“This manual is under review in order to comply with the changes in regulations of the local and states agencies. However, this document will be effective until the new changes are incorporated in the manual”.

STILL UNDER REVISION

The OSHA Lab Standard and the MSC Chemical Safety Manual

In January 1990, the Occupational Safety and Health Administration (OSHA) released its final ruling on occupational exposure to hazardous chemicals in laboratories. This ruling, commonly referred to as the Laboratory Standard, was to be implemented by January 31, 1991. The Laboratory Standard is a generic, performance-based standard, emphasizing safe handling and use of hazardous chemicals through procedures to be established by the employer and outlined in a written Chemical Hygiene Plan.

In order to comply with the regulations of this standard, the Chemical Safety Manual has been incorporated by the University. It is further required that Principal Investigators develop Chemical Hygiene Plans unique to their laboratories. This manual can serve as a basic model from which all Principal Investigators can create more specific documents. The details of this requirement are outlined below.

Scope and Application

Laboratories are covered by the Laboratory Standard if they use even relatively small amounts of chemicals. The standard supersedes the requirements of all other OSHA standards applicable to laboratories, except for the requirement to maintain employee exposures below permissible exposure limits (PELs). Permissible exposure limits are maximum air concentrations of hazardous chemicals to which an employee can be exposed regularly. If atmospheric concentrations are routinely high, then specific exposure monitoring and medical surveillance requirements apply.

Chemical Hygiene Plan

The basic requirement of the Laboratory Standard is for employers to establish a written Chemical Hygiene Plan (CHP) that outlines specific practices and procedures that ensure employee protection from health hazards associated with hazardous chemicals with which they work. The Principal Investigators have adapted and tailored the Chemical Safety Manual to fit their needs, creating a CHP applicable to the particular circumstances of their laboratory's operations.

Outlined below are the major elements that must be included in each laboratory's Chemical Hygiene Plan:

a) Standard Operating Procedures.

Included in the Chemical Safety Manual are approved operating procedures for dealing with hazardous chemicals; these procedures shall be adopted by individual laboratories to meet the requirements of the OSHA Lab Standard. In addition, the Material Safety Data Sheets (MSDSs) for every chemical in use in the laboratory must be available to all employees of that laboratory. The MSDS provides essential information on chemical handling, containment, and labeling procedures.

b) Criteria to determine and implement specific control measures such as methodology, engineering controls and personal protective equipment.

The Chemical Safety Manual addresses specific control measures such as engineering controls and personal protective equipment. The Safety Office will assist with training and special needs as they arise.

c) A requirement that fume hoods be functioning properly.

Safety Services tests fume hoods at least once a year. Chemical fume hoods should have a minimum face velocity of 100 linear feet per minute with the sash at 25 inches. Call the Safety Office if you have any questions about the chemical fume hoods in your area.

d) Information and training requirements.

Employee training is a central element of the Laboratory Standard. The training shall be appropriate for each specific laboratory and take into account the level of education and knowledge of the individuals being trained. The Department of CASSO offers comprehensive radiation, chemical and biological safety training programs. Contact the Department of CASSO for the current program schedule.

e) Circumstances under which a particular laboratory operation shall require prior approval from the employer.

In most cases, the "employer" will be the Principal Investigator. The Principal Investigator may wish to institute procedures for prior approval for the use of certain extremely hazardous chemicals. A list of extremely hazardous chemicals, as defined by OSHA, is contained in Appendix C of the Chemical Safety Manual. Except for Class IA flammable liquids (those having flash points below 73oF and a boiling point below 100oF), Safety Services does not require prior approval for the possession of any chemicals (check with Safety Services for exceptions); however, an approved laboratory chemical protocol is required as part of the Laboratory Standard Program.

f) Provisions for medical consultation and medical exams.

Whenever (1) an employee develops signs or symptoms of exposure to a hazardous chemical, (2) medical surveillance reveals routine exposure above the action level or Permissible Exposure Limit (PEL) or (3) a hazardous chemical spill, leak, or explosion takes place, employers shall provide employees an opportunity to receive medical attention, including any follow-up exams with Health Services.

The University Occupation Health Clinic will address OSHA Laboratory Standard-related medical consultations and medical exams. Call the **University Occupational Health Clinic** at **x2910** for additional information and the CASSO office immediately if a hazardous exposure occurs during the course of your work.

g**) Designation of a Chemical Hygiene Officer**

OSHA regulations stipulate that a Chemical Hygiene Officer must be designated for each laboratory.

Since Principal Investigators hold the primary responsibility for safety in their laboratory, the Principal Investigator will therefore be designated as Chemical Hygiene Officer. The department chairperson may, under special circumstances, designate an alternate person to assume this responsibility.

h) Development of additional protection when working with select carcinogens, reproductive toxins and substances with a high degree of acute toxicity. Protective measures include the following:

* establishment of a designated area
* use of containment devices
* procedures for safe removal of waste
* decontamination procedures.

The effectiveness of the Chemical Hygiene Plan must be reviewed annually within each laboratory. Additionally, CASSO Office conducts safety inspections to ensure chemical hygiene and laboratory safety procedures are up-to-date and in compliance.
This introduction summarizes the requirements of the OSHA Lab Standard, Code of Federal Regulations, Chapter 29, Section 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories." If you have any questions as to what is required for the development of the Chemical Hygiene Plan or wish to obtain a copy of the standard or information on any other aspect of the OSHA Lab Standard, contact CASSO Office at 758-2525, x1054.

Chapter 1
GENERAL CONSIDERATIONS

I. SAFETY POLICY

This manual has been written to acquaint all laboratory personnel with an important phase of their responsibility--safety, or accident prevention. Accident prevention must be included in the performance of every task. It cannot be considered a separate entity but is an integral part of everyone's work. Safety is made possible by careful planning of all work based on an understanding of the hazards involved and a knowledge of the work area and safe working procedures. The policy is to provide a safe and healthy work environment and to prevent injury to personnel and loss or damage to property.

Accident prevention pays in the injuries it prevents, the research time it saves and the healthy attitude it creates. It also assures us that we will return home safely after each day's work.

The objective of this manual is two-fold:

1. To provide guidelines and recommendations for safe laboratory practices

2. To comply with the Occupational Safety and Health Administration's law on laboratory safety

This manual is not intended to be, nor can it be, complete and all-inclusive.

II. RESPONSIBILITY

The implementation of this policy is the responsibility of the managerial and supervisory staff of the University. Vice Presidents, Deans, Chairpersons, Directors, Heads of Units, Laboratory Supervisors, Principal Investigators and all other supervisory personnel will be accountable for the health and safety of employees engaged in activities under their supervision. This responsibility cannot be delegated. Supervisors must realize that it is their responsibility to ensure that workers are educated about safety issues and comply with safety rules. Supervisors must simultaneously promote safety and insist upon it.

CASSO Office will assist supervisory personnel in establishing and maintaining a safe working environment. This department will initiate the establishment of standards and regulations for safety, education, information monitoring and recommendations for improvements. Safety Services will also maintain and provide facilities to ensure safety.

III. EMERGENCIES AND FIRST AID PROCEDURES

A. Emergencies

Each laboratory should develop its own protocol for emergency situations, taking into account the following information:

1) RCM Emergency Telephone Numbers:

Numbers 758-2525

* Emergency (Injury, Fire, Life-endangering spill) x2911
* Security Department x1000
* Department of Occupational and Environmental Safety

* Radiation Safety Division X1648, x1647
* Safety Services Division x1054

2) General Emergency Procedures

* Alert those working in the critical areas.
* Call for help - Dial 2911.
* Give description and location of the event as clearly as possible.
* Indicate if an ambulance is needed.
* Specify location where ambulance attendants, fire fighters or police will be met by the caller.
* Do not hang up the phone.

* In case of an injury or chemical splash:

1. Remove the source of the chemical hazard and any contaminated clothing.
2. In case of a chemical splash into the eyes, flush them in an eyewash station or running portable eye wash for 15 minutes. See Chapter II, Section II for further discussion of eyewash procedures.
3. If a chemical comes in contact with the skin, rinse thoroughly with water by using a safety shower or faucet.
4. In case of an accident, serious illness, or injury, do not attempt to move the injured person. Call Security (x2911). Remember: All injuries are potentially dangerous. It is better to err conservatively and have the injury inspected as soon as possible by medical personnel.
5. Report all incidents to your department chairperson and the Director of CASSO Office in writing.
6. Students who suffer injuries in the lab must report to their supervisor (professor) or teaching assistant after receiving assistance. Minor injuries can be treated at the University Occupational Safety Clinic. For serious injuries and/or ambulance call x2911.
7. Faculty or staff members who suffer relatively minor injuries during working hours (8:00 a.m.- 5:00 p.m.) can receive treatment at the University Occupational Safety Clinic (x2911). At all other times report to the Emergency Room of Centro Medical.

B. First Aid Procedures

These first aid tips are intended as emergency measures only. Promptly consult University Occupational Safety Clinic after first aid is applied. All minor *non-trivial* injuries should be reported to responsible personnel, such as department heads or safety coordinators, and Workers' Compensation.

1) **Bleeding.** Rubber gloves must be worn when handling bleeding individuals. Control bleeding by direct pressure with the

hand over a gauze or cloth. Elevating a bleeding arm or

leg may be helpful. Apply pressure to pressure points between

the wound and heart, if necessary. Some people have a mild shock reaction when they see their own blood. If this happens, have the person lie down and elevate their legs.

2) **Burns**. Application of ice or cold water can lessen the amount of pain and blistering. Do not apply ointments, butter, or similar substances. Major burns require medical care.

3) **Electric shock**. Disconnect power to device or apparatus before touching victim. Mouth-to-mouth resuscitation and external cardiac massage (cardiopulmonary resuscitation or CPR) may also be required. **This should be done ONLY by trained people.** Dial 9-911 for an ambulance.

4) **Inhalation of Toxic Materials** (gases, vapors, fumes, mists and dusts). Anyone who has inhaled irritating or toxic materials should be immediately removed to fresh air and emergency medical services should be called to the scene (call 9-911). Do not give mouth to mouth resuscitation.

5) **Head injuries**. If the victim is dazed or unconscious, call x2911 for an ambulance.

6) **Back injuries**. The patient should not be moved unless a life-threatening situation exists. Call x2911 for an ambulance.

7) **Shock**. A person in shock should lie down with legs elevated, unless there is bleeding from the head. Keep the victim warm.

8) **Eye Splash**. Flush eyes immediately with running water for 15 minutes at an eyewash station. If contact lenses are worn, remove them before flushing eyes. The injured person should then be sent to medical services.

9) **Small cuts and abrasions.** Clean with soap and water and cover with a band-aid or sterile dressing.

C. Hazardous Chemical Spills

Accidents involving hazardous chemicals require special consideration. The following steps MUST be taken:

1) **<u>Evacuate affected area at once. Call CASSO Office at x1054.</u>**

2) **<u>DO NOT REENTER THE AREA UNTIL CASSO Office has arrived and indicates that it is safe to do so.</u>**

a) The importance of keeping everyone out of the room where the accident occurred cannot be overemphasized. If a hazard exists and the area must be entered, personnel from CASSO Office can do so in protective clothing that allows them to work safely in contaminated environments.

b) Remember that even though an area looks safe, it may still be dangerous. Chemical spills may evaporate and be swept away rapidly or may remain for a long time. Probability of fire or explosion is high when flammable solvents are spilled and ignition sources are present.

c) Any incident in University Hospitals which involves RCM personnel must be reported to CASSO Office.

3) Post signs "DANGER- DO NOT ENTER, CONTAMINATED AREA." Notify CASSO Office, x1054, of the circumstances and that the sign has been posted.

a) CASSO Office will assist supervisors in cleaning up the spill and directing exposed persons to treatment and check-up facilities.

b) Supervisors are responsible for submitting appropriate accident reports to CASSO Office and Occupational Safety Clinic.

D. Decontamination Procedures

1) Chemical Spill Response: General

Spills of many innocuous laboratory chemicals can be handled by laboratory personnel with appropriate procedures outlined below. If laboratory personnel have knowledge of the chemical involved and can discern that the spill does not pose any hazards, clean-up may begin without the presence of safety technicians from Safety Services. If at any time there is any doubt as to the nature or extent of the hazard, call CASSO Office.

Regardless of the nature of the spill, contact CASSO Office before proceeding with any decontamination or cleanup.

2) Chemical Spill Kit

Spill kits should be available in every laboratory. Spill clean-up kits suitable for responding to typical laboratory spills are available from commercial services. Alternatively, you may prepare your own spill kit. A spill kit should contain the following items:

* spill pillows
* silicon-based absorbent such as Oil-Dry, kitty litter or vermiculite
* dust pan

* broom or brush
* plastic bags
* waste labels
* rubber gloves (check chemical compatibility before use)
* rubber boots or foot protectors
* chemical splash goggles

IV. LABORATORY DECOMMISIONING PROCEDURES

CASSO Office has developed the following decommissioning procedures for PIs whose research will terminate. Follow these guidelines when preparing to leave the University:

1. Send a letter to CASSO Office stating you wish to terminate your status at least 3 weeks prior to departure. Indicate which of the following procedures you have completed at this time. All of the following must be completed prior to your termination.

2. All equipment that has a RMC inventory control sticker present must be released from the university. In addition, the facility to which you will be moving must accept the equipment into their facility by written reply.

3. All mechanical, electrical, and other laboratory equipment that is to be removed from the University must be examined by CASSO Office. The survey must also include a PCB check (e.g. capacitors and transformers found in electric/electronic equipment) performed by Plant Services prior to removal from the University property. Contact CASSO Office for PCB determination and proper labeling if the equipment is to leave the University or be placed in the University storage area.

4. All chemicals need to be packed and moved by professional services. For transporting chemicals please contact CASSO Office for Transportation (DOT) information. He will arrange for a contractor to move your chemicals according to DOT standards. A letter from the

new facility's Safety Officer stating acceptance of the materials must be presented to CASSO Office.

5. All chemicals that will not be taken to your new location must be either disposed of by CASSO Office or transferred to another PI. Any RCM investigator to whom you transfer part of your chemical inventory must present an acceptance letter of that material and an updated chemical inventory to CASSO Office. All chemical, radioactive, biohazard, and sharps waste must be removed prior to moving the lab. There should not be leftover chemicals or materials left upon departure.

6. Contact the CASSO Office for disposal and recycling information.

7. Make sure that all equipment is decontaminated. Equipment which will be moved to another location on or off campus must be cleaned If you use carcinogenic, biohazardous, or other hazardous materials, these hazards must be eliminated prior to handling of the equipment.

8. Remove chemical and biohazardous labeling from the laboratory when informed to do so by CASSO Office.
Contact CASSO Office (x1054) if you have any questions concerning the above procedures. Procedures for decommissioning laboratories using radioactive materials are available in the Radiation Safety Manual. It is important that these procedures be completed before you leave.

Chapter 2
SAFETY RULES FOR LABORATORIES

I. STANDARD OPERATING PROCEDURES

A. Introduction to Safe Laboratory Practices

A number of rules for safe laboratory practice are outlined below. This listing is intended to provide a practical base line for laboratories required to handle hazardous chemicals. Because of the nature of specific chemical hazards, this list is not comprehensive, but it will help investigators to provide an appropriate safety plan for their laboratories.

The University Department of Occupational Safety and Health is available for consultation on all safety and health issues at 758-2525 x1054.

1) General Safety

a) **Be alert to unsafe conditions and actions and call attention to them so that corrections can be made as soon as possible. Safety is a community responsibility.**

b) Post warning signs when unusual hazards such as radiation, lasers, flammable materials, infectious agents or other special hazards exist. **Signs are to be posted on all entrances to the laboratory. Three panel signs are available from CASSO Office. All laboratories must also post emergency contact information. Make sure these signs are clearly visible.**

c) Unauthorized personnel (minors and the general population) are prohibited in all laboratories.

d) Visitors in laboratories must be accompanied by faculty or staff members or a graduate student. Visitors must wear eye protection while in laboratories that may present a chemical or physical hazard.

e) No undergraduate laboratory class work shall be carried out in the absence of an instructor. Unauthorized experiments and horseplay are prohibited. Unapproved variations in experiments, including changing the quantities of reagents, may be dangerous, and must be strictly guarded against in undergraduate laboratories.

f) DO NOT CARRY OUT HAZARDOUS PROCEDURES WHEN WORKING ALONE. This rule may be relaxed whenever there is another person within call.

g) Eating, drinking, chewing gum, applying cosmetics and hand lotion, and smoking are prohibited in laboratory areas.

2) Personal Protective Equipment (PPE)

a) Clothing shall be appropriate to the laboratory--long pants and regular shoes, for example. Sandals or open-toed shoes, shorts, ties or other dangling clothing can pose a threat in the laboratory.

b) Lab coats, gloves, and other PPE shall not be worn outside the laboratory area.

c) Wear proper eye protection when working in a laboratory.

d) Contact lenses are a risk when working with hazardous chemicals. Particulate matter, vapors, and liquids can lodge behind the contact lenses and cause considerable eye damage before they can be washed out with water from an eyewash station. In addition, solvent vapors can weld contact lenses to your eyes, requiring surgery to remove them.

e) Select appropriate gloves when working with toxic or corrosive materials. Call the glove manufacturer or consult Appendix D for discussion of glove compatibilities. See Chapter II, Section B, for more information on glove selection.

f) Proper personal protective equipment must be worn at all times in the laboratory. Avoid direct contact with all chemicals. Keeping chemicals away from hands face and clothing (including shoes or other foot-covering) is especially important. Many substances are readily absorbed into the body and through the skin, or may enter through the mouth because of contamination of the hands. In case of any accidental contact with chemicals, wash immediately with soap and water, but take care not to abrade the skin.

g) A change of clothing should be available in the laboratory in case of an accident.

3) Physical Housekeeping

a) Aisles and hallways shall have proper egress. (see glossary for definition)

b) Keep drawers and cabinets closed while working. Avoid slippery floors by picking up any ice, glass beads, glass rods, or other small items. Mop up any spilled water.

c) Keep workplace uncluttered--benches, desks, and tables are work areas, not storage space. Have only necessary materials (instructions, notebook, pen or pencil) at hand. Keep workplace free from extraneous chemicals and non-essential objects.

4) Safety With Chemicals

a) All heating of chemicals must be performed in a fume hood. Prior to heating a liquid, place boiling stones in vessels (other than test tubes). Use a thermometer in a boiling liquid if there is the possibility of a dangerous exothermic decomposition, as in some distillations. Explosions are one of the most serious physical hazards in the laboratory.

b) *Never* put your nose directly over a container to smell the contents.

c) *Never* look down the opening of a vessel unless it is empty.

d) Caution should be used when opening bottles on which the lid or stopper is stuck; for example, wrap the bottle with a towel and place it in a container before applying more force.

e) All containers containing hazardous chemicals must be clearly labeled with the contents of the container. Use the complete chemical name, not abbreviations (See Chapter Four, Section I, Part B).

f) Never use any substance from an unlabeled or inadequately labeled container. Any unlabeled containers should be disposed of according to the University Guidelines on Waste Disposal (See Chapter Four, Section I, Part B).

g) Flasks containing large volumes of toxic solutions, volatile solvents, boiling liquids and so forth, should be kept in pans large enough to contain the contents if the flask breaks. These should also be transported in appropriate transport containers.

h) All chemicals or biological material with an objectionable odor should be kept in the hood or in an appropriately vented safety cabinet.

i) Use of chemicals shall be guided by precautions indicated in the chemical's MSDS.

5) Waste Disposal

a) Hazards to the environment must be avoided by following required waste disposal procedures (See Chapter Four).

b) Chemicals shall not be poured down drains. See Chapter Four for waste disposal procedures.

B. Laboratory Practices for Specific Procedures

1) Flammable Substances

a) Learn the location and the use of the nearest fire extinguisher.

b) A hood should be used for reactions in which flammable vapors are released, e.g., during the distillation of ether. If noxious or flammable gases are likely to be evolved in any process, the experiment must be confined to a fume hood behind an explosion shield. See Chapter Two, Section II, Subpart b for a complete discussion of fume hoods.

c) Ethers and other peroxide-forming chemicals should be dated when they are received and when they need to be disposed of. Ether should not be stored past the expiration date. Purchased ethers generally contain inhibitors to prevent the build-up of peroxides. Any distilled or processed ether no longer contains these inhibitors and should be used immediately or disposed of. Follow the disposal procedures for ethers described in Chapter Four.

d) Do not pour ether, petroleum, or other flammable water-immiscible liquids into sinks to be washed down with water. Fires and explosions have been caused in laboratories by vapors returning through the drainage system (e.g., during aspiration or rotary evaporation). See Chapter Four for general waste guidelines.

e) Set up and label special waste receptacles for paper and glass. Oily rags and other oil-impregnated materials shall be stored in an approved, covered metal container and disposed of by placing the container in the trash bin.

f) Never use flammable substances close to an open flame or if an open flame is being used in the same laboratory

2. Reactive Substances

a) When conducting a reaction where there is any possibility of even a mild explosion, use of a shield that is sufficiently large and strong to protect the body, especially face and hands. Eye protection must be worn even when using a shield.

b) When sodium, potassium, or lithium are used, the cuttings or residual pieces must be properly disposed of immediately. Store any of these metals in kerosene, oil, toluene, xylene, or other saturated hydrocarbon.

c) Never leave chemical reactions which have not achieved kinetic equilibrium unattended. Follow MSDS recommendations.

3. Corrosive Substances

a) Always pour acid into water, never water into acid, as it can cause an exothermic reaction. For the same reason, pour concentrated solutions into water or less concentrated solutions while stirring.

b) *Always* rinse the outside of acid bottles before opening them. Do not put down a stopper from an acid bottle on a surface where a person may rest a hand or arm. Keep acid bottles tightly stoppered; rinse and dry them before replacing them on the reagent shelf. Make certain that no spills remain on tables, floor or bottle.

c) Bottles containing acids or other corrosive liquids shall be carried in the protective containers supplied for that purpose. Follow any other recommendations in MSDS.

d) Use the proper techniques for inserting and removing a glass tube from a stopper. Protect your hands. Shortcuts can lead to a severe puncture wound.

4. Electrical Equipment

a) All electrical connections should be grounded.

b) Service cords for electrical equipment should be in good condition. Frayed cords or exposed wires should be repaired by qualified personnel.

c) Avoid overloading circuits. Do not use multiple outlet plugs for additional connections.

d) Do not handle any electrical connections with wet hands or when standing in or near water.

e) Do not use electrical equipment, such as mixers or hot plates, around flammable solvents.

f) Do not try to repair equipment yourself unless you are qualified and fully understand the repairs required. All repairs should be done by qualified personnel.

g) Never try to bypass any safety device such as fuses, on a piece of electrical equipment.

h) In case of a fire on or near any electrical equipment, turn it off if it can be done so safely.

5. Apparatus

a) Use pipetting devices. Do not mouth pipette chemicals or solutions.

b) Know the location of the nearest safety shower, fire extinguisher, fire blanket, eyewash station and clean-up kit to be used after a chemical has been spilled.

c) Apparatus attached to a ring-stand should be positioned so that the system's center of gravity is over the base and not to one side--the lower the better. Leave adequate room for removing burners or baths.

d) Equipment with moving parts (gears, belts, pulleys) must be equipped with protective guards.

e) Make sure all personnel who operate centrifuges are well-trained. Centrifuge tubes should be in good condition, with no chips or other flaws. Tubes and rotor buckets must be balanced when in use. Inspect the rotors periodically and do not use them beyond their stated lifetime.

f) Each water supply outlet within the laboratory must be equipped with either a vacuum breaker or a back flow prevention device. No auxiliary plumbing should be connected to a water distribution line unless adequate back-flow prevention is provided.

g) Secure all gas cylinders against walls or lab benches with safety straps or chains to prevent them from toppling over.

h) Use undamaged, clean glassware without chips or other flaws.

i) Dewar flasks should be taped when in use or enclosed in metal mesh to protect personnel from flying glass in case of breakage.

j) Glass devices in vacuum systems should be epoxy-coated, taped, or shielded with glass or wire mesh to protect personnel from fragmentation.

k) Sink traps and floor drains should be kept filled with water at all times to prevent escape of sewer gases into the laboratory. Such gases may be toxic or flammable and may be ignited, causing flash fires.

l) DO NOT USE or allow burners, hot plates, or non-explosion-proof motors near experiments which may generate flammable gases.

m) Use beaker covers to prevent splattering when heating liquids on a hot plate. Keep a pair of tongs conveniently at hand. A specific tong for the dish crucible, beaker, casserole or flask should be used.

n) In general, if apparatus is likely to shatter, either because of pressure or vacuum, surround it with mesh or cloth to limit the travel of shattered glass particles.

o) Glassware or any potential "sharps" (including chemical bottles and test tubes) should be set well back from the front edge of the work bench to lessen the risk of injury if there is an accidental breakage of glass.

p) Adequate traps must be used in vacuum systems. Do not release the vacuum in any apparatus when the temperature is above 150 degrees Celsius. Since the hot vapors may explode.

q) Oven temperature regulators should be checked periodically to ensure they are working reliably.

r) Bunsen burners should never be left burning when not in use. They should be turned off at the petcocks--do not depend upon the valve at the base of the burner.

s) If possible avoid the use of natural gas in laminar flow hoods or non-vented hoods. Inadequate use (high flames or unsupervised burners) can harm the NEPA filters of biological safety cabinets.

II. PERSONAL PROTECTION: METHODOLOGY, ENGINEERING CONTROLS AND PERSONAL PROTECTIVE EQUIPMENT (PPE)

A. Introduction

Methodology, engineering controls and personal protective equipment are designed to address and prevent hazards associated with the introduction of chemicals into the body. The major routes of entry into the body are inhalation, skin absorption, ingestion, injection, and subcutaneous entry. Engineering controls that ventilate gases, vapors, and small particulates are designed to eliminate the hazards associated with inhalation, the major route of entry. Personal protective equipment (PPE) is designed to eliminate exposure through all above routes of entry.

Personal protective devices are to be used only where methodology or engineering controls cannot be used or while controls are being implemented.

B. Methodology

Methodological procedures are those incorporated into activities in order to eliminate or minimize the potential for exposure. These include:

* isolation of the operator or the process
* hazard education
* job rotation to limit exposure to hazardous substances
* substitution of less hazardous equipment or process (e.g. safety cans for glass bottles)
* substitution of a less hazardous substance

C. Engineering Controls

Engineering controls include tools or devices that limit exposure to a hazard:

* local and general ventilation (e.g. use of fume hoods)

*   use of biological safety cabinets or glove boxes
*   placing walls or increased distance between the operator and the hazard
*   using appropriate disposal containers

1) Laboratory Ventilation

a) Control of Air Flow in the Laboratory

Safety in laboratory areas partially depends upon keeping infectious, toxic and flammable airborne materials away from personnel. Controlling air flow helps accomplish this.

b) Doors to Laboratories

In general, doors to laboratories should remain closed. When the air flow is correctly balanced, air pressure in the corridor is higher than in the laboratories and the air flows under the doors and through the door slots into the laboratory. This moving curtain of air keeps airborne substances generated in the work areas from entering the corridors.

2) Chemical Fume Hoods

a) General

Hoods offer two significant types of protection from atmospheric exposure to hazardous materials:

i) local ventilation to prevent toxic, offensive, or flammable vapors from entering the room.

ii) a physical barrier between the researcher and the chemical reaction when that reaction is performed in a hood, especially with the hood sash closed. This barrier can protect researchers from hazards such as chemical splashes or sprays, fires and minor explosions.

Hoods should be considered primary safety devices that can contain and exhaust toxic, offensive, or flammable materials when the design of an experiment fails and dusts or vapors escape from the apparatus being used. Hoods should never be used as a means of disposing chemicals.

A properly functioning hood should have an average face velocity of at least 100 linear feet per minute (lfm) at a sash height of 25 inches or greater.

Chemical fume hoods are tested at least annually by Safety Services. If you need assistance or more information about a chemical fume hood in one of your laboratories, or if your fume hood is not posted with a label showing that it has been tested in the last year, please contact CASSO Office at x1054.

NOTE: Use perchloric acid in a specifically designated fume hood. DO NOT use other chemicals in that hood. Clearly mark that the fume hood is for use only with perchloric acid.

b) Safe Hood Work Practices

i) Keep work surfaces clear

ii) Make sure the exhaust blower is operating and air is entering the hood prior to starting an experiment.

iii) Periodically check air flow through the hood using a source of visible smoke or other air flow indicator, such as a Kimwipe. If there is a problem with air flow, call CASSO Office (x1054).

iv) Do not disable flow measurement devices or alarms.

v) Work with the sash at the proper operating level as indicated by CASSO Office test arrows.

vi) Do not place your face inside of the hood. Keep hands out as much as possible.

vii) Keep sources of emission at least six (6) inches inside the hood.

viii) Do not store chemicals in the hood. Clean up all minor spills immediately.

ix) Avoid blocking the baffle exhaust slots in any manner. Keep large equipment two (2) inches off the base of the hood and two inches from the sides of the hood.

x) Be aware of other room ventilation factors that may interfere with your hood operation, such as open doors, open windows, blocked exhaust ports or heating and air conditioning vents.

xi) Avoid cross drafts and disruptive air currents in front of the fume hood.

xii) Use the sash as a safety shield when boiling materials or conducting an experiment with reactive materials.

xiii) Close the fume hood sash when the fume hood is not in use.

3) Use of Laminar Air Flow Equipment

*note: Laminar flow hoods are not safety devices. If biological safety is an issue with your work, use a biosafety cabinet with or without glove attachments as warranted by the experiment. Biosafety cabinets include 100% exhaust laminar flow hoods and glove boxes with chemical traps or exhaust access to a fume hood.

Laminar flow equipment will be leak tested, adjusted or repaired by a certified contractor.

Two types of laminar flow equipment, the laminar flow clean bench and the biological hood, are discussed in this section.

a) Laminar Flow Clean Bench

The laminar flow clean bench protects the product from airborne contamination, but does not protect the operator. Because of the risk to personnel, work with hazardous material on a laminar flow clean bench is not advisable. Use of clean benches should be limited to the preparation of sterile media, the assembly of sterile components into complete units (e.g., membrane filters), the examination of sterilized equipment and materials for possible contamination, and similar operations. **Work with pathogens is not permitted.**

A large number of companies manufacture both vertical and horizontal laminar flow clean benches. Most of the commercially available equipment is adequate when:

* The High Efficiency Particulate Air (HEPA) filter has been tested and certified. To meet standards, this filter should be at least 99.97 percent efficient in removing particles 0.3 microns or larger by the di-octylphthalate (DOP) test.
* The HEPA filter housing has been properly sealed around the edges to prevent unfiltered air from bypassing the filter.
* The air flow is adjusted to 80-100 linear feet per minute.
* The pre-filter is periodically cleaned or replaced when the magnahelic gage indicates it is full because of a pressure drop.

b) Biological Hood

The biological hood protects both product and operator and may be used for organisms which exceed biosafety level 2. (See CDC/NIH publication **Biosafety in Microbiological and Biomedical Laboratories,** 3rd ed, USDHHS, 1996, for a list of organisms and applicable biosafety levels. Check their website for information: http://www. cdc.gov/ods/ohs). Safety and desirability of using this equipment to contain infectious material should be determined on an individual basis, depending upon the agent, the proposed activity, and the need to prevent cross-contamination. This hood, however, cannot replace the standard gastight Class III biological safety cabinet for extremely hazardous work.

D. Personal Protective Equipment (PPE)

Along with engineering controls and carefully planned workplace methodology, personal protective equipment (PPE) is the key element in minimizing the potential for worker exposure to chemicals.

Proper use of PPE requires that the supervisor assess the hazard presented and attempt to apply engineering controls and/or administrative controls first. PPE is used when engineering controls and/or administrative controls will not be effective.

The performance of PPE as a barrier to chemicals is determined by the materials and quality of its construction. Three important factors to keep in mind when considering PPE are:

1) in general, there is no such thing as "impermeable" plastic or rubber clothing;

2) no one clothing material will be a barrier to all chemicals;

3) for certain chemicals or combinations of chemicals, there is no commercially available glove or clothing that will provide more than an hour's protection following contact. In these cases, it is recommended

that PPE be changed frequently or as soon as it comes into contact with the chemical or mixture.

Of principal importance in the selection of PPE for protection from chemicals is the rate at which chemicals permeate clothing materials and the time elapsed between the contact with the chemical and the appearance of the chemical on the inside of the PPE, called breakthrough time.

1. Respirators

The basic purpose of any respirator is to protect the respiratory system from inhalation of hazardous atmospheres. Respirators provide protection either by removing contaminants from the air before it is inhaled or by supplying an independent source of respirable air.

Safety Services has implemented a comprehensive Respiratory Protection Program. This training involves taking a physical exam at Health Services and getting properly trained and fit-tested with a respirator. Contact the CASSO Office for further information.

2. Gloves and Lab Coats

a) Gloves

Gloves are a type of PPE that should be used frequently, selected on the basis of chemical compatibility (see Appendix D). In general, latex gloves do not provide adequate protection and are not recommended for any chemical operations.

Reusable gloves that are readily available on campus include:

* Neoprene - Provides protection against a broad range of corrosive chemicals. Resists oils, greases, alcohols, resins, alkalis, and many solvents. Neoprene is poor for chlorinated aromatic solvents, phenols, and ketones.
* Nitrile-Butadiene Rubber (NBR) - Marketed as SOL-VEX or Nitrile. Work well in aromatic petroleum and chlorinated solvents. Resistant to cuts, snags and punctures.

Contact CASSO Office or refer to the glove compatibility table listed in Appendix D for the best glove for your operation.

b. Lab Coats

Lab coats should always be worn during active work in the laboratory. They should be buttoned to protect more completely. Lab coats are loose-fitting by design, so that in case of chemical contact there is ample time to react before the chemical gets to the undergarments and ultimately to the skin. They should not be taken home or taken home to be washed; instead arrangements should be made in the lab group for laundry service.

3. Eye Protection

This guide defines eye-hazard areas where wearing eye-protective equipment is mandatory. It also sets forth the supervisor's responsibilities, both in identifying locations where possible damage to the eyes could occur and in enforcing precautionary procedures in these areas.

The Occupational Safety and Health Act of 1970 and good safety practices dictate that "protective eye and face equipment shall be required where there is a reasonable probability of injury that can be prevented by such equipment--suitable eye protectors shall be provided where machines or operations present the hazard of flying objects, glare, liquids, injurious radiation, or a combination of these factors."

The type of eye protection required depends on the hazard. For most situations, safety glasses with side shields are not adequate. Where there is danger of splashing chemicals, special non-ventilated sealed goggles are required. For more hazardous operations, a face shield or a combination face shield and safety goggles or glasses (some of which may be supplied with prescription lenses) should be used. Failure to wear the prescribed eye-protection equipment will be grounds for disciplinary action. CASSO Office will assist in the choice of suitable protective equipment.

a) Special Hazards

Contact lenses shall not be worn by persons exposed to hazardous chemicals. It is the responsibility of supervisors to identify employees who wear contact lenses. Contact lenses do not provide eye protection. The capillary space between the contact lenses and the cornea may trap material present on the surface of the eye. Chemicals trapped in this space cannot be washed off the surface of the cornea. If the material in the eye is painful or the contact lens is displaced, muscle spasms will make it very difficult to remove the lens.

Supplies of caustic chemicals, e.g. ammonia solution, liquid phenol, acids, strong bases, etc., should be stored no higher than countertop level to minimize the possibility of facial and upper body burns in the event of spills or breakage of containers. It is also a good practice to use the smallest size container compatible with the need.

b) Eyewash Facilities

Emergency eyewash facilities shall be available in areas where:

* Corrosive or caustic materials are handled

* Explosive materials are handled
* Hollow glassware is under vacuum or pressure
* Cryogenic materials are handled
* Flying particles may be generated (grinders, mills, power saws, drill presses, lathes, etc.)
* Molten metal is used or metal is melted (soldering, leading joints, etc.)
* Gas or electric arc welding is done
* Processes can produce aerosols of infectious agents (e.g., removing lyophil vials from liquid nitrogen)

c) Supervisor's Responsibilities

i) The supervisor is responsible for:

* Determining that an eye hazard exists
* Placarding the work area with proper signage
* Determining the type of eye protection equipment needed
* Obtaining necessary assistance from Safety Services
* Ensuring that the equipment is available to employees
* Ensuring that the necessary personal protective equipment is worn by employees
* Supplying all PPE as necessary

ii) Failure of the supervisor to enforce eye-protective requirements will be grounds for disciplinary action.

If you have a condition which requires special consideration, please contact Safety Services (x2907).

III. CHEMICAL STORAGE

A. General Rules

Contact CASSO Office for any assistance.

1) Keep minimum quantities of chemicals in the laboratory. Purchase only what is needed. Never acquire more than a year's supply of reactive or combustible chemicals.

2) Chemicals shall be stored in cabinets or on shelves. Long-term storage of chemicals on the floor, on benches, or in hoods is discouraged. Liquids should be stored below eye level.

3) Use spill trays under containers of strong reagents. Perchloric acid should be kept on glass or ceramic trays of sufficient capacity to hold all of the acid in case of breakage.

4) Do not store chemicals past their expiration date. Ethers, for example, generally contain inhibitors to prevent the build-up of peroxides. Any distilled or processed ether no longer contains any inhibitors and should be used immediately or disposed of. Follow disposal procedures for ethers described in Chapter Four.

5) Store chemicals according to compatibility. Within compatible classes, chemicals may be stored alphabetically. See Appendix E for a table of incompatible chemicals or consult your MSDS.

6) Label all containers (new bottles as well as temporary containers) properly. Information that should be on the container is as follows: your name, PI , date, contents, purity, location, hazards (if known).

7) Dispose of unwanted chemicals promptly. See waste disposal procedures, Chapter Four, Section A).

B. Storage of Flammable Solvents

1) Policy

This guide establishes policy and describes cabinets for storing flammable solvents in the lab. In this guide, flammable solvents are defined as liquid substances having a flash point below 140_ F and having a vapor pressure not exceeding 40 p.s a. at 100_ F.

The following items will be stored in National Fire Protection Association (NFPA)-approved solvent storage cabinets:

a) All containers of flammable solvents larger than one half-gallon.

b) All flammable solvent supplies, when cumulative amounts of greater than two gallons are kept in one laboratory room.

2) Storage Cabinets

Several sizes of cabinets are manufactured, allowing a choice to fit funds and available space. Many laboratories may require storage of only a few solvents and the supervisors may wish to share cabinets with adjoining laboratories.

Commercially manufactured flammable solvent storage cabinets are sold by several laboratory supply firms. These larger boxes hold either 30 or 45 one-gallon containers. CASSO Office can advise on NFPA-approved cabinets.

Laboratory supervisors should determine their storage needs and order appropriately sized cabinets.

IV. HAZARD WARNING SIGNS

In an effort to bring the system of signs used at RCM into agreement--to warn of danger and to direct "pedestrian traffic" away from laboratory work areas-- uniform hazard warning signs will be provided by the CASSO Office. This guide describes the signs and setsforth the conditions under which the signs are to be posted. It is important that all employees and visitors comply with the policy for entering areas where these signs have been posted.

A**.** Description

Samples of commonly used warning signs are illustrated in Figure 2. The signs inform employees and visitors that a hazard exists in an area. The degree of danger is indicated by the sign. In high risk areas, admission is forbidden to all except those assigned to that area. In lower risk areas, visitors must secure permission to enter from the investigator in charge of the work.

B. Policy

The investigator in charge of the laboratory is responsible for posting the signs in accordance with policy set forth in this guide. Upon request, CASSO Office will assist investigators in determining the need for posting warning signs.

The signs will be posted only while a hazard exists and must be taken down as soon as the source of danger is removed. Hazard signs will not be posted when no hazard exists simply to discourage traffic through an area.

At the end of working hours, decontaminate laboratory work areas so that janitors, plant personnel, firefighters and others can safely enter the areas. If this is not done, post a special "DANGER--DO NOT ENTER" sign. Hazard warning signs will show the name of the hazard(s), the investigator and an alternate, and their home telephone numbers. When appropriate, similar signs will be posted on both the laboratory and animal holding rooms.

The investigator named on the hazard sign will determine when visitors can be allowed in the laboratory. He or she is responsible for their safety while they are there. Visits are restricted to those who have a need to observe laboratory procedures. Social visits by staff and visitors are prohibited in areas where biohazards are present.

C. Methods of Posting

Signs that are to be used permanently will be posted only in permanent frames. The investigator in charge of the laboratory is responsible for requesting the installation of the frames. Signs that are to be used on a temporary basis (less than one month) will be posted in permanent frames if such frames have been installed. If frames have not been installed, these signs will be posted with masking tape on a glass surface or, if more appropriate, on refrigerators, freezers, doors, etc.

Signs will not be posted with tacks, pins, or any adhesive material that would damage the doors, walls, or building when the signs are removed.

D. NFPA Signage

The Occupational Safety and Health Administration has adopted NFPA signage to indicate the hazards present in a given location. The NFPA diamond, as shown in *Figure 3*, contains four (4) sections as described in the diagram. Each of these sections contains a number from zero (0) for no hazard to four (4) indicating the highest possible hazard. These signs shall be posted outside each laboratory and shall be filled in with the information on the highest possible hazard which is present in each room.

E. Availability of Signs
The investigator in charge of the laboratory is responsible for securing the appropriate signs and frames. These are available through most

laboratory supply companies. Most commonly used signs are available from CASSO Office.

Chapter 3:

HEALTH HAZARDS

I. TOXICOLOGY

"All substances are poisons; there is none which is not a poison. The right dose differentiates a poison and a remedy."

Paracelsus

A. General Definitions

1) "Toxicology" is the study of the nature and action of poisons.

2) "Toxicity" is the ability of a chemical molecule or compound to produce injury once it reaches a susceptible site in or on the body.

3) "Toxicity hazard" is the probability that injury will occur considering the manner in which the substance is used.

B. Dose-Response Relationships

The potential toxicity inherent in a substance is manifest only when that substance comes in contact with a living biological system. A chemical normally thought of as "harmless" will evoke a toxic response if added to a biological system in sufficient amount. The toxic potency of a chemical is thus ultimately defined by the relationship between the dose (the amount) of the chemical and the response that is produced in a biological system.

C. Routes of Entry Into the Body

1) There are three main routes by which hazardous chemicals enter the body:

a) Absorption through the **respiratory tract**. Most important in terms of severity and most common route of exposure.

b) Absorption through the **skin**. Runs first in the production of occupational disease (such as dermatitis).

c) Absorption through the **digestive tract**. Can occur through eating with contaminated hands or in contaminated work areas.

2) Most exposure standards, Threshold Limit Values (TLVs) and Permissible Exposure Limits (PELs), are based on the inhalation route of exposure. They are normally expressed in terms of either parts per million (ppm) or milligrams per cubic meter (mg/m3) in air.

3) If a significant route of exposure for a substance is through skin contact, its MSDS will have a "skin" notation. Examples: pesticides, carbon disulfide, carbon tetrachloride, dioxane, mercury, thallium compounds, xylene, hydrogen cyanide, and benzene.

D. Exposure Definitions

1) **Acute poisoning** is characterized by rapid absorption of the substance and the exposure is sudden and severe. Normally, a single large exposure is involved. Examples: carbon monoxide or cyanide poisoning.

2) **Chronic poisoning** is characterized by prolonged or repeated exposures of a duration measured in days, months or years.

Symptoms may not be immediately apparent. Examples: lead or mercury poisoning and pesticide exposure.

3) **Local** refers to the site of action of an agent and means the action takes place at the point or area of contact. The site may be skin, mucous membranes, the respiratory tract, gastrointestinal system, eyes, etc. Absorption does not necessarily occur. Examples: strong acids or alkalis.

4) **Systemic** refers to a site of action other than the point of contact and presupposes absorption has taken place. Examples: an inhaled material may act on the liver; arsenic affects the blood, nervous system, liver kidneys, and skin; benzene affects bone marrow.

5) **Cumulative poisons** are characterized by materials that tend to build up in the body as a result of chronic exposure. The effects are not seen until a critical body burden is reached. Example: heavy metals.

6) **Synergistic ot potentiating effect** occurs when two or more hazardous materials are present in combination. The resulting effect can be greater than the effect predicted based on the individual substances. Example: exposure to alcohol and chlorinated solvents.

E. Other Factors Affecting Toxicity

1) Rate of entry and route of exposure; that is, how fast the toxic dose is delivered and by what means.

2) Age, possibly affecting the capacity to repair tissue damage.

3) Previous exposure history, possibly leading to tolerance or increased sensitivity.

4) State of health, physical condition and lifestyle; pre-existing disease can result in increased sensitivity.

5) Environmental factors such as temperature and pressure.

6) Host factors including genetic predisposition and the sex of the exposed individual.

II. MATERIAL SAFETY DATA SHEETS (MSDS)

Definition and Policy

An chemical's MSDS provides the user with information on that particular chemical. The information is provided by the manufacturer or distributor of that chemical.

OSHA requires that the MSDS for each chemical used in the laboratory be accessible to every employee of that lab.

Appendix B contains a sample MSDS, with all sections explained.

III. CLASSIFICATION OF TOXIC MATERIALS

A. Physical Classifications

1) A **gas** is a substance which exists in a gaseous state at room temperature and pressure.

2) A **vapor** is the gaseous phase of a material which is ordinarily a solid or a liquid at room temperature and pressure. When considering the toxicity of gases and vapors, the solubility of the substance is a key factor. Highly water-soluble materials like ammonia irritate the upper respiratory tract. On the other hand, relatively water-insoluble materials like nitrogen dioxide penetrate deep into the lung. Fat soluble materials, like pesticides, tend to have longer residence times in the body.

3) A **liquid** is the state of matter between a solid and a gas. Liquids present skin and ingestion hazards. A liquid can evaporate to the gaseous state and present a respiratory hazard.

4) An **aerosol** is composed of solid or liquid particles of microscopic size dispersed in a gaseous medium. The toxic potential of an aerosol is only partially described by its concentration in milligrams per cubic meter (mg/m3). For a proper assessment of the toxic hazard, the size of the aerosol's particles is important. Particles above 1 micrometer tend to deposit in the upper respiratory tract. Particles below 1 micrometer enter the lungs. Very small particles (<0.2 um) are generally not deposited.

B. Physiological Classifications

1) Respiratory

a) **Mucous membranes** may become inflamed by contact with certain chemical irritants. Inflammation of tissue results from concentrations far below those needed to cause corrosion. Examples of these irritants include: ammonia, alkaline dust and mist, arsenic trichloride, diethyl/dimethyl sulfate, hydrogen chloride, hydrogen fluoride, halogens, nitrogen dioxide, ozone, phosgene, and phosphorus chlorides.

Irritants can also cause changes in the mechanics of respiration and lung function. Examples include: acetic acid, acrolein, formaldehyde, formic acid, iodine, sulfuric acid, and sulfur dioxide

Long-term exposure to irritants can result in increased mucous secretions and chronic bronchitis.

*   A **primary irritant** exerts no systemic toxic action either because the products formed on the tissue of the respiratory tract are non-toxic

or because the irritant action is far in excess of any systemic toxic action. Example: hydrogen chloride.

* A **secondary irritant's** effect on mucous membranes is overshadowed by the systemic effect resulting from absorption. Exposure to a secondary irritant can result in pulmonary edema, hemorrhage and tissue necrosis. Examples include: hydrogen sulfide and aromatic hydrocarbons.

b) **The central nervous system**, especially the brain, may be depressed by anesthetics. Examples include: chloroform, diethyl ether, hexane and other nerve-depressing organic substances and alcohols. Many solvents also affect the central nervous system.

c) **Asphyxiants** have the ability to deprive tissue of oxygen. Simple asphyxiants are inert gases which displace oxygen. Examples include: carbon dioxide, hydrogen and helium, nitrogen, nitrous oxide. Chemical asphyxiants render the body incapable of utilizing an adequate oxygen supply. They can cause damage at very low concentrations. Examples include carbon monoxide and hydrogen cyanide.

d) **Pulmonary agents** damage the lungs. Examples include: asbestos, coal dust, cotton dust, silica, and wood dust. Dusts can cause a restrictive disease called pneumoconiosis. Other types of lung injuries include: edema, which can be caused by hydrogen fluoride, nickel carbonyl and perchlorethylene; and emphysema, which can be caused by ozone and oxides of nitrogen. Signs and symptoms: tightness in chest, shortness of breath.

2) Skin and Ingestion

a) **Skin Toxins** may result in anything from acute irritation to corrosion. Benzocaine, formaldehyde, and neomycin are all common chemicals which cause contact allergies. A **sensitizer** causes a substantial proportion of exposed people to develop an allergic reaction in normal tissue after repeated exposure to the chemical. The reaction may be as mild as a rash (contact dermatitis) or as serious as anaphylactic shock. Examples include: chlorinated hydrocarbons, chromium compounds, epoxies, nickel compounds, and toluene diisocyanate. Signs and symptoms include defatting of the skin, rashes, and irritation.

b) **Eye toxins** cause damage to the eye by direct contact, like any of the skin or mucous membrane toxins, or by systemic chemicals. The antimalarial drugs quinacrine and chloroquine have been shown to affect the cornea after oral administration. Signs and symptoms include conjunctivitis, and corneal damage.

3) Systemic

a) **Hepatotoxic agents** cause damage to the liver. Examples include: carbon tetrachloride, nitrosomines, and tetrachloroethane. Signs and symptoms include jaundice and liver enlargement.

b) **Nephrotoxic agents** damage the kidneys. Examples include: halogenated hydrocarbons and uranium compounds. Signs and symptoms include edema and proteinurea.

c) **Neurotoxic agents** damage the nervous system. The nervous system is especially sensitive to organo-metallic compounds and certain sulfide compounds. Examples include: carbon disulfide, manganese, methyl mercury, organo-phosphate insecticides, tetraethyl lead, thallium, and triakyl tin compounds. Signs and symptoms include narcosis, behavioral changes, decrease in motor function.

d) **Hematotoxic agents** act on the blood, bone marrow or hematopoietic system. Examples include: aniline, benzene, nitrites, nitrobenzene, and toluidine. Benzene damages bone marrow which can lead to leukemia. Signs and symptoms include cyanosis (a bluish coloration to the skin) and loss of consciousness.

e) A **carcinogen** commonly describes any agent that can initiate or speed the development of malignant or potentially malignant tumors or other malignant neoplastic proliferation of cells. Known human carcinogens are listed in Appendix C, subpart 1.

f) **Reproductive toxins** are chemicals which cause damage either to the reproductive system directly or to the fetal tissue. 1,2-Dibromo-3-chloropropane (DBCP) causes infertility (azoospermia) in males, while lead and ethylene oxide can cause infertility in males and females. **Teratogens** (embryotoxic or fetotoxic agents) interfere with normal embryonic development without damage to the mother or lethal effect on the fetus. Effects are not hereditary. Examples include: lead and 1,2-Dibromo-3-chloropropane (DBCP). See Appendix C, subpart 2, for a list of reproductive toxins. Signs and symptoms include sterility and birth defects.

g) **Immune system** effects, specifically immunosuppression, can be caused by a wide variety of chemicals, including arsenic, benzene, cadmium, lead, methyl mercury, nitrous oxide, and polycyclic aromatic hydrocarbons (PAHs).

h) The **cardiovascular system** may be damaged by exposure to a variety of chemicals. These chemicals may be cardiotoxic, i.e., causing damage to the heart directly, such as aliphatic alcohols, aldehydes and glycols, or they may cause damage to the vascular system. Heavy metals such as lead and cadmium fall into this latter category.

IV. WORKING SAFELY WITH HAZARDOUS CHEMICALS

It is the responsibility of the PI to determine the hazards associated with all of the chemicals used in his or her laboratory. There are many excellent compilations of the hazards associated with chemicals. The following references can be extremely useful and it is recommended that each unit have a least one of the following reference manuals available. All are available through University Libraries.

Suggested References on Hazardous Chemicals

Klaasen, C.D., Amdur, M, Doull, J., **Cassarett and Doull's Toxicology: The Basic Science of Poisons**, Third Edition, Macmillan Publishing Company, New York, New York, 1986

Lenga, R.A., **The Sigma-Aldrich Library of Chemical Safety Data,** Edition II, Volumes I and II, Sigma-Aldrich Corporation, 1988

Lewis, R.J. **Sax's Dangerous Properties of Industrial Materials.** 8th ed. 3 vols. New York: Van Nostrand Reinhold; 1996.

Lewis, R.J. **Hazardous Chemicals Desk Reference.** , New York: Van Nostrand Reinhold; 1997.

National Research Council. **Prudent Practices for Handling Hazardous Chemicals in Laboratories**. Washington DC: National Academy Press; 1981.

Perrin, D.D., Armarega, W.L.F., Perrin, D.R. **Purification of Laboratory Chemicals**. 4th ed. New York: Pergamon Press: 1996.

Raffle, P.A.B., Lee, W.R., McCallum, R , Murray, R., **Hunter's Diseases of Occupations**. 8th ed. London, Boston: E. Arnold; 1994.

See the Select Bibliography for additional references.

A. Hazardous Chemicals

The following is a list of types of hazardous chemicals, divided into eight general classes based on the predominant effects of those general chemical types.

1) Caustic or corrosive chemicals: These are acids or bases which may burn or otherwise damage human tissue on contact. The corrosion of equipment should also be considered. Examples include chromic acid cleaning solutions, concentrated acids such as hydrochloric, sulfuric, and nitric, and acid-releasing substances such as thienyl chloride and halogens (bromine, chlorine).

2) Poisons: The relative toxicity of this general class of chemicals is dependent on a large number of factors. This class would also include carcinogens. Examples include cyanide and azide salts.

3) Flammables: These are materials that will easily ignite, burn and serve as a fuel for a fire. Examples include most common laboratory organic solvents such as ether, acetone, tetrahydrofuran, and diethlyether.

4) Explosives: Chemicals in this class should be protected from shock, elevated temperatures, sparks, rapid temperature changes, and mixture with other reactive chemicals. Examples include nitroglycerin, nitrocellulose and organic peroxides.

5) Oxidizing and reducing chemicals: The reactions of oxidizing and reducing agents can generate heat and are often explosive. Oxidizing agents include oxygen, perchloric acid, and peroxyacids. Reducing agents include hydrogen, metallic hydrides, alkali metals, and activated zinc and phosphorus.

6) Water-sensitive chemicals: These chemicals react with water, steam and moisture in the air to evolve heat and/or flammable or explosive gases. Isolate water sensitive substances from other reactive

chemicals and store in a cool, dry area. Examples of chemicals that liberate heat only are strong acids and bases, acid anhydrides and sulfides. Substances that liberate flammable gases are alkali metals, hydrides, nitrides, and anhydrous metallic salts.

7) Acid-sensitive chemicals: These chemicals react with acids to evolve heat, flammable and/or explosive gases and toxicants. Examples include alkali metals, cyanides, sulfides, carbonates, arsenic and related elements.

8) Pyrophoric agents: These chemicals burn when exposed to air. In general, they require absolute protection from air. Examples include phosphorus and activated zinc and nickel Raney catalyst.

B. Controlled Substances

Chemicals which are considered controlled substances are regulated by specific state and federal regulations. In order to purchase and distribute controlled substances (such as opiates, barbituates or anesthetics), appropriate State and Federal licenses must be obtained. If use of these classes of chemicals is required, contact CASSO Office for information.

C. Chemical Safety

The potential dangers that may be encountered when working with hazardous chemicals are very diverse and depend greatly on the type of exposure. The dangers inherent in use of all chemicals in this manual are not completely described. It is the responsibility of the PI to be aware of potential hazards that exist when using the chemicals in his or her own laboratory. MSDSs are available for most specific chemicals and contain detailed information to inform workers about potential dangers of these materials.

V. WORKING SAFELY WITH EXTREMELY HAZARDOUS CHEMICALS: Select Carcinogens, Reproductive Hazards and Chemicals with a High Degree of Acute Toxicity

When working with certain hazardous chemicals the OSHA Lab Standard requires that you designate an area for such work. Chemicals for which special precautions are to be taken include carcinogens, including reproductive toxins, and certain chemicals with a high degree of acute toxicity.

A list of these substances is provided in Appendix C.

A. Creating A Designated Area

The designated area for use of extremely hazardous substances as defined by the standard may be a fume hood or a portion of the lab or the entire lab itself, depending on individual circumstances. The only requirements are that the area must be posted as to the nature of the hazard and that all employees who work in this area be informed as to the hazards involved. **"Employees" include maintenance people who may be exposed to the hazard when working in the area.**

In general, containment devices such as fume hoods or glove boxes are only required when using select hazardous substances that may become volatile, may result in the release of aerosols during manipulation, or may, through handling or reaction, result in the uncontrollable release of the substance. In addition, procedures for decontamination and the safe removal of contaminated waste must be outlined. The PI is strongly urged to seek the advice of Safety Services prior to experimentation with these substances.

1) General Procedures

a) All guidelines for safe laboratory practice--such as use of eye protection, wearing proper protective clothing, following correct pipetting procedures, wearing gloves, and not permitting smoking, eating and drinking in the laboratory--must be observed when working with extremely hazardous chemicals.

b) Laboratory clothing should be adequate to protect street clothing completely and should not be worn outside of the laboratory area. Disposable gloves should be discarded after each use and immediately after overt contact with extremely hazardous chemicals.

c) All personnel should wash their hands immediately after the completion of any procedure using chemical hazards.

2) Operational Procedures

a) Work areas within a laboratory should be clearly marked with a warning sign which reads: CAUTION-POTENTIAL CANCER HAZARD, AUTHORIZED PERSONNEL ONLY or CAUTION: POTENTIAL REPRODUCTIVE TOXIN-AUTHORIZED PERSONNEL ONLY. Those areas used for storage of these chemicals should also be identified in a similar manner.

b) Work areas where select hazards are being used should only be entered by authorized personnel. When extremely hazardous chemicals are being used in an area of a larger laboratory, the area should be clearly identified and should not be a high traffic area in order to minimize contact of uninvolved laboratory personnel with hazardous substances.

c) Work surfaces should be covered with impervious material such as dry absorbent plastic backed paper. The protective material should be decontaminated or disposed of after the procedures are completed. Adequate chemical traps must be used on all vacuum lines to prevent contamination of the vacuum systems. A separate vacuum pump should be used for extremely hazardous chemicals, and any service company should be informed of this use of the pump prior to service.

d) Procedures involving volatile chemicals or those which may result in the generation of aerosols or dispersible particulates should be conducted in a chemical fume hood. Work which may present a biological hazard should be conducted in a biological safety cabinet or glove box. Precautions should also be taken to prevent exposure to aerosols that may be generated during these procedures. Such equipment should be positioned so that any vapors or aerosols produced can be vented into a chemical fume hood. Aerosols can be generated from opening and closing vessels, transfer of chemicals (weighing chemicals), homogenization, open vessel centrifugation, and the application, injection or intubation of extremely hazardous chemicals to experimental animals. Minimum containment for tissue culture can be provided by a Class II, type B Biological Safety Cabinet. The PI should refer to the CDC/NIH publication **Biosafety in Microbiological and Biomedical Laboratories,** 3rd ed, USDHHS, 1996, for information concerning appropriate containment equipment and its usage. Check the CDC website for information on this manual (http://www. cdc.gov.od/ohs).

e) Stock and sample containers of extremely hazardous chemicals should be stored in a designated area that is clearly marked with the warning: CAUTION-POTENTIAL CANCER HAZARD or CAUTION-POTENTIAL REPRODUCTIVE HAZARD. The PI should maintain an inventory of each carcinogen or other select hazard. This inventory should include the quantities and the date purchased. The storage vessel should also be marked with a label indicating the specific potential danger of the substance. Working quantities should be kept to a minimum and should also have the same label.

f) If it is necessary to transfer the chemicals from one site to another, the chemical should be placed in a durable outer container. Contaminated materials should be placed in properly labeled biohazard bags to indicate the potential hazard. LABORATORY SAFETY Office should be contacted for the proper disposal of such material. Organic liquid waste should also be disposed of in containers per the chemical waste disposal guidelines by LABORATORY SAFETY Office, set forth in Chapter Four. In all cases, prior to initiating any experiments with select chemical hazards, the PI should make plans for the handling of chemical waste.

g) In order to ensure that the laboratory meets the standards for the use of a select chemical hazard (i.e., flow rate of the hood), the PI should contact LABORATORY SAFETY Office prior to initiating experiments.

B. Working With Select Carcinogens

"Select carcinogens" are defined by the OSHA Lab Standard as being any substance which meets one of the following criteria:

* It is regulated by OSHA as a carcinogen
* It is listed under the category "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP, latest edition)
* It is listed under Group 1, "carcinogenic to humans," by the International Agency for Research on Cancer Monographs (IARC, latest edition)
* It is listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP. These chemicals cause statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

* After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime at dosages of less than 10 mg/m3
* After repeated skin application of less than 300 mg/kg of body weight per week
* After oral dosages of less than 50 mg/kg of body weight per day.

The most recent list which fulfills the first three of these criteria is in Appendix C, List of Extremely Hazardous Chemicals, Subpart 1, Carcinogens.

Additional information on the use of chemical carcinogens can be obtained from the U.S. Department of Health and Human Services by requesting "NIH Guidelines for the Laboratory Use of Chemical Carcinogens" and from Chemsyn Science Laboratories which will supply "Handling Chemical Carcinogens: A Safety Guide for the Laboratory Researcher" by Mary K. Dornhoffer. Check the MSDS to determine whether a particular chemical falls into this category.

C. Working With Reproductive hazards

Reproductive hazards are defined by the OSHA lab standard as:

"toxins (which) may manifest themselves in lethal effects on the fertilized egg, developing embryo or fetus or teratogenic (malformation) effects in the fetus. In addition, certain reproductive toxins may cause infertility in males and females."

Reproductive hazards include chemicals which target developing embryos and fetuses. Embryonic and fetal development is characterized by rapid growth and differentiation. In addition, maternal blood flow through the placenta increases and allows for fetal exposure to potential teratogens. Due to this unique sensitivity, any woman who believes she is pregnant should take special precautions to protect the developing fetus. If she chooses to declare her pregnancy, she should speak to her supervisor, informing him or her of her pregnancy, and they should then work together to develop ways to minimize her exposure to hazardous chemicals. The use of personal protective equipment or fume hoods may substantially reduce exposures and they are of particular significance for a pregnant employee. While no employee may be forced to abandon her job due to pregnancy, the PI should discuss any potential risks of exposure as soon as the fact of the pregnancy is known and assist the employee in developing programs to minimize exposure.

Examples of reproductive toxins include: benzene, mercury, ethylene dibromide, carbon monoxide, anesthetic gases (halothane) ionizing radiation, ethylene oxide, ethylene thiourea, and glycidyl ethers. A more complete list of known reproductive hazards is presented in Appendix C, Subpart 2, Reproductive Hazards. In addition, Material Safety Data Sheets may be consulted for information on additional chemicals with reproductive toxicity which may be in use in the laboratory. Laboratory Safety Services is available at x 1647 for consultation on both hazards and means of reducing exposures.

D. Working With Substances With High Acute Toxicity

The OSHA Lab Standard requires that **"substances with high acute toxicity** such as hydrogen cyanide, hydrogen sulfide and nitrogen dioxide are included under the category of substances for which employers must consider the need for special precautions. Such substances may be fatal or cause damage to target organs as a result of a single exposure or exposures of short duration."

E. Experimentation with Animals

The use of extremely hazardous chemicals in experimental animals should be arranged with the personnel in IACUC.

VI. ULTRAVIOLET RADIATION EXPOSURE

A. Effects of Exposure

The eyes and skin should not be exposed to direct or strongly reflected ultraviolet radiation. The effect of radiation overexposure is dependent on such factors as dosage, wavelength, portion of body exposed and the sensitivity of the individual.

Overexposure of the eyes will result in a painful inflammation of the conjunctiva, cornea, and iris. Symptoms will develop 3 to 12 hours following exposure. There is a very unpleasant foreign body sensation accompanied by watery eyes . The symptoms usually disappear in a day or two.

Exposure to the skin will produce erythema (reddening) 1 to 8 hours following exposure.

B. Protection Against Ultraviolet Radiation Exposure

Adequate eye and skin protection must be worn when working in a UV irradiated area. Safety glasses designed specifically for use with UV light and with side shields or goggles with solid side pieces should be worn. The side pieces prevent the entrance of reflected radiation and direct radiation from a side source. Skin protection is afforded by face shields, caps, gloves, gowns, etc.

Overexposure to ultraviolet radiation should be reported to Health Services.

VII. BIOLOGICAL HAZARDS

Any person working with infectious agents should be familiar with the CDC/NIH manual "Biosafety in Microbiological and Biomedical Laboratories." See the CDC website for ordering information (http://www.cdc.gov/od/ohs).

Chapter 4

WASTE DISPOSAL AND WASTE REDUCTION

This chapter discusses the University procedures for chemical and hazardous waste classification, packaging, labeling and handling. These procedures are necessary for compliance with regulations of the Environmental Protection Agency, the Nuclear Regulatory Commission, The Department of Transportation, the Occupational Health and Safety Administration, and the Environmental Quality Board. Principal Investigators and area supervisors must ensure that the appropriate personnel follow these procedures. All researchers who handle any potentially hazardous materials should recognize the hazards and be aware of procedures required to protect themselves and the environment from the effects of these materials.

I. CHEMICAL WASTE

The purpose of this document is to assist you in understanding the regulations and how to comply with them.

A. Disposal of Chemicals

Wastes regulated by the EPA are not permitted to be disposed of down the sanitary sewer. These waste chemicals must be retained by each laboratory in a container labelled with the words "Hazardous Waste." No more than 55 gallons of waste may be accumulated.

1. Procedure

a) Segregate your chemical waste by compatibility (see Tables below) and clearly label waste bottles with the terms "Hazardous Waste." Plastic bottles are preferred over glass for storing hazardous wastes, but check the compatibility of the waste with the specific plastic first (compatibility charts are available in the LABORATORY SAFETY Office).

b) When containers are full, fill out a Hazardous Waste and Unwanted Chemical Disposal Listing form (See Appendix F for sample) and return it to LABORATORY SAFETY Office. Chemicals will be picked up for disposal at the earliest possible date after receipt of this form.

Chemical waste containers should be labeled with the following:

1) exact composition of the waste

2) age of the waste

3) place of origin (department, room)

4) hazardous properties

5) PI's name and telephone number

6) bottle number assigned on corresponding waste sheet.

Waste containers must be accompanied by a completed Hazardous Waste Information form (See Appendix F).

2. Table of Incompatible Chemicals

TABLE 2. General Classes of Incompatible Chemicals*

The following general classes of chemicals are incompatible with one another.

Acids or Bases, metals, or

oxidizing agents, reducing agents

Chlorates Ammonia, anhydrous and aqueous

Chromates, Carbon

Chromium trioxide, Metals

Dichromates, Metal hydrides

Halogens, Nitrites

Halogenating agents, Organic compounds

Hydrogen peroxide, Phosphorus

Nitrates, Silicon

Nitric acid, Sulfur

Perchlorates

Peroxides

Permanganates

Persulfates

*These examples of oxidizing and reducing agents are illustrative of common laboratory chemicals; they are not intended to be exhaustive.

See Appendix E for a table of specific chemical incompatibilities.

B. Specific Labeling and Waste Procedures

1) Hazardous Wastes

All materials that are regulated by the EPA under CFR 40 and may not be disposed of to the environment are considered hazardous wastes. Their containers must be labeled "hazardous waste" as well as having all the information listed in Section I, Part B of this chapter.

2) Handling and Storage Instructions for Hazardous Wastes

a) Ignitable Liquids and Organic Solvents

* Keep halogenated solvent wastes separate from nonhalogenated solvent wastes whenever possible.
* Separate organic solvents from aqueous solutions whenever possible.
* For larger waste volumes, use a metal 5-gallon can.
* For smaller volumes, or for solvents that react with metal, use a 1-gallon glass (or, preferably, plastic) container (check compatibility).

b) Acids, Bases and Aqueous Solutions

* Collect concentrated acids or bases in 1-gallon glass bottles if possible; otherwise, use a 5-gallon container. **Exception:** hydrofluoric acid must be stored in plastic.
* Do not mix strong acids or oxidizers with organic compounds.
* Keep all perchloric acid wastes in exclusive-use containers.

c) Heavy Metal Solutions

* Keep solutions containing arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, or other heavy poisonous metals separate from other wastes.

d) Paint and Paint Thinners

* Separate solid paint sludge from paint thinners by pouring off thinners into a separate waste container.
* Keep water and water-based paint wastes separate from oil-based wastes. Rinsate from water-based paint clean up is nonhazardous and can be disposed of down the sanitary sewer.

f) Used Chromatographic Adsorbent

* When possible, segregate chromatographic adsorbents from liquid wastes.
* Indicate the chemical and its concentration of contaminants in the adsorbent material.

g) Animal Waste Contaminated with Hazardous Chemicals

* Procedures for handling these wastes are implemented by the IACUC. Contact the IACUC at 758-2525 x1053.

h) Broken Thermometers

* Attach a waste tag to the container and label the material as "broken thermometer and elemental mercury."
* Please note: mercury volatilizes and can be a hazard. Even the mercury from one thermometer can create a potential health risk. Call CASSO Office promptly for disposal and pick up.
* For larger spills or mercury, (>3cc), evacuate the area and call CASSO Office (8:00 am - 5:00 pm, M-F). They will respond, clean up the spill and monitor the room air to ensure the area is safe to reenter.

*   Mercury spill kits and neutralization sponges should be available in all labs in the event of an after hours spill. All waste materials from the cleaning will be disposed of by CASSO Office.

2) Discarded Hazardous Substances

a) Gas Cylinders

*   Promptly return discarded or empty gas cylinders and lecture bottles to the vendor to regain your deposit on the cylinder and minimize rental charges. Contact General Stores for this service. See Chapter 5, Section II for more information.

b) Chemicals in Original Container

*   Label these containers with the same information as you would a hazardous waste, only do not write "hazardous waste" on the container. Alternately, this material often can be re-used or recycled.

C) Procedures for Disposal of Explosive or Extremely Reactive Materials

*   Potentially explosive materials, such as dry picric acid or old ethers, will be picked up separately from other wastes. Contact CASSO Office as soon as possible upon discovering any potentially explosive materials.
*   In general, extremely reactive materials should be disposed of in glass bottles.
*   Alert handling and disposal personnel to the hazardous nature of these items.

D. Disposal of Chemicals in Sanitary Sewers (Drains)

Hazardous wastes are regulated by the Environmental Protection Agency under the Resource Conservation and Recovery Act (RCRA). In general, these regulations do not permit any drain disposal, except for those items listed below.

THE FOLLOWING CLASSES OF CHEMICALS MAY BE DISPOSED OF IN THE SANITARY SEWER (DRAIN)

* Inorganic acids and bases that have a pH between 5.0 and 10.0. These pH limits are imposed by local regional sewer regulations.

Sewer disposal is permitted provided that no other regulated chemical is present. Neutralization is permitted to change the pH to within acceptable limits if it is written into the experiment's protocol.

* Aqueous buffer solutions containing no regulated materials, e.g., common salt solutions or tissue culture media.

Such solutions may contain millimolar concentrations of common biochemicals, buffers, serum by-products, or cell metabolites.

When in solution, common salts (chlorides, bicarbonates, citrates, phosphates, sulfates, acetates) of sodium, potassium, magnesium, and calcium may be disposed of in the sanitary sewer.

* Aqueous High Performance Liquid Chromatography (HPLC) solutions or other solutions containing less than 24% ethanol, propanol, or isopropanol (no other alcohols). The 24% limit is based on flammability of the alcohol.

HPLC solutions containing any amount of acetonitrile or other organic solvents must be disposed of through CASSO Office.

* Bacteriological and tissue culture media

Such media containing live organisms must be sterilized by autoclaving or another acceptable procedure and must not contain anything other than common biochemicals.

Mixed waste (radioactive waste combined with a solvent or inorganic material) must be classified by chemical before drain disposal. Refer to the Radiation Safety Manual for procedures and acceptable limits.

No more than unavoidable traces of highly toxic organic chemicals, such as those found on glassware surfaces, of either synthetic or biological origin, should be allowed in the sanitary sewer.

Please note that hazardous materials cannot be diluted with a material which is not a waste, e.g., fresh water, in order to bring them to concentration suitable for drain disposal, unless this dilution is part of an experimental procedure.

II. DISPOSAL OF OTHER LABORATORY WASTE

A. Classification of Waste and Disposal Procedures

Prior to disposal, non-chemical waste must be classified as one of the following:

* Sharps
* Biohazardous/Infectious Waste
* Uncontaminated Lab Waste

Wastes which contain both chemical waste and another type of waste, e.g., animal parts stored in formalin, must be separated and disposed of according to each pertinent waste policy. That is, the animal waste is treated as biohazardous waste and the formalin is disposed of as chemical waste.

In addition, local landfills no longer permit the University to dispose of any biohazardous waste (whether or not autoclaved) or SHARPS in the general trash. Thus, it is essential to classify waste properly. CASSO Office is available for consultation on a case-by-case basis.. A summary of the following "bag" policies is illustrated in *Figure 4 (Disposal of Biohazardous Waste and General Laboratory Waste).*

1) Sharps

Definition: Discarded hypodermic needles, syringes, and scalpel blades. Cannulas, coverslips, microscope slides, all pipettes (glass or plastic) and pipette tips, test tubes, or broken Petri dishes. Broken glass or any other item capable of causing puncture wounds or cuts.

Procedure: All sharps, whether contaminated or not, must be contained in puncture-proof containers. Call Security (x3333) for the disposal of all sharps.

* All contaminated sharps; needles, syringes and scalpel blades; and all materials designed for use in biological, etiological, bacteriological or tissue culture work must be placed in red rigid SHARPS containers. Call Purchasing (x2560) for a list of vendors.

* All other sharps (such as broken glassware) which are **not** contaminated may be discarded in red SHARPS containers OR in a cardboard box labeled "SHARPS." The box should be lined with a plastic bag to prevent leaking and sealed with tape. The box must be clearly labeled "SHARPS" so that anyone inspecting the box will be

aware of the nature of the hazard. The box can then placed into a black or clear plastic garbage bag.

* Empty glass chemical bottles must be marked "MT," have their label defaced, and be placed in cardboard boxes marked "SHARPS" and sealed with tape. All bottle caps must be removed.

Hypodermic needles should not be recapped, clipped, broken or disassembled prior to disposal.

IMPORTANT: **NO** items that have been contaminated by chemotherapeutic drugs or antineoplastic agents (with the exception of trace amounts) can be disposed of in SHARPS containers. Please call Safety Services (x2907) for disposal alternatives.

For pick-up of RADIOACTIVE SHARPS, contact the Radiation Safety Office at 368-2906.

Under no circumstances are contaminated sharps; hypodermic needles, syringes, scalpel blades; or materials designed for use in biological, etiological, bacteriological or tissue culture work permitted to be disposed of in any container other than the red rigid SHARPS container.

2) Infectious waste

Definition: All infectious plastic Petri plates and plastic tissue culture vessels containing media, cultures and stocks of infectious agents, devices used to transfer, inoculate or mix such agents, and paper or cloth material contaminated with these agents.

Procedure: All of the above materials present a potential hazard to workers and must be treated prior to disposal. Treatment of this waste is the responsibility of EACH researcher.

Steam sterilization for the appropriate amount of time and at the proper temperature is the simplest, most effective method. STEAM STERILIZATION SHOULD BE CONDUCTED AS CLOSE TO THE POINT AND TIME OF WASTE GENERATION AS POSSIBLE.

All waste must be sterilized in red or orange biohazardous bags. All bags must be autoclavable and conspicuously labeled with the international biohazard symbol. Biohazard bags can be ordered from scientific supply houses.

After sterilization and cooling, these bags are to be denoted "sterilized" and tagged with the Primary Investigator's name and date of sterilization.

NO SHARPS (which includes glass and plastic pipettes) are permitted to be placed in these autoclaved bags or any other bag. Such sharps are a hazard when handling these bags and cause contaminants to leak from bags in transit. These must be disposed of in the red rigid SHARPS container as biohazardous sharps.

After all AUTOCLAVED BIOHAZARDOUS WASTE HAS BEEN APPROPRIATELY TAGGED, University safety technicians will remove the waste during the evening for incineration. All biohazardous bags must remain in the room/laboratory for evening pick up. Biohazardous waste must be disposed of expeditiously.

Liquid biomedical waste that has been treated to render it non-infectious should be poured down a sanitary drain, which should then be flushed with water.

EXCEPTIONS:

Most radioactive wastes as set forth in the University Radiation Safety and Control Program.

Any liquid biomedical waste which contains hazardous chemicals as set forth in the University Chemical Disposal Policy.

Please contact Safety Services (x2907) to receive disposal instructions for these exceptions.

3) General Uncontaminated Laboratory Waste

Definition: All laboratory waste which has not been contaminated by radioactive, chemical or infectious agents: such as petri plates, plastic tissue culture vessels, paper cloths, gloves , tubing, nonsharp laboratory wastes, EMPTY chemical containers, as well as "ordinary trash" such as computer paper, cardboard, packing material and the like.

Procedure: Pick-up is provided by cutodial services.

III. RADIOACTIVE WASTE DISPOSAL SERVICE

The Radiation Safety Office provides radioactive waste pickup and radiation disposal services for all University units. Typically, individual units collect radioactive wastes in suitable containers, label the material with a yellow radioactive waste tag, provide secondary packing if necessary, and call the Radiation Safety Office to arrange for a pick-up.

IV. WASTE REDUCTION AND RECYCLING

Wastes regulated by the EPA are not permitted to be disposed of down the sanitary sewer or into a landfill, making them expensive to dispose of in an environmentally responsible way. Reducing the amount of hazardous waste produced, both before the experimental procedure and after, and recycling whenever possible provide vital means of controlling the amount of hazardous waste.

A. Waste Reduction Procedures

1) Pre-Experiment Techniques

a) Pre-weigh chemicals for undergraduate teaching labs. This will reduce spills and other wastes generated by students weighing their own materials.

b) Substitute less hazardous chemicals in experiments to reduce the cost of the disposal of hazardous chemicals. For example, use alcohol instead of benzene; use sodium hypochlorite instead of sodium dichromate.

c) Use alcohol or digital thermometers instead of mercury thermometers, which break easily and are extremely expensive to clean up and dispose of.

d) Purchase only what is needed. Do not order larger quantities to take advantage of unit cost savings. Disposal costs down the road for the unused portion of the chemical greatly exceeds the initial savings.

2) Post-Experiment Techniques

1) When cleaning with solvents, use spent solvent for the initial cleaning and use fresh solvent only for the final rinse.

2) Destroy wastes as part of the last step of the experiment if possible, provided the result is not a regulated material (call Safety Services to confirm). Such end-procedure neutralization techniques include oxidation-reduction or precipitation and filtration of solids.

3) Label all containers, new or temporary, with the proper information, even if the solutions they contain are innocuous. Disposing of an unknown waste, which is what materials in unlabeled containers often become, requires time-consuming and costly analysis. In addition,

unknowns are dangerous in that they may explode or cause adverse reactions at any time.

B. Recycling Procedures

Safety Services now has a still that can recycle many would-be waste solvents to near-pure form. Call the CASSO Office to see if your department creates such reusable waste. Acetone, for example, is ideal. We have also recycled xylene and ethanol with success.

Chapter 5

SPECIFIC LABORATORY PROCEDURES

I. CENTRIFUGE SAFETY

This guide provides standards for the use of bench and floor centrifuges commonly in use in clinical and biochemical laboratories and procedures to be followed if a centrifuge accident occurs. Each employee using the centrifuge must become familiar with requirements for operation of this instrument. Assistance is available upon request from Safety Services. Each operator shall be instructed on proper operating procedures before being allowed to use the centrifuge. Instructions should include requirements for balancing loads, using the proper centrifuge head, and using accessory equipment. Conditions for loading and operating an ultra-centrifuge and preparative centrifuge vary considerably. Therefore, even experienced investigators should review procedures before operating an unfamiliar instrument.

Each employee who uses a centrifuge is responsible for the condition of the machine at the end of the procedure. This includes entering data in the log books, turning off the power, and cleaning up spills, broken glass, etc. Detailed records of operation should be made for most high speed centrifuges and rotors. The safe speed that rotors can be operated is determined by a rating formula which is based on numbers of starts and stops, r.p.m., and total "G" loads. Also, warranty coverage and service procedures for the machine are determined by hours of operation. These records should be kept in log books placed near each machine.

A. Safety Precautions

1) Laboratory Area

Rooms where live etiologic agents are centrifuged should be identified with a warning sign. Because of the hazards involved, continuous flow centrifugation of live etiologic agents may be done only in installations approved by CASSO Office, including using batch type zonal rotors that require seal disconnection when in operation. This protocol must be included in the laboratory's Exposure Control Plan.

2) Tubes

Reuseable centrifuge tubes and centrifuge buckets should be carefully inspected prior to each ultra-centrifuge cycle. Only sound tubes and buckets should be used to process infectious material. Reuseable tubes used in an ultra-centrifuge are subjected to great pressure which sometimes cause them to break, especially after they have been through several cycles. Tubes likely to fail can often be identified by stress lines which appear in the area of junction of the sides and the bottom. Such tubes should be discarded.

Tubes to be used in angle-head centrifuges must never be filled to the point that liquid is in contact with the lip of the tube when it is placed in the rotor, even though the meniscus will be vertical during rotation. When the tube lip is wetted, high G forces drive the liquid past the cap seal and over the outside of the tube.

Nitrocellulose tubes should be used only when "fresh"--clear, without discoloration, and flexible. Small lots should be ordered several times a year instead of one large lot once a year. Storage at 4 degrees C. extends shelf life. Used nitrocellulose tube s should be disinfected in a solution known to be effective against the agent being processed and discarded as solid waste.

3) Carrier Rotors and Cups

Rotor corrosion can create a hazardous condition, best prevented through cleanliness. Ultra-centrifuge heads particularly must be protected. After each use, the rotor should be rinsed in warm tap water and then with distilled water. If solid deposits persist, clean with a mild detergent solution and a stiff test tube brush. Do not scratch the surface of tube wells in aluminum rotors. Rinse the detergent away with warm tap water and distilled water and dry before use. Caustic solutions are particularly damaging to rotors, so clean them promptly after use.

When centrifuge tubes are used in dirty or rough cups, the tubes expand and seize against the walls of the cup, making it very difficult to remove the tubes. In some instances, tubes have had to be pulled with pliers and have been torn or broken in removal. To avoid this possibility, the inside of the cups may be sprayed with a silicon aerosol spray or similar product (see instructions that come with these ultra-centrifuges, as rotors require special care which may differ from instructions in this guide).

B. Postaccident Procedures

When an accident occurs, the operator of the centrifuge should

leave the room at once. Contact CASSO Office immediately from a safe location.

The laboratory staff should not re-enter the area or attempt clean-up if there are any doubts of the safety about this procedure.

Clean-up and decontamination of laboratory equipment for reuse are the responsibilities of the user. Disposal of equipment contaminated with biohazards or radioactivity will be carried out by the Department of Occupational and Environmental Safety. If the spill involves pathogens or radioactive materials, the CASSO Office must be contacted.

II. COMPRESSED GASES IN CYLINDERS

Users of compressed gases should be familiar with the pertinent equipment and the characteristics of the gases. CASSO Office has information available on most of the gases likely to be used in the laboratories. It has detailed information available on detecting leaks, selecting needle valves and regulators, toxicity, explosion hazards, chemical incompatibilities, etc. Use of flammable or explosive gases (i.e. hydrogen gas) requires notification of and prior approval by CASSO Office.

A. General Standards

1) Rules for Handling Compressed Gases

a) Always use a cylinder hand truck for transport.

b) Chain or otherwise secure cylinders in an upright position at all times.

c) Do not drop cylinders or permit them to fall against each other.

d) Leave valve caps on cylinders until secured and ready for use.

e) Close all valves when not in use.

f) Use the proper regulator for the particular gas.

g) Always consider cylinders to be full and handle accordingly.

h) Cylinders should be considered empty when approximately 25 psi still remains in order to prevent contaminated air from entering the tank.

i) No more that 24 cylinders are permitted in any one laboratory unit. See chart below.

j) Identify the contents of cylinders with decals, stencils, glued or wired-on tags, or other markings on the cylinders. Color codes alone or tags hung around the necks of the cylinders are not acceptable. Cylinders lacking proper identification must not be accepted from the vendors.
Maximum Quantity and Size Limitations for
Compressed or Liquefied Gas Cylinders in Work Area

k) Employees must not attempt to repair cylinders or cylinder valves or to force stuck or frozen cylinder valves.

l) Empty cylinders must be marked "empty" or "MT" with grease pencils. Generally, this marking should be on a large piece of adhesive or masking tape stuck on the cylinder. Some cylinders have tags wired to the valve that identify their contents; in this case, the bottom half of this tag may be torn off to indicate an empty cylinder. In all cases, empty cylinders must be easily identifiable so as not to be confused or stored with full cylinders.

m) Cylinders not in use must have cylinder caps in place.

n) It is both prudent safety practice and cost effective to return cylinders to vendors as soon as they are empty.

2) Storing Compressed Gases

a) Store cylinders in a fire-resistant, cool, dry, and adequately ventilated area.

b) The storage area should not contain any sources of ignition.

c) Storage area temperature should not exceed 100_ Fahrenheit.

d) The floor should be level and designed to protect cylinders from dampness.

e) Cylinders should be protected from weather extremes, direct sunlight, and other heat sources.

f) Store oxygen-containing cylinders at least 25 feet from fuel gases, preferably in another storage area.

3) Other Tips for Safe Handling of Compressed Gases

a) Oil should never be used with oxygen. Oxygen under pressure will rapidly oxidize oil or grease and result in an explosion. Only equipment cleaned for oxygen service must be used for oxygen application.

b) Without a proper regulator or when exposed to an ignition source, acetylene can explode. It can also form explosive compounds in contact with copper or brass. An automatic pressure regulator is the only type of recommended control valve satisfactory for acetylene.

c) Regulators can leak and build pressure within a closed gas delivery system. Insert pressure relief devices and include appropriate traps in outlet lines to prevent liquid from flowing back into the cylinders.

If the liquid phase is being delivered from the cylinder, a trap will not prevent back flow, but a check valve will. Traps should be of sufficient capacity to hold all of the materials which could be drawn back into a cylinder during its operation.

d) Open the cylinder valve only after connecting the regulator to the cylinder using a proper Compressed Gas Association regulator.

e) Do not pressurize glass equipment. A general rule is: Do not apply pressure greater than 10 inches of water if you are not wearing protective equipment.

f) Never mix gases in a cylinder. Explosion, contamination, corrosion, and other hazards can result.

g) To prevent corrosion, regulators, valves and fittings used in compressed gas systems which conduct corrosive gases should be flushed with nitrogen or dry air after each use.

h) Make sure the cylinder cap is firmly in place when the cylinder is moved.

i) Any system should be leak-test before it is used. To check for leaks, use leak detector or spread soap over all joints. The system is leaking if any bubbles appear.

j) The researcher is responsible for knowing the characteristics of the gases being used: toxicity, flammability, compatibility with materials and other gases.

k) Contact the cylinder manufacturer immediately if a leak or other malfunction is discovered. If a poison gas, such as chlorine, or a flammable gas, such as hydrogen, is found leaking, contact Security and LABORATORY SAFETY OFFICE immediately.

l) Do not purchase a concentrated gas (such as hydrogen) and mix to a lower concentration. Purchase gas at the needed working concentration to avoid the possibility of explosion. Gas cylinders must be kept chained to a firm surface when they are in storage.

B. Restricted Products

1) Highly toxic gases may have regulations concerning their use. Ethylene oxide is one such gas. Therefore, consult and obtain written permission from Safety Services before purchase of any such product. Safety Services must be notified of intent prior to their proposed purchase to allow time for making necessary safety preparations. Large cylinders of toxic gases should not be purchased if it is possible to use small cylinders.

2) Laboratories using toxic gases should have respirators available that are effective against the agent. The supervisor is responsible for ensuring that employees are instructed in how to use respirators and other protective equipment. **Respirators can only be used after training by CASSO Office.** Contact CASSO Office for information on respirator selection and training requirements of the University's Respiratory Protection Program. Purchase and use of the following gases are controlled and some require respirator training before use:

Boron trifluoride

Chlorine

Chlorine trifluoride

Dimethylamine

Ethylene oxide

Fluorine

Hydrogen bromide (hydrobromic acid)

Hydrogen chloride (hydrochloric acid)

Hydrogen fluoride (hydrofluoric acid)

Hydrogen sulfide

Iodine pentafluoride (liquid shipped in gas-type cylinders)

Methyl bromide (bromomethane)

Methyl chloride

Nitric oxide

Nitrogen dioxide (nitrogen tetroxide)

Nitrogen trioxide

Nitrosyl chloride (nitrogen oxychloride)

Phosgene

Silicon tetrafluoride (tetrafluorosilane)

Sulfur dioxide

3) Safety Services will notify investigators in charge of laboratories as soon as technicians determine that requirement for safe use of the gas have been fulfilled. Investigators planning to use these gases are reminded that some of them are extremely toxic and may require both isolated laboratory space and equipment that is not immediately available. Also, additional training may be required for some gases,

such as ethylene oxide or hydrogen. For these reasons, certification for use should be requested well in advance of the proposed use.

C. Flammable Gases

Because of the fire and explosive hazards that can result when these products are used in confined spaces, special care must be taken.

1) When reactive cylinders are kept inside a building, two or more cylinders should not be man folded together. However, several instruments may be operated from one cylinder.

2) If more than one cylinder of highly flammable gas is to be placed in a laboratory, written permission must be obtained from Safety Services. Considerations for granting permission will include size and location of the room, airflow, other equipment in use, and ease of access to cylinders.

3) Standby cylinders of flammable gases (full reserve cylinders) or empty cylinders must not be stored in laboratories. Cylinders must be stored in restricted shaded spaces outside and delivered to the laboratory on demand.

4) Limit cylinder size to 210 cubic feet.

5) Close valves on flammable gas cylinders before all employees leave the laboratory at night, unless they are in use in a controlled experimental environment.

6) Tank adapters may be used only upon written permission from Safety Services.

7) Piping must be compatible with the gas, e.g., no copper for acetylene, no plastic tubing in any high pressure portion of a system.

D. Accepting Cylinders from Vendors

1) The contents of cylinders must be identified with decals, stencils, glued or wired-on tags, or other markings on the cylinders.*

*Refer to page 72, paragraph j.

2) Cylinders must not be accepted from the vendors unless the valve safety covers are in place and properly tightened.

3) Cylinder valves must conform to standards of the National Compressed Gas Association, i.e., they must be in serviceable condition and free of corrosion.

E. Pressure Regulators and Needle Valves

1) The valve fittings of cylinders used to store different families of gases are different and will only allow regulators or needle valves to be attached that are safe for use with those gases. Cylinders must not be purchased or accepted whose fittings do not conform to standards of the National Compressed Gas Association. Use of adapters to connect regulators to cylinder valves defeats this safeguard and must not be used without written permission from CASSO Office. Only pressure regulators and needle valves approved for the specific gases may be used.

2) Threads and points of unions must be clean and should be inspected before they are connected. Personnel must not attempt to lubricate threads or fittings.

3) When attaching regulators or needle valves, personnel must tighten the connections firmly. Nonadjustable wrenches of the proper size should be used. Pliers or adjustable wrenches should not be used, as they damage the nuts, most of which are brass and rather soft. Need for excessive force often indicates that the regulators or needle valves do not fit the cylinders. Leaks at the unions between the regulators and

the cylinder valves are usually due to damage to the faces of the connections. Attempts to force a tight fit may damage the previously undamaged half of the connection. If the cylinder valve faces are damaged, the cylinders must be returned to the vendor. Employees must not attempt to repair cylinders in regulators. Damaged regulators must not be used until repaired.

4) After attaching the pressure regulator to the cylinder, personnel should turn out the delivery pressure adjusting screws of the regulators until they turn freely. The cylinder valves should be opened slowly. Laboratory personnel should avoid standing directly in front of the regulators at any time as the pressure of the cylinders may blow out the glass from the front of a faulty gauge. The cylinder valve handles should be left attached to the valves while the cylinders are in use. Cylinder valves that "stick" and do not open when the usual amount of force is applied may be damaged. Personnel must not attempt to force them open, but should return these cylinders to the vendors, stating on the cylinders that the valves are stuck.

5) Pressure in full cylinders should be indicated on the cylinders or labels. Lack of full pressure may indicate leaks at the connections between the cylinders and valve regulators, damaged regulators, or incompletely filled cylinders.

6) Connect delivery lines to the low pressure outlets of the regulator valves or to the needle valves. Where low pressure lines are used, their valves should be closed and line pressure-adjusted by turning the regulator delivery pressure-adjusting screws until the desired pressures are shown on the delivery pressure gauges.

7) If the gases are not to be used over a considerable length of time (i.e., 24 hours), the cylinder valves should be closed, the lines bled, and the pressure-adjusting screws turned back until they turn freely. Damage to gauges and inaccurate readings may result if pressure is left on the gauges during extended periods of nonuse.

F. Leak Testing

Compressed gas cylinders are tested for leaks when they are filled; however, leaks have been detected when cylinders were received in laboratories. Personnel should not attempt to repair cylinder leaks or leaks caused by loose valve stem packings.

1) Leak testing using a soap solution should be done twice. The first test should be made before the regulator or needle valve is attached to determine if there are leaks at the union of the cylinder and the cylinder valve and to determine if the valve is leaking. The second test should be made after the regulator is attached and the cylinder valve is opened to detect leaks around the valve stem packing, the connecting fittings, the regulator or needle valve, and the transfer lines to the instrument.

2) Cylinders leaking nontoxic, nonflammable gas may be taken to a loading dock or other place having suitable air flow for regular and scheduled vendor pick-up. Leaks from cylinders of toxic or flammable gases require immediate attention and should be reported to the CASSO Office or University Security when noticed.

Assistance with problems arising during use of gas products can be obtained from Safety Services or local fire departments, depending on the location of the laboratory and the hazard.

III. ULTRAVIOLET LIGHTS - USE AND MAINTENANCE

Ultraviolet radiation includes that portion of the radiant energy spectrum between visible light and X-rays (approximately 3900 to 136 angstrom units). Under certain conditions, including radiation intensity and exposure time, ultraviolet radiation will kill many kinds of microorganisms, its greatest effectiveness being against vegetative forms of organisms. Ultraviolet light is not a sterilizing agent, however, except in certain exceptional circumstances. Rather, it is used to substantially reduce the number of microorganisms on surfaces and in the air.

A. Guidelines

Low pressure mercury vapor lamps, which emit 95 percent of their radiation in the 2537 angstrom units region, are generally used for germicidal purposes. These lamps are used to reduce the numbers of microorganisms on exposed surfaces and in the air. Since such factors as lamp age and dust accumulation contribute to decrease efficiency of these lamps, and since care is required to maintain and use them properly and safely, the following guidelines have been developed:

1) Laboratories shall perform periodic intensity testing of all ultraviolet installations. Ultraviolet lamps in constant use should be replaced every six months. NOTE: Ultraviolet lights often still emit blue light after effective energy output has fallen well below a useful range. Periodic monitoring with an appropriate light energy meter is necessary to verify proper output of ultraviolet light sources.

2) Ultraviolet lamps in air locks and door barriers will be turned on continuously. Skin or eye protection is not usually required for persons walking through these areas. Protection is required, however, for persons exposed to the radiation for longer than a few seconds.

Ultraviolet lamps in Biological Safety Cabinets (BSC) will be turned on only when the cabinet is not in use. (The lamps in the BSC lethal chamber above the filters are turned on automatically when the blower is turned on.)

Personnel must wear protective equipment (goggles, caps, gowns and gloves) or turn off the lights before entering laboratories, animal rooms, or exposing spaces that have ultraviolet installations.

3) All ultraviolet lamps except those located in the BSC lethal chamber above filters must be cleaned at two-week intervals, or more often if located in an unusually dusty area. The lamps should be turned off and wiped with a soft cloth pad moistened with alcohol. Cleaning is the responsibility of the personnel in charge of the laboratory. Cleaning dates should be noted on a card attached to the installation.

4) Special problems concerning use, cleaning, or installation of ultraviolet lamps should be referred to Safety Services.

IV. DECONTAMINATION OF LABORATORY SINK DRAINS TO REMOVE AZIDE SALTS

All laboratory sink traps and drains which have not been converted to polyvinyl chloride (PVC) are potentially contaminated with azides. Therefore, they must be chemically treated prior to any maintenance to remove the salts (usually lead azide). If you believe that azides were previously disposed of in your laboratory's drains and they have not been decontaminated, call CASSO Office for information or assistance in decontaminating prior to any maintenance work.

Appendix A

Table of Permissible Exposure Limits, Threshold Limit Values and Short-Term Exposure Limits (TLV-STEL)

The attached table shows the most recent values adopted by the Occupational Safety and Health Administration for exposures to air contaminants.

The following terms are referred to in this table:

Permissible exposure limit (PEL): the term used by OSHA to indicate the maximum air concentration to which employees can be exposed during an eight hour day on a regular basis. Exceeding these levels may result in additional duties, such as medical monitoring, or introduction of engineering controls to reduce air exposure levels.

Threshold limit value (TLV or TLV-TWA): the term used by the American Conference of Governmental and Industrial Hygienists (ACGIH), an independent group, to indicate the time weighted average concentration for a normal 8-hour work day and a 40 hour workweek, to which nearly all employees may be repeatedly exposed, day after day, without adverse exposure.

Short-term exposure limit (STEL or TLV-STEL): the concentration to which an employee can be exposed for no more than 15 minutes at a time no more than 4 times a day. There must be at least 60 minutes between exposures at the STEL level.

Ceiling (TLV-C): the highest concentration to which an employee can ever be exposed.

Chemicals which have an X in the skin designation column may be absorbed through the skin and are thus hazardous to use without the use of chemical protective clothing, such as gloves.

Appendix B
Sections of an MSDS

Below are the standard main categories of information on a/*88542. MSDS. Not all sections are present for every chemical--in some cases the information is unavailable or not applicable. Unfamiliar terms may be looked up in the glossary at the end of this manual.

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

CAS NUMBER: RTECS NUMBER:
SUBSTANCE:
TRADE NAMES/SYNONYMS: CHEMICAL FAMILY: CREATION DATE: REVISION DATE:
This section contains not only common names but may contain trade names or other synonyms as well as CAS number and an identifying number from that particular manufacturer or supplier. ---
SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS
COMPONENT : CAS NUMBER: PERCENTAGE:
OTHER CONTAMINANTS:
This section contains a breakdown of the materials present and their amounts. --
SECTION 3 HAZARDS IDENTIFICATION
NFPA RATINGS (SCALE 0-4): HEALTH= FIRE= REACTIVITY=
EMERGENCY OVERVIEW:
POTENTIAL HEALTH EFFECTS: INHALATION: SHORT TERM EFFECTS: LONG TERM EFFECTS: SKIN CONTACT: SHORT TERM EFFECTS: LONG TERM EFFECTS: EYE CONTACT: SHORT TERM EFFECTS: LONG TERM EFFECTS: CARCINOGEN STATUS: OSHA: NTP: IARC:
This section gives an emergency overview of all possible effects of contact with the chemical. These effects are not listed with relevance

to concentration. --

SECTION 4 FIRST AID MEASURES
INHALATION: SKIN CONTACT: EYE CONTACT: INGESTION:
NOTE TO PHYSICIAN ANTIDOTE:
Information in this section, general first aid procedures, is sometimes included in section 3. --

SECTION 5 FIRE FIGHTING MEASURES
FIRE AND EXPLOSION HAZARD: EXTINGUISHING MEDIA:
FIREFIGHTING: FLASH POINT: LOWER FLAMMABLE LIMIT:
UPPER FLAMMABLE LIMIT: AUTOIGNITION:

HAZARDOUS COMBUSTION PRODUCTS:
This section contains vital information in the event of a fire--if the chemical is flammable or combustible, what its flashpoint is. (See Section . . . for CWRU's policy.) --

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:
This section contains spill or leak procedures for the chemical listed. (See Section . . . for CWRU's policy.) --

SECTION 7 HANDLING AND STORAGE
This section contains only regulatory information, not as applicable to the lab worker as section 10 of the MSDS. --

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION
EXPOSURE LIMITS: HYDROGEN BROMIDE: OSHA ceiling ACGIH ceiling NIOSH recommended ceiling DFG MAK TWA; DFG MAK 5 minute peak, momentary value, 8 times/shift
Measurement method:
VENTILATION:
EYE PROTECTION: Emergency wash facilities:

CLOTHING:
GLOVES: RESPIRATOR: FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:
This section contains the OSHA permissible exposure limit (PEL) or time-weighted average (TWA), STEL or short-term exposure limit, and other OSHA/NIOSH exposure standards. (Not all MSDSs contain PELs, TWAs or STELs because this information is only available for certain chemicals.) It also gives information concerning ventilation and proper PPE. (See Appendix ?? for definitions). ---
SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES
DESCRIPTION: MOLECULAR WEIGHT: MOLECULAR FORMULA: BOILING POINT: FREEZING POINT: VAPOR PRESSURE: VAPOR DENSITY: SPECIFIC GRAVITY: WATER SOLUBILITY: PH: ODOR THRESHOLD: EVAPORATION RATE: SOLVENT SOLUBILITY:
This section includes information which could assist in identifying an unknown compound by stating obvious physical characteristics such as appearance (e.g. " a colorless liquid"), boiling point, and melting point. ---
SECTION 10 STABILITY AND REACTIVITY
REACTIVITY: CONDITIONS TO AVOID:
INCOMPATIBILITIES: HAZARDOUS DECOMPOSITION:
POLYMERIZATION:
This section tells how the chemical reacts with other chemicals and what special precautions must be taken in handling and storage, if any.

SECTION 11
TOXICOLOGICAL INFORMATION
CARCINOGEN STATUS: LOCAL EFFECTS: ACUTE TOXICITY LEVEL: TARGET EFFECTS: HEALTH EFFECTS INHALATION:
ACUTE EXPOSURE CHRONIC EXPOSURE
SKIN CONTACT: ACUTE EXPOSURE CHRONIC EXPOSURE EYE CONTACT: ACUTE EXPOSURE CHRONIC EXPOSURE
INGESTION: ACUTE EXPOSURE CHRONIC EXPOSURE

This section contains information about specific possible effects of exposure, as opposed to the more general and basic information given in Section 3; the effects in this section are listed with relevance to concentration. --
--
SECTION 12 ECOLOGICAL INFORMATION
ENVIRONMENTAL IMPACT RATING (0-4):
ACUTE AQUATIC TOXICITY:
DEGRADABILITY:
LOG BIOCONCENTRATION FACTOR (BCF):
LOG OCTANOL/WATER PARTITION COEFFICIENT:
This section contains information about how a chemical reacts in the environment. --
SECTION 13 DISPOSAL CONSIDERATIONS

This section contains regulatory information about disposal; please refer to Chapter Four of this manual for CWRU's disposal policy. --------
----
SECTION 14 TRANSPORT INFORMATION This section contains regulatory information about shipping the chemical. Call Safety Services if you wish to ship any chemical or biological materials. --------
----
SECTION 15 REGULATORY INFORMATION
TSCA INVENTORY STATUS:
CERCLA SECTION 103 (40CFR302.4): SARA SECTION 302 (40CFR355.30): SARA SECTION 304 (40CFR355.40): SARA SECTION 313 (40CFR372.65): OSHA PROCESS SAFETY (29CFR1910.119): HYDROGEN BROMIDE CALIFORNIA PROPOSITION 65:
SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21) ACUTE HAZARD: CHRONIC HAZARD: FIRE HAZARD: REACTIVITY HAZARD: SUDDEN RELEASE HAZARD:
This section contains the regulatory guidelines for the chemical, the details of which can be supplied by Safety Services. -----------------------
----

SECTION 16 OTHER INFORMATION This section contains any miscellaneous information. ---

Appendix C
List of Extremely Hazardous Substances

Subpart 1-Carcinogens

The following is a list of chemicals which the American Council of Governmental and Industrial Hygienists (ACGIH) considers confirmed human carcinogens. *(Code of Federal Regulations, Chapter 29, section 1910.1450(b)*

4-aminodiphenyl asbestos benzene benzidine bis(chloromethyl) ether hexavalent chromium compounds 4,4-methylene bis(2-chloroaniline) beta naphthylamine nickel carbonyl 4-nitrophenyl vinyl chloride

Select carcinogens are defined by the standard as being any substance which meets one of the following criteria:

i) It is regulated by OSHA as a carcinogen.

ii) It is listed under the category, "known to be carcinogens" in the Annual Report on Carcinogens published by the National Toxicology Program (NTP, latest edition).

iii) It is listed under Group 1, "carcinogenic to humans," by the International Agency for Research on Cancer Monographs(IARC, latest edition).

iv) It is listed in either Group 2A or 2B by IARC or under the category "reasonably anticipated to be carcinogens" by NTP and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3;

B) After repeated skin application of less than 300 (mg/kg of body weight) per week or
C) After oral dosages of less than 50 mg/kg of body weight per day. Though many of these chemicals are in common use, they have been listed by the corresponding agencies as being carcinogenic. The following is a list of chemicals which fulfills the first three of the above criteria with an indication of the agency or group which has so classified that chemical:

<u>Substance Source</u>

2-acetylaminofluorene OSHA,
NTP acrylonitrile OSHA,
NTP adriamycin
NTP aflatoxins
NTP,IARC aluminum production
IARC 4-aminobiphenyl OSHA,
IARC, NTP 1-amino-2-methylanthraquinone
NTP 2-aminoanthraquinone
NTP o-aminoazotoluene
NTP amitrole
NTP o-anisidine
NTP o-anisidine hydrochloride
NTP arsenic OSHA, IARC,
NTP asbestos OSHA, IARC,
NTP azathioprine IARC,
NTP benzene OSHA, IARC,
NTP benzidine OSHA, IARC,
NTP benzotrichloride
NTP beryllium and Be compounds OSHA,
NTP betel quid with tobacco IARC
N,N-bis(2-chloroethyl)-2-naphthylamine (chlornaphazine)
IARC bischloroethyl nitro-sourea
NTP bis(chloromethyl) ether and chloromethyl methyl ether(technical grade) OSHA, IARC,
NTP 1,3 butadiene
NTP 1,4 butanediol dimethanesulfonate(myleran) IARC,

NTP cadmium and Cd compounds
NTP carbon tetrachloride
NTP chlorambucil
NTP, IARC chlorendic acid
NTP chlorinated paraffins(C12, 60% chlorine)
NTP 4-chloro-o-phenylene diamine
NTP 1-(2-chloroethyl)-3-cyclohexyl-1-nitrosourea(CCNU)
NTP 1-(2-chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (methyl CCNU)
IARC chloroform NTP 3-chloro-2-methylpropene
NTP chromium(hexavalent) and Cr compounds IARC,
NTP C Basic Red 9 monohydrochloride
NTP p-cresidine
NTP cupferron
NTP cyclophosphamide IARC,
NTP dacarbazine
NTP diethylstilbestrol IARC,
NTP DDT NTP di(2-ethylhexyl)phthalate
NTP 2,4-diaminoanisole sulfate
NTP 2,4-diaminotoluene
NTP 1,2-dibromo-3-chloropropane OSHA,
NTP 1,2 dibromoethane(EDB) OSHA,
NTP 1,4 dichlorobenzene NTP 3,3-dichlorobenzidine OSHA,
NTP 3,3-dichlorobenzidine dihydrochloride
NTP 1,2-dichloroethane
NTP dichloromethane(methylene chloride)
NTP diepoxybutane
NTP di(2-ethylhexyl)phthalate
NTP diethylsulfate
NTP 3,3-dimethoxybenzidine
NTP diglycidyl resourcinol ether
NTP dimethyl sulfate
NTP 4-dimethylaminoazobenzene OSHA,
NTP 3,3-dimethylbenzidine
NTP dimethylcarbamoyl chloride

NTP 1,1-dimethylhydrazine
NTP dimethyl vinyl chloride
NTP 1,4-dioxane
NTP Direct Blue 6
NTP Direct Black 38
NTP epichlorohydrin
NTP erionite IARC estrogens IARC,
NTP estradiol benzoate estradiol monopalmitate estradiol 17 beta estrone ethinyl estradiol mestranol ethyl acrylate
NTP ethyleneimine OSHA ethylene oxide
Substance Source ethylene thiourea
NTP formaldehyde OSHA,
NTP hexachlorobenzene
NTP hexamethylphosphoramide
NTP hydrazine and hydrazine sulfates
NTP hydrazobenzene
NTP iron dextran complex
NTP kepone(chlordecone)
NTP lead acetate
NTP lead phosphate
NTP lindane
NTP hexachlorocyclohexane y-hexachlorocyclohexane b-hexachlorocyclohexane melphalan IARC,
NTP 8-methoxypsoralen(methoxsalen) with Ultraviolet A therapy(PUVA) IARC,
NTP 2-methylaziridine(propyleneimine)
NTP 4,4-methylenebis(N,N-dimethyl) benzenamide (Michler's base)
NTP methyl chloromethyl ether OSHA 4,4-methylenebis(2-chloroaniline)(MBOCA) OSHA,
NTP 4,4-methylenedianiline and its dihydrochloride NTP metronidazole
NTP Michler's ketone
NTP Mineral oils, untreated and mildly treated IARC Mirex
NTP MOPP(combined therapy with nitrogen mustard, vincristine, procarbazine and prednisone) and other combined chemotherapy

including alkylating agents IARC mustard gas(sulfur mustard) IARC,
NTP 2-naphthylamine IARC,
NTP alpha naphthylamine OSHA beta naphthylamine OSHA nickel and Ni compounds IARC,
NTP 4-nitrobiphenyl OSHA nitrilotriacetic acid
NTP 5-nitro-o-anisidine
NTP N-nitrosodiethylamine
NTP N-nitrosodimethylamine
NTP P-nitrosodiphenylamine
NTP N-nitrosomethylvinylamine
NTP N-nitrosomorpholine
NTP N-nitrosonornicotine
NTP Substance Source
N-nitrosopiperidine
NTP N-nitrosopyrrolidine
NTP N-nitrososarcosine
NTP norethisterone
NTP nitrofen
NTP nitrogen mustard hydrochloride
NTP 2-nitropropane
NTP N-nitroso-N-ethylurea
NTP N-nitroso-N-methylurea
NTP N-nitrosodi-N-butylamine
NTP N-nitrosodi-N-propylamine
NTP N-nitrosodiethanolamine
NTP 4,4-oxydianiline
NTP oxymetholone
NTP polycyclic aromatic hydrocarbons(PAHs)
NTP benz(a)anthracene benzo(b)fluoranthene benzo(j)fluoranthene benzo(k)fluoranthene benzo(a)pyrene dibenz(a,h) acridine dibenz(a,j)acridine dibenz(a,h)anthracene 7H dibenzo(c,g)carbazole dibenzo(a,e)pyrene dibenzo(a,h)pyrene dibenzo(a,i)pyrene dibenzo(a,l)pyrene indeno(1,2,3-cd)pyrene 5-methylchrysene phenacetin IARC,
NTP phenazopyridine hydrochloride

NTP phenoxybenzamine hydrochloride
NTP phenytoin and its sodium salts
NTP polybrominated biphenyls(PBB)
NTP polychlorinated biphenyls(PCB)
NTP procarbazine hydrochloride
NTP progesterone
NTP 1,3 propane sultone
NTP beta propiolactone OSHA,
NTP propylene oxide
NTP propylthiouracil
NTP reserpine
NTP saccarine
NTP Substance Source
safrole
NTP selenium sulfide
NTP streptozocin
NTP sulfallate
NTP talc containing asbestos fibers IARC 2,3,7,8-tetrachlorodi-benzo-p-dioxin(TCDD)
NTP tetrachloroethylene(perchloroethylene)
NTP thioacetamide
NTP thiourea
NTP thorium dioxide
NTP tobacco products IARC toluene diisocyanates
NTP o-toluidine and o-toluidine hydrochloride
NTP toxaphene
NTP 2,4,6-trichlorophenol
NTP tris(2,3-dibromopropyl)phosphate
NTP tris(1-aziridinyl)phosphine sulfide
NTP treosulfan IARC urethane
NTP vinyl chloride OSHA, IARC,
NTP

Subpart 2-Reproductive Hazards

Reproductive toxins are chemicals or other hazards which may manifest themselves in lethal effects on the fertilized egg, developing embryo, or fetus or have teratogenic effects in the fetus. In addition, certain reproductive toxins may cause infertility in males and females. The following is a list of chemicals which have been found to have at least one of the above effects. Source: Zenz, Occupational Medicine, Second Edition, Yearbook Medical Publishers, 1988.

Substance Effect

anesthetic gases (halogenated gases) fetal effects
benzene decreased fertility
cadmium fetal effects, decreased fertility
carbaryl decreased fertility
carbon disulfide decreased fertility, increased menstrual bleeding
carbon monoxide decreased fertility, fetal effects
chlordecone(kepone) decreased fertility
2-chlorobutadiene(chloroprene) decreased fertility
dibromochloropropane(DBCP) decreased fertility
diethylstilbestrol(DES) decreased fertility, adenocarcinoma in offspring
epichlorhydrine decreased fertility
ethylene dibromide decreased fertility, fetal effects
ethylene oxide fetal effects
ethylene thiourea fetal effects
glycidyl ethers testicular degeneration
glycol ethers decreased fertility, fetal effects
ionizing radiation(x-rays and gamma rays) decreased fertility, fetal effects
lead decreased fertility, fetal effects
mercury fetal effects
microwaves fetal effects
polychlorinated biphenyls(PCB) decreased fertility, fetal effects
vinyl chloride decreased fertility, fetal effects

Fetal effects may include: spontaneous abortion, low birth weight, still births, neonatal deaths, congenital anomalies and behavioral or developmental disabilities.

Decreased fertility may include both male and female fertility disorders.
Subpart 3-Chemical with a High Degree of Acute Toxicity
Chemicals with a high degree of acute toxicity are so classified because they may be fatal or cause damage to target organs as a result of a single exposure or exposures of short duration. Examples include: Hydrogen cyanide, hydrogen sulfide and nitrogen dioxide.

Appendix E
Table of Chemical Incompatibilities

Chemicals in columns A and B should be kept separate. These examples are illus-trative of common laboratory chemicals; this list is not intended to be exhaustive.

A B

Acetylene and monosubstituted Group IB and IIB metals and

acetylenes (RC=CH) their salts

Halogens

Acids Bases

Alkali and alkaline earth metals Water

carbides Acids

hydrides Halogenated organic hydroxides compounds

oxides Oxidizing agents*

peroxides Chromates, dichromates Halogens

Halogenating agents

Hydrogen peroxide and peroxides

Nitric acid, nitrates

Perchlorates and chlorates

Permanganates

Persulfates

Ammonia, anhydrous and aqueous Halogens

Halogenating agents

Silver Mercury

Inorganic azides Acids

Heavy metals and their salts

Oxidizing agents*

*Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

Inorganic cyanides Acids

Strong bases

Inorganic nitrates Acids

Metals

Nitrites

Sulfur

Inorganic nitrites Acids

Oxidizing agents*

Inorganic sulfides Acids

Mercury and its amalgams Acetylene

Ammonia, anhydrous and aqueous

Nitric acid

Sodium azide

Nitric acid Chromic acid and chromates

Metals

Nitrites, reducing agents

Permanganates

Sulfides

Sulfuric acid

Organic compounds Oxidizing agents*

organic acyl halides Bases

Organic hydroxy compounds

organic anhydrides Bases

Organic hydroxy compounds

organic halogen compounds Aluminum metal

organic nitro compounds Strong bases

Oxalic acid Mercury and its salts

Silver and its salts

*Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

Phosphorus (yellow) Oxygen

Oxidizing agents* Strong bases

Phosphorus pentoxide Halogenating agents

Water

Powdered metals Acids

Oxidizing agents*

Sulfuric acid Metals

Chlorates Perchlorates

Permanganates

Nitric acid

*Oxidizing agents include the types of compounds listed in the entry for alkali and alkaline earth metals, etc.

Appendix F

Sample Hazardous Waste Information form

Select Bibliography

ACGIH. **Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices**. Cincinnati, Ohio: ACGIH; 1995.

American Chemical Society. **Safety in Academic Chemistry Laboratories.** 6th ed. Washington, DC; 1995.

Bretherick, L. **Handbook of Reactive Chemical Hazards**. 5th ed. Oxford, Boston: Butterworth-Heineman; 1995.

CDC/NIH. **Biosafety in Microbiological and Biomedical Laboratories**. 3rd ed. Washington DC;1993.

Dux, J.P., Stalzer, R.F. **Managing Safety in the Chemical Laboratory**. New York, New York: Van Nostrand Reinhold; 1988.

Furr, A.K. **CRC Handbook of Laboratory Safety**. 4th ed. Boca Raton, Florida: CRC Press; 1990.

Klaasen, C.D., Amdur, M, Doull, J., **Cassarett and Doull's Toxicology: The Basic Science of Poisons**, Third Edition, Macmillan Publishing Company, New York, New York, 1986

Lenga, R.A., **The Sigma-Aldrich Library of Chemical Safety Data,** Edition II, Volumes I and II, Sigma-Aldrich Corporation, 1988

Lewis, R.J. **Sax's Dangerous Properties of Industrial Materials.** 8th ed. 3 vols. New York: Van Nostrand Reinhold; 1996.

Lewis, R.J. **Hazardous Chemicals Desk Reference.** , New York: Van Nostrand Reinhold; 1997.

The Merck Index, Eleventh Edition, 1989

National Research Council. **Prudent Practices for Disposal of Chemicals from Laboratories**. Washington, DC: National Academy Press; 1983.

National Research Council. **Prudent Practices for Handling Hazardous Chemicals in Laboratories**. Washington DC: National Academy Press; 1981.

National Institutes for Occupational Safety and Health. **Pocket Guide to Chemical Hazards**. Washington DC: USDHHS; 1994.

Patty, F. A. **Industrial Hygiene and Toxicology**. 4th ed. New York: John Wiley and Sons, 1991.

Perrin, D.D., Armarega, W.L.F., Perrin, D.R. **Purification of Laboratory Chemicals**. 4th ed. New York: Pergamon Press: 1996.

Raffle, P.A.B., Lee, W.R., McCallum, R , Murray, R., **Hunter's Diseases of Occupations**. 8th ed. London, Boston: E. Arnold; 1994.

Glossary of Terms

Acute Severe, often dangerous conditions in which relatively

rapid changes occur.

Acute Exposure An intense exposure over a relatively short period of time.

Asphyxiant A chemical (gas or vapor) that can cause death or unconsciousness by suffocation. Simple asphyxiants, such as nitrogen, either use up or displace oxygen in the air. They becomes especially dangerous in confined or enclosed spaces. Chemical asphyxiants, such as carbon monoxide and hydrogen sulfide, interfere with the body's ability to absorb or transport oxygen to the tissues.

Boiling Point The temperature at which the vapor pressure of a liquid equals atmospheric pressure or at which the liquid changes to a vapor. The boiling point is usually expressed in degrees Fahrenheit. If a flammable material has a low boiling point, it indicates a special fire hazard.

"C" or Ceiling A description usually seen in connection with a published exposure limit. It refers to the concentration that should not be exceeded, even for an instant. It may be written as TLV-C or Threshold Limit Value Ceiling. (see also THRESHOLD LIMIT VALUE)

Carcinogen A substance or physical agent that may cause cancer in animals or humans.

C.A.S. number Identifies a particular chemical by the Chemical Abstracts Service, a service of the American Chemical Society that indexes and compiles abstracts of worldwide chemical literature called "Chemical Abstracts."

Chemical As broadly applied to the chemical industry, an element or a compound produced by chemical reactions of a large scale of either direct industrial and consumer use or for reaction with other chemicals.

Chemical Reaction A change in the arrangement of atoms or molecules to yield substances of different composition and properties. (see REACTIVITY)

Chronic Persistent, prolonged, or repeated conditions.

Chronic Exposure A prolonged exposure occurring over a period of days,

weeks, or years.

Combustible Liquid According to the DOT and the NFPA, combustible liquids are those having a flash point at or above 100o F (37.8o C), or liquids that will burn. They do not ignite as easily as flammable liquids. However, combustible liquids can be ignited under certain circumstances, and must be handled with caution.

Concentration The relative amount of a material in combination with another material. For example, 5 parts (of acetone) per million (parts of air).

Corrosive A substance that, according to the DOT, causes visible destruction or permanent changes in human skin tissue at the site of contact or is highly corrosive to steel.

Cubic Meter A measure of volume in the metric system.

Cutaneous Pertaining to, or affecting the skin.

Decomposition The breakdown of a chemical or a substance into different parts of simpler compounds. Decomposition can occur due to wear, chemical reaction, decay, etc.

Dermatitis An inflammation of the skin.

Designated Area An area which may be used for work with "select carcinogens," reproductive toxins, or substances with a high degree of acute toxicity. A designated area may be the entire lab or just a section of it, such as a laboratory hood.

Dilution Ventilation See GENERAL VENTILATION.

Dyspnea Shortness of breath; difficult or labored breathing.

Employee An individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

Epidemiology The study of disease in (human) population.

Erythema A reddening of the skin.

Evaporation Rate The rate at which a material is converted to vapor (evaporates) at a given temperature and pressure when compared to the evaporation rate of a given substance.

Explosive A chemical that causes a sudden, almost instantaneous release of pressure, gas, or heat when subjected to sudden shock, pressure, or high temperature.

Eye Hazard A chemical which affects the eye or visual capacity.

Signs and symptoms: conjunctivitis, corneal damage; chemicals: organic solvents, acids.

Flammable **a) Aerosol, flammable** -- an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening or a flashback (a flame extending back to the valve) at any degree of opening.

b) Gas, flammable --

1) a gas that, at ambient temperature and pressure, forms a flammable mixture with air as a concentration of 13% by volume or less, or

2) a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12% by volume, regardless of flash point below 100o F, except any mixture having components with flash points of 100o F or higher, the total of which make up 99% or more of the total volume of the mixture.

c) Liquid, flammable -- According to the DOT and NFPA, a liquid which has a flash point below 100o F (37.8o C) (see FLASH POINT)

d) Solid, flammable -- a solid, other than a blasting agent or explosive as defined in 1910.109(a), that is liable to cause fire through friction, absorption or moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.45, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Flash Point The lowest temperature at which liquid gives off enough vapor to form an ignitable mixture and burn when a source of ignition (sparks, open flame, cigarettes, etc.) is present. Two tests are used to determine flash point: open cup and closed cup. The appropriate test method is indicated on the MSDS after the flash point.

General Ventilation Also known as general exhaust ventilation. This is a system of ventilation consisting of either natural or mechanically induced fresh air movements to mix with and dilute contaminants in the workroom air. This is not the recommended type of ventilation to control contaminants that are highly toxic, when there may be corrosion problems from the contaminant being generated, and where fire or explosion hazards are generated close to sources of ignition. (see also LOCAL EXHAUST VENTILATION)

Hazardous Material Any substance or compound that has the capability of producing adverse effects on the health and safety of humans.

Hematopioetic Agents which act on the blood or the hematopoietic system. They decrease hemoglobin function and deprive the body tissues of oxygen. Signs and symptoms: cyanosis, loss of consciousness; chemicals: carbon monoxide, cyanides.

Hepatoxins Chemicals which produce liver damage. Signs and symptoms: jaundice, liver enlargement; chemicals: carbon tetrachloride, nitrosamines.

Highly Toxic **a)** A chemical that has a medial lethal dose (LD50) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.

b) A chemical that has a median lethal dose (LD50) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kilograms each

c) A chemical that has a median lethal concentration (LC50) in air of 200 parts per million by volume or less or gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust when administered by continuous inhalations for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

Ignitable A solid, liquid, or compressed gas waste that has a flash point of less than 140o F. Ignitable material may be regulated by the EPA as a hazardous waste as well.

Incompatible The term applied to two substances to indicate that one material cannot be mixed with the other without the possibility of a dangerous reaction.

Ingestion Taking a substance into the body through the mouth, as in food, drink, medicine, or unknowingly as on contaminated hands or cigarettes, etc.

Inhalation The breathing in of an airborne substance that may be in the form of gases, fumes, mists, vapors, dust or aerosols.

Inhibitor A substance that is added to another to prevent or slow down an unwanted reaction or change.

Irritant A substance that produces an irritating effect when it contacts skin, eyes, nose or respiratory system.

Kilogram A unit of (kg) weight in the metric system equal to 2.2 pounds.

Lethal Dose 50 The dose of a (LD50) substance or chemical that will kill 50% of the test animals in a group during a single exposure.

Local Exhaust Also known as exhaust ventilation. A ventilation Ventilation system that captures and removes the contaminants at the point they are being produced before they escape into the workroom air. The system consists of hoods, ductwork, a fan, and possibly an air-cleaning device. It works by removing the contaminant, not just diluting it, making it more economical over the long term. However, the system must be properly designed with the correctly-shaped hoods and correctly-sized fans and ductwork.

Lower Explosive Also known as the Lower Flammable Limit (LFL). The Limit (LEL) lowest concentration of a substance that will produce a fire or flash when an ignition source is present. It is expressed in the percent of vapor or gas in the air by volume. Below the LEL or LFL, the air/contaminant mixture is theoretically too "lean" to burn. (see also UEL)

Lung Hazards Signs and symptoms

Melting Point The temperature at which a solid changes to a liquid. A melting range may be given for mixtures.

MPPCF "Millions of particles of particulate per cubic foot of air."

Material Safety Data Safety information about a chemical provided by the

Sheet (MSDS) manufacturer or distributor. OSHA regulations require that an MSDS for each chemical in use in a laboratory be accessible to every employee of that laboratory.

Mutagen Anything that can cause a change (or mutation) in the genetic material of a living cell.

Narcosis Stupor or unconsciousness caused by exposure to a chemical.

Nephrotoxins Chemicals which produce kidney damage. Signs and symptoms: edma, proteinuria; chemicals: halogenated hydrocarbons, uranium.

Odor Threshold The minimum concentration of a substance at which a majority of test subjects can detect and identify the substance's characteristic odor.

Oxidation The process of combining oxygen with some other substances or a chemical change in which an atom loses electrons.

Oxidizer A substance that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Oxygen Deficiency An atmosphere having less than the normal percentage of oxygen (20%) found in normal air.

Permissible Exposure The term used by OSHA to indicate the maximum air Limit (PEL) concentration to which employees can be exposed. PEL may either be a time-weighted average (TWA) exposure limit (8 hour), a 15 minute short-term exposure limit (STEL), or a ceiling (C).

Personal Protective Any devices or clothing worn by the worker to protect Equipment (PPE) against hazards in the environment. Examples include respirators, gloves, lab coats, and splash goggles.

PPM Parts (of vapor or gas) per million (parts of air) by volume.

Polymerization A chemical reaction which two or more small molecules combine to form larger molecules that contain repeating structural units of the original molecules. A hazardous polymerization is the above reaction with an uncontrolled release of energy.

Pyrophoric A chemical that will ignite spontaneously in air at a temperature of 130o F or below.

Reactivity A substance's susceptibility to undergoing a chemical reaction or change that may result in dangerous side effects, such as explosions, burning, and corrosive or toxic emissions. The conditions that cause the reaction, such as heat, other chemicals, or dropping, will usually be specified as "Conditions to Avoid" when a chemical's reactivity is discussed on a MSDS.

Reproductive Toxins Chemicals which affect the reproductive capabilities, including chromosomal damage (mutations) and effects on fetuses (teratogenesis). Signs and symptoms: birth defects, sterility; chemicals: lead, DBCP

Respirator A device which is designed to protect the wearer from inhaling harmful contaminants.

Respirator Hazard A particular concentration of an airborne contaminant that, when it enters the body by way of the respiratory system or by being breathed into the lungs, results in some impairment of a bodily function.

Risk Assessment Evaluation of existing hazards concerned with a procedure or process in the work environment.

"Select Carcinogen" See Appendix C for the full definition.

Short-term Represented as STEL or TLV-STEL. The maximum exposure limit concentration to which an employee can be exposed for no more than 15 minutes at a time no more than 4 times a day. There must be at least 60 minutes between exposures at the STEL level. Also, the TLV-TWA must not be exceeded.

"SKIN" This designation sometimes appears on an MSDS alongside a TLV or PEL. It refers to the possibility of absorption of the particular chemical through the skin and eyes. Thus, protection of large surface areas of skin should be considered so that the TLV is not invalidated.

Skin Hazards Chemicals which affect the dermal layer of the body. Signs and symptoms: depletion of fats of the skin, rashes, irritation; chemicals: ketones, chlorinated compounds.

Systemic Spread throughout the body, affecting many or all body systems or organs not located in one spot or area.

Teratogen An agent or substance that may cause physical defects in the developing embryo or fetus.

Threshold Limit Airborne concentrations of substances devised by the Value ACGIH that represent conditions under which it is believed that nearly all employees may be repeatedly exposed, day after day, without adverse effects. TLVs are advisory guidelines, not legal standards, that are based on evidence from industrial experience, animal studies, or human studies when they exist. TLVs include: Time Weighted Average (TLV-TWA), Short- term exposure limit (TLV-STEL), and ceiling (TLV-C). (see also PEL)

Time Weighted Represented as TLV-TWA. The average time over a Average given work period (e.g., a normal 8-hour work day) of a person's exposure to a chemical or agent. The average is determined by sampling for the contaminant throughout the time period.

Upper Explosive Also known as the Upper Flammable Limit (UFL). Limit (UEL) The highest concentration of a substance that will burn or explode when an ignition source is present. It is expressed in the percent of vapor or gas in the air by volume. Above the UEL or UFL, the air/contaminant mixture is theoretically too "rich" to support combustion. The difference between the LEL and the UEL constitutes the flammable range or explosive range of a substance. That is, if the LEL is 1 ppm and the UEL is 5 ppm, then the explosive range of the chemical is 1 ppm to 5 ppm. (see also LEL)

Unstable A chemical which in the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure, or temperature.

Vapor The gaseous form of substances which are normally in the liquid or solid state (at normal room temperature and pressure). Vapors evaporate into the air from liquids, such as solvents. Solvents with low boiling points will evaporate readily.

Water-Reactive A chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

Glossary of Organizations

ACGIH The American Conference of Governmental Industrial Hygienists is a voluntary membership organization of professional industrial hygiene personnel in governmental or educational institutions. The ACGIH develops and publishes recommended occupational exposure limits each year called Threshold Limit Values (TLVs) for hundreds of chemical, physical agents, and biological exposure indices.

ANSI The American National Standards Institute is a voluntary membership organization (operating with private funding) that develops consensus standards nationally for a wide variety of devices and procedures.

DOT The Department of Transportation is the Federal Agency that regulates the labeling and transportation of hazardous material.

EPA The Environmental Protection Agency is the Federal Agency responsible for administration of laws to control and/or reduce pollution of water, air, and land systems.

IARC International Agency for Research on Cancer.

NFPA The National Fire Prevention Association is a voluntary membership organization whose aims are to promote and improve fire protection and prevention. The NFPA has published 16 volumes of codes known as the National Fire Codes. Within these codes in Standard No. 704, "Identification of the Fire Hazards of Materials." This system rates the hazards of a material during a fire. These hazards are divided into health, flammability, and reactivity hazards and appear in a color-coded diamond system using from 0 (no special hazard) through 4 (severe hazard) indicated severity of the hazard.

NIOSH The National Institute for Occupational Safety and Health is a national organization that, among its various responsibilities, trains occupational health and safety professionals, conducts research on health and safety concerns, and tests and certifies respirators for use in the workplace.

NIHS National Institute of Health Science.

NSF National Science Foundation.
OSHA The Occupational Safety and Health Administration is a federal agency under the Department of Labor that publishes and enforces safety and health regulations for most businesses and industries in the United States.