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CHEMICAL HYGIENE PLAN
Revised October 11, 2010

INTRODUCTION
Faculty, staff and students who work in science laboratories are exposed to many kinds of hazards that involve a greater variety of possible hazards than do most workplaces. In particular, laboratories in which chemicals are used must be prepared to deal with substances known to be hazardous, with the possible hazards of new substances, and with new types of experiments. Furman University has the responsibility of administering safe and healthy instructional laboratories, where relatively inexperienced students must be introduced to the safety precautions necessary to the conduct of various laboratory operations.

In addition to the moral obligation of providing a safe and healthy environment to our students, Furman University has a legal obligation to provide for the safety of laboratory employees by complying with the provisions of the Occupational Safety and Health Administration (OSHA). In particular, the University must comply with 29 CFR 1910.1450, “Occupational Exposure to Hazardous Chemicals in Laboratories.” The main element of this “Lab Standard” is its requirement for employers to develop and carry out the provisions of a written Chemical Hygiene Plan (CHP).

This manual contains specific details about how the University intends to comply with the OSHA Lab Standard, and provides information on chemical hazards and procedures for the safe handling of hazardous chemicals and equipment commonly used in laboratories. Physical hazards such as flammable liquids, reagents, explosives, compressed gas cylinders, and cryogenic liquids are covered. Health hazards associated with chemicals such as corrosives, toxins, carcinogens and embryotoxins are included. Information is also presented on personal protective equipment, safety equipment that can reduce exposures and prevent accidents, and protection from other hazards commonly found in laboratories such as electrical equipment.

IMPLEMENTATION AND RESPONSIBILITIES
The University Chemical Hygiene Plan will be implemented and administered by the Risk Management Office Safety Office (RMO). The Risk Manager has been designated as the University’s Chemical Hygiene Officer (CHO). The CHO is responsible for developing, implementing, and reviewing the written Chemical Hygiene Plan which will be reviewed annually and updated as needed. The Chemical Hygiene Plan will apply to all areas or laboratories engaged in the laboratory use of hazardous chemicals and agents to include the departments of Biology, Chemistry, Earth and Environmental Science, and Psychology.

Although ultimate responsibility for the development and implementation of the Chemical Hygiene Plan for the University rests with the CHO, it is important to realize that the responsibility for the chemical hygiene itself rests at all levels of the University as outlined below:

1. The President of the University, as the chief executive of the University, has ultimate responsibility for chemical hygiene within the institution and, with other administrators, provides continuing support for the Chemical Hygiene Plan.
2. Vice-Presidents, Deans, and Department Heads are responsible for compliance with the University Chemical Hygiene Plan within their areas. This includes, ensuring that all employees under their direct supervision are complying with the Chemical Hygiene Plan.
3. Laboratory Instructors and Managers have overall responsibility for chemical hygiene in their laboratories.
They will develop and implement standard operating procedures and training programs specific to the work being carried out in their laboratories. In addition, they shall ensure that lab workers understand and follow the Chemical Hygiene Plan.

4. Laboratory employees and students are ultimately responsible for developing and applying good chemical hygiene practices as outlined in the Chemical Hygiene Plan. They must always use the appropriate personal protective equipment which will be provided for their use. Laboratory occupants are required to report all accidents, injuries, and illnesses to their supervisor, so that the circumstances of the incident can be investigated and corrective action(s) taken.

COMPONENTS OF THE CHEMICAL HYGIENE PLAN

The OSHA Lab Standard specifies that eight elements be addressed in order to ensure the protection of laboratory employees. These eight elements are summarized below, and are fully detailed in 29 CFR 1910.1450(e)(3) of the regulation.

1) Standard operating procedures for handling toxic chemicals.
2) Control measures to reduce worker exposures.
3) Fume hood performance.
4) Employee information and training (including emergency procedures).
5) Requirements for prior approval of laboratory activities.
6) Medical consultation and medical examinations.
7) Chemical hygiene responsibilities.
8) Special precautions for work with particularly hazardous substances.

Copies of the University Chemical Hygiene Plan will be maintained in the following locations:
- Risk Management Department
- Main office of Biology, Chemistry, Earth and Environmental Science, and Psychology
GENERAL SAFETY RULES
The following should be used for essentially all laboratory work with chemicals:

ACCIDENTS AND SPILLS
Eye Contact: Promptly flush eyes with water for a minimum of 15 minutes in provided eyewash and seek medical attention.
Ingestion: Encourage the victim to drink large amounts of water and seek medical attention.
Skin Contact: Promptly flush the affected area with soap and water and remove any contaminated clothing.
   If symptoms persist after washing, seek medical attention.
Clean-Up: Promptly clean up spills using the appropriate protective apparel and equipment located at the designated area within each department and dispose of in accordance with this Plan.

AVOIDANCE OF ROUTINE EXPOSURE
Develop and encourage safe habits; avoid unnecessary exposure to chemicals by any route;
   • Do not smell or taste chemicals.
   • Vent apparatus which may discharge toxic chemicals into fume hoods.
   • Inspect gloves and test glove boxes before use.
   • Verify performance of fume hoods and safety cabinets.

CHOICE OF CHEMICALS
Use only those chemicals for which the quality of the available ventilation system is appropriate.

EATING, DRINKING, ETC.
Avoid eating, drinking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present; wash hands before conducting these activities outside the lab areas.

Avoid storage, handling, or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations.

HORSEPLAY
Avoid practical jokes or other behavior which might confuse, startle or distract another worker.

MOUTH SUCTION
Do not use mouth suction for pipeting or starting a siphon.

PERSONAL APPAREL
Confine long hair and loose clothing. Wear closed-toe shoes at all times in the laboratory. Do not wear sandals or perforated shoes in laboratories where there is a risk of exposure to falling glassware or chemicals.

PERSONAL HOUSEKEEPING
Keep the work area clean and uncluttered; properly label and store all chemicals; clean up the work area on completion of an operation or at the end of each day.

PERSONAL PROTECTION
Assure that appropriate eye protection is worn by all persons, including visitors, where chemicals are stored or
handled. Regular prescription glasses are not a substitute for proper eye protection against chemical splashes or potential flying particles. Depending on the hazard potential (corrosiveness of chemical and risk of splash or flying particles), either safety glasses with side-shields, safety goggles, or safety glasses with face shield shall be worn in the labs.

Wear appropriate gloves when the potential for contact with toxic materials exists; inspect the gloves before each use, wash them before removal, and replace them periodically if they are not disposable. (A table of resistance to chemicals of common glove materials is given in the appendix). Disposable gloves are to be used only for incidental contact and are not intended as the only means for protecting skin against toxic materials when contact is likely.

Wear appropriate clothing to protect skin against spills, cuts and burns to include lab coats, long pants, and closed-toe shoes.

Use any other protective and emergency apparel and equipment as appropriate.

PRIOR APPROVAL

Prior approval by the supervising faculty member is required in order to proceed with a non-routine task involving hazardous materials or equipment. Prior approval shall not be given until each student, teaching assistant, etc. assigned to the non-routine task has received a safety briefing of the hazards associated with the task. Such a briefing shall be given by the supervising faculty member. Non-routine tasks occur whenever:

1. A new procedure, process, or test is requested, even if it is similar to old processes.
2. There is a change or substitution of ingredient chemicals in a procedure, or a substantial change in the amount of chemicals used.
3. Attendees become ill, suspect chemical exposure, or otherwise suspect a failure of engineered safeguards.
4. Experiments involving human blood, or other potentially infectious materials.

UNATTENDED OPERATIONS

Reactions that are left to run unattended overnight or at other times are prime sources for fires, floods, and explosions. Leave lights on and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation. Do not let equipment such as power stirrers, hot plates, heating mantles, and water condensers run overnight without fail-safe provisions and the instructor’s consent. Check unattended reactions periodically. Plainly post emergency contact numbers.

USE OF FUME HOOD

Use the fume hood for operations which might result in release of toxic chemical vapors or dust. In general, use a hood or other local ventilation device when working with any appreciably volatile substance with a Threshold Limit Value (TLV) of less than 50 parts per million (ppm). In addition:

- confirm adequate hood performance before use;
- keep hood sash closed at all times except when adjustments with the hood are being made;
- work at the hood with sashes closed as much as practical to provide protection from explosions, chemical splashes, and exposure;
- keep materials stored in hoods to a minimum and do not allow them to block vents or air flow.

WASTE DISPOSAL

Hazardous chemical waste should be disposed in containers labeled as “Hazardous Waste.” Follow all waste disposal procedures outlined in this plan. Proper waste labels are required and can be obtained from the departmental office and/or RMO.
Do not discharge to the sewer concentrated acids or bases, flammable, toxic, malodorous, or lachrymatory substances, or any other substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow. RMO shall be consulted for approval prior to any discharge to the sewer.

**WORKING ALONE**

Avoid working alone in a building. If necessary, be certain that the lab supervisor is aware that you will be working alone.
CHEMICAL PROCUREMENT, DISTRIBUTION, AND STORAGE

PROCUREMENT
Proper chemical management and safety practices begin with the purchasing of chemicals. The following procedures should be used by the responsible department:
1. Preplan all laboratory and work activities. Carefully estimate the amount of each chemical required to reduce disposal costs. Do not order in bulk unless the material will be utilized in a timely manner.
2. Prepare the work area for the arrival of the chemical to include:
   - proper storage and work area;
   - appropriate signs posted;
   - personal protective equipment obtained and personnel trained on usage.
3. Request Material Safety Data Sheets (MSDS) from vendors when chemicals are ordered and retain in the departmental MSDS notebook when they are received. Ensure that incoming chemicals are added to the inventory.
4. Donated materials must not be accepted without prior approval from the department head and the RMO. In any event, donated materials should be limited to the amount of chemical actually needed.
5. Authorization to use controlled substances for research purposes usually rests with the department head. The holder of the license must sign all purchases and maintain records of the purchase. Copies of the license must be provided to the RMO.

DISTRIBUTION
The following procedures shall be used for the receipt and distribution of chemicals:
1. Observe all warnings on the receiving package. If the chemical is not properly labeled, either do not accept the chemical or label it appropriately. Labels must contain the name of the chemical, appropriate hazard information, and the name and address of the manufacturer.
2. Review and observe information on the safe handling and storage of the chemical.
3. When transporting gas cylinders, use an appropriate hand truck and strap the cylinder down. Never drag or roll cylinders. Leave the cover cap on until the cylinder is located in its area of intended use.
4. Do not stack boxed chemicals beyond two levels on a delivery cart.

STORAGE
Numerous hazards are associated with the storage of chemicals. Accidents can be reduced by the careful planning of storage procedures and facilities. Chemical containers should be periodically inspected to ensure that labels are legible and intact, containers are not leaking or rusting, and that chemicals have not dangerously deteriorated or peroxided. Containers should always be kept tightly sealed. Storage in laboratories should be minimized. Chemicals should be inventoried periodically and unnecessary chemicals returned to the stock room or disposed through the RMO.

Chemicals should be stored in a definite storage area and returned to that location after each use. Chemicals should be stored on shelves with a one-half inch retaining lip. Shelves should not be above shoulder height. This is especially true of corrosive storage due to the risk of injury to eyes. Shelves should be sturdy and coated with a chemically resistant paint. Chemicals should not be stored on bench tops or in hoods. Storage areas should be cool, dry, well ventilated, and out of direct sunlight.

Every effort should be made to separate chemicals that may react together and create a hazardous situation. A common and unsafe practice is storing chemicals alphabetically. This practice often increases the potential for explosions or the release of toxic vapors. Chemicals should be stored according to chemical class as specified in the appendix.
Stock quantities of carcinogens should be stored in a designated area or cabinet and posted with the appropriate hazard sign. Volatile chemicals should be stored in a ventilated storage area in a secondary container having sufficient volume to contain the material in case of an accident.

Corrosive chemicals should not be stored with combustibles, flammables, organics, and other highly reactive and toxic compounds. Acid and bases should not be stored together. Organic acids should be separated from sulfuric, nitric, perchloric acid and other strong oxidizers.

Flammable liquid storage in laboratories is limited to 5 gallons (except Class 1A liquids which is limited to 1 gallon) outside of flammable storage cabinets or approved safety cans. Storage in glass containers is limited to 1 pint for Class 1A liquids and 1 quart for Class 1B liquids unless permission has been obtained from the RMO.

Flammable liquids should not be stored near exits, sources of heat, ignition, or near strong oxidizing agents, explosives, or reactives. Storage areas should be adequately ventilated to prevent vapor from building up. Fire extinguishers should be readily available. Metal dispensing and receiving containers should be grounded and bonded together by a suitable conductor to prevent static sparks.

Reactive chemicals should be protected from shock, heat, ignition sources, and rapid temperature changes. Containers should be separated from corrosives, flammables, organic materials, toxins, and other reactive chemicals. Depending on the quantity, explosives may need to be stored in specially constructed magazines. Water reactive chemicals should be separated from sprinkler systems, emergency showers, eyewash stations and other water sources. Keep containers well sealed. Store water reactives under an inert non-flammable solvent.

Cylinders must be secured, and stored upright with the valve protector in place. Storage areas should be well ventilated and dry. Cylinders should be stored away from ignition sources, heat, and combustibles. Flammable gas and oxidizing cylinders must be separated by 20 feet or a 5 foot high wall with a half-hour fire rating. Highly toxic gas cylinders must be stored in ventilated storage closets, or in a manner that will not contaminate breathing air.

Individuals holding licenses to use drugs in their research must provide safe secure storage for these drugs. The storage must be lockable and difficult to move.

Ethers, picric acid, and perchloric acid that have deteriorated in storage present potential explosion hazards. These materials shall be formally inspected on a periodic basis, such as quarterly, to ensure the integrity of the chemical. High risk ethers older than one year since last inspection for peroxides, and picric acid and perchloric acid with visible crystal formation should not be touched or opened. The RMO should be called for proper disposal of these items.
CONTROL MEASURES

Control measures are actions taken by the department to provide a safe working area to use, store, and conduct required activities that involve hazardous materials. It is important that each work area be designed and utilized by taking into consideration the collective properties of chemicals to be used so that exposure can be prevented. Similarly, the equipment designed for the safe use of chemicals must be overseen and/or monitored by all individuals in the work area and deficiencies corrected or reported.

ENGINEERING CONTROLS

Engineering controls relate to the physical design and operation of laboratory equipment to eliminate hazards associated with the use of chemicals. Laboratories at the University are designed to meet applicable fire, electrical, plumbing, HVAC, lighting, structural, and safety codes. It is the responsibility of each department to provide a safe working laboratory environment by providing the appropriate design for the storage, use, and handling of chemicals. Ventilation is the most common and most important form of engineering control used to reduce exposures to hazardous chemicals.

Laboratory fume hoods serve to control exposure to toxic, offensive or flammable vapors. The hood is not an appropriate means for disposing of chemicals through evaporation, nor is it a storage cabinet. Stored chemicals can interfere with efficient hood operation, and in the event of an accident or fire, every item in the hood may become involved.

Before each use, be sure that the hood is working properly and contact Facilities Services if maintenance is required. Hoods are equipped with low flow alarms and gauges indicating adequate operation to the user. The RMO shall also verify proper performance on all hoods biannually. Sash openings should be kept to a minimum. Users should keep their faces outside the plane of the hood sash and should remain alert to changes in air flow. Equipment should be placed as far back in the hood as practical and activities carried out at least 6 inches from the front edge of the hood. Information on specific types of hoods can be found in the section on “Generalized Procedures for Lab Equipment” and in the appendix.

PERSONAL PROTECTIVE APPAREL AND EQUIPMENT

Each department must take steps to correct situations that endanger the health and safety of workers. It is the workers responsibility to use personal protective equipment once the need for this equipment has been established by the department and/or the RMO. It is also the responsibility of the laboratory supervisor to enforce disciplinary action for lab occupants that disregard safety requirements. Several types of personal protective equipment are available for the laboratory worker to reduce exposures to hazardous chemicals. These include eye protection, gloves, protective clothing, and, in rare circumstances, respirators.

Eye Protection

In chemical laboratories, flying glass, splattering chemicals, and dust particles are among the hazards that represent serious accident potential to the eyes. The type of protection required depends on the hazards involved and may range from safety glasses or chemical splash goggles, to full face shields. Eyewear and face protection must provide reasonable protection, be comfortable, durable, well fitted, and easily cleaned. Appropriate eye protection is required for workers and visitors in all areas where chemicals are used or stored if there is a reasonable possibility that injury might be prevented from the use of that equipment. All safety eye wear must comply with ANSI Z87.1-2003.

Safety glasses are primarily designed for impact protection. Minimal protection from chemical splashes is afforded by the addition of side shields and a brow bar. As a minimum, laboratory workers in low hazard labs must wear safety glasses equipped with a brow bar and side shields.

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Chemical splash goggles should be worn in all work areas of the laboratory where there is a significant danger of chemical splashes or flying particles.

Face shields should be worn when maximum protection is needed from flying particles, chemical splashes (e.g., working with highly reactive materials), and radiant energy. Face shields must be at least 1 mm in thickness. Face shields are not intended to provide full eye protection and must be worn over safety glasses or goggles.

Gloves
There are numerous types of physical and chemical environments necessitating a specific kind of hand protection. Many chemicals can be readily absorbed through the skin, so appropriate protection is necessary. Gloves must be selected on the basis of the chemical being handled, the hazards involved, and the suitability for the operation being considered. The most important step in selecting gloves is the permeability of the glove to the particular chemical or solvent. Gloves should be worn when handling corrosive chemicals, toxins, radioactive materials, pathogenic microorganisms, cryogenics, or any material which may penetrate the skin.

Common glove materials include neoprene, polyvinyl chloride, nitrile, butyl, natural rubber, viton, and polyvinyl alcohol. These materials differ in their ability to prevent the penetration of liquids or vapors through to the hand. In general, viton gloves protect workers handling chlorinated and aromatic solvents such as 1,2-dichloroethane and benzene. Butyl gloves protect against ketones, esters, dioxane, ethyl amine, formaldehyde, and glycol ethers. Nitrile latex gloves protect against commonly used chemicals such as petroleum solvents, oils, grease, amino acids, cyclohexanol, formaldehyde, and hydrazine. Neoprene gloves are good for protection from most common oils and aliphatic hydrocarbons. Polyvinyl alcohol gloves provide protection against the aromatic and chlorinated hydrocarbons. Leather gloves may be worn when handling broken glassware or for inserting glass tubes into stoppers. Insulated gloves should be used when working at temperature extremes. Specific information concerning resistance to various chemicals is available in the Appendix, the glove manufacturer’s catalog, or the RMO.

Gloves should be inspected prior to use for discoloration, punctures, or tears. Gloves should be cleaned or replaced periodically depending on the frequency of use and the permeability of the chemical. When handling highly corrosive and toxic chemicals two pairs of gloves should be worn. The outer pair may be of a different material to increase the range of protection against a variety of compounds. The glove should be long enough so that a cuff can be made in the top of the glove to prevent chemicals from running down the arm.

Protective Clothing
Protective clothing should be used for most types of general laboratory work. It is required for work with highly toxic chemicals and carcinogens. Protective clothing is designed to prevent vapors, dusts, and toxic and corrosive chemical spills from coming in contact with the skin. The garment should resist these hazards, be relatively comfortable and allow the execution of manual tasks. Protective clothing such as laboratory coats, aprons, rain gear, and disposable suits should be readily available to all laboratory personnel. The clothing can be disposable or washable. When working with pyrophorics and flammable liquids, lab coats should be fire-resistant to include Nomex (offers highest level of protection from fire), fire-resistant cotton (fire resistance will dissipate after repeated laundering), or 100% cotton (superior to synthetic blends for fire-resistance, but inferior to Nomex and fire-resistant cotton).
Respirators
Respirators may only be worn when engineering controls cannot keep exposure to chemicals below permissible exposure levels (PELs) set by OSHA. Under normal operating procedures, fume hoods will reduce exposure to acceptable levels. Employees (and students) may not wear a respirator until they have been cleared by a physician, attended Respiratory Protection training provided by the RMO, and been fit tested for the respirator they will be using.

HOUSEKEEPING
In the laboratory and elsewhere, keeping things clean and neat generally leads to a safer environment. Avoid unnecessary hazards by keeping drawers and cabinets closed while working. Never store materials, especially chemicals in small containers on the floor, even temporarily. Work spaces and storage areas should be kept clear of broken glassware, leftover chemicals and scraps of paper. Avoid slipping hazards and keep aisles free of obstructions such as chairs, boxes, containers and waste receptacles.

LABORATORY AND WORKING AREA INSPECTIONS
Chemical work areas, equipment operation, and safety procedures should be periodically reviewed through a routine departmental unit safety inspection. In addition, the RMO will inspect areas periodically to include routine lab inspections, emergency eyewash and shower functioning, and fire extinguisher and fume hood checks.

SAFETY EQUIPMENT
Laboratory safety equipment is designed to protect personnel from injury and minimize damage if an accident occurs. Safety equipment should be in useable condition and available to all laboratories. Laboratory workers should know the location, operation and limitations of safety equipment. Lab personnel should inspect safety equipment for operation and accessibility frequently.

Fire Extinguishers
Every laboratory must have a working, annually-inspected fire extinguisher (either carbon dioxide or dry chemical or both). Laboratories handling larger quantities of metals such as sodium, potassium, magnesium, and lithium will require a Class D extinguisher.

Flammable Storage Cabinets
Quantities of flammable liquids greater than 10 gallons per lab space must be stored in flammable storage cabinets, approved safety cans, or a properly designed flammable storage room. Approved storage cabinets are designed to protect flammable liquids from involvement in an external fire for 10 minutes. This is the time it would normally take for an area to become seriously involved in a fire.

Safety Cans
Portable approved safety cans may be used to safely store, carry, and pour flammable and combustible liquids. The main purpose of the safety can is to prevent an explosion of the container when it is heated. Safety cans are constructed of terne plate steel, stainless steel, or high density polyethylene. Safety cans must be UL listed and FM approved, and properly labeled to identify contents.

Refrigerators
Chemicals stored in refrigerators should be sealed, double packaged if possible, and labeled with the name of the material, the date placed in the refrigerator, and the name of the person who stored the material. Old chemicals should be disposed of after a specified storage period. Food should never be stored in a refrigerator used for chemical storage. These refrigerators should be clearly labeled “No Food”. Refrigerators located in breakrooms and which are located in the vicinity of laboratories should be marked “Food Storage Only! No Chemicals!”
Confined vapors from flammable liquids are easily ignited and represent a major hazard in laboratory refrigeration units. There are a number of potential ignition sources in a normal refrigerator or freezer. Spark producing devices include the thermostat, light switch, defrost mechanism and compressor. In addition, self-defrosting units have a drain hole at the bottom. Vapors can escape through the hole and be ignited by the compressor. Because of the danger of fires and explosion, standard refrigerators and freezers may not be used for storage of flammable liquids. These refrigerators should be posted as unsafe for storage of flammable liquids. Only “Explosion-Safe” or “Flammable Storage” refrigerators and freezers, which have been modified to eliminate the spark producing mechanism, can be used for the storage of flammable liquids.

**Eyewash Fountains and Emergency Showers**
Suitable eye-wash facilities and emergency showers must be available to laboratories using hazardous chemicals that may be injurious to the eyes or skin or that can be absorbed through the skin. In addition to providing protection from chemical splashes, emergency showers can be used to extinguish clothing fires. All personnel should be familiar with the location and operation of emergency showers and eye-wash stations before beginning hazardous procedures. Eye-wash stations should be flushed weekly for a few minutes to ensure that they are in operating condition and to clean out the water lines. They will be tested by the RMO quarterly. Deluge showers will be tested and flushed periodically by the RMO.

**First Aid Kits**
If first aid kits are made available, they should contain adequate first aid instructions and an assortment of material packaged in single disposable packages. Bottles of antiseptic liquids or large tubes of antiseptic creams that can break or leak should be avoided. A kit should at least be readily available in the departmental office at all times work is being performed. The location of the kit should be clearly identified and access should not be blocked. Phone numbers for emergency personnel should be posted in the same area. The kit should be inspected periodically and re-supplied as necessary.

**Machine guards**
Mechanical equipment, such as vacuum pumps, must be adequately guarded to prevent access to rotating parts, pulleys or electrical connections. Guards on fan blades shall have openings no larger than one-half inch.

**Safety shields**
Transparent safety shields made of shatter-proof glass, polycarbonate, acrylic, or similar material should be used to protect the worker from potentially explosive reactions. This includes highly exothermic reactions, evaporation of ethers, and the heating of chemicals such as polynitro compounds, diazo and diazonium compounds, peroxides, metallic acetylides, and perchlorates. Portable shields may be used to protect against limited hazards such as small splashes and fires. Fixed shields that surround the process on all available sides should be used if detonation is possible.
Spill Kits
Chemical spill kits are available in each chemical laboratory to contain and clean up spilled chemicals. All materials collected during spill cleanup must be placed in an appropriate container and properly labeled. The RMO should be contacted to replenish supplies as they are used.

Below is the equipment recommended for use in a general spill kit for chemical spills up to 4 liters.
1. One plastic five-gallon bucket with lid, for storage. The bucket is labeled “Chemical Spill Kit.”
2. Chemical absorbents.
3. A plastic brush about 5 inches wide. (inert, non-sparking)
4. A plastic scoop about 5 inches wide. (inert, non-sparking)
5. One pair of silver shield gloves
6. One heavy poly trash bag
7. Shoe covers
8. Goggles
GENERALIZED STANDARD OPERATING PROCEDURES

SAFE USE OF FLAMMABLES AND COMBUSTIBLES

Flammables and combustibles are materials which, under standard laboratory conditions, can generate sufficient vapors to cause a fire in the presence of an ignition source. Materials which generate sufficient vapors to ignite at temperatures below 100 °F are “flammables”, whereas materials which require temperatures above 100 °F to provide sufficient vapors to ignite are “combustibles.” MSDS and/or reference materials should be consulted for individual flash points. Depending on density, vapor trails can rise, sink, or traverse horizontally to reach an ignition source, resulting in a flashback fire. Fire can also result from reactions between flammables or combustibles and oxidizers.

The following precautions should be observed when using these materials:

1. Flammable and combustible liquids used in the laboratory that are in glass containers shall not exceed 1 liter unless the chemical purity must be protected. In that case, 4 liter quantities are permissible.
2. Generally, metal storage containers can be used with up to 20 liters of flammable liquids per lab when not stored in flammable lockers. Exceptions include Class 1A and 1B liquids (see below) which can total only .5 liter and 1 liter, respectively.
3. Secure screw caps on containers immediately following dispensing. Do not dispense into beakers and allow to remain at bench level. Flammable and combustibles in open containers should be placed under a hood as soon as possible and used up in a reasonable time normally allotted for the particular activity.
4. Flammable liquids should never be heated with an open flame. Steam baths, water or oil baths, or heating mantles should be used.
5. Segregate flammables from oxidizing acids and oxidizers.
6. Flammable solvents must not be stored in standard refrigerators and freezers. Explosions may result from the ignition of confined flammable vapors by sparking electrical contacts. Only explosion-proof or flammable refrigerators may be used.
7. Bulk quantities of flammable liquids, such as 30 or 55 gallon drums, must be stored in the bulk storage room at the loading dock. This storage room meets the requirements of OSHA Standard 1910-106(d). These standards include spark-proof electrical fixtures, fire suppression equipment, and ventilation requirements.
8. Transferring liquids from one metal container to another may produce static electricity sparks capable of igniting the flammable vapors. To discharge the static electricity, dispensing drums should be adequately grounded and bonded to the receiving container before pouring. Bonding between containers may be made by means of a conductive hose or by placing the nozzle of the dispensing container in contact with the mouth of the receiving container. If the container cannot be grounded, then the liquid should be poured slowly to allow the charge time to disperse.
9. Smoking is prohibited in the vicinity of flammables or combustibles.
10. Appropriate spill kits should be available to laboratories using flammable liquids. Materials should absorb the solvent and reduce the vapor pressure so that ignition is impossible.

Flammable and combustible liquids are divided into the following classes based on flash points and boiling points. Flammable liquids are defined as those with flash points below 100 °F and combustible liquids have flash points at or above 100 °F. Flammable and combustible liquids are further subdivided into the following classes:

*Class IA - Flash point below 73 °F (22.8 °C) and boiling point below 100 °F. (37.8 °C). Examples include acetaldehyde, diethyl ether, pentane, ethyl chloride, ethyl mercaptan, hydrocyanic acid, and gasoline.*
*Class IB - Flash point below 73 °F (22.8 °C) and boiling point at or above 100 °F (37.8 °C). Examples include acetone, benzene, carbon disulfide, cyclohexane, ethyl alcohol, heptane, hexane, isopropyl alcohol, methyl*
alcohol, methyl ethyl ketone, toluene, petroleum ether, acetonitrile, and tetrahydrofuran.  
Class I - Flash point at or above 73°F (22.8 °C) and below 100 °F (37.8 °C). Examples include glacial acetic acid, acetic anhydride, cyclohexanone, and dichloroethylether.  
Class II - Flash point at or above 100 °F (37 °C) and below 140 °F (60 °C). Examples include kerosene, diesel fuel, hydrazine, and cyclohexanone.  
Class IIIA - Flash point at or above 140 °F (60 °C) and below 200 °F (93.4 °C). Examples include aniline, cyclohexanol, phenol, o-cresol, naphthalene, nitrobenzene, and p-dichlorobenzene.  
Class IIIB - Flash point at or above 200 °F (93.4 °C). Examples include diethyl sulfate, diethylene glycol, and p-cresol.

SAFE USE OF CORROSIVES
Corrosive chemicals (those which cause visible destruction of, or irreversible alterations at, the site of contact) are generally acids and bases, oxidizing agents, and some dehydrating agents. Corrosives react with skin and are particularly damaging to the lung and eyes. The following precautions should be observed when using these materials:
1. Segregate acids from bases.
2. Use bottle carriers for transporting bottles of corrosives.
3. Store large bottles of acids on a low shelf or in acid cabinets.
4. Use personal protective equipment when working with corrosives to possibly include neoprene gloves, face shield and goggles, and rubber apron.
5. Always add acid to water (never the reverse) to avoid violent reaction and splattering.
6. Wherever corrosives are used or stored, be sure that a working safety shower and eyewash are readily accessible. Should there be contact between corrosives and any body tissue, particularly the eyes, immediately flush the area of contact with cool water for at least fifteen (15) minutes. Remove all affected clothing and immediately get medical assistance.

SAFE USE OF REACTIVES
Reactive materials can release energy quickly and forcefully, depending on various environmental conditions. In some cases, the release of energy may result in detonation. Some of the common classes of reactives, with examples and precautions for handling, are as follows:

Oxidizers
These chemicals are fire and explosion hazards when they are in contact with organic compounds or strong reducing agents. Examples include perchloric acid, fuming nitric acid, and chromic acid.  
Precautions: Oxidizers should be stored and used in glass containers with tight fitting screw-top lids. Store away from organics, flammable materials, and reducers.

Water Reactives
These chemicals react with water to form heat and flammable or explosive gases (hydrogen). Examples: potassium and sodium metals and many metal hydrides, aluminum alkyls, acid anhydrides, and acid chlorides.  
Precautions: Do not handle in the presence of water. Store in an area free from water contact. Use dry sand to smother fire. Be especially careful in humid weather. Check all apparatus and water hoses for potential leaks.

Pyrophorics
In contact with air, these chemicals ignite spontaneously. Examples include finely divided or activated magnesium powder, activated zinc dust, phosphorous, and metal alkyls.
Precautions: Store and use in inert environments.

Peroxide-Forming Chemicals
Organic peroxides are a class of compounds with unusual stability problems and, as such, are one of the most hazardous classes of chemicals regularly handled in the laboratory. Many common laboratory chemicals can form peroxides when exposed to air, so even opening the container to remove some of its contents can allow the formation of peroxides to take place. Some compounds form peroxides which are violently explosive in concentrated solutions or as solids, therefore, they should never be allowed to become dry through evaporation. Others are polymerizable unsaturated compounds which can initiate a runaway, explosive polymerization reaction.

Precautions for storing and handling peroxide-formers include the following:
1. Label the chemicals as known peroxide-formers or, in some cases, as possible peroxide-formers.
2. Limit the stock of any item to 3 months supply or less.
3. All peroxidizable compounds should be stored away from heat and light. They should be protected from physical damage and ignition sources.
4. Unless it would compromise the material’s usefulness, add an oxidation inhibitor to it. The recommended amount is from 0.001 to 0.01% of inhibitors such as hydroquinone, 4-tert-butylicatehol (TBC) or 2,6-di-tert-butyl-p-methylphenol (BHT).
5. Before distilling any known or suspected peroxide-former, check it carefully for peroxide. If any is present, eliminate it by chemical treatment or percolation, or add an inert high boiling substance (such as mineral oil) to prevent the peroxide from concentrating to a dangerous level.
6. A record must be maintained for all peroxidizable compounds to indicate the date of receipt, the date the container was opened, and the date material was tested for peroxides (when applicable). Containers must be dated when purchased and disposed of after 12 months if unopened, or after the time period listed below if opened, or tested for peroxides and re-dated.
The table below provides specific examples of common chemicals that present a serious hazard due to peroxide formation. Time limits from the date when the original container is first opened are given as guidelines for testing or discarding of these compounds.

<table>
<thead>
<tr>
<th>Severe Peroxide Hazard on Storage with Exposure to Air (Use within 3 months)</th>
<th>Peroxide Hazard on Concentration (Use or Test for peroxides within 6 months)</th>
<th>Hazard of Rapid Polymerization Initiated by Internally Formed Peroxides (Use or Test for peroxides within 6 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diisopropyl ether (isopropyl ether)</td>
<td>Acetaldehyde diethyl acetal</td>
<td>Chloroprene (2-chloro-1,3-butadiene)</td>
</tr>
<tr>
<td>Divinylacetylene (DVA)</td>
<td>Cumene</td>
<td>Styrene</td>
</tr>
<tr>
<td>Potassium metal</td>
<td>Cyclohexane</td>
<td>Vinyl acetate</td>
</tr>
<tr>
<td>Sodium amide (sodamide)</td>
<td>Decalin (decahydronaphthalene)</td>
<td>Vinylpyridine</td>
</tr>
<tr>
<td>Diacetylene (butadiene)</td>
<td>Diacetylene (butadiene)</td>
<td>Diethyl ether (ether)</td>
</tr>
<tr>
<td>Dicyclopentadiene</td>
<td>Diacetylene (butadiene)</td>
<td>Dichloroethane</td>
</tr>
<tr>
<td>Diethyl ether (ether)</td>
<td>Diacetylene (butadiene)</td>
<td>Dioxane</td>
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<tr>
<td>Diethylene glycol dimethyl ether</td>
<td>Diacetylene (butadiene)</td>
<td>Ethylene glycol dimethyl ether</td>
</tr>
<tr>
<td>Dioxane</td>
<td>Diacetylene (butadiene)</td>
<td>Ethylene glycol ether acetates</td>
</tr>
<tr>
<td>Ethylene glycol dimethyl ether</td>
<td>Diacetylene (butadiene)</td>
<td>Ethylene glycol mono-ethers (cellusolves)</td>
</tr>
<tr>
<td>Furan</td>
<td>Diacetylene (butadiene)</td>
<td>Furan</td>
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<tr>
<td>Methylacetylene</td>
<td>Diacetylene (butadiene)</td>
<td>Methylacetylene</td>
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<tr>
<td>Methylcyclopentane</td>
<td>Diacetylene (butadiene)</td>
<td>Methylcyclopentane</td>
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<tr>
<td>Tetrahydrofuran (THF)</td>
<td>Diacetylene (butadiene)</td>
<td>Tetrahydrofuran (THF)</td>
</tr>
<tr>
<td>Tetralin (tetrahydronaphthalene)</td>
<td>Diacetylene (butadiene)</td>
<td>Tetralin (tetrahydronaphthalene)</td>
</tr>
<tr>
<td>Vinyl ethers</td>
<td>Diacetylene (butadiene)</td>
<td>Vinyl ethers</td>
</tr>
</tbody>
</table>

**SAFE USE OF CHEMICALS WITH ACUTE TOXICITY**

Some chemicals have properties that necessitate placing them in special hazard classes. These chemicals require special handling procedures because of their health and safety risk.

**Carcinogens**

There are numerous chemicals that are classified as carcinogenic. It is important to designate appropriate areas for the storage and use of these toxic chemicals. Stock quantities of carcinogens should be stored in a designated area or cabinet and posted with the appropriate hazard sign. Volatile chemicals should be stored in a ventilated storage area in a secondary container having sufficient volume to contain the material in case of an accident. Storage areas should be separated from flammable solvents and corrosive liquids.

Entrances to work areas where carcinogens are used or stored should be posted with a sign stating "Danger Carcinogen - Authorized Personnel Only." In addition, the area should also be posted with a sign stating "No Eating, Drinking, or Smoking."

OSHA publishes a list of known carcinogens that are strictly regulated (see Appendix). The regulations on each are specific and detailed. Their use involves a long list of requirements concerning recordkeeping, posting, monitoring, facilities, training, contamination control and medical surveillance. Air monitoring must be conducted if there is reason to believe that exposure to the regulated carcinogen may exceed an action level or permissible exposure level (PEL). The relevant OSHA standard will be followed if initial monitoring exceeds an action level or PEL.

**Reproductive Toxins**
Chemicals that increase the potential for mutation (mutagens) or tend to cause developmental malformations (teratogens) need to be controlled with specific procedures. Elimination of potential ingestion, inhalation, and skin content is important. Follow standard laboratory safety practices listed throughout this Chemical Hygiene Plan, including training and information about the specific chemical involved.

Special Procedures for Acute Toxics
Work with acute toxic chemicals will be:
- restricted to employees who have been specifically trained to work with these chemicals;
- used within designated areas identified by signs in minimum quantities;
- stored appropriately and securely;
- used only when lab safety procedures are submitted by the applicable department, and reviewed and approved by the RMO.

SAFE USE OF COMPRESSED GASES IN CYLINDERS
There are over 500 kinds of gases available in compressed gas cylinders. Most of them are available in commercial or lecture size cylinders. The Compressed Gas Association (CGA) publishes monographs for all aspects of operation and safety, related to the design, valves, gauge fittings, and labels. Department of Transportation (DOT) regulations cover materials and transportation.

Compressed gas cylinders are especially dangerous because they possess both mechanical and chemical hazards. Due to the large amount of potential energy resulting from compression of the cylinder, gas cylinders should be handled as high energy sources and as a potential explosive. If a cylinder falls and breaks a valve, the energy released is sufficient to propel the cylinder through concrete walls.

In addition, the gases contained in the cylinders are hazardous because of their flammable, toxic and corrosive properties. The most common hazard associated with gas cylinders is leakage from regulators which allows the gas to diffuse throughout the room. Flammable gases can mix with air, causing fires and explosions. Most flammable gases have explosive ranges greater than flammable liquid vapors. In most cases, there is no visual warning or odor associated with the escaping gases. Some gases are toxic at concentrations below the odor threshold and some gases can quickly paralyze the sense of smell. Even harmless gases such as nitrogen may displace the oxygen in an unventilated room and cause asphyxiation. The best protection against accidents is knowledge of proper handling and storage techniques.

Classes
Compressed gas cylinders may be classified into the following six groups based on similar chemical and physical properties, storage compatibility, and handling procedures. Common examples are included.

Highly toxic gases - Phosgene, phosphene, arsine, nitric oxide, nitrogen dioxide, chlorine, fluorine, carbonyl fluoride, diborane, hydrogen cyanide, hydrogen selenide, nickel carbonyl, ozone.

Non-flammable, non-corrosive, low toxicity gases - Air, argon, helium, krypton, neon, carbon dioxide, nitrogen, nitrous oxide, oxygen.

Flammable, non-corrosive, low toxicity gases - Acetylene, butane, cyclopropane, ethane, ethylene, hydrogen, isobutane, methane, natural gas, propane, propylene.

Flammable, toxic, corrosive gases - Carbon monoxide, ethylene oxide, hydrogen sulfide, methyl bromide, methyl chloride, propylene oxide.

Acid and alkaline gases - Ammonia, hydrogen bromide, hydrogen chloride, hydrogen fluoride, boron
trichloride, boron trifluoride, dimethylamine, nitrosyl chloride, trimethylamine, ethylamine, methylamine, sulfur dioxide.

Spontaneously flammable gases - Slane.

Identification
The contents of compressed gas cylinders should be clearly identified and bear the appropriate DOT hazard label. Labels should not be removed or defaced. Color coding systems used to identify contents are not reliable because cylinder colors vary among manufacturers. If the labeling on a cylinder becomes defaced, the cylinder should be marked "contents unknown" and returned to the manufacturer.

Transportation
Manual transportation of cylinders (excluding lecture bottles) should always be done with a handtruck. Cylinders should be securely fastened with a strap or rope. The valve cap must be in place. Cylinders should never be lifted by the valve cap or dragged, rolled, dropped, or permitted to strike hard objects or another cylinder.

Training
Persons who handle corrosive and toxic gas cylinders should be adequately trained in the physical and chemical properties of the gas and the proper methods to use the cylinders.

General storage
Cylinders shall be stored upright where they are unlikely to be knocked over, or secured by a heavy chain, strap, or base support. Cylinders cannot be stored in stairwells or within a required exit corridor. The valve protection cap must always be in place when the cylinder is not being used. Cylinders should never be stored on their sides or near a heat or ignition source. Storage areas shall be posted with the name of the gases stored. Storage areas should be well ventilated (one-half to one air change per hour minimum) and dry. Storage rooms should be of fire resistant construction. Temperatures shall not exceed 130 F. Some rupture devices may release at approximately 160 F. Lecture bottles are usually not fitted with rupture devices and may explode if exposed to high temperatures. Cylinders shall not be stored near readily ignitable substances such as gasoline, waste, or bulk combustibles.

Outdoor storage
Cylinders may be stored outdoors if they are adequately protected from the weather and direct sunlight. It is recommended that cylinders be stored under a non-combustible canopy, protected from the ground by a concrete pad, and surrounded by a secure fence.

Handling flammable gas cylinders
Flammable gas cylinders stored inside of occupied buildings shall be separated from flammable liquids, highly combustible materials, and oxidizing cylinders by at least 20 ft. or a 5 ft. high wall with a 1/2-hour fire rating. Flammable gas cylinders in storage and in use should be kept away from arcing electrical equipment, open flames, or other sources of ignition. Adequate portable fire extinguishers shall be located in storage areas and “No Smoking” signs shall be posted. Hydrogen gas systems shall not exceed 400 cubic feet unless approved by the RMO. Spontaneously flammable gases should be used only with equipment that has been purged with an inert gas. A vacuum break or other protective device should be used to prevent back-flow into the cylinder.

Handling oxidizing gases
Oxidizing gas cylinders in storage shall be separated from flammable gas cylinders or combustible materials such as oil or grease by at least 20 feet or by a 5 foot high wall with a 1/2-hour fire rating. Oxidizing gas cylinders, valves, regulators, and hoses shall be kept free from oil or grease.
Handling acid and alkaline gases
Proper protective clothing such as goggles, face shields, rubber gloves, and aprons shall be worn when working with acid and alkaline gases. Areas in which acid and alkaline gases are utilized shall be equipped with an OSHA approved deluge shower and eye-wash station. Acid and alkaline gases should be utilized in a well ventilated area. Corrosive gases should be used only with compatible equipment. The total quantity of gases on site should be kept to a minimum. Proper respiratory equipment shall be readily available for use in an emergency. When discharging gases into a liquid, a trap should be used to prevent back-flow of liquids into the regulator or cylinder.

Handling highly toxic gases
Highly toxic gas cylinders (except lecture bottles) shall be stored outdoors or in an unoccupied building or room with a one-hour fire rating. Lecture bottles may be stored in a laboratory if they cannot contaminate breathing air. Storage, for example, in a constantly running hood is appropriate. Areas in which toxic gas cylinders are used or stored should be posted with an appropriate warning sign. The quantity of highly toxic gas cylinders should be kept to a minimum. Highly toxic gas cylinders shall be utilized only in forced ventilation areas, or preferably in hoods or cabinets with forced ventilation. Highly toxic gases should be used only with compatible equipment. Gases emitted in high concentrations shall be discharged into appropriate scrubbing equipment. Users shall only be exposed to concentrations of highly toxic gases that are below OSHA permissible levels. When discharging gases into a liquid, a trap should be used to prevent back-flow of liquids into the regulator or cylinder. Proper respiratory equipment shall be readily available for use during an emergency.

Dispensing contents
The cylinder should be secured, and the protective cap removed. The proper regulator should be connected being careful not to cross thread or over tighten the connections. The delivery pressure screw turns counterclockwise to close and loosens as it closes. The fine flow valve closes clockwise and tightens. Open the main tank valve slowly until full tank pressure is seen on the gauge; generally around 2000 pounds per square inch. Open the delivery pressure screw (turns clockwise and tightens) until the desired pressure is reached. Open the fine flow valve to the desired flow rate.

To shut off the gas, close the main tank valve first and allow the residual gas in the regulator to bleed off. When the gauge reads zero, close the delivery pressure screw (turns counterclockwise and loosens) and the fine flow valve.

Never stand in front of or behind the pressure gauge as the main tank valve is opened. Pressure gauges can explode. When opening the valve on a cylinder containing a corrosive or toxic gas, the user should stand on the side opposite the valve opening. Safety glasses should be worn when dispensing compressed gases to prevent eye damage from equipment failure.

Regulators
Always use the appropriate regulator. Regulators for non-corrosive gases are usually made of brass. Corrosion resistant regulators should be used with gases such as ammonia, boron trifluoride, chlorine, hydrogen chloride, hydrogen sulfide, and sulfur dioxide. Special regulators should be used with carbon dioxide because of potential freeze-up and corrosion problems. Connections should never be forced. Regulators and valves should never be oiled or greased, a fire or explosion could result. Pressure should be removed from the regulator when not in use. The main tank valve should be closed and the pressure bled off from the regulator valves. To prevent explosions, regulators made of brass or copper should not be used with acetylene.

Traps
A trap, check valve, or vacuum break should be used to prevent the back-flow of contamination into the cylinder.
Empty cylinders
Cylinders should not be completely emptied. Approximately 25 pounds of pressure should remain in the cylinder. The tank valve should be closed to prevent contamination from air and water. Empty cylinders should never be refilled by the user. Remove the regulator, replace the cap, mark the cylinder empty, and return it to the storeroom and vendor as soon as possible. Segregate empty cylinders from full cylinders to reduce handling by the supplier. The cylinder should be securely fastened in the storeroom.

SAFE USE OF CRYOGENIC LIQUIDS
Cryogenic liquids are liquefied gases. The primary risks associated with the use of these materials are physical injuries caused by exposure of tissue to extreme cold, typically below -150 F, the potential for fires and explosions, and asphyxiation. Even very brief skin contact with a cryogenic liquid is capable of causing frostbite injury. Prolonged contact may result in blood clots. Flooding the affected tissue with warm water as soon as possible is the recommended treatment for exposure to cryogenic liquids.

Gases such as hydrogen, methane, and acetylene present fire and explosion hazards. Liquid oxygen greatly increases the flammability of ordinary combustibles and may even cause non-combustibles to burn. Because oxygen has a higher boiling point than nitrogen, helium, or hydrogen it can condense out of the atmosphere during the use of these lower boiling cryogenic liquids. Conditions may exist for an explosion, particularly with hydrogen.

Liquid nitrogen is commonly transported in vacuum flasks called Dewars containing from 15 to 50 liters at atmospheric pressure. If the vacuum in the Dewar flask should fail, the nitrogen would rapidly escape and could displace enough air in a small confined space to asphyxiate someone. However, the most likely consequence of a sudden vacuum loss would be an implosion which could result in flying glass. Water vapor condensing to ice on vents or pressure relief valves blocking the route of gas escape can also result in a pressure explosion in these vessels.

Personal Protection
Personnel should wear suitable eye protection such as chemical splash goggles or a face shield. Long sleeves, long pants and hand protection should be worn. Adequate hand protection must be worn to prevent contact with the cold liquid. Pads or pot holders should be used instead of gloves to prevent the cold fluid from being trapped inside the glove.

Containers
All exposed glass surfaces of vacuum flasks used to transport or store cryogenic fluids must be taped to guard against flying glass from an implosion. Containers should be handled and stored in an upright position. Containers must not be dropped, tipped, or rolled on their sides. Containers and systems should be periodically inspected to guard against ice buildup on vents and pressure relief valves. Vessels used for the storage and handling of liquefied gases should not be filled to more than 80% capacity to reduce the likelihood of expansion of the contents and rupture of the vessel. Cryogenic liquids should be handled in multi-wall, vacuum insulated containers specifically designed for cryogenic liquid. Store bought glass thermos bottles are not appropriate. Containers shall be provided with pressure relief devices adequate to prevent excessive pressure within the container. Cryogenic fluids should be used and stored in well ventilated areas to prevent excessive accumulation of the gas.

Specific Gases
Liquid air: The use of liquid air as a substitute for liquid nitrogen is prohibited. The concentration of oxygen in liquid air containers can increase over time creating an explosion hazard.
Liquid oxygen - Liquid oxygen poses a serious fire hazard and should only be used if absolutely essential. Liquid oxygen must be used with a monitoring device. Ignition sources or flammable liquids are not allowed in the vicinity of liquid oxygen systems. Containers, piping, and equipment should be free of grease, oil, and organic material to prevent the possibility of an explosion. The RMO should be notified before using liquid oxygen.

Liquid hydrogen - Smoking, open flames, and arcing electrical equipment is prohibited in areas where liquid hydrogen is used or stored. Liquid hydrogen shall be stored and transferred under positive pressure to prevent air from entering the system.

Liquified natural gas - Smoking, open flames, and arcing electrical equipment is prohibited in areas where liquified natural gas is used or stored. Liquified natural gas shall be stored and transferred under positive pressure to prevent air from entering the system.

Liquid helium and neon - Liquid helium and neon shall be stored and transferred under positive pressure.

Liquified inert gases - Gases such as argon, carbon dioxide, helium, krypton, neon, nitrogen, and xenon are asphyxiants which can displace the oxygen in a room and cause suffocation. Self-contained breathing apparatus must be worn when entering an area suspected or being oxygen deficient.

SAFE USE OF WORKING WITH CHEMICALS AND ANIMALS

Working with animals is particularly hazardous because of the possibility of the formation of aerosols and dusts containing carcinogenic chemicals. These dusts and aerosols can easily contaminate the work area through the animal feed, urine, or feces if proper procedures are not followed. Procedures should be implemented to handle potentially contaminated material in a controlled manner to minimize the possible exposure of personnel.

The principal routes of exposure from chemicals occur through inhalation or direct contact. These exposures can occur during the initial handling of the chemicals, dosage preparations and administration, post-treatment, holding and examination of animals, and disposal of waste.

Initial handling
Activities involving the storage, dispensing and use of stock quantities of chemicals provide a significant opportunity for release of contaminants into the work area. Contaminants typically occur on the outer surface of the containers, floors and bench tops, the analytical balance, on protective clothing, and in adjacent rooms. Solid test materials should be handled with extra caution because they can be easily released and dispersed into the work area. Liquids are less likely to disperse but local contamination is still possible. Another route of exposure may come from solids and liquids that volatilize easily. Even materials with a moderate vapor pressure can expose workers to significant vapor concentrations of the chemical. Procedures involving chemicals that volatilize easily or procedures that produce aerosols should be performed in a hood.

Dosage preparation
The worst contamination problem typically occurs in the dosage preparation areas. Aerosol production occurs when the pure chemical is added to the appropriate feed vehicle and vigorously mixed. To reduce aerosol formation, all mixing procedures should be done within closed containers and within a hood.

Administration of dose
Animal holding areas can easily become contaminated when the material is being administered. The greatest potential to create contamination of the facility occurs during feed studies, followed by dosed water, gavage, skin painting, and injection. Filling of the feed hoppers generates large amounts of aerosols that can contaminate the work area. Volatilization of the dose material and exhalation by the test animal may occur.
when the test material is administered by gavage. To reduce contamination, administration of the dose to the animal should be performed in a hood, biological safety cabinet or controlled by local exhaust ventilation.

Animal holding
Experimental animals need to be held under controlled conditions after the treatment because hazardous metabolites or the parent compound may be eliminated in the urine or feces. The removal of contaminated bedding and cage matting can create large amounts of aerosols and dust. Vacuum cleaners equipped with HEPA filters and wetting the bedding to reduce dusts should be used. If the caging system does not protect personnel from contamination, workers should wear completely closed jump suits, booties, head covers, and a respirator. Under no circumstances should protective clothing and respirators be allowed out of the work area. Large scale studies should be carried out in special facilities or rooms having restricted access.

SAFE USE WORKING WITH BIOHAZARDS
In general, the handling and manipulation of biological agents and toxins, as well as recombinant DNA molecules, requires the use of various precautionary measures depending on the material(s) involved. It is imperative that anyone involved or working with these materials seek additional advice and training when necessary. The RMO is available to provide assistance in this training.

Classification of Infectious Agents on the Basis of Hazard
Worldwide there are several systems for classifying human and animal pathogens according to the hazard they present to an individual and the community. Although these classifications differ from each other, they all are based on the notion that some microorganisms are more hazardous than others. In general, the pathogenicity of the organism, mode of transmission, host range, availability of effective preventative measures and/or effective treatment are some of the criteria taken into consideration when classifying infectious agents. The most current classification in the U.S. is found in the NIH Guidelines for Research Involving Recombinant DNA Molecules. The human etiologic agents addressed in these guidelines are classified into four risk groups with Risk Group 1 (RG-1) of low or no hazard and Risk Group 4 (RG-4) representing highly infectious agents. Only agents in RG-1 or 2 shall be used at the university. If agents in RG-2 are anticipated, prior approval by EHS is required to verify proper safeguards and emergency procedures.

Risk Group 1 (RG-1) Agents that are not associated with disease in healthy adult humans.

Risk Group 2 (RG-2) Agents that are associated with human disease which are rarely serious and for which preventative or therapeutic interventions are often available.

Risk Group 3 (RG-3) Agents that are associated with serious or lethal human disease for which preventative or therapeutic interventions may be available (high individual risk but low community risk).

Risk Group 4 (RG-4) Agents that are likely to cause serious or lethal human disease for which preventative or therapeutic interventions are not usually available (high individual and community risk).

Practices and Procedures
Infection occurs when disease-causing microorganisms enter the human body in sufficient numbers and by a particular route and overcome the body’s defense system. The following routes of infection have been reported for laboratory-acquired infections:

Ingestion
Eating, drinking and smoking in the laboratory
Mouth pipetting

25
Transfer of microorganisms to mouth by contaminated fingers or articles

**Through the skin**
Accidental inoculation with a needle, other sharp instrument, or glass
Cuts and scratches

**Through the eye**
Splashes of infectious material into the eye
Transfer of microorganisms to eyes by contaminated fingers

**Through the lungs**
Inhalation of airborne microorganisms

**Biohazard Spill Cleanup**
Since spills of biological materials will happen, it is important to be prepared prior to dealing with the problem. Laboratories working with biohazards should have a basic biological spill kit ready to use at all times.

### Basic Biological Spill Kit
- Disinfectant (bleach 1:10 dilution, prepared fresh)
- Absorbent Material (paper towels)
- Waste Container (biohazard bags and sharps containers)
- Personal Protective Equipment (labcoat, gloves, eye and face protection)
- Mechanical Tools (forceps, dustpan and broom)

### Spill Inside the Laboratory (RG-2)

Clear spill area of all personnel. Wait for any aerosols to settle before entering the spill area. Remove any contaminated clothing and place in biohazard bag for further processing by laundry (on campus). Don a disposable gown or labcoat, safety goggles and gloves.

Have a complete biological spill kit ready to go before you start the clean-up.

Initiate clean-up with disinfectant as follows:

- If spill occurs inside a biological safety cabinet, allow cabinet to run during clean-up and at least 10 minutes after clean-up.
- Cover spill with paper towels containing disinfectant.
- Encircle the spill with disinfectant (if feasible and necessary), being careful to minimize aerosolization.
- Decontaminate and remove all items within spill area.
- Remove broken glassware with forceps or broom and dustpan and dispose in sharps container. Do not pick up any contaminated sharp object with your hands.
- Remove paper towels and dispose in biohazard bags.
- Apply disinfectant to the spill area and allow for at least 10 minutes contact time to ensure germicidal action of the disinfectant.
- Remove disinfectant with paper towels and dispose of in biohazard bag.
- Wipe off any residual spilled material and reapply disinfectant before final clean-up.
- Wipe equipment with compatible disinfectant and rinse with water, if necessary.
- Place disposable contaminated spill materials in biohazard bags for autoclaving.
- Place contaminated reusable items in biohazard bags, or heat resistant pans or containers with lids before autoclaving.
- Reopen area to general use only after spill clean-up and decontamination is complete.
- Inform all personnel and laboratory supervisor about the spill and successful clean-up as soon as possible.

**Spill Outside the Laboratory, During Transport on Campus**

Always transport biohazardous materials in an unbreakable, well-sealed primary container placed inside a leakproof, closed and unbreakable secondary container, labeled with the biohazard symbol.

Should a spill of RG-2 material occur in the public, contact Public Safety and they will contact the RMO. Do not attempt to clean-up the spill without the proper personal protective equipment and spill clean-up material.
GENERALIZED PROCEDURES FOR LAB EQUIPMENT

Although attention is usually concentrated on chemical hazards in laboratories, consideration must be given to the safe use of laboratory equipment. Equipment in the laboratory must be set up and operated properly to ensure that accidents are minimized. Cuts and burns from handling glassware are among the most common sources of laboratory accidents. Breaking glassware may give rise to a chemical spill and possible injury. Chemicals exploding in glassware can send fragments of glass flying into the laboratory. Vacuum systems may implode sending flying glass and chemicals across the room. Flammable vapors coming in contact with sparking electrical equipment may cause an explosion. Laboratory workers may be electrocuted if they handle electrical equipment improperly. The following safety procedures should reduce the potential for incidents and injuries in laboratories.

FUME HOODS

General

Laboratory fume hoods are ventilated enclosures in which toxic, offensive, or flammable materials can be handled safely. Operations that involve hazardous reactions, heating or evaporating solvents, and transfer of hazardous chemicals from one container to another should be performed in a fume hood. The purpose of a hood is to capture gases, dust, vapors, or fumes from these operations and prevent them from escaping into the laboratory where they could injure personnel. This is accomplished by an exhaust fan on the roof which draws hazardous material into the hood away from the operators breathing zone and exhausts it safely away from the building. In addition to providing protection from gases and dust, the sliding sash on the hood offers some protection from chemical splashes and explosions of hazardous materials within the hood. Periodic inspections and measurements will be made by the RMO to determine the condition of the hood, to check for proper functioning of the ducts and exhaust system, and to check the uniformity of air flow over the face of the hood.

Procedures for the operation of a chemical fume hood are as follows:

1. The RMO must be notified prior to purchasing a hood to ensure that the proper hood has been ordered and that it will be installed correctly.
2. Fume hoods should be constructed of heat and corrosion resistant materials such as epoxy resins, fiberglass, cement-asbestos, and stainless steel. Control valves, electrical receptacles, and other fixtures should be located outside the hood to minimize the need to reach into the hoods, and to reduce explosion hazards.
3. Each hood must be independently ducted to the roof of the building. This eliminates the possibility that toxic vapors released into one hood could be channeled into an unused hood. Ducts from hoods in the same room may be combined. The exit duct should be of the updraft type and designed to discharge the effluent away from the building and air intakes. The exhaust duct should never discharge out the side of the building. This could allow potentially hazardous fumes to collect in the vicinity of the building. Ducts penetrating a floor must be encased in a 2 hour fire rated enclosure which extends to the ground. The motor must be located on the roof. This ensures that the ducts within the building are under negative pressure and that leakage will occur into the duct.
4. The sash insures safe operation, reaction containment and proper airflow. In order to maximize the capture efficiency of hazardous fumes the sash opening should not be greater than 18 inches. The sash should be opened fully only when placing large items in or removing them from the hood. The sash should be closed when conducting procedures that produce high velocity aerosols, particulate contamination or when conducting experiments with high pressure systems that produce gases and vapors.
5. To increase the effectiveness of the hood, work should be done as deeply within the hood as possible (at least 8 inches from the edge). Equipment should be arranged in the hood as far back as possible without blocking the rear baffles. Operations producing gases should be vented towards the rear of the hood. Possible sources of ignition should be eliminated from the hood if there is a potential for an explosion.
6. If highly toxic, corrosive, or offensive vapors will be produced, local scrubbing of the effluent should be
done before exhausting the vapors into the duct work. If this is impossible, then HEPA filters and activated charcoal filters should be installed at the exit duct to trap particulates and absorb gases.

7. If a fume hood malfunctions, stop all lab work if necessary, close the sash, and report it to Facilities Services immediately. Place a warning sign on the hood to prevent others from using it until it is repaired and re-certified by the RMO as working properly.

Radioisotope Hood
Hoods used for radioactive material must be designated as a radioisotope fume hood by the vendor. The interior shall be of a seamless material, preferably stainless steel, with coved corners free of joints, cracks, or gaskets to facilitate decontamination. Ducts shall be of stainless steel. Hoods must be ducted independently directly to the roof. Blowers shall be roof mounted, spark-proof and explosion-proof. A HEPA filter must be installed in the exhaust duct if the hood is used for radioisotope work that may present a particulate problem.

Self-Contained Hood
Self-contained units may be used only when venting a hood is not practical and the chemical is of low hazard. Long-term use of self-contained units will be discouraged due to the difficulties and expensed in maintaining routine filter changes. These units re-circulate air through activated charcoal filters and remove small quantities of solvents, acids, and annoying odors from the air. Filters should be designed to release a pungent odor when they become saturated. Purchase of these hoods must be approved by the RMO.
**Biological Cabinets**

Biological safety cabinets (BSC) are among the most effective and commonly used primary containment devices in laboratories working with infectious agents. Primary barriers are important because most laboratory techniques produce aerosols that can be readily inhaled. The majority of reported laboratory acquired infections for which no specific cause was identified have been attributed to exposure to aerosols. There are three basic types of biological safety cabinets:

- **Class I Biological Safety Cabinet** - This is a ventilated cabinet with an uncirculated inward airflow away from the operator. This unit is fitted with a HEPA filter to protect the environment from discharged agents. A Class I BSC is suitable for work involving low to moderate risk agents, where there is a need for containment, but not for product protection (e.g., sterility).

- **Class II Biological Safety Cabinet** - This is a ventilated cabinet for personnel, product and environmental protection which provides inward airflow and HEPA-filtered supply and exhaust air. The Class II cabinet has four designs depending on how much air is recirculated and/or exhausted and if the BSC is hard-ducted to the ventilation system or not. Class II cabinets may be of use with low to moderate risk biological agents, minute quantities of toxic chemicals, and trace quantities of radionuclides; however, care must be exercised in selecting the correct Class II cabinet design for these purposes.

- **Class III Biological Safety Cabinet** - A class III cabinet is a totally enclosed ventilated cabinet which is gas-tight, and maintained under negative air pressure (0.5 inches water gauge). The supply air is HEPA-filtered and the exhaust air has two HEPA filters in series. Work is performed in the cabinet by the use of attached rubber gloves.

Class I and II cabinets are designed for general research operations with low and moderate risk biological agents (Biosafety levels 1, 2, and 3). Class I and II cabinets are not recommended for use with highly infectious agents (Biosafety level 4) because an interruption in the inward air flow could allow aerosols to escape from the cabinet. Work with high risk biological agents (Biosafety level 4) must be performed in a Class III cabinet.

All cabinets will be certified and tested in accordance with the manufactures recommendations and the design shall meet National Sanitation Foundation Standard 49. The integrity of Class II and III cabinets must be certified upon receipt, any time the cabinet is moved, and at least annually.

**GLASSWARE**

The proper selection of glassware is very important because glassware is designed with unique characteristics and for specific operations. Systems containing custom glassware should be evaluated to ensure the integrity of the glass under all operational parameters. Only glassware specially designed for vacuum work should be used for that purpose. Inexperienced users should receive training in the proper handling of glassware, especially with systems that present unusual risks such as excess pressure or vacuums.

Careful handling and storage of glassware is necessary to prevent damage to the glassware and injury to the worker. Care must be used while inserting glass tubing through a stopper or when connecting flexible tubing to the glass. The glass tubing should be polished, or rounded and lubricated with glycerine or stopcock grease. Hands must be protected with cloth or leather gloves. The hands should be held close together to reduce pressure on the tubing, and out of the direct line of the glass should it break. Vacuum glass apparatus should be handled with extreme caution. Dewar flasks and other glass vacuum vessels should be taped or shielded to protect against flying glass in the event of an implosion. Broken glass should never be placed in a trash bag. It should be placed in the cardboard boxes marked “Broken Glass” for disposal.

**SYRINGES AND NEEDLES**
Syringes and needles are dangerous objects that need to be handled with extreme caution to avoid accidental injection and aerosol generation. Generally, the use of syringes and needles should be restricted to procedures for which there is no alternative. Do not use a syringe and needle as a substitute for a pipette. Use needle locking syringes or disposable syringe-needle units in which the needle is an integral part of the syringe. If materials do not contain a hazardous material or biohazard/infectious material, place the unit in an approved sharps container. When the container is two-thirds full, deface any biohazard label, seal the container and place in a trash bag. The trash bag may then be disposed in a trash dumpster.

When using syringes and needles with biohazardous or potentially infectious agents:

- work in a biosafety cabinet whenever possible;
- wear gloves;
- fill the syringe carefully to minimize air bubbles; and
- expel air, liquid and bubbles from the syringe vertically into a cotton pad, moistened with a disinfectant.

Needles should not be bent, sheared, replaced in the sheath or guard (capped), or removed from the syringe following use. If it is essential that a contaminated needle be recapped or removed from a syringe, the use of a mechanical device or the one-handed scoop method must be used. Always dispose of needle and syringe unit promptly into an approved sharps container. Do not overfill sharps containers. When the container is two-thirds full, take the container to Student Health Services for proper disposal.

**DISTILLATION APPARATUS**

*Water supply* - Most distillation units operate with water cooled condensers. Water pressure can change however, and cause unexpected problems. Inadequate water supply can allow distillate vapors to escape. Too high a flow can cause the tubing connectors to burst, flooding the laboratory. All flexible hoses should be free of cracks, slits, or kinks and kept away from hot plates and flames. All hose connections should be firm and clamped or wired for prolonged use. Flow rates should be approximately one liter per minute. For unattended operations, the water pressure should be regulated automatically.

*Heating supply* - Heating mantles must be used to heat distillation flasks. A variable voltage transformer should be used. The temperature of the mantle must be monitored carefully. If left unattended the mantle must be connected to a thermal cut-off device that turns the heater off if too high a temperature is reached.

*Distilled water supply units* - These units are usually intended to operate automatically and are left unattended for long periods of time. This unit must be equipped with a thermal cut off, independent of the temperature controlling devices. This feature is needed to prevent overheating which could cause a fire. When a still is set up, or ceases to operate, the RMO should be notified.

**VACUUM EQUIPMENT**

In a vacuum system the pressure on the outside of the containment vessel is greater than on the inside. A break in the container will cause an implosion, resulting in flying glass, splattered chemicals, and a possible fire. Even equipment under moderate pressure, such as those achieved in water aspirators, can be potentially hazardous. Another hazard associated with vacuum equipment is rapid pressure changes which can draw hazardous liquids and gases into the building vacuum system or equipment. Depending on the hazard, safety goggles, impact resistant glasses, or face shields must be worn when working with vacuum equipment.

*Glass vessels* - Glass flasks should be taped with friction tape or placed in a metal container large enough to hold the flask. If this is not possible, a safety shield should be placed between the flask and the operator. The vessel should be inspected for cracks or scratches prior to use. Only round bottomed or thick walled flat bottomed flasks specifically designed for vacuum work should be used. Ordinary glassware, especially flat
bottomed flasks, are not intended for vacuum work and may burst.

Dewar flasks - Dewar flasks are capable of imploding from thermal shock or a very slight scratch. They should be wrapped with friction tape all the way up the neck or shielded in a wooden or metal container to guard against flying glass in the event of an implosion.

Vacuum desiccators - Glass vacuum desiccators should be made of glass specifically designed for vacuum work. They should be enclosed in a shield or wrapped in friction tape.

Vacuum distillations - The reaction flask should be taped and placed in a wire cage. The distillation should be performed behind an explosion shield. Operators should wear a face shield. A safety trap should be used to protect equipment (such as a manometer) and the vacuum source from contamination. Pressure should be equalized slowly after the experiment is over and the flask has cooled to room temperature.

Water aspirator - A trap or check valve should be placed between the aspirator and the container under vacuum to prevent water from being drawn back from the aspirator into the container.

Vacuum pump - A safety trap should be placed between the apparatus and the pump to prevent solvents and corrosives from the reaction getting into the pump oil or the atmosphere of the laboratory. Exhaust from pumps should be vented to a hood.

Mercury manometers - A sudden change in pressure may cause the mercury to break the closed end of the glass tube and scatter the mercury. A capillary section should be incorporated into the manometer that will prevent surges or a bleeder arrangement should be installed into the trap. The manometer should be placed in a container that will hold any spilled mercury.

ELECTRICAL EQUIPMENT

The improper use of electrical equipment is a common source of accidents in laboratories. Electrical shocks, fires, and explosions are some of the potential hazards found in the laboratory. Effects of contact with electrical circuits range from a mild tingling sensation to painful shock and burns to cardiac arrest. Because electrical shorts often get worse, any equipment which produces a mild shock should be reported immediately to the lab supervisor and removed from service. Proper design of equipment, maintenance, and training of personnel should reduce these hazards.

To reduce shock hazards, all electrical equipment must be properly grounded. Equipment that does not have a three-prong plug should be re-wired unless it is double insulated. Electrical equipment should not be handled with wet hands or while standing on a wet floor. Wet equipment should never be turned on. Any electrical equipment which emits noises and odors should be turned off and unplugged. Safety devices or interlocks on electrical equipment should not be bypassed. Electrical equipment should be located to minimize the possibility that water or chemicals could accidentally be spilled into the equipment.

The power must be turned off before modifying any circuit or servicing any equipment. Electrical equipment should only be serviced by qualified individuals. High voltage equipment must be serviced by qualified electricians. Equipment must be secured and a sign must be posted if an interlock or safety device has been bypassed for repair purposes.

Use With Flammable Solvents - Arcing electrical equipment may cause an explosion in laboratories where volatile flammable solvents are present. Equipment with non-sparking induction motors and enclosed electrical contact must be used with volatile flammable solvents. This applies to the motors used in vacuum pumps, mechanical shakers, heating devices, magnetic stirrers and rotary evaporators. Kitchen appliances such as mixers and blenders are not equipped with induction motors and should not be used in labs where
flammable materials may be present. Electrical fixtures may need to be explosion-proof if flammable vapors or gases reach high concentrations. Flammable liquids must be stored in explosion-safe or explosion-proof refrigerators or freezers.

Extension Cords - Extension cords are for temporary use only and are not designed to replace permanent wiring. Insulation and wire size should be adequate for the voltage and current carried. Extension cords should be as short as possible and protected so they do not present a trip hazard.

HEATING DEVICES
Heating devices are the most common type of electrical device found in the laboratory. Although much safer than Bunsen burners, these devices pose electrical and fire hazards if used improperly.

Variable transformer - Variable transformers control the temperature on many laboratory heating devices. Because some sparking may occur when the control knob is turned, transformers should be located where they will not be exposed to flammable liquids or vapors. Connections from the variable transformer to the heating device should not be made with alligator clips because of the potential shock and spark hazard. Heating devices left unattended overnight should be equipped with a device that turns the power off if a preset temperature is exceeded.

Heating element - The heating element in any laboratory heating device should be enclosed in an insulated case that prevents contact with the worker and protects against sparks.

Laboratory hot plates - Laboratory hot plates are normally used when solutions must be heated above 100 C. Hot plates should be designed specifically for laboratory use. Household type units should never be used in the laboratory. Hot plates with exposed heating elements or spark producing switches should not be used to heat flammable liquids. Care should be exercised when heating solvents on hot plates with enclosed elements to ensure that the liquid does not boil over into the electrical heating equipment.

Hot air blowers - Hot air blowers are used to dry glassware and samples, heat plastic tubing, and to heat the upper parts of a distillation apparatus. Although hot-air blowers provide flameless heat, they are potentially hazardous because the heating element is open and the switch and motor are usually not spark free. Hot air blowers should not be used near open containers of flammable liquids or where there may be appreciable concentrations of flammable vapors. Household hair dryers should only be used if they are double insulated or have a three-prong plug.

Heating mantles - Heating mantles consist of an insulated electric heating element enclosed in several layers of fiberglass cloth. They are commonly used to heat round bottom flasks, and related reaction vessels. Heating mantles should always be used with a variable auto-transformer. Exceeding the voltage recommended by the manufacturer may cause the mantle to melt and expose the bare heating element. Fiberglass mantles protected by outer metal cases should be grounded to protect the worker in case the heating element shorts against the metal case. Precautions should be taken to prevent water or other chemicals from spilling into the mantle and creating a shock hazard.

Oil baths - Electrically heated oil baths are commonly used when a constant temperature is desired. Mineral oil, paraffin and glycerin are used for temperatures below 200 C. Silicon oil is used for temperatures up to 300 C. Oil baths must be carefully monitored to ensure that the temperature has not approached the flash point of the oil vapor. If the oil bath thermostat fails, the oil will overheat and a fire may start. Heating baths containing combustible liquids must have an independent thermal cut-off to ensure that the system will not reach a temperature high enough to ignite the oil bath.

Heated oil should be contained in a metal pan or heavily-walled porcelain dish; never in a glass dish or beaker.
The oil bath should be mounted on a stable horizontal support such as a laboratory jack. Because of its instability, an oil bath should never be mounted on a ring stand. Water should never come in contact with the hot oil. Highly oxidizing substances (perchlorates, nitrates, peroxides) should never be heated in an oil bath.

**Laboratory ovens** - Electrically heated ovens are commonly used in the laboratory to remove water or solvents from chemicals and to dry glassware. Because these ovens are usually improperly vented, gases and vapors produced in them will discharge into the laboratory atmosphere. It is also possible for dangerous concentrations of explosive and flammable mixtures to build up inside the oven. Many fires have started by placing solvents with low flash points in ovens at temperatures where they will ignite.

Ovens should never be used to dry toxic chemicals that are even moderately volatile unless the oven is properly vented. Glassware that has been rinsed with an organic solvent should be rinsed with distilled water before being placed in the oven to dry. Because of the explosion hazard, laboratory ovens should be constructed so that the heating element and temperature controls are physically separated from the interior atmosphere. Ovens not meeting these requirements should be posted with a sign stating “This oven is not safe for flammable liquids.”

**REFRIGERATORS**
Chemicals stored in refrigerators should be sealed, double packaged if possible, and labeled with the name of the material, the date placed in the refrigerator, and the name of the person who stored the material. Old chemicals should be disposed of after a specified storage period. Food should never be stored in a refrigerator used for chemical storage. Flammable materials should only be stored in refrigerators designed for the storage of flammable’s and will be clearly marked as safe for the storage of flammable materials.

If used for storage of radioactive materials, a refrigerator should be plainly marked with the standard radioactivity symbol and lettering, and routine surveys will be made by the RMO to ensure that the radioactive material has not contaminated the refrigerator.

**CENTRIFUGES**
If a tabletop centrifuge is used, make certain that it is securely anchored in a location where its vibration will not cause bottles or equipment to fall. The following rules apply to the safe operation of centrifuges:
- Always close the centrifuge lid during operation.
- Do not leave the centrifuge until full operating speed is attained and the machine appears to be running safely without vibration.
- Stop the centrifuge immediately and check the load balances if vibration occurs. Check swing-out buckets for clearances and support.
- Regularly clean rotors and buckets with non-corrosive cleaning solutions.

**UV LAMPS**
All radiation of wavelengths shorter than 250 nm should be considered dangerous. Protective safety glasses with UV-absorbing lenses should be worn when the eyes may be accidentally exposed to light in this wavelength region. It is advisable to operate such UV irradiation systems in a completely closed radiation box. Skin areas exposed to illumination from UV lamps can receive painful burns similar to severe sunburn, and so precautions should be taken to protect the skin.
EMERGENCY RESPONSE PROCEDURES

PLANNING
When a spill or injury occurs involving chemicals, there needs to be a definite emergency response plan and procedures to keep injury and/or loss of property to a minimum. Knowledge of chemical properties and the correct response to an emergency is expected before work activities are carried out. Each person in a laboratory must be familiar with the locations of, and procedures for using, this equipment. The safety equipment includes eyewash fountain, safety shower, fire extinguisher, and an alarm and telephone system. All laboratory personnel must know the main and alternate evacuation routes, as well as, the procedures for accounting for each person in the laboratory. The RMO will conduct periodic fire drills to test occupant knowledge of evacuation procedures.

CHEMICAL SPILLS
All spills should be cleaned up promptly, efficiently and properly. Often the volume spilled is not so important as the toxicity of the substance. Proper planning should minimize exposure of personnel in the event of a chemical spill. Each lab work area should develop written procedures for the proper handling of potential chemical spills. The following factors should be part of the plan:
• potential location of the spill
• quantities that might be released
• chemical and physical properties
• hazardous properties
• personal protective equipment
• cleaning supplies and equipment

Small Spill Response
In laboratory settings, it is mandatory that appropriate equipment be available for responding to and containing spills. An emergency kit containing the following materials should be readily available:
• neutralizing agents (sodium carbonate and sodium biosulfate)
• clay absorbents (kitty litter or similar)
• paper towels and sponges
• personal protective equipment
• plastic bags
• pail
• brushes and scoops

Minor spills should be cleaned up if the material is not immediately dangerous to life and health, e.g. small acid spills. If flammable solvents are spilled turn off all nearby sources of ignition and evacuate all non-essential personnel from the area. Consult a reference such as the MSDS or a chemical dictionary, or call EHS for clean-up procedures and assistance. Wear the appropriate gloves, eye protection, and laboratory coat. Respirators should be worn if hazardous vapors are present. Prevent the spill from spreading. Cover the spill with the appropriate neutralizing agent and absorbent material. Carefully scoop up the material, place in a plastic bag. While still wearing gloves, clean the contaminated area with soap and water and mop it dry. Don’t leave paper towels or other materials used to clean up a spill in open trash cans in the work area. After cleanup, all materials, including paper towels used in the cleanup, must be disposed of as waste (call the RMO). Be particularly careful that flammable liquids absorbed during cleanup do not present an absorbent fire hazard.
Large Spill Response
If it is determined that the amount and/or hazardous nature of a spill is beyond the ability to respond safely, vacate the area immediately, secure the area, and call the Public Safety Department and advise the dispatcher what type of chemical(s) was spilled, amount spilled, exact location of spill/fire/injuries (building, room number, etc.).

Mercury Handling and Spill Procedures
There are various uses for mercury-containing instruments, particularly in the laboratory setting. Accidentally released/spilled mercury will continually give off vapors that can be absorbed through the skin. The absorbed mercury is a poison and affects the central nervous system. The poisoning can be progressive unless the mercury is removed from the environment. It is important that individuals involved in a mercury spill quickly isolate the area so that no exposure or tracking from the spill occurs. Please adhere to the following procedures when a mercury spill occurs:

1. Isolate the area of the spill by placing chairs, or other items, around the spill area to prevent persons from tracking through the spill. Place a temporary sign in the area stating “Mercury Spill”. Continue to monitor the area of the spill until clean-up activities begin.
2. Place all broken apparatus that contains mercury in a covered plastic pan, bucket, or sealable plastic bag for pick up by the RMO.
3. Mercury is a metal that can be reclaimed and recycled, however the clean-up of the spill constitutes a health risk unless performed correctly.

FIRE AND FIRE RELATED EMERGENCIES
Small fires in the laboratory can usually be successfully extinguished with the laboratory portable fire extinguisher. For a large, possibly rapid spreading fire, do the following:
Activate the building alarm.
Have someone call Public Safety at 2111 and give pertinent details.
Evacuate the building, shutting doors and providing assistance to other building occupants on the way out.
Provide fire and police officials with information about the incident upon their arrival.

ACCIDENT INVOLVING PERSONAL INJURY
Whenever possible, follow procedures that have been established and practiced. When helping another person, remember to evaluate the potential danger to yourself before taking action. When an emergency occurs, the following actions are recommended:
1. In the event of an emergency act immediately, keep calm, assist injured personnel and remove them from the hazard if injuries are minor
2. Report the nature and location of the emergency to the Public Safety dispatcher at 2111; give your name, telephone number, and location. Tell where you will meet the emergency vehicle. If individuals are involved, report how many; whether they are unconscious, burned, or trapped; whether an explosion has occurred, and whether there is or has been a chemical or electrical fire.
3. Tell others in the area, including the instructor, about the nature of the emergency.
4. Do not move any injured persons unless they are in immediate danger from chemical exposure or fire. Keep them warm. Unnecessary movement can severely complicate neck injuries and fractures.
5. Meet the ambulance or fire department at the place you indicated. Send someone else if you cannot go.
6. Do not make any other telephone calls unless they directly relate to the control of the emergency.
7. Report all injuries, no matter how minor, to your supervisor. The supervisor will fill out a Furman University Accident Reporting Form (see Appendix).

Inhalation Exposure
Remove the victim as quickly as possible to fresh air. Rescue personnel must wear proper respiratory equipment and protective clothing. If the contamination is immediately dangerous to life and health a self-contained breathing apparatus must be worn. Keep the victim at rest and warm. If the patient is unconscious keep the airway clear. Administer artificial respiration if breathing has stopped. Do not leave unconscious victims unattended.

**Skin Exposure**
Prompt action is essential; corrosive chemicals can damage the skin very rapidly. If only a small area of the skin is exposed, flood promptly with water and wash gently with soap. If large areas of skin are involved, go to the nearest emergency shower and flood with large amounts of water for 15 minutes. Remove clothing while standing in the shower. Wash the skin thoroughly with soap. If chemicals are splashed on the head, eye protective equipment should be left on until the chemical has been washed away. Do not use chemical neutralizers on the skin.

**Eye Exposure**
If a chemical is splashed into the eye go immediately to the nearest eye wash fountain. The first few seconds are critical; immediate flushing may prevent permanent damage. Spread the eyelid open with the fingers and wash the eye for at least 15 minutes. Flood all surfaces of the eye and the underside of the eyelids with water. It is important to flood the eye for 15 minutes because chemicals such as alcali can penetrate deeply into the eye. If no eyewash station is available, lay the victim on his/her back and pour water into the eye. Do not attempt to remove foreign bodies from the eye. Cover the eye with a sterile pad and seek medical care immediately.

**Ingestion**
Quickly take the container to the phone and call the Poison Control Center (see Appendix) and follow their instructions. Care for shock and monitor breathing while waiting for emergency help. Do not give anything by mouth unless instructed to do so by medical professionals.

**Bleeding**
Lay the victim down. Direct pressure will stop most bleeding. To control profuse bleeding, place a cloth or your bare hands over the wound and push down. Elevate the wound if the cut is deep. Use pressure points to control bleeding for severe cuts. Pressure points are located on the inside of the upper arm and groin area. Securely bandage the wound. A tourniquet should only be used if there is no other way to stop the bleeding. A record of the time it was applied must be kept. Remove foreign materials from small cuts and carefully wash with soap and water. Apply an antiseptic and bandage.

**Shock**
Following a severe injury the victim may go into shock. Signs of shock include pallor, cold and clammy skin, perspiration on the forehead or hands, weakness, nausea, vomiting, shallow breathing and a weak rapid pulse. The patient should be kept warm and lying down. If there are no head or neck injuries the patient’s legs should be elevated. Keep the victim’s airway open. Turn the head to the side if the patient vomits.
Clothing fire
Proceed to a safety shower if it is immediately available. If not, fall to the floor and roll to smother the flames. Fire blankets should only be used as a last resort, because they tend to hold heat in and increase the severity of burns. Fire extinguishers should not be used because they can freeze the skin or increase the likelihood of infections in the burn. Do not remove clothing that adheres to burnt skin.

Thermal burns
Immerse minor burns into cold water to relieve pain. Apply cold water compress to first and second degree burns with no open wounds. Apply a dry sterile dressing on open wounds and third degree burns. Do not use ice or ointments on a burn. Treat patient for shock. Seek medical attention.

Cryogenic burns
For short contact, immediately flush the area with large quantities of water. For prolonged exposure, or if visible tissue damage is apparent, seek medical help immediately to restore tissue to normal temperature.

Fractures
Do not move the patient unless it is necessary to prevent further injury. Improvise a splint if the patient must be moved. Treat for bleeding and shock.

Electrical
Disconnect the power and cautiously remove the current source with an insulator such as a dry stick or board. Don’t use metal or anything that is wet. Do not touch the victim until he/she has been removed from the electrical circuit. Begin CPR immediately.
EMPLOYEE INFORMATION AND TRAINING

Furman University requires that individuals working with hazardous materials and equipment be informed of the types and levels of hazards associated with these items. In addition, they must receive practical training in all aspects of the safe use of these substances, including the response to emergencies. The information and training must be provided when individuals are initially assigned to an area where hazardous chemicals and equipment are present, and prior to assignments involving new hazardous materials.

RESPONSIBILITY FOR TRAINING

Applicable departments have the moral and professional responsibility to train students in safe laboratory practices. Each science department is responsible for the training not only of the students who are taking the various laboratory courses, and of the assistants provided by the department, but also for other employees working with or exposed to chemicals. Students are expected to adhere to all safety rules and to participate in any training exercises. Furthermore, students have the responsibility to seek advice and guidance whenever they are in doubt about safety procedures or potential hazards in their laboratory work.

REQUIRED INFORMATION AND TRAINING TOPICS

Instruction should be given to students and staff members regarding:

1. the contents and appendices of the “Lab Standard”, OSHA 29 CFR 1910.1450;
2. the contents and appendices of this Chemical Hygiene Plan;
3. hazards of the specific chemical(s) being used in a particular course;
4. the location and availability of known reference materials (including any Material Safety Data Sheets), on the content of chemical labels, on the hazards and safety practices (safe handling, storage, and disposal) associated with chemicals;
5. the permissible exposure limits (PELs) of OSHA-regulated chemicals and recommended exposure limits to nonregulated materials;
6. the signs and symptoms associated with exposure to chemicals;
7. measures that can be taken to protect oneself (including PPE, SOPs, emergency procedures, and control measures);
8. methods to detect the presence or release of chemicals; and
9. proper reporting of all injuries.

DOCUMENTATION

Supervisors will be responsible for documenting training.

POSTING AND WARNING SIGNS

Each laboratory or work area where chemicals are used or stored shall be posted with:

1) a hazard label for all areas or equipment in which Risk Group 2 or 3 agents are handled or stored. The appropriate place for posting the label is at the main entrance door(s) to laboratories and animal rooms, on equipment like refrigerators, incubators, transport containers, and/or lab benches.
2) emergency information, including names and phone numbers of the laboratory supervisor or other responsible person to contact in the event of a fire, accident, or spill;
3) location signs for safety showers, eyewash stations, other safety and first aid equipment, exits, and areas where food and beverage consumption and storage are permitted; and
4) other appropriate placards or warning signs to note the presence of specific types of hazards such as radiological, carcinogen, laser, X-ray, etc.). Contact the RMO for specific signs that may be required.
HAZARD COMMUNICATION

It is important that the health and safety information on chemicals be provided to those in a laboratory setting. As required by the Hazard Communication Standard, an OSHA regulation found in 29 CFR 1910.1200, Material Safety Data Sheets (MSDS) are references used primarily for training concerning the hazards and precautionary measures applicable to those particular chemicals that workers will handle in the workplace.

Material Safety Data Sheets
OSHA requires that MSDSs be maintained for all incoming shipments of chemicals and be made readily accessible to employees. MSDS will be maintained for each department at a location accessible at all times while laboratories are occupied. The location of the MSDS will be specified on the lab safety poster in each lab.

The main headings on a typical MSDS with appropriate information are as follows:

Chemical Identity
The chemical and common names(s) must be provided.

Manufacturer's Identity
The name of the manufacturer and their location.

Hazardous Ingredients
Chemical and common names of all ingredients determined to be health hazards. Those comprising less than 1% (0.1% for carcinogens)

Physical and Chemical Characteristics
Includes vapor density, vapor pressure, flash point, flammable limits, odor, boiling point, heat of combustion, and molecular or formula weight.

Fire and Explosion Hazard Data
The fire hazards of the chemical and the conditions under which it could ignite or explode must be identified. Fire fighting methods and the extinguishing agent of choice should be listed.

Reactivity Data
Information should be provided on possible interaction with other chemicals.

Health Hazards
Describes the nature of the hazardous affect resulting from exposure if no proper first aid is given. The primary routes of exposure such as inhalation, ingestion, skin, or eyes should be listed along with the affects, signs, and symptoms that could occur from acute and chronic exposure.
Precautions for Safe Handling and Use
This information is important in case the chemical is accidentally released or spilled. Precautions for safe handling and storage must be included, and the EPA waste disposal method sometimes included in this section.

Control Measures
Control measures are those taken to protect individuals from exposure. These include engineering controls, personal protective equipment, safe handling procedures, and special information necessary to prevent exposure.

LABELING
Precautionary labeling is concise information that must be affixed to each container of hazardous material. The Hazard Communication Standard mandates the use of warning labels where hazardous substances are used. A warning label meeting the Hazard Communication Standard consists of three required parts:
- Identity of the chemical contents (same as on MSDS)
- Appropriate hazard warning (specific words, pictures or symbols conveying hazard such as carcinogen, irritant, corrosive, flammable)
- Name and address of manufacturer
EXPOSURE ASSESSMENT AND MEDICAL SURVEILLANCE

EXPOSURE ASSESSMENT
The intent of the Chemical Hygiene Plan is to provide individuals with knowledge and information about their laboratory work environment, to assist in assessment of possible exposure(s), and to prevent themselves from becoming overexposed to chemicals. Laboratory personnel are expected to initially assess chemical processes or activities being conducted to determine if exposures may occur. If necessary, the RMO will determine exposure levels by conducting air sampling of the work area when the following conditions exist:

- If there is reason to believe that exposure levels for a chemical exceed the OSHA “action level” or Permissible Exposure Level (PEL).
- Whenever an employee exhibits signs or symptoms of an exposure to a chemical.

If monitoring indicates that a chemical exposure above the action level is occurring, the RMO will make recommendations for corrective actions or alternative procedures. Each department head is responsible for carrying out the recommended corrective action(s). Additional monitoring will be conducted in order to establish the effectiveness of the corrective action(s), and periodically thereafter as specified by the particular standard involved.

MEDICAL EXAMINATIONS
Pre-employment and periodic physical examinations shall be conducted as required for employees exposed to specific hazardous materials in accordance with specific OSHA standards. The RMO will provide guidance on specific requirements, as needed.

Non-routine consultations and examinations shall be conducted for persons who suspect or who indicate signs or symptoms from possible exposure. If there is acute exposure/accidental injury, employees shall go directly to the pre-selected Worker’s Compensation Health Care facility. Students shall go directly to Student Health Services. In all cases where employees who may have been exposed have sought medical care, the Worker’s Compensation “Accident Reporting Form” must be completed. Student Health Services will complete incident information for students seeking treatment.

If an employee reports to a health care facility for medical surveillance other than in an emergency situation, the following information must be provided as a supplement to the Worker’s Compensation Accident Form and given to Human Resources for review:

1. Identity of chemicals being used by the individual and those suspected to be involved in the exposure incident.
2. Measurements from the RMO monitoring or other information should be included in the report to indicate how the exposure may have occurred.
3. A description of the signs and symptoms as they relate to the exposure. The duration of time, onset of symptom, and other supporting information about the incident is helpful.
4. A copy of the MSDS for each chemical suspected to be involved in the exposure incident.
**ROUTES OF EXPOSURE**

Toxic chemicals may enter the body through three routes: inhalation, ingestion, or contact with the skin and eyes.

**Inhalation**

Inhalation of toxic substances represents the most common means by which injurious substances enter the body. Air contaminants in the workplace present both acute and chronic dangers to health. Inhalation of toxic substances can cause serious local damage to the mucous membranes of the mouth, throat, and lungs or pass through the lungs into the circulatory system and produce systemic poisoning at sites remote from the point of entry.

**Ingestion**

Anything ingested may be absorbed into the blood and cause systemic poisoning. Oral toxicity is generally lower than inhalation toxicity because of the relatively poor absorption of many chemicals from the intestines into the bloodstream. The ingestion of laboratory chemicals may cause severe local damage to the lining of the mouth, throat, and gastrointestinal tract. In addition, if the chemical is absorbed into the bloodstream, systemic poisoning may result. Ingestion of chemicals may occur from eating contaminated food, smoking cigarettes contaminated with chemicals, or swallowing chemicals deposited in the throat through inhalation.

**Skin contact**

Chemical damage to the skin of the hands and arms is the most common occupational injury. Damage to the skin may include inflammation, burning, blistering, and complete destruction of the skin. The extent of the damage depends on the type of chemical, its concentration, and the duration of the contact. Chemicals that affect the skin are divided into two classes: irritants and sensitizers. Exposure to irritants can result in contact dermatitis, the most common occupational skin disease. Contact dermatitis is any local inflammation of the skin following exposure to damaging substances. Most organic and inorganic acids and metallic salts are strong irritants. Exposure to these chemicals can result in serious local damage to the skin often requiring medical attention. Exposure to milder irritants such as detergents and solvents may cause redness, burning, and swelling. The irritation is usually confined to the area of skin that contacted the chemical and may heal in a few days.

Initial contact with a chemical sensitizer may produce no reaction. Once sensitized, however, subsequent exposures may result in an allergic-type of response called contact allergic dermatitis. Reactions usually develop several hours after re-exposure and may last for several days. Skin reactions may also appear at sites remote from the initial contact. Once a worker has become sensitized to a chemical, very small amounts of it may trigger a reaction. Typical sensitizers include arsenic, chromates, mercury, nickel compounds, trichloroethylene, carbon disulfide, petroleum distillates, detergents, and many pesticides.

Skin contact is also the primary route of entry into the body for many hazardous chemicals. Chemicals such as parathion and related organophosphates, aniline, hydrocyanic acid, and phenol may pass through the skin and cause serious or even fatal poisoning. The largest problem associated with skin absorption of chemicals occurs with organic solvents. Solvents such as benzene, carbon tetrachloride, and methyl alcohol may be absorbed in sufficient quantities to cause systemic injury or even cancer at other organ sites. In addition, some solvents such as DMSO may act as vehicles that carry other chemicals through the skin.

**Eye contact**

The effects of accidentally splashing corrosive chemicals into the eye can range from minor irritation, to scarring of the cornea and loss of vision. Injury to the eye from bases is much more damaging than acid burns. Acids cause a protein barrier to form in the eye preventing further penetration of the acid. Bases, however,
continue to soak into the eye and cause further damage. In addition, mists, vapors, and gases may produce varying degrees of damage to the eyes. Some chemicals may be absorbed by the eye and produce systemic poisoning.

**CHEMICAL INTERACTIONS**

It is common in laboratories for workers to be exposed to a wide range of chemicals. Consideration must be given to the possible interaction of these chemicals and how they may affect personnel. There is growing evidence that many chemicals may have a synergistic effect and produce toxic effects that are much greater in combination than would be predicted from their individual effects. Since standards for maximum permissible levels of chemicals are based on the effects of a chemical acting alone it is prudent to keep exposures to chemicals to the lowest possible level. Another possible hazard involves the interaction of chemicals with cigarettes. Cigarettes can convert chemicals in the atmosphere into more harmful forms. For example, chloroform can be converted by the heat from a cigarette into the highly toxic gas phosgene. Interactions may also occur inside the body of the worker, producing harmful metabolites.

**THRESHOLD LIMIT VALUES**

Exposure limits to airborne concentrations of common chemicals are published yearly by the American Conference of Governmental Industrial Hygienists (ACGIH). These limits are recommendations, not legal standards, and represent conditions to which nearly all workers may be exposed without experiencing significant adverse effects. They are based on the best currently available data from industrial experiences, human population studies, and animal experiments. Three categories of Threshold Limit Values (TLV) are specified: Time Weighted Average (TWA), Short Term Exposure Limit (STEL), and Ceiling Value. TLV's are expressed in parts per million (ppm) or mg/cubic meter.

**SAFETY PRECAUTIONS**

**Alternative reagents**

Before a chemical is used, information about its toxicity should be obtained. If the chemical is highly toxic, alternative reagents should be used if possible. For example, toluene or xylene can often be substituted for benzene. If the material must be used, adequate personal protection and containment are required.

**Heavy metals**

Inhalation of heavy metal dust should be avoided. Work must be conducted in a carefully controlled manner. Adequate exhaust ventilation is the most important factor in reducing exposure to heavy metals. Fine powders should be handled in a hood and care must be taken to avoid dispensing the metal into the laboratory atmosphere. For the most toxic compounds, a totally enclosed system may be required. Protective clothing such as gloves, laboratory coat, dust masks and eye protection must be worn. Respirators must be worn if engineering controls are not feasible. Removal of dust should never be done by dry sweeping or with a air hose. Surfaces should be cleaned by vacuuming with a special HEPA vacuum or wetting down the surface prior to sweeping. Water sprays should be used to prevent the formation of dust and to prevent dust from becoming airborne.

**Mercury**

Every effort should be made to use an alternative to mercury whenever possible. Spirit-filled thermometers are an adequate substitute in most cases. Contact the RMO for suitable alternatives to mercury.

Mercury flows easily and gets into cracks and crevices where it can be extremely difficult to pick up. Mercury also vaporizes very easily and creates an inhalation hazard. Under static conditions 0.03 grams (about 1/100 the volume contained in a standard laboratory thermometer) can volatilize into the air in a standard laboratory and exceed the threshold limit value. Mercury should be stored in unbreakable plastic bottles. Containers should be sealed, kept in a cool, well ventilated area, and stored in secondary containers. Instruments containing
mercury should be placed in a tray that is large enough to contain the mercury. Transfers of mercury from one container to another should be done in a hood over a tray to hold spills. Spills should be cleaned up immediately. Droplets should be pushed together and collected by suction using an aspirator bulb or a suction flask. Alternatively, a commercial mercury clean-up kit which includes special pads for picking up mercury may be used.
CHEMICAL WASTE DISPOSAL

Proper disposal of chemicals is an important responsibility of laboratory personnel. Chemicals must be disposed of in a manner that will not harm the public or the environment. The disposal of hazardous chemicals is strictly regulated under the Resources Conservation and Recovery Act (RCRA). This is a federal law administered at the state level by the Division of Solid Waste Management. Hazardous waste must be disposed of only through the University’s Chemical Disposal Program. This will normally be done at no cost to the generator.

GENERAL GUIDELINES

1) Minimize waste by ordering the smallest amount of chemical necessary for the experimental procedure.

2) In general, only water soluble, non-toxic substances may be poured down the laboratory sink. Strong acids and bases must be neutralized to pH 3-11. Acids and bases must be neutralized as part of an ongoing process and not as part of a waste treatment process. Toxic, organic solvents, noxious, or lachrymatory chemicals cannot be disposed of in the sink. Departments must comply with local regulations regarding what can be poured into the sewer system. Contact the RMO before disposing of any chemical in the laboratory sink.

3) Chemicals for disposal must be placed in a sealed container with a screw type cap. Containers with cracked or corroded caps, or rubber, cork, or glass stoppers will not be accepted. The exterior of all containers must be clean. Combine partially full containers of compatible waste so that containers are full whenever possible. Contact EHS for chemical compatibility guidelines. Place small amounts of waste in small containers. Waste containers cannot exceed 5 gallons in size for liquids and 50 pounds for solids. Small vials may be overpacked in a larger glass container.

4) Glass (with the exception of thermometers) shall be rinsed clean with water and disposed in red waste containers labeled “Broken Glass” located in each of the labs.

5) All waste containers shall be clearly labeled with an appropriate Hazardous Waste label, as provided by the RMO. Label waste appropriately such as “Non-halogenated Solvents”, “Halogenated Solvents”, “Acetone Wash”, etc. All chemical constituents shall be logged on a separate notepad to include chemical name and amount.

WASTE CHARACTERIZATION

The Environmental Protection Agency (EPA) classifies wastes by their reaction characteristics. A summary of the major classifications are listed below.

Ignitability: These substances generally include flammable solvents and certain solids. Flammable solvents should never be poured down the drain. They should be collected for disposal in approved flammable solvent containers.

Corrosivity: This classification includes common acids and bases. They must be collected in waste containers that will not ultimately corrode and leak, such as plastic containers.

Reactivity: These substances include reactive metals such as sodium and various water reactive reagents. Compounds such as cyanides or sulfides are included in this class if they can readily evolve toxic gases such as hydrogen sulfide.

Toxicity: Although the EPA has specific procedures for determining toxicity, all chemicals may be toxic in certain concentrations.
SPECIAL HANDLING
Certain waste materials require special handling and packaging to be acceptable for pickup. Please note the following:

- Peroxide forming ethers (ethyl ether, 1,4 dioxane, etc.) should not exceed 1 gallon glass or 1 pint metal containers. These compounds must be dated when they are received and discarded within 90 days.
- Pentachlorophenol, dioxin, and unknowns will be handled on a case by case basis.
  - Uncontaminated chemicals should be appropriately labeled as such and may be used by someone else at the University as surplus.
- Gas cylinders are very expensive and/or impossible to dispose of through a hazardous waste company. The cylinders should be returned to the supplier, if possible. Generally, a rental charge or cash deposit on the empty cylinder is included in the purchase price of the gas. This is extra incentive to return the cylinders. Lecture bottles of gas should also be returned to the supplier.
- Chemical which are explosive require special handling for disposal. The procedure is very time consuming and expensive. Explosive-type materials should be purchased in only the smallest quantity required in order to completely use all of the material. It is in the best interest of laboratory personnel to take the necessary precautions to prevent the production (and storage) of waste explosives in laboratories. Many laboratories produce explosives by simply not following safety guidelines. Two of the most common items produced in this way are peroxidized ethers and dry picric acid.

BIOHAZARDOUS WASTE DISPOSAL
At Furman University, biohazardous waste is used to describe different types of waste that might include infectious agents. These types of waste include:

- solid waste which is generated in the diagnosis, treatment, or immunization of human beings or animals (sharps, lab wastes, cultures and stocks of infectious agents and associated biologicals);
- liquid or semi-liquid blood or other potentially infectious materials containing or contaminated with blood;

INFECTIOUS WASTE
All infectious wastes and materials contaminated with infectious waste will be autoclaved prior to disposal. The responsibility for decontamination and proper disposal of biohazardous wastes lies with the producing facility. Biohazardous waste that has been successfully decontaminated by autoclaving is no longer considered hazardous, and can be disposed of in the normal trash with the exception of sharps.

ANIMAL WASTE
Proper disposal of laboratory animals will depend on the particular carcinogens used, concentration, toxic properties, and if the waste contains radioactive materials. If animals are not contaminated with toxics, they will be collected in plastic bags, labeled, and stored in area freezers until pickup is arranged by the RMO. The RMO should be consulted for proper disposal strategies whenever animals are contaminated with hazardous chemicals or radioisotopes.

SHARPS
All sharps must be placed in a rigid, puncture resistant, closable and leakproof container, which is labeled with the word “Sharps” and the biohazard symbol. Sharps containers should not be filled more than 2/3. The sharps container shall be disposed of through an outside biomedical sharps disposal company if contaminated as Biohazardous. Non-contaminated sharps containers can be placed in the regular trash dumpster after placing in a trash bag.