Universidad Central del Caribe
Laboratory Safety Manual

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GENERAL SAFETY AND OPERATIONAL RULES

A. General Rules of Safety

1. No running, jumping, or horseplay in laboratory areas shall be permitted.

2. No employee shall work alone in a laboratory or chemical storage area when performing a task that is considered unusually hazardous by the laboratory supervisor.

3. Spills shall be cleaned immediately. Water spills can create a hazard because of the slip potential and flooding of instruments. Small spills of liquids and solids on bench tops shall be cleaned immediately to prevent contact with skin or clothing.

4. Ladders shall be in good condition and used in the manner for which they were designed.

5. Lifting of heavy items must be performed in the proper fashion, using the legs to lift, and not the back.

6. It is the responsibility of everyone working in the laboratory to make certain that the laboratory is left clean after work is performed.

7. As per UCC policy, children are not allowed in the workplace or in areas of potentially high hazards.

8. Animals, except for those that are the subject of experimentation are to be excluded from all University laboratory areas.

B. Personal Hygiene

1. Wash promptly whenever a chemical has contacted the skin. Know what you are working with and have the necessary cleaning/neutralization material on hand and readily available.

2. No sandals, open toed shoes or clogs shall be worn by laboratory personnel.

3. Clothing worn in the laboratory should offer protection from splashes and spills, should be easily removable in case of accident, and should be at least fire resistant. Nonflammable, nonporous aprons offer the most satisfactory and the least expensive protection. Lab jackets or coats should have snap fasteners rather than buttons so that they can be readily removed. These coats are to be fastened closed while working and removed prior to exiting the laboratory.

4. Laboratory clothing should be kept clean and replaced when necessary. Clothing should be replaced or laundered using appropriate decontamination procedures whenever contamination is suspected.

5. Lab coats are **not** to be worn outside the laboratory, especially in rest room or break facilities. Any lab coats, respirators, or other protective gear must be left in the lab areas. Employees must, as a matter of routine, be responsible for washing, cleaning, and any other decontamination

required when passing between the lab and the other areas. Washing should be done with soap and water; **do not** wash with solvents.
6. Inhalation is one of the four modes of entry for chemical exposure. "Sniff-testing" should not be done.

7. **Never** pipette by mouth. **Always** use a bulb to pipette.

8. Do not drink, eat, smoke, or apply cosmetics in the laboratory or chemical storage areas.

9. Do not use ice from laboratory ice machines for beverages.

10. No food, beverage, tobacco, or cosmetics products are allowed in the laboratory or chemical storage areas at any time. Cross contamination between these items and chemicals or samples is an obvious hazard and should be avoided.

C. Housekeeping
1. The area must be kept as clean as the work allows.

2. Each laboratory employee shall be responsible for maintaining the cleanliness of his/her area.

3. Reagents and equipment items should be returned to their proper place after use. This also applies to samples in progress. Contaminated or dirty glassware should be placed in specific cleaning areas and not allowed to accumulate.

4. Chemicals, especially liquids, should never be stored on the floor, except in closed door cabinets suitable for the material to be stored. Nor should large bottles (2.5L or larger) be stored above the bench top.

5. Reagents, solutions, glassware, or other apparatus shall **not** be stored in hoods. Besides reducing the available workspace, they may interfere with the proper air flow pattern and reduce the effectiveness of the hood as a safety device.

6. Counter tops should be kept neat and clean. Bench tops and fume hoods shall not be used for chemical storage. All work done in fume hoods shall be performed in the "Safety Zone", (6" minimum from the sash).

7. Stored items, equipment, and glass tubing shall not project beyond the front of shelf or counter limits.

8. Stored items or equipment shall not block access to the fire extinguisher(s), safety equipment, or other emergency items.

9. Stairways, hallways, passageways/aisles and access to emergency equipment and/or exits must be kept dry and not be obstructed in any fashion, including storage, equipment, phone or other wiring.

10. No combustible material such as paper, wooden boxes, pallets, etc., shall be stored under stairwells or in hallways. Hallways shall be kept free of boxes and materials so that exits or normal paths of travel will not be blocked.

11. Materials stored near aisles shall be restrained to prevent their falling.

12. Mats and carpeting shall be kept in good condition.

13. All working surfaces and floors should be cleaned regularly.

14. All containers must be labeled with at least the identity of the contents and the hazards those chemicals present to users.

D. Electrical

1. All electrical equipment shall be properly grounded.

2. Sufficient room for work must be present in the area of breaker boxes. All the circuit breakers and the fuses shall be labeled to indicate whether they are in the "on" or "off" position, and what appliance or room area is served. Fuses must be properly rated.

3. Equipment, appliance and extension cords shall be in good condition.

4. Extension cords shall not be used as a substitute for permanent wiring.

5. Electrical cords or other lines shall not be suspended unsupported across rooms or passageways. Do not route cords over metal objects such as emergency showers, overhead pipes or frames, metal racks, etc. Do not run cords through holes in walls or ceilings or through doorways or windows. Do not place under carpet, rugs, or heavy objects. Do not place cords on pathways or other areas where repeated abuse can cause deterioration of insulation.

6. Multi-outlet plugs shall not be used unless they have a built-in circuit breaker. This causes overloading on electrical wiring, which will cause damage and possible overheating.

8. All building electrical repairs, splices, and wiring shall be performed by the Physical Plant Department.

E. Vacuum Operations

1. When working with a vacuum be aware of implosion hazards. Apply vacuum only to glassware specifically designed for this purpose, i.e. heavy wall filter flasks, desiccators, etc.

2. Do not apply vacuum to scratched, cracked, or etched glassware.

3. Vacuum glassware which has been cooled to liquid nitrogen temperature or below should be annealed prior to reuse under vacuum.

4. Rotary evaporator condensers, receiving flasks, and traps should be taped or kept behind safety shields when under a vacuum.

5. All condensers connected to rotary evaporators should at least be cooled with circulating ice water.

6. The use of a vacuum for the distillation of the more volatile solvents, e.g. ether, low boiling petroleum ether and components, methylene chloride, etc., should be avoided whenever possible. In situations requiring reduced pressure, two alternatives should be considered; 1) Utilization of Rotovac System, or 2) Solvent recovery via atmospheric pressure distillation (preferred method).

7. Water, solvents, or corrosive gases should not be allowed to be drawn into a building vacuum system.

8. When a vacuum is supplied by a compressor or vacuum pump to distill volatile solvents, a cold trap should be used to contain solvent vapors. Cold traps should be of sufficient size and low enough temperature to collect all condensable vapors present in a vacuum system. If such a trap is not used, the pump or compression exhaust must be vented to the outside using explosion proof methods.

9. After completion of an operation in which a cold trap has been used, the system should be vented. This venting is important because volatile substances that have been collected in the trap may vaporize when the coolant has evaporated and cause a pressure buildup that could blow the apparatus apart.

10. After vacuum distillations, the pot residue must be cooled to room temperature before air is admitted to the apparatus.

11. All desiccators under vacuum should be completely enclosed in a shield or wrapped with friction tape in a grid pattern that leaves the contents visible and at the same time guards against flying glass should the vessel collapse. Various plastic (e.g., polycarbonate) desiccators now on the market reduce the implosion hazard and may be preferable.

F. Handling Glassware

1. Glass breakage is a common cause of injuries in laboratories. Only glass in good condition should be used.

2. Discard all broken, chipped, starred or badly scratched glassware. Hand protection should be used when picking up broken glass.

3. When using glass tubing, all ends should be fire polished. Lubricate tubing with glycerin or water before inserting into rubber stoppers or rubber tubing.

4. Protect hands with leather gloves when inserting glass tubing. Hold elbows close to the body to limit movement when handling tubing.

5. Do not store glassware near the edge of shelves. Store large or heavier glassware on lower shelves.

6. Use glassware of the proper size. Allow at least 20% free space. Grasp a three-neck flask by the middle neck, not a side neck.

7. Do not attempt to catch glassware if it is dropped or knocked over.

8. Conventional laboratory glassware must never be pressurized.

GENERAL SAFETY EQUIPMENT

A. Fire Extinguishers

The Deanship of Administration is responsible for the procurement, placement, inspection, and maintenance of all fire extinguishers on campus.

1. Laboratory personnel should be adequately trained regarding pertinent fire hazards associated with their work.

2. Fire extinguishers must be clearly labeled to indicate the types of fire they are designed to extinguish. The following codes as presented in NFPA 10 "Portable Fire Extinguishers" are:

- Class A-fires in ordinary combustible materials such as wood, cloth, paper, rubber, and many plastics.

- Class B-fires in flammable liquids, oils, greases, tars, oil-base paints, lacquers and flammable gases.

- Class C-fires that involve energized electrical equipment where the electrical conductivity of the extinguishing medium is of importance; when electrical equipment is de-energized, extinguishers for class A or B fires may be safely used.

- Class D-Fires of combustible metals such as magnesium, titanium, zirconium, sodium, lithium and potassium.

3. Fire extinguishers of the "Halon" type are specially designed so they leave no residue that could damage instruments or computers. (However, the area should be thoroughly ventilated before being reoccupied.)

4. Fire extinguishers should never be concealed from general view or blocked from access.

5. The Deanship of Administration will install all fire extinguishers. Once a fire extinguisher has been installed, they will inspect and maintain the device.

6. If an employee notices a fire extinguisher discharged or not fully charged, an extinguisher with the safety pin pulled out, an extinguisher obstructed from view, or one not hanging in its proper location, please notify the Deanship of Administration.

B. Safety Showers

1. Employees should familiarize themselves with the location of the nearest safety shower.

2. Employees should be familiar with the operation of the safety showers.

3. Safety showers are designed to flood the entire body in the event of a clothing fire or a major spill of a chemical. In either case, an employee should simply stand under the shower and activate the shower. Flood the affected area for a minimum of 15 to 30 minutes.

4. In the case of a corrosive liquid spill, the employee should remove the affected portion of clothing to reduce potential contact. Removal of clothing should be done while the individual is under the activated shower.

5. The Chemical Safety Officer or laboratory supervisor should be notified as soon as possible if the employee required the use of the safety shower.

6. Safety showers are tested by the Deanship of Administration.

C. Eyewash Fountains

1. Employees should familiarize themselves with the location and operation of the nearest eyewash fountain.

2. Always flood the eyes for at least 15 to 30 minutes to be sure there is no residue of the corrosive liquid. Flush from the eye outward.

3. After thorough washing, the proper authorities should be notified and subsequent medical care for the employee should be seriously considered. This is because serious damage may have already occurred before the eye was thoroughly rinsed and/or the damage may not be immediately apparent.

4. Eyewash fountains are checked for proper location and operational status by the Deanship of Administration.

D. First Aid Kits

1. First aid kits should be located in conspicuous place.

2. Minor injuries requiring first aid shall always be reported to a supervisor:

   a. A minor injury may indicate a hazardous situation which should be corrected to prevent a more serious injury.

   b. It is important to document a minor injury as having been "work related" for the purpose of obtaining Worker's Compensation, should the injury lead to later, more serious, complications.

3. The location and phone number of emergency services and the Puerto Rico Poison Control Center should be clearly posted.

4. A designated party should be responsible for monitoring and maintaining the first aid kit(s).

5. First aid kit contents should include items such as Band-aids®, sterile gauze pads, bandages, scissors, antiseptic wipes or ointments, and a first aid card. All kits should also contain examination gloves for response to emergencies in which blood is present. Pocket masks for CPR procedures are also recommended.

6. The following items are **not** recommended for use in a first -aid kit:

a. Iodine - Tissue damage can be caused by improper use.

b. Ice Pack Compress - If there is swelling of soft tissue, or other need for an ice pack, the person should be examined by a physician.

c. Ammonia Inhalants - If an individual is unconscious, obtain help -- **do not use ammonia**.

d. Tourniquet - Not required for minor injuries; use the pressure technique until medical assistance is available.

7. Laboratories where ***high-voltage*** equipment is in use should have available an emergency electrical response board. This will contain an instruction card and a non-conductive stick to turn off the equipment and remove the shock victim from contact with the source.

8. Laboratories using material for which the immediate administration of an antidote or neutralizing agent is manifested (such as hydrofluoric acid and calcium gluconate) should be considered. Additionally, these procedures should be included in the Chemical Hygiene Plan and have the appropriate special handling procedures outlined within it.

E. Explosion-Proof Refrigerators

If there is a need to refrigerate a substance that is flammable, it shall be refrigerated in an U.L. listed or F.M. approved explosion-proof refrigerator. This refrigerator is designed as such that any flammable vapors in the refrigerator do not contact sparks.
This refrigerator must **not** be used for the storage of food.

F. Ventilation Hoods

1. Laboratory Hoods

Work that involves hazards and noxious materials which are toxic, odoriferous, volatile or harmful shall be conducted within a laboratory hood. The primary purpose of a laboratory hood is to keep toxic or irritating vapors and fumes out of the general laboratory working area. A secondary purpose is to serve as a shield between the worker and equipment being used when there is the possibility of an explosive reaction. This is done by lowering the sash of the hood.

a. Hood ventilation systems are best designed to have an airflow of not less than 60 ft/min (linear) and not more than 120 ft/min (linear) across the face of the hood. Flow rates of higher than 125 ft/min can cause turbulence problems and are not recommended. If possible, a mark will have been placed on the hood so the sash can be drawn to a point where 100 linear ft/min can be achieved.

b. Avoid creation of strong cross drafts (100 fpm) caused by open doors and windows, air conditioning and/or heating vents, or personnel movement. Drafts will pull contaminants from the hood and into the laboratory. One hundred FPM is generally not perceptible (100 fpm is approximately 3 mph, a normal walking pace). Air conditioning and heating vents and personnel traffic all create airflows in excess of 200 FPM, often much higher. Therefore, laboratory activity in the hood area should be minimized while the hood is in use.

c. DO NOT ADJUST BAFFLES unless you have been instructed to do so by your CSO. Do not remove baffles. If ventilation problems develop, contact the Physical Plant immediately.

d. When not in use, the sash of the hood should be kept closed. While performing work in the hood, the sliding sash should be kept at the height designated to provide the minimum face velocity required (usually 100 lfm). This will ensure maximum velocity of air flow into the hood and out of the laboratory.

e. Work should be performed as deeply within the fume hood as possible. Equipment, reagents, and glassware should be placed as far back in the hood as is practical without blocking the rear baffle. Solid objects placed at the face of the hood cause turbulence in the air flow. Therefore, each hood should have a clearly marked "safety zone" in which no work should be conducted or equipment placed.

f. ONLY ITEMS NECESSARY TO PERFORM THE PRESENT EXPERIMENT SHOULD BE IN THE HOOD. The more equipment in the hood, the greater the air turbulence and the chance for gaseous escape into the lab.

g. When instrumentation is utilized for a process inside a hood, all instruments should be elevated a minimum of two inches from the hood base to facilitate proper air movement.

h. The purpose and function of a hood is **NOT** to store chemicals or unused items. The fume hood is not a storage cabinet.

i. Hoods shall not be used as a means of disposing of toxic or irritating chemicals, but only as a means of removing small quantities of vapor which might escape during laboratory operations. If vaporization of large quantities of such materials is a necessary part of the operation, a means of collecting the vapor by distillation or scrubbing should be considered, rather than allowing it to escape through the hood vent. The collected liquid can then be disposed of as a liquid waste.

j. Some hoods are constructed of stainless steel. These are usually "perchloric acid hoods" or "radioisotope hoods." Never use perchloric acid in a hood not designed for that use. Perchloric acid hoods have a wash-down feature which should be used after each use of the hood and at least every two weeks when the hood is not in use. Date of wash-down should be recorded by the laboratory.

k. Always look to assure fan motor power switch is in the "on" position before initiating experiment. Note: Some hoods do not have individual "on/off" switches and remain "on" continuously.

l. Do not use infectious material in a chemical fume hood.

m. Exhaust fans should be spark-proof if exhausting flammable vapors and corrosive resistant if handling corrosive fumes.

n. Controls for all services (i.e., vacuum, gas, electric, water) should be located at the front of the hood and should be operable when the hood door is closed.

o. Radioactive materials may not be used in the hoods without prior approval of the Radiological Safety Officer.

p. An emergency plan should be prepared in the event of ventilation failure or other unexpected occurrence such as fire or explosion in the hood. ALWAYS ASSURE THE HOOD IS OPERATIONAL BEFORE INITIATING AN EXPERIMENT.

2. Laminar Flow Hoods

Laminar flow hoods are designed to protect the work surface from contaminants and blow out into the face of the person using the hood. Therefore, any chemical use will cause the person to be exposed to the chemical. Toxic, volatile chemicals may not be used in a laminar flow hood.

3. Biological Safety Cabinets

Biological Safety cabinets are among the most effective, as well as the most commonly used, primary containment devices in laboratories working with infectious agents.

Class I and II biological safety cabinets, when used in conjunction with good microbiological techniques, provide an effective partial containment system for safe manipulation of moderate and some high-risk microorganisms. It is imperative that Class I and II biological safety cabinets are tested and certified in situs, any time the cabin is moved, and at least annually thereafter. Certification at locations other than the final site may attest to the performance capability of the individual cabinet or model but does not supersede the critical certification prior to use in the laboratory.

As with any other piece of laboratory equipment, personnel must be trained in the proper use of the biological safety cabinets. Of particular note are those activities which may disrupt the inward directional airflow through the work opening of Class I and II cabinets. Aerosol particles can escape the cabinet in various ways. Among these are repeated insertion and withdrawal of workers' arms in and from the work chamber, opening and closing doors to the laboratory or isolation cubicle, improper placement or operation of materials or equipment within the work chamber, or brisk walking past the cabinet while it is in use. Strict adherence to recommended practices for the use of biological safety cabinets is as important in attaining the maximum containment capability of the equipment as is the mechanical performance of the equipment itself. Always decontaminate the hood using procedures adopted by the laboratory after each use or at the end of the work day.

BIOLOGICAL SAFETY CABINETS ARE NOT CHEMICAL FUME HOODS AND SHALL NOT BE USED AS SUCH.

4. Specialized Local Ventilation
Some instruments such as atomic absorption spectrophotometers (AA's) or inductively coupled argon spectrometers (ICP's) emit small quantities of hazardous materials during use. To prevent excessive accumulations of these materials, each of these instruments should be provided with an individual ventilation exhaust duct (as required by the manufacturer and ASHRAE). Gas chromatography equipment using thermal conductivity detection should be kept in a hood or have a vent over the column outlets.

5. Cold Rooms

a. Room Design
Cold rooms should be designed or retrofitted with doors that allow anyone trapped inside to get out easily. The electrical system within environmental rooms should be independent of the main power supply so that persons are never left in these areas without light.

b. Chemical Use
Cold rooms usually re-circulate the air using a closed air circulation system. Hazardous chemicals must not be stored in these rooms because ambient concentrations of volatile chemicals can accumulate to dangerous levels.

Flammable solvents should not be used in cold rooms. Ignition sources in these rooms could ignite vapors.

Avoid using volatile acids in cold rooms because vapors can corrode the cooling coils, leading to possible refrigerant leaks.

If solid carbon dioxide (dry ice) is placed into a cold room, its sublimation will raise the carbon dioxide levels within the room, possibly to dangerous levels. Use extra precautions if you must use or store dry ice in these spaces.

G. Flammable-Liquid Storage Cabinets
Cabinets designed for the storage of flammable liquids should be properly used and maintained.

a. Store only compatible materials inside a cabinet.

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

c. The manufacturer establishes quantity limits for various sizes of flammable-liquid storage cabinets; do not overload a cabinet. NFPA Guidelines and OSHA Standards on Flammable Liquids are utilized as standards for Worker/Fire Protection at the Universidad Central del Caribe. In all laboratory work with flammable liquids the requirements of 29 CFR (H)-(L), NFPA 30, and NFPA 45 should be consulted and followed.

H. Safety Shields
Safety shields should be used for protection against possible explosions, implosions or splash hazards. Laboratory equipment should be shielded on all sides so that there is no line-of-sight

exposure of personnel. Provided its opening is covered by closed doors, the conventional laboratory exhaust hood is a readily available built-in shield. However, a portable shield should also be used when manipulations are performed, particularly with hoods that have vertical-rising doors rather than horizontal-sliding sashes.

Portable shields can be used to protect against hazards of limited severity, e.g., small splashes, heat, and fires. A portable shield, however, provides no protection at the sides or back of the equipment and many such shields are not sufficiently weighted and may topple toward the worker when there is a blast (permitting exposure to flying objects). A fixed shield that completely surrounds the experimental apparatus can afford protection against minor blast damage.

PERSONAL PROTECTIVE EQUIPMENT

OSHA's standard on personal protective equipment, 29CFR 1910 132, Subpart I (here-after referred to as the standard), imposes several requirements relating to basic safety and health programs. The standard adds general requirements for the selection and use of personal protective equipment (PPE). Included in these requirements are the following:

• Employers must conduct a hazard assessment to determine if hazards present necessitate the use of PPE.

• Employers must certify in writing that the hazard assessment was conducted.

• PPE selection must be made on the basis of hazard assessment and affected workers properly trained.

• Defective or damaged PPE must not be used.

• Established training requirements for employees using PPE must be established. This should include requirements for employees to demonstrate an understanding of the training.

• Employer must certify in writing that training programs were provided and understood.

A variety of laboratory personal protective equipment is commercially available and commonly used in laboratories. However, for the equipment to perform the desired function, it must be used and managed properly. Laboratory supervisors and/or the Chemical Safety Officer shall determine a need for such equipment, monitor its effectiveness, train the employees, and monitor and enforce the proper use of such equipment.

A. Eye Protection

Eye protection is mandatory in all areas where there is potential for injury. This applies not only to persons who work continuously in these areas, but also to persons who may be in the area only temporarily, such as maintenance or clerical personnel. All eye protective equipment shall comply with the requirements set forth in the American National Standard for Occupational and Educational Eye and Face Protection, Z 87.1-1968.

1. The type of eye protection required depends on the hazard. For most situations, safety glasses with side shields are adequate. Where there is a danger of splashing chemicals, goggles are required. More hazardous operations include conducting reactions which have potential for explosion and using or mixing strong caustics or acids. In these situations, a face shield or a combination of face shield and safety goggles or glasses should be used.

2. Plastic safety glasses should be issued to employees.

3. It is recommended that contact lenses not be permitted in the laboratory. The reasons for this prohibition are:

a. If a corrosive liquid should splash in the eye, the natural reflex to clamp the eyelids shut makes it very difficult, if not impossible, to remove the contact lens before damage is done.

b. The plastic used in contact lenses is permeable to some of the vapors found in the laboratory. These vapors can be trapped behind the lenses and can cause extensive irritation.

c. The lenses can prevent tears from removing the irritant. If the Chemical Safety Officer chooses to allow contact lenses to be worn, they shall be protected by goggles designed specifically for use with contact lenses. (The protective goggles for use with contact lenses fit loosely around the eyes and have no vents for access by vapors.) If chemical vapors contact the eyes while wearing contact lenses, these steps should be followed:

(1) Immediately remove the lenses.

(2) Continuously flush the eyes, for at least 15 to 30 minutes.

(3) Seek medical attention.

4. Although safety glasses are adequate protection for the majority of laboratory operations, they are not sufficient for certain specific operations where there is danger from splashes of corrosive liquids or flying particles. Examples are: washing glassware in chromic acid solution, grinding materials, or laboratory operations using glassware where there is significant hazard of explosion or breakage (i.e., in reduced or excess pressure or temperature). In such cases, goggles or face shields shall be worn if there is need for protection of the entire face and throat.

5. If, despite all precautions, an employee should experience a splash of corrosive liquid in the eye, the employee is to proceed (with the assistance of a co-worker, if possible) to the nearest eyewash fountain and flush the eyes with water for at least 15 to 30 minutes. Flush from the eye outward. During this time, a co-worker should notify the proper authorities.

6. Visitors shall follow the same eye protection policy as employees. If they do not provide their own eye protection, it is the laboratory's responsibility to provide adequate protection. It should be the responsibility of the employee conducting the tour to enforce this policy. After use safety glasses/goggles used by visitors should be cleaned prior to reuse.

B. Clothing

The following guidelines for laboratory clothing are offered strictly from a safety standpoint.

1. Due to the potential for ignition, absorption, and entanglement in machinery, loose or torn clothing should be avoided unless wearing a lab coat.

2. Dangling jewelry and excessively long hair pose the same type of safety hazard.

3. Finger rings or other tight jewelry which is not easily removed should be avoided because of the danger of corrosive or irritating liquids getting underneath the piece and producing irritation.

4. Lab coats should be provided for protection and convenience. They should be worn at all times in the lab areas. Due to the possible absorption and accumulation of chemicals in the material, lab coats should not be worn in the lunchroom or elsewhere outside the laboratory.

5. Where infectious materials are present, closed (snapped) lab coats and gloves are essential.

6. Shoes shall be worn at all times in the laboratories. Sandals, open-toed shoes, and shoes with woven uppers, shall not be worn because of the danger of spillage of corrosive or irritating chemicals.

7. Care should be exercised in protective clothing selection; some protective clothing has very limited resistance to selected chemicals or fire.

8. Consult the MSDS for a chemical to find out the recommended clothing or PPE for a particular chemical. (Examples are latex, nitrile, or PVC gloves, or aprons.)

C. Aprons - Rubber or Plastic

Some operations in the laboratory, like washing glassware, require the handling of relatively large quantities of corrosive liquids in open containers. To protect clothing in such operations, plastic or rubber aprons may be supplied. A high-necked, calf- or ankle-length, rubberized laboratory apron or a long-sleeved, calf- or ankle-length, chemical- and fire - resistant laboratory coat should be worn anytime laboratory manipulation or experimentation is being conducted. Always wear long-sleeved and long-legged clothing; do not wear short -sleeved shirts, short trousers, or short skirts.

D. Gloves

When handling chemicals, it is recommended that the correct gloves be used to protect the worker from accidental spills or contamination. If the gloves become contaminated they should be removed and discarded as soon as possible. There is no glove currently available that will protect a worker against all chemicals.

Protection of the hands when working with solvents, detergents, or any hazardous material is essential in the defense of the body against contamination. Exposure of the hands to a potentially hazardous chemical could result in burns, chafing of the skin due to extraction of essential oils, or dermatitis. The skin could also become sensitized to the chemical and once sensitized, could react to lesser quantities of chemicals than otherwise would have any effect. It is well documented that primary skin irritations and sensitizations account for significantly greater numbers of lost time incidents on the job than any other single type of industrial injury.

Proper selection of the glove material is essential to the performance of the glove as a barrier to chemicals. Several properties of both the glove material and the chemical with which it is to be used should influence the choice of the glove. Some of these properties include: permeability of the glove material, breakthrough time of the chemical, temperature of the chemical, thickness of the glove material, and the amount of the chemical that can be absorbed by the glove material (solubility effect). Glove materials vary widely in respect to these properties; for instance, neoprene is good for protection against most common oils, aliphatic hydrocarbons, and certain other solvents, but is unsatisfactory for use against aromatic hydrocarbons, halogenated hydrocarbons, ketones, and many other solvents.

Gloves of various types are available and should be chosen for each specific job for compatibility and breakthrough characteristics. An excellent information source is Guidelines for the Selection of Chemical Protective Clothing published by the American Conference of Governmental Industrial Hygienists (ACGIH) or information provided by glove manufacturers.

1. Selection
For concentrated acids and alkalis, and organic solvents, natural rubber, neoprene or nitrile gloves are recommended. For handling hot objects, gloves made of heat-resistant materials (leather or Nomex) should be available and kept near the vicinity of ovens or muffle furnaces. A hot object should never be picked up with rubber or plastic gloves. Special insulated gloves should be worn when handling very cold objects such as liquid N2 or CO2. Do not use asbestos containing gloves.

2. Inspection
Before each use, gloves should be inspected for discoloration, punctures, and tears. Rubber and plastic gloves may be checked by inflating with air and submersing them in water to check for air bubbles.

3. Usage
Gloves should always be rinsed with a compatible solvent, soap and water prior to handling wash bottles or other laboratory fixtures.

4. Cleaning
Before removal, gloves should be thoroughly washed, either with tap water or soap and water.

5. Removal
Employees shall remove gloves before leaving the immediate work site to prevent contamination of door knobs, light switches, telephones, etc. When gloves are removed, pull the cuff over the hand.

E. Respirators
Respirator use should be avoided if at all possible (and is usually not required if adequate precautions are taken). Where possible, engineering controls (fume hoods, etc.) should be utilized to minimize exposure. If respirators are worn because OSHA PELs are being exceeded or other reasons, a respirator program must be established in accordance with OSHA 29 CFR 1910.134. Your CSO should be consulted for additional information and guidance.

COMPRESSED GAS SAFETY

Many laboratory operations require the use of compressed gases for analytical or instrument operations. Compressed gases present a unique hazard. Depending on the particular gas, there is a potential for simultaneous exposure to both mechanical and chemical hazards. Gases may be combustible, explosive, corrosive, poisonous, inert, or a combination of hazards. If the gas is flammable, flash points lower than room temperature compounded by high rates of diffusion (which allow for fast permeation throughout the laboratory) present a danger of fire or explosion. Additional hazards of reactivity and toxicity of the gas, as well as asphyxiation, can be caused by high concentrations of even "harmless" gases such as nitrogen. Since the gases are contained in heavy, highly pressurized metal containers, the large amount of potential energy resulting from compression of the gas makes the cylinder a potential rocket or fragmentation bomb. In summary, careful procedures are necessary for handling the various compressed gases, the cylinders containing the compressed gases, regulators or valves used to control gas glow, and the piping used to confine gases during flow.

A. Identification

1. The contents of any compressed gas cylinder shall be clearly identified for easy, quick, and complete determination by any laboratory worker. Such identification should be stenciled or stamped on the cylinder or a label, provided that it cannot be removed from the cylinder. Commercially available three-part tag systems can be very useful for identification and inventory. No compressed gas cylinder shall be accepted for use that does not legibly identify its contents by name. Color coding is not a reliable means of identification; cylinder colors vary with the supplier, and labels on caps have little value as caps are interchangeable. If the labeling on a cylinder becomes unclear or an attached tag is defaced to the point the contents cannot be identified, the cylinder should be marked "contents unknown" and returned directly to the manufacturer.

2. All gas lines leading from a compressed gas supply should be clearly labeled to identify the gas, the laboratory served, and the relevant emergency telephone numbers. The labels should be color coded to distinguish hazardous gases (such as flammable, toxic, or corrosive substances) (e.g., a yellow background and black letters).

Signs should be conspicuously posted in areas where flammable compressed gases are stored, identifying the substances and appropriate precautions (e.g., HYDROGEN - FLAMMABLE GAS - NO SMOKING - NO OPEN FLAMES).

B. Handling and Use

1. Since gas cylinders are tall and narrow, they shall be secured at all times to prevent tipping . Cylinders may be attached to a bench top, individually to the wall, placed in a holding cage, or have a non-tip base attached.

2. When new cylinders are received, they should be inspected. During this inspection, one should insure the proper cap is securely in place and the cylinder is not leaking. Cylinders shall have clear labels indicating the type of gas contained. If the cylinders are acceptable, they shall be stored in a proper location. If a leaking cylinder is discovered, move it to a safe place (if it is safe

to do so) and inform the Deanship of Administration. You should also call the vendor as soon as possible. Under no circumstances should any attempt be made to repair a cylinder or valve.

3. Cylinders containing flammable gases such as hydrogen or acetylene shall not be stored in close proximity to open flames, areas where electrical sparks are generated, or where other sources of ignition may be present. Cylinders containing acetylene shall never be stored on their side. An open flame shall never be used to detect leaks of flammable gases. Hydrogen flame is invisible, so "feel" for heat. All cylinders containing flammable gases should be stored in a well-ventilated area.

4. Oxygen cylinders, full or empty, shall not be stored in the same vicinity as flammable gases. The proper storage for oxygen cylinders requires that a minimum of 50 feet be maintained between flammable gas cylinders and oxygen cylinders or the storage areas be separated, at a minimum, by a fire wall five feet high with a fire rating of 0.5 hours. Greasy and oily materials shall never be stored around oxygen; nor should oil or grease be applied to fittings.

5. Standard cylinder-valve outlet connections have been devised by the Compressed Gas Association (CGA) to prevent mixing of incompatible gases. The outlet threads used vary in diameter; some are internal, some are external; some are right-handed, some are left-handed. In general, right-handed threads are used for non-fuel and water-pumped gases, while left-handed threads are used for fuel and oil-pump gases. To minimize undesirable connections, only CGA standard combinations of valves and fittings should be used in compressed gas installations; the assembly of miscellaneous parts should be avoided. The threads on cylinder valves, regulators and other fittings should be examined to ensure they correspond and are undamaged.

Cylinders should be placed with the valve accessible at all times. The main cylinder valve should be closed as soon as it is no longer necessary that it be open (i.e., it should never be left open when the equipment is unattended or not operating). This is necessary not only for safety when the cylinder is under pressure, but also to prevent the corrosion and contamination resulting from diffusion of air and moisture into the cylinder after it has been emptied.

Cylinders are equipped with either a hand wheel or stem valve. For cylinders equipped with a stem valve, the valve spindle key should remain on the stem while the cylinder is in service. Only wrenches or tools provided by the cylinder supplier should be used to open or close a valve. At no time should pliers be used to open a cylinder valve. Some valves may require washers; this should be checked before the regulator is fitted.

Cylinder valves should be opened slowly. Main cylinder valves should never be opened all the way. When opening the valve on a cylinder containing an irritating or toxic gas, the user should position the cylinder with the valve pointing away from them and warn those working nearby.

6. Regulators are gas specific and not necessarily interchangeable. Always make sure that the regulator and valve fittings are compatible. If there is any question as to the suitability of a regulator for a particular gas, call your vendor for advice. After the regulator is attached, the cylinder valve should be opened just enough to indicate pressure on the regulator gauge (no more

than one full turn) and all the connections checked with a soap solution for leaks. Never use oil or grease on the regulator of a cylinder valve.

7. Piping material shall be compatible with the gas being supplied. Copper piping shall not be used for acetylene, nor plastic piping for any portion of a high pressure system. Do not use cast iron pipe for chlorine; do not conceal distribution lines where a high concentration of a leaking hazardous gas can build up and cause an accident. Distribution lines and their outlets should be clearly labeled as to the type of gas contained. Piping systems should be inspected for leaks on a regular basis. Special attention should be given to fittings as well as possible cracks that may have developed.

8. A cylinder should never be emptied to a pressure lower than 172 kPa (25 psi/in2) (the residual contents may become contaminated if the valve is left open). When work involving a compressed gas is completed, the cylinder must be turned off, and if possible, the lines bled. When the cylinder needs to be removed or is empty (see above), all valves shall be closed, the system bled, and the regulator removed. The valve cap shall be replaced, the cylinder clearly marked as "empty," and returned to a storage area for pickup by the supplier. Empty and full cylinders should be stored in separate areas.

9. Where the possibility of flow reversal exists, the cylinder discharge lines should be equipped with approved check valves to prevent inadvertent contamination of cylinders connected to a closed system. "Sucking back" is particularly troublesome where gases are used as reactants in a closed system. A cylinder in such a system should be shut off and removed from the system when the pressure remaining in the cylinder is at least 172 kPa (25 psi/in2). If there is a possibility that the container has been contaminated, it should be so labeled and returned to the supplier.

10. Liquid bulk cylinders may be used in laboratories where a high volume of gas is needed. These cylinders usually have a number of valves on the top of the cylinder. All valves should be clearly marked as to their function. These cylinders will also vent their contents when a preset internal pressure is reached, therefore, they should be stored or placed in service where there is adequate ventilation. If a liquid fraction is removed from a cylinder, proper hand and eye protection must be worn and the liquid collected in a Dewar flask.

11. Always use safety glasses (preferably a face shield) when handling and using compressed gases, especially when connecting and disconnecting compressed gas regulators and lines.

12. All compressed gas cylinders, including lecture -size cylinders, shall be returned to the supplier when empty or no longer in use.

C. Transportation of Cylinders

The cylinders that contain compressed gases are primarily shipping containers and should not be subjected to rough handling or abuse. Such misuse can seriously weaken the cylinder and render it unfit for further use or transform it into a rocket having sufficient thrust to drive it through masonry walls.

1. To protect the valve during transportation, the cover cap should be screwed on hand tight and remain on until the cylinder is in place and ready for use.

2. Cylinders should never be rolled or dragged.

3. When moving large cylinders, they should be strapped to a properly designed wheeled cart to ensure stability.

4. Only one cylinder should be handled (moved) at a time.

D. Cryogenic Liquids

A number of hazards may be present from the use of cryogenic liquids in the laboratory. Employees should be properly trained in these hazards prior to use. The transfer of liquefied gases from one container to another should not be attempted for the first time without the direct supervision and instruction of someone experienced in the operation.

1. Fire/Explosions

    a. Neither liquid nitrogen nor liquid air should be used to cool a flammable mixture in the presence of air because oxygen can condense from the air and lead to a potentially explosive condition.

    b. Adequate ventilation must always be used to prevent the build-up of vapors of flammable gases such as hydrogen, methane, and acetylene.

    c. Adequate ventilation is also required when using gases such as nitrogen, helium, or hydrogen. In these cases, oxygen can be condensed out of the atmosphere creating a potential for explosive conditions.

2. Pressure

Cylinders and other pressure vessels used for the storage and handling of liquefied gases should not be filled to more than 80% of capacity, to prevent the possibility of thermal expansion and the resulting bursting of the vessel by hydrostatic pressure.

3. Embrittlement of Structural Materials

Appropriate impact-resistant containers must be used that have been designed to withstand the extremely low temperatures.

4. Contact With and Destruction of Living Tissue

Even very brief contact with a cryogenic liquid is capable of causing tissue damage similar to that of thermal burns. Prolonged contact may result in blood clots that have potentially serious consequences. In addition, surfaces cooled by cryogenic liquids can cause severe damage to the skin. Gloves and eye protection (preferably a face shield) should be worn at all times when handling cryogenic liquids. Gloves should be chosen that are impervious to the fluid being handled and loose enough to be tossed off easily. Appropriate dry gloves should be used when handling dry ice. "Chunks" or cubes should be added slowly to any liquid portion of the cooling bath to avoid foaming over.

5. Asphyxiation

As the liquid form of gases warm and become airborne, oxygen may be displaced to the point that employees may experience oxygen deficiency or asphyxiation. Any area where such materials are used should be well ventilated. For this same reason, employees should avoid lowering their heads into a dry ice chest. (Carbon dioxide is heavier than air, and suffocation can result.)

LEAKING COMPRESSED GAS CYLINDERS

Occasionally, a cylinder or one of its component parts develops a leak. Most such leaks occur at the top of the cylinder in areas such as the valve threads, safety device, valve stem, and valve outlet. If a leak is suspected, do not use a flame for detection; rather, a flammable-gas leak detector or soapy water or other suitable "snoop" solution should be used. If the leak cannot be remedied by tightening a valve gland or a packing nut, emergency action procedures should be effected. Laboratory workers should never attempt to repair a leak at the valve threads or safety device; rather, they should consult with the supplier for instructions.

If the substance in the compressed gas cylinder is not inert, or is hazardous, then use the procedures in Chemical Spills.

If the substance in the compressed gas cylinder is inert, or non-hazardous, contact the supplier for instructions.

SAFETY PRACTICES FOR DISPOSAL OF BROKEN GLASSWARE

Inspect all glassware before use. Do not use broken, chipped, starred or badly scratched glassware. If it cannot be repaired, discard it in containers specifically designated for broken glass. All broken glass requires special handling and disposal procedures to prevent injury not only to lab personnel, but members of the janitorial staff as well.

All broken glass shall be disposed in rigid, puncture proof containers such as a cardboard box with taped seams, or a plastic bucket or metal can with a sealing lid. All broken glass disposal containers shall be clearly marked "DANGER - BROKEN GLASS" Limit quantities to no more than approximately 15 to 20 pounds so that lifting of the container will not create a situation that could cause back injury.

1. Food, beverage, and uncontaminated glassware: Dispose in a rigid, puncture proof container such as a box with sealed or taped edges or a metal or thick plastic can or bucket with a sealing lid. Label container "DANGER - BROKEN GLASS".

2. Radioactive glassware: Contact the Radiological Safety Officer for specific instructions.

3. Glassware with biological contamination: Glassware that has been in contact with infectious agents may include: used slides, cover slips, test tubes, beakers, pipettes, etc. Contaminated glassware shall be disinfected before disposal. Dispose in a rigid, puncture proof container such as a box with sealed or taped edges or a metal or thick plastic can or bucket with a sealing lid. Label container "DANGER - BROKEN GLASS". Contact the Biological Safety Officer if you require further information.

4. Glassware with chemical contamination: Empty the contents of the glassware into a suitable container if safe to do so. (See "Chemical Waste" for disposal procedures.) Contact the CSO for assistance with decontamination and disposal of the contaminated glassware.

CENTRIFUGE SAFETY

This partial checklist is submitted for your convenience. Protocol calls for centrifugation. The following are suggested steps.

1. Which centrifuge

2. Which rotor

3. Correct tube size and adapter

4. What speed & length of time

After the above selections have been made, and the owner's manual and centrifuge log consulted (especially critical on ultra centrifuge), insure the tube fits properly in the rotor. This is important because up to 600,000 G forces may be generated during the centrifugation procedure.

Insure you are using the appropriate level of containment. Is the material potentially infectious/radioactive? If so, are you using aerosol containment tubes? Are you loading and unloading the rotor in a biological safety cabinet?

Suggested steps to follow BEFORE starting the centrifuge:

1. Insure centrifuge bowl and tubes are dry.

2. Is the centrifuge spindle clean?

3. Avoid overfilling of tubes and bottles

4. Insure rotor is properly seated on drive hub.

5. Make sure tubes are properly balanced in rotor (½ gram at 1 G is roughly equivalent to 250 Kg @ 500,000 G's).

6. Are O-rings properly attached to the rotor? Is the vacuum grease fresh?

7. Has the rotor been properly secured to drive?

8. Is the centrifuge lid shut properly?

After the above steps are taken and the centrifuge has started, make sure the run is proceeding normally before you leave the area. Once the centrifuge run is complete, make sure the rotor has STOPPED completely before you open the centrifuge lid; then check for spills. If leak or damage has occurred, close the lid and plan proper decontamination and cleanup. For biological spills, contact the Biological Safety Officer.

Maintenance/Cleaning:

1. Keep rotors clean and dry. If spills occur, make sure rotor has been cleaned/decontaminated. If salts or corrosive materials were used, ensure they have been removed from the rotor.

2. Avoid mechanical scratches. The smallest, scarcely visible scratch allows etching to enlarge the fracture, which is subject to enormous rupturing forces at high G's--a vicious cycle leading to rotor explosion.

3. Avoid bottle brushes with sharp metal ends and harsh detergents when cleaning aluminum rotor heads.

4. After proper clean-up, rinse the rotor with de-ionized water.

Inspections:

1. Check the rotor for rough spots, pitting, and discoloration. If discovered, check with the manufacturer before using. Use professional rotor inspection services frequently. These visits can be arranged to accommodate numerous users throughout the University.

2. Consult the centrifuge manufacturer and centrifuge log for the derating schedule for the rotor. Remember--an unlogged ultra -speed centrifuge is a ticking time bomb.

STANDARD AND SPECIAL OPERATING PROCEDURES

Each research laboratory has unique requirements. If necessary, use the following models to address any special needs.

Standard Operating Procedures provides for those operations in a laboratory which are considered routine for that laboratory.

Special Procedures supplies a place to detail procedures for those operations which require special prior approval or which represent severe hazards to workers.

Respiratory Protection Program supplies a place to insert a Respiratory Protection Program, if required.

Special Substances section supplies a place to insert details of procedures for dealing with substances for which OSHA has substance-specific standards.

STANDARD OPERATING PROCEDURES

For laboratory work at ____
which involves the use of hazardous chemicals, standard operating procedures have been addressed in order to reduce potential safety and/or health hazards caused by such use. These procedures include the use of appropriate personal protective equipment and the maintenance of such equipment.

The specific procedures that have been implemented are as follows:
(List or insert specific standard operating procedures. Add additional pages as deemed necessary. Please print or type.)

SPECIAL PROCEDURES

This laboratory has certain procedures or activities that require prior approval from

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(name, title, campus address and campus phone number) before implementation. These procedures are as follows:
(List or insert specific procedures/circumstances that apply. Please print or type.)

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There are special provisions for additional employee protection for work where particularly hazardous substances are used. These substances include "select" carcinogens, reproductive toxins, and substances that have a high degree of acute toxicity or reactivity.

Specific considerations for the particular hazardous substances are listed as follows:
(List or insert specific procedures for each particularly hazardous substances which could include establishment of a designated area, use of containment devices such as fume hoods or glove boxes, procedures for safe removal of contaminated wastes, and decontamination procedures. Please print or type. Add additional pages as deemed necessary.)

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RESPIRATORY PROTECTION PROGRAM

If your laboratory requires a respiratory protection program, please inserted here.

SUBSTANCE-SPECIFIC SAFETY PROCEDURES

The following is a list of the OSHA substance-specific standards from 29 CFR 1910:

1001 - Asbestos, Tremolite, Anthophyllite, and Actinolite
1003 - 4-Nitrobiphenyl
1004 - alpha-Naphthylamine
1006 - Methyl Chloromethyl Ether
1007 - 3,3'-Dichlorobenzidine (and its salts)
1008 - Bis-Chloromethyl Ether
1009 - beta-Naphthylamine
1010 - Benzidine
1011 - 4-Aminodiphenyl
1012 - Ethyleneimine
1013 - beta-Propiolactone
1014 - 2-Acetylaminofluorene
1015 - 4-Dimethylaminoazobenzene
1016 - N-Nitrosodimethylamine
1017 - Vinyl Chloride
1018 - Inorganic Arsenic
1025 - Lead
1028 - Benzene
1029 - Coke Oven Emissions
1043 - Cotton Dust
1044 - 1,2-Dibromo-3-chloropropane
1045 - Acrylonitrile
1046 - Ethylene Oxide
1048 - Formaldehyde

If your laboratory requires any substance-specific safety procedures they will be inserted here.