manual".

   When TLV or PEL values are not available for that substance, the Lethal Dosage information (LD50) will be assessed. If that is low, then the chemical must also be used in a fume hood if possible, or a respirator must be used.

   Whenever the chemical has a high vapor pressure, meaning that it evaporates quickly at room temperature, it will be used in a fume hood or else respiratory protection is needed. Those controls are necessary even if the chemical with the high vapor pressures also has a very high TLV or LD50, because such chemicals are likely to reach their exposure limits in air at least as quickly as a chemical with low exposures guidelines and a low vapor pressure.

   Fume hoods or respirators will be used when:

   a. The TLV or PEL is below 50 ppm or 100 mg/M^3;

b. The LD50 is below 200 ppm or 2000 mg/M^3;

2. The following examples were chosen and categorized for use as general information:

a. Irritants

Irritant materials are corrosive or cause blisters in their action, inflaming moist or mucous surfaces. The concentration factor is the single most important exposure factor, followed by the duration of exposure. Some representative irritants are:

i. Irritants affecting chiefly the upper respiratory tract: aldehydes (acetaldehyde, acrolein, formaldehyde), alkaline dusts and mists, ammonia, chromic acid, ethylene oxide, hydrogen chloride, hydrogen fluoride, sulfur dioxide, and sulfur trioxide;

ii. Irritants affecting both the upper respiratory tract and lung tissues: bromine, chlorine, chlorine oxides, cyanogen bromide, cyanogen chloride, dimethyl sulfate, diethyl sulfate, fluorine, iodine, ozone, sulfur chlorides, phosphorus trichloride, and phosphorus pentachloride;

iii. Irritants affecting primarily the terminal respiratory passages and air sacs: arsenic trichloride, nitrogen dioxide, nitrogen tetroxide, and phosgene. (To the extent that their action frequently terminates in death, lung irritants are related to the chemical asphyxiants).

b. Asphyxiants

Asphyxiants interfere with how tissues receive oxygen and are divided into simple and chemical asphyxiants. Simple asphyxiants are physiologically inert gases that act principally by dilution of atmospheric oxygen below that required to maintain respiration. Chemical asphyxiants exert chemical action to either prevent the blood from transporting oxygen from the lungs or to prevent normal oxygenation of the tissues, even though the blood is well-oxygenated. Examples of asphyxiants are:

i. Simple asphyxiants: carbon dioxide, ethane, helium, hydrogen, methane, nitrogen, nitrous oxide;

ii. Chemical asphyxiants: carbon monoxide, which combines with hemoglobin; cyanogen, hydrogen cyanide, and nitrites, which inhibit tissue oxidation by combining with cellular catalysts; aniline, methyl aniline, dimethyl aniline, and toluidine, which form methemoglobin; nitrobenzene, which has the nitrite effect,

forms methemoglobin, lowers blood pressure, disturbs and finally halts breathing; and hydrogen sulfide, which causes respiratory paralysis.

c. Anesthetics and Narcotics

The principle action is anesthesia, which has a depressant action on the central nervous system. The following examples are arranged in the order of their decreasing anesthetic action compared with other actions:

i. Acetylene hydrocarbons (acetylene, allylene, crotonylene);

ii. Olefin hydrocarbons (ethylene to heptylene);

iii. Ethyl ether and isopropyl ether;

iv. Paraffin hydrocarbons (propane to decane);

v. Aliphatic alcohols (ethyl, propyl, butyl, amyl);

vi. Esters (not particularly anesthetic, but placed here for want of a better classification) - they hydrolyze in the body to organic acids and alcohols.

d. Systemic Poisons

i. Materials that cause organic injury to one or more of the internal organs: the majority of the halogenated hydrocarbons;

ii. Materials damaging the blood system: benzene, phenols, and, to some degree, toluene, xylene, and naphthalene;

iii. Nerve poisons: carbon disulfide, methyl alcohol, thiophene;

iv. Toxic metals: lead, mercury, cadmium, antimony, manganese, beryllium, etc.;

v. Toxic nonmetal and metal inorganics: compounds of arsenic, phosphorus, selenium, and sulfur; fluorides;

vi. Excessive application of agents topically to the eye may result in some systemic effects through absorption via the nasolacrimal duct.

e. Inhalation Absorption

Inhalation is undoubtedly the single most important route of entry (of toxic substances) into the body. Any gas or vapor breathed in the air

tends to pass through the lungs into the bloodstream to be distributed throughout the body. The respiratory tissue in the lungs, acts as the exchange surface between blood and air. Two membranes of the utmost delicacy (one cell thickness) separate the air in the alveoli from the blood in the capillaries, so equilibrium between blood and alveolar air is rapidly reached. The accumulation of the foreign gas or vapor in the body depends, however, upon a number of factors: concentrations in the air, the solubility of the material in the blood and tissues, the length of the exposure, the rate of breathing, the rate of circulation, whether the material is reactive, and others.

The exposure of any person to environments known to contain toxic substances must be controlled, especially when exposures to concentrations in excess of the TLV is possible. Adequate engineering control and/or respiratory protection must be provided.

f. Ingestion Absorption

Ingestion is a secondary route of entry as a result of inhalation. Other sources of ingestion include contaminated food, beverages, and tobacco products, all of which must not be permitted in the laboratory if hygiene and safety are to be maintained. The hand-to-mouth syndrome of putting fingers or other contaminated objects into the mouth must be guarded against. All pipetting must be done with pipetting devices. No mouth pipetting is allowed at any time.

g. Skin Absorption

Many gaseous and liquid materials are absorbed to some extent through the skin. Most electrolytes do not penetrate significantly, but other chemicals such as alkaloids, phenols, oxalic, and salicylic acids and esters, lead acetate, and lead oleate are absorbed in appreciable quantities. Salts of lead, tin, copper, arsenic, bismuth, antimony, and mercury are reported to penetrate by combining with the oil of the skin. Small amounts of hydrogen sulfide and rapidly dangerous quantities of hydrogen cyanide may be absorbed from contaminated air. Nitrobenzene, dinitrobenzene, nitrotoluene, dinitrotoluene (probably), trinitrotoluene, aniline, dimethylaniline, and nitroglycerine are readily absorbed. Alcohols, aldehydes, acetone, benzene, toluene, xylene, chlorinated hydrocarbons, and other fat solvents are absorbed to a degree. Tetrachloroethane and other unusually toxic solvents may produce a body accumulation of a significant order. The list of materials which can be absorbed through the skin is extensive. Lesions in the skin will, of course, produce a much more rapid absorption than through the intact skin. Also note that many chemicals can carry other contaminants with them during skin absorption.

Examples of Chemicals Absorbed Through Intact Skin

Allyl alcohol	Dimethylaniline	Phenols
Carbon disulfide	Dimethylfomamide	Trinitrotoluene (TNT)
Cresols	Dimethylsulfoxide	
Cyanides	Dinitrobenzene	
Decaborane	Ethylene chlorohydrin	

i. Skin Allergic Reactions

Allergic or sensitivity reactions may be caused by surface contact and/or inhalation. Immediate allergic reactions to epoxide monomers and their catalysts and to toluene diisocyanate (TDI) are limited to those who have been sensitized or who have exhibited some other hay-fever-like reactions. The danger is primarily respiratory and requires complete isolation of the person from any contact with the offending chemical. Skin sensitivity reactions resemble those of poison ivy and follow repeated contact with the sensitizing chemical.

Many substances can sensitize a susceptible individual, and some common sensitizing materials can affect almost everyone. Some chemical sensitivities may be more pronounced after medication. Below are a few particularly troublesome chemicals.

Compounds Which Sensitize of Cause Allergic Reactions

Epoxide monomers & catalysts	Aliphatic mono- and polyamines
Aromatic amines	Aromatic hydrazines
Aromatic isocyanates	Aromatic nitro compounds (some)
Chlorinated biphenyls	Toluene diisocyanate (TDI)

ii. Skin Corrosion

Laboratory personnel are familiar with the corrosive effects of sulfuric or chromic acid and the blistering action of phenol or mustard gas. Some other agents, because of their delayed or less obvious action, cause more serious damage. Good housekeeping and protective clothing can eliminate the direct chemical contact that causes skin damage.

Common Chemicals Causing Skin Injury

Acetic acid	Formic acid	Hydrofluoric acid	Oxalates
Ammonia	Monochloroacetic acid	Hydrogen peroxide	Phenols
Arsenic trioxide	Phosphorus	Iodine	Phosphorus
Chromic acid	Alkalis (NaOH, lime)	Mustard gas	Picric acid
Dimethyl sulfate	Carbon disulfide	Hydrochloric acid	Sulfuric acid

Formaldehyde	Gold Salts	Nitric acid	Most solvents

h. Eye

Many chemicals damage the eyes, either from direct contact with the eye or from excessive inhalation. Methyl alcohol and aniline are notable eye inhalation hazards. Prolonged inhalation of air concentrations above the safe limit for these materials may cause loss of vision.

Hydrofluoric acid and bromine are serious hazards in direct contact with the eye. If these or similar substances splash into the eye, IMMEDIATELY WASH WITH COPIOUS AMOUNTS OF WATER OVER THE EYE FOR 15 - 20 MINUTES TO PREVENT FURTHER DAMAGE TO THE EYE. NEVER STOP TO SEARCH FOR THE PROPER (RINSING) NEUTRALIZER. Follow up with medical aid.

M. Fire Guidelines

In general, a flammable chemical is determined by its flash point, the lowest temperature at which an ignition source can cause the chemical to ignite. Although the lowest temperature at which the chemical will catch fire with an ignition source is called the "fire point," it is rarely more than one or two degrees greater than the "flash point." Therefore, the flash point will be used as the reference of "fire hazard".

Cal-OSHA, OSHA, Department of Transportation (DOT) and the National Fire Protection Association (NFPA) have guidelines on when a chemical is considered flammable. Those guidelines are herein adopted for use in the laboratory.

"Flammable" is generally used to refer to chemicals with a flash point below 100°F or 37.8°C. Chemicals with flash points between 100°F/37.8°C and 200°F/93.3°C are termed "Combustible." Chemicals having a flash point below 200°F will be considered a "fire hazard" and will be stored in a flammable solvent area or flammable storage cabinet. They will be used in a vented fume hood, away from sources of ignition.

More detailed discussions of fire hazards can be found in Subchapter 7: General Industry Safety Orders, Group 16: Control of Hazardous Substances, Article 109: Hazardous Substances and Processes, Section 5191: Occupational Exposure to Hazardous Chemicals in Laboratories and in Section 4.2 and in OSHA's regulation (29 CFR 1910), NFPA manuals such as NFPA 30, and your local fire codes.

The following are some examples of flammable hazardous substances. In addition to flammable liquids, some solids and gases are flammable. Picric Acid, Benzoyl Peroxide, Calcium Carbide, and Phosphorus are flammable solids.

Some Common Flammable Gases

Acetylene	Carbon monoxide	Hydrogen sulfide
Ammonia	Ethylene	Methane
Butane	Ethylene oxide	Propane
Ethyl chloride	Formaldehyde	Propylene
Ethane	Hydrogen	Carbon disulfide

Common Flammable Liquids

Acetaldehyde	Acetone	Actyl Chloride
Allyl alcohol	Allyl chloride	n-Amyl Acetate
n-Amyl alcohol	Benzene	n-Butyl acetate
n-Butyl alcohol	n-Butylamine	Carbon Disulfide
Chlorobenzene	Cyclohexane	Diethylamine
Diethyl carbonate	p-Dioxane	Ethanol
Ethyl acetate	Ethyl acrylate	Ethylamine
Ethyl benzene	Ethyl dichloride	Ethyl ether
Ethyl formate	Furan	Gasoline
Heptane	Hexane	Hydrazine
Isobutyl alcohol	Isopropyl acetate	Isopropyl alcohol
Isopropyl ether	Mesityl oxide	Methanol
Methyl acetate	Methyl acrylate	Methylal (Dimethoxy methane)
Methyl butyl ketone	Methyl formate	Methyl ethyl ketone
Methyl propyl ketone	Naphtha (Petroleum ether)	Nitrohydrocarbons
Octane	Piperidine	Propanol
Propyl Acetate	Propylene oxide	Pyridine
Styrene	Tetrahydrofuran	Toluene
Turpentine	Vinyl acetate	Xylene

N. Reactivity Guidelines

While NFPA has developed some guidelines on what constitutes a reactive chemical, their emphasis is centered on a fire emergency.

Other guidelines which define reactive chemicals can be found in regulations from Cal-OSHA Subchapter 7: General Industry Safety Orders, Group 16: Control of Hazardous Substances, Article 109: Hazardous Substances and Processes, §5191: Occupational Exposure to Hazardous Chemicals in Laboratories, the Department of Transportation (49 CFR) and the Environmental Protection Agency (40CFR).

A reactive chemical is one which meet any of the following:

1. Ranked by NFPA as 3 or 4 for reactivity;

2. Determined by the U.S. D.O.T. as either:

   a. An oxidizer;

   b. An organic peroxide;

c. An explosive (Classes A, B, or C);

d. Fits the U.S. EPA definition of reactive in 40 CFR 261;

e. Fits the OSHA definitions of unstable or polymer forming;

f. Is found to be reactive with ordinary substances.

Once a chemical has been determined to be reactive, all proper safety precautions will be used including extra segregation in storage and prohibition on mixing with other chemicals without appropriate personal protection and precautions.

1. Pyrophorics

Pyrophoric chemicals ignite on contact with air. Minimize the possibility of explosion by working with small quantities, avoiding friction and sparks, and keeping incompatible materials away. Consider the outcome of an explosion when setting up work.

Some Pyrophoric Chemicals

Boron	Diborane	Manganese*
Cadmium	Dichloroborane	Nickel*
Calcium	2-Furaldehyde	Phosphorus, yellow*
Chromium*	Iron*	Titanium*
Cobalt*	Lead*	Zinc*

*finely divided metals (powders)

2. Explosive or Reactive Chemicals

Explosive or Reactive chemicals can react under a variety of conditions. Some will explode on the slightest mechanical shock. Others explode in the presence of heat, air, light, or water. Mixing of incompatible materials is also a source of explosion hazard; examples are substances which form peroxides. Peroxide formers are usually solvents, such as Diethyl ether, that form peroxide upon exposure to the air. They can become shock, heat and light sensitive such that they may explode. In general, consider the following types of chemicals explosive: acetylide, azide, diazo, halamine, nitroso, ozonide, oxidizers, and peroxide. Following is a table of a few common explosives.

Explosive Chemicals and Storage Requirements

Chemical	Hazard	Safety measures
Dimethyl sulfoxide	Explosive if contacts metal, hydrides or halogens	Segregate from incompatibles.

Ether	Explosive, forms peroxides on contact with air and light	Test for peroxide formation before use.
Hydrogen peroxide	>30% conc. explosive if contaminated with organics	Avoid contamination; keep container closed, avoid contaminated with metals, alkaline, dust, and dirt.
Perchloric acid	Explosive if contact organics	Shelf life up to 12 months; avoid contact with organics; clean up spills with lots of water.
Permanganate	Reacts with organics	Keep organics away; clean up all spills immediately.
Picric acid	Unstable explosive	Use small amounts, limit shelf life, dissolve in hot water then dispose of properly.
Trichloroethylene	Pyrophoric if contacts KOH or NaOH	Segregate from incompatibles.

Procedures for Working with Reactive Chemicals

a. Know how reactive chemicals are set off. Never move, mix, or work with a reactive chemical until you understand its precautions and dangers;

b. Keep reactive chemicals away from flammables. Avoid all sources of ignition, including hot surfaces;

c. Avoid contacting reactive chemicals with incompatible materials. Check the incompatibility data or references available from EHS;

d. Assure proper ventilation of the working area. If the fume hood is not working, get it fixed immediately. Protect yourself with adequate personal protective equipment;

e. Consider the worst possible reaction and plan work to be safe under those conditions;

f. Consult sections of this manual relating to specific nature of reactive chemicals (explosive, peroxide forming, for example).

3. Water Reactive and Light Sensitive Chemicals

Other Reactive Chemicals are hazardous when in contact with water or light. Avoid contact of the following chemicals with water and flammables:

Some Water Reactive Chemicals

Most hydrides	Phosphorous	Sodium
Oxides	Sodium hydrosulfite*	Metal carbides
Acid anhydrides	Alluminum trialkyls	Alkalis

Acetyl chloride	Chlorosulfonic acid	Phosphorous trichloride
Phosphorous pentasulfide	Phosphorous pentachloride	Stannic chloride
Sulfur chloride	Sulfuryl chloride	Thionyl chloride
Magnesium	Lithium	Ferrous sulfide

Some Light Sensitive Chemicals

Bromine	Ethyl ether	Ferric ammonium citrate
Hydrobromic acid	Mercuric salts	Oleic acid
Potassium ferrocyanide	Silver salts	Sodium iodide

* on contact with moisture and/or air.

4. Handling Procedures for Peroxide-Forming Compounds

   a. Always wear safety glasses, or preferably a face shield, and gloves when working or handling peroxide-forming compounds;

   b. Label all containers with date received;

   c. Do not use past either the manufacturer's expiration date or storage limits (see below);

   d. Notify surrounding personnel that you are working with an explosive and instruct them to extinguish all sources of ignition. Also, do not use flames or sparking equipment when working with peroxide formers;

   e. If distilling peroxidizable compounds, a test must first be conducted to ensure no peroxides are present. Also, leave 10% residue when distilling to avoid explosion which occur when residue dries out. Peroxide test paper is available in the Chemistry Department Solutions Stockroom;

   f. Periodically test for presence of peroxides;

   g. If a small spill occurs, absorb quickly with vermiculite or other dry absorbent, and dispose of safely;

   h. Use wooden or ceramic spatulas for handling. Do not use metal spatulas which are incompatible.

   i. Solutions containing peroxides in a volatile solvent should not be allowed to vaporize.

   j. Avoid friction, impact (DO NOT DROP), and actions such as grinding peroxide formers.

5. Storage of peroxide-forming compounds

a. Always purchase small quantities, to ensure that a compound will be consumed before its shelf life expires;

b. Three months is the maximum storage time for opened containers, one year, with some exception, for unopened containers;

c. Avoid storing peroxide-formers in glass bottles with screw caps or glass stoppers. Polyethylene is acceptable, as is metal, if compatible;

d. Store cold or cool, except for ethers, which should never be stored in a refrigerator. Check the freezing point of the chemical, and do not store near this temperature, as this increases the explosive hazard;

e. Avoid storage of peroxides and peroxide forming compounds with acids;

f. Avoid friction that may initiate a reaction;

g. Check monthly for expired containers and dispose of immediately (as hazardous waste);

h. If you suspect a container is unstable and may explode, don't move it. Call EHS at 657-278-7233 immediately and ensure that all persons leave the laboratory;

i. Follow the storage limits listed in the table below.

Storage Limits for Common Peroxide-Forming Compounds

Storage Hazard (Recommended shelf-life 3 months.)	Concentration Hazard (Recommended shelf-life 12 months.)	Polymerization Hazard+ (Recommended shelf-life 12 months.)
Isopropyl ether	Ethyl ether	Styrene
Divinyl acetylene	Tetrahydrofuran	(Butadiene) in first column
Vinylidene chloride	Dioxane	(Tetrafluoroethylene) in first column
Potassium metal	Acetal	Chlorofluoroethylene
Sodium amide	Methyl 1-butyl ketone	Vinyl acetylene
Butadiene*	Methylcyclopentane	Vinyl acetate
Chloroprene*	Cyclohexene	Vinyl chloride
Tetrafluoroethylene*	Vinyl ethers	Vinyl pyridine
Dioxane	Dicyclopentadiene	Chlorobutadiene
	Diacetylene	(Chloroprene) in first column
	Methyl acetylene	
	Cumene	
	Tetrahydronaphthalene	
	Ethylene glycol dimethyl ether (glyme)	
	2-Propanol	

*when stored as a liquid
+add polymerization inhibitor before distilling

6. Disposal of peroxide forming compounds

   a. Small quantities (25 g or less) can be diluted with water to 2% or less, and then added to a polyethylene container with an aqueous solution of ferrous sulfate or sodium bisulfite. Dispose of as hazardous waste (do not mix with any other containers);

   b. Large quantities, opened or not, should be disposed of as hazardous waste through EHS.

   Some compounds which form peroxides, and which should be handled carefully include:

Compounds Which Form Peroxides

Aldehydes	Isopropyl benzene	Allyl compounds
Tetralin (1, 2, 3, 4, Tetra hydronaphthalene)	Cylohexene	Cyclooctene
	p - Dioxane	Ethyl ether
Decalene	2-Propanol	
Vinyl and vinylidene compounds		

O. Corrosivity and Contact Hazard Guidelines

A corrosive chemical is defined by Cal-OSHA, OSHA, DOT, and EPA. A chemical is a corrosive if it fits the definition of corrosive found in regulation:

1. Cal OSHA (Subchapter 7, Group 16, Article 109, §5191)

2. OSHA (29 CFR)

3. DOT (49 CFR)

4. EPA (40 CFR)

5. or it has a very low or very high pH.

A skin or eye contact hazard chemical is one where the chemical's route of entry for its toxic effects is through the skin or eyes. Chemicals which are contact hazards can be determined by consulting SDSs and other references available from EHS.

1. Corrosive

   Corrosives represent the class of chemicals which are hazardous upon contact. These include acids, bases, alkalis, dehydrating agents, and

oxidizers. If a corrosive contacts your skin, eyes, or other body site, that area will burn almost immediately, or in some cases, after a short period of time. Inhalation of a vapor can cause severe bronchial irritation. Take care to avoid contact with these materials, but if skin, clothing, or eye exposure occurs, immediately flush with large amounts of water for at least 20 minutes to avoid burns.

a. Working with Acids

Avoid contact, and store in an acid storage cabinet, or on a low shelf in a chemical storage cabinet. Segregate oxidizing acids from organic acids (see below), flammables, and combustibles. Segregate acids from bases and active metals. Always carry acids in an acid bottle carrier when transporting. Know the location of acid or base spill neutralizing supplies in the building. Oxidizing acids can also present fire and explosion hazards if contacted with organic compounds or other oxidizable chemicals.

Strong Oxidizing Acids	Organic Acids
Chromic acids	Acetic acid
Hydrobromic acid	Benzoic acid
Iodic acid	Formic acid
Nitric acid	Phenol
Perchloric acid	Trichloroacetic acid
Sulfuric acid	Propionic acid
	Sulfamic acid
	Sulfanilic acid

b. Working With Bases or Alkalines

Segregate bases from acids. Store solutions of inorganic hydroxides in polyethylene container (never in glass). Avoid skin and eye contact, and breathing vapors. Ammonia gas and Ammonium Hydroxide are a severe bronchial irritants, avoid inhaling vapors. Metal hydrides are extremely damaging to eyes. Consult medical help if eye exposure occurs.

2. Dehydrating Agents

Dehydrating Agents include concentrated sulfuric acid, sodium hydroxide, phosphorous pentoxide and calcium oxide. Always add these reagents to water to avoid a violent reaction from the large amount of heat generated when water is added to these reagents. Dehydrating agents cause severe burns to the skin and eyes. Wash immediately with large amounts of water if contacted.

3. Oxidizers

Oxidizers are corrosive and fire and explosion hazards. Avoid contact of these chemicals with organic compounds, flammables, combustibles and other oxidizable compounds. Keep away from reducing agents such as zinc, alkaline metals, and formic acid. Store in glass or inert containers, but do not cap with cork or rubber stopper.

Some Common Oxidizers

Ammonium dichromate	Ammonium perchlorate
Ammonium persulfate	Benzyl peroxide
Bromates, salts of	Calcium hypochlorite
Cerric sulfate	Chlorates, salts of
Chromium trioxide	Ferric trioxide
Ferric chloride	Iodates, salts of
Iodine	Magnesium perchlorate
Magnesium dioxide	Nitrates, salts of
Periodic acid	Potassium dichromate
Peroxides, salts of	Potassium permanganate
Potassium ferricyanide	Sodium chlorite
Sodium bismuthate	Sodium nitrite
Sodium dichromate	Sulfates, salts of
Sodium perborate	

P. Exposure Evaluations, Medical Consultations, and Examinations

1. Suspected Exposures to Toxic Substances

There may be times when laboratory workers suspect that they may have been exposed to a hazardous substance in the laboratory to a degree and in a manner that might have caused harm to themselves. If the circumstances suggest a reasonable suspicion of exposure, the laboratory worker is entitled to an exposure evaluation. If the exposure evaluation warrants, a medical consultation and/or examinations will be recommended.

a. Criteria for Reasonable Suspicion of Exposure.

It is the policy of EHS to promptly investigate all laboratory worker reported incidents in which there may be a possibility of overexposure to a toxic (hazardous) substance. The following are examples of events or circumstances which might reasonably be considered as evidence of overexposure:

i. A hazardous substance was spilled, leaked, or released in an uncontrolled manner;

ii. A laboratory worker has direct skin or eye contact with a hazardous substance;

iii. A chemical odor was noticed, especially if the laboratory worker was working with any chemical whose TLV was lower than the odor threshold;

iv. A laboratory worker manifests health hazard symptoms such as headache, rash, nausea, coughing, tearing, irritation or redness of eyes, irritation of nose or throat, dizziness, loss of motor dexterity or judgment, etc.;

v. Some or all the above symptoms disappear when the laboratory worker is removed from the exposure area and into fresh air;

vi. Some or all of the above symptoms reappear soon after the laboratory worker returns to the exposure area and begins to work with the hazardous substances again;

vii. Two or more persons in the same laboratory have similar complaints.

b. Exposures

Once a complaint of a possible hazardous substance exposure has been received, the complaint should be documented along with the decision of appropriate action. If it was decided that no further evaluation of the incident is necessary, the reason for that decision should be included in the document. If a decision is made to investigate the complaint, then an Exposure Evaluation will commence.

2. Exposure Evaluation

Exposure Evaluations should be done under advisement of a qualified safety professional or Industrial Hygienist and include the following:

a. An interview with the complainant and/or laboratory worker involved in the incident;

b. A list of essential information regarding the circumstances of the complaint or incident, including:

i. The chemical(s) under suspicion.

ii. Other chemical(s) used by the laboratory worker.

iii. All chemicals being used by other laboratory workers in the immediate area.

iv. Other chemicals stored in that area.

v. Symptoms exhibited or claimed by complainant.

vi. How these symptoms compare to symptoms described in the SDS for each of the identified chemicals.

vii. Were control measures, such as personal protective equipment and fume hoods, used properly?

viii. Were any air sampling or monitoring devices in place? Can the monitoring results be compared to the complaint?

c. Monitor or sample the air in the area under suspicion for suspect chemicals;

d. Determine if symptoms documented in the interview compare to the symptoms described in the appropriate SDS or other pertinent reference literature;

e. Decide whether to send the complainant for medical consultation and/or examination;

f. Determine if present control measures and safety procedures are adequate. Review procedures in use at time of incident to determine if a change might reduce the possibility of an exposure.

3. Notification of Results of Monitoring

Laboratory workers will be notified within 15 days of receipt of monitoring results.

Q. Medical Consultation and Examination

When, from the results of an exposure evaluation, it is suspected or known that a laboratory worker was overexposed to hazardous substance(s) or chemical(s), the laboratory worker should receive prompt medical consultation. When warranted, the laboratory worker should receive a medical examination supervised by a licensed physician. This medical consultation and/or examination should be done under the supervision of a licensed physician, who is experienced in diagnosing and treating victims of chemical overexposure. The medical professional should also be knowledgeable of tests and procedures, which help determine if there has been an exposure, called "Differential Diagnosis." The following provisions apply to medical consultation and examinations:

1. Laboratory workers who work with hazardous chemicals must be provided an opportunity to receive medical consultation and examination when:

a. The laboratory worker develops signs or symptoms associated with a hazardous chemical to which the laboratory worker may have been exposed in the laboratory.

b. Monitoring determines that there could have been an exposure above the action level, or PEL if there is no action level, for a chemical for which a substance-specific standard has been established.

c. There is a spill, leak, or other uncontrolled release of a hazardous chemical.

2. Provide the physician with:

a. The identity of the hazardous chemical(s) to which the laboratory worker may have been exposed.

b. Exposure conditions.

c. Signs and symptoms of exposure that the victim is experiencing.

d. SDS(s) appropriate to the exposure evaluation.

3. Physicians should furnish a written form to the laboratory worker including some or all of the following:

a. Recommendation for follow-ups, if necessary.

b. A record of the results of the consultation and/or examination and any tests that were conducted.

c. Conclusions about any other medical condition noted that could put the laboratory worker at increased risk.

d. A statement that the laboratory worker has been informed of all results of the medical consultation or examination and of any medical condition that may require further examination or treatment.

4. Documentation

All documentation related to a complaint or incident of actual or possible exposure to hazardous chemicals must be maintained as part of the record. These records will be kept by EHS.

5. Notification

Laboratory workers shall be notified of the results of any medical consultation or examination with regard to any medical condition that exists or might exist as a result of overexposure to a hazardous chemical.

Responsible Executive: Vice President for Administration and Finance
Responsible Office: Environmental Health and Safety
Originally Issued: 1992
Revised: 5/1994, 3/1997, 7/1997, 12/2007, 1/2009, 8/2011, 6/2018, 12/2021