

Introduction

Purpose

In February, 1993, New Jersey's Public Employees OSHA adopted 29 CFR 1910.1450, Federal OSHA's "Occupational Exposure to Hazardous Chemicals in Laboratories Rule", (also known as the Laboratory Standard). The standard provides for the health and safety of employees in the laboratory by generally requiring the following:

- Development of a laboratory Chemical Hygiene Plan.
- Designation of a Chemical Hygiene Officer.
- Standard operating procedures to be followed when using hazardous chemicals.
- Consideration for establishment of "designated areas", as well as other protective measures, when working with select carcinogens, reproductive toxins, or particularly hazardous materials.
- Procedures for the "prior approval" of hazardous laboratory operations.
- Training of laboratory workers.
- Medical consultations and examinations for employees with hazardous chemical exposures.
- Identification of hazards.
- Recordkeeping for any measurements of employee exposure and medical consultations/examinations.

An overview of the Laboratory Standard, as well as a full copy of the regulation is given in Appendix 1.

The purpose of this Guide is to provide a model for the development and implementation of a Chemical Hygiene Plan (CHP) for each university laboratory, as required by the Laboratory Standard. While it is not mandatory that all University laboratories use this model plan, it is provided as a guide for compliance for those who do wish to use it. This document is "generic" and applies to many types of laboratories; however, it must be modified and amended for each specific laboratory. When properly developed and followed, this plan should serve as a comprehensive health and safety program for each laboratory. If this model plan is not used, it is the responsibility of the principal investigator to produce a Chemical Hygiene Plan that is thorough and complete, will demonstrate compliance with the Laboratory Standard and is fully consistent with the policies contained herein.

Scope/Applicability

At Rutgers University, the Laboratory Standard applies to all employees and students engaged in the "laboratory use" of hazardous chemicals. It applies to research and teaching laboratories which are carrying out small-scale operations (those which can be handled safely and easily by one person) using multiple chemicals and procedures, where the procedures are neither a part of, nor simulate, a production process.

Designation of Responsibility

The following designates responsibility for implementation of the Laboratory Standard at Rutgers University:

- LABORATORY WORKER - Follows safe work practices, attends required training and is familiar with the laboratory Chemical Hygiene Plan.
- LABORATORY SUPERVISOR - Assures that all employees/students in the lab follow safe work practices, provides necessary hands-on training, develops the laboratory Chemical Hygiene Plan, ensures the Chemical Hygiene Plan is available to all occupants of the lab, and provides "prior approval", when necessary.
- CHEMICAL HYGIENE OFFICER - Implements the laboratory Chemical Hygiene Plan, provides guidance on safe laboratory procedures, and assists in the annual review and update of the Chemical Hygiene Plan.
- DEPARTMENT CHAIR - Designates the Chemical Hygiene Officer (either one for the department, or individual CHO's for each lab), assures department compliance with the standard, appoints department Unit Safety Committee.

- UNIVERSITY LABORATORY SAFETY AND DESIGN COMMITTEE (Subcommittee to the University Health Safety Council) - Serves as the University Chemical Hygiene Committee, reviews annually the Chemical Hygiene Guide, reviews and approves University policy on laboratory safety.

This Chemical Hygiene Plan encompasses the following area (to be completed by CHO):

Name of Department or Division: **W.M. Keck Center for Collaborative Neuroscience**

Name(s) of Chemical Hygiene Officer(s): **Ronald P. Hart**

List building/room(s) covered by the Plan: **Nelson Laboratories, Room D251, Busch Campus**

CHEMICAL HYGIENE PLAN ELEMENTS

The Laboratory Standard requires that the CHP, when implemented, be capable of protecting employees from health hazards associated with chemicals in the laboratory and that it keep exposures below occupational exposure limits**. At Rutgers University, these occupational exposure limits include either Threshold Limit Values (TLVs), which are established by the American Conference of Governmental Industrial Hygienists (ACGIH) or Permissible Exposure Limits (PELs) promulgated by Federal OSHA, whichever is LOWER.. The laboratory CHPs must be made readily available to all laboratory employees, and must contain the following elements:

- A. Standard operating procedures for laboratory safety and health.
- B. Criteria that Rutgers University will use to determine and implement control measures to reduce employee exposures to hazardous chemicals.
- C. Documentation of requirements that fume hoods and other protective equipment are functioning properly, and measures that will be taken to ensure their adequate performance.
- D. Provisions for employee information and training, as detailed in the standard.
- E. Documentation of circumstances under which certain laboratory operations will require prior approval.
- F. Provisions for medical consultations and exams, as detailed in the standard.
- G. Provisions for additional employee protection when working with “particularly hazardous substances”, as defined in the standard.

A. STANDARD OPERATING PROCEDURES

The following SOPs are generic, and apply to most laboratories where chemicals are used. They should be modified, as appropriate, for each specific laboratory. SOPs specific to procedures and operations in each laboratory must be developed and included in each laboratory's CHP.

1. Emergency Procedures

a. Priorities

An emergency is any event that requires an immediate stop in work and the following of a special procedure to protect life, health, and property.

The best time to know what to do in an emergency is before, not after, it happens. The best time to read this Guide, then, is at your leisure—before the fire begins, and before the chemical is spilled. Though no single guide can possibly cover the range and combination of events that can constitute an emergency, it is hoped that careful reading of the following emergency procedures will help you begin the planning process that will best fit your situation. Your experimental protocols or written procedures must always include safety measures, and at times may need to include specific emergency procedures. In any case, all such emergency procedures will need to be practiced and reviewed periodically.

Most emergencies will be small, consisting of a single unexpected event. More serious emergencies involve a series of events which stem from an initial incident, expanding in unfortunate sequence. Under any circumstances, decisions may have to be made quickly, often without adequate information, in a context that may have no precedent. Use the best and calmest judgment you have, and try to stay within the following general priorities:

- 1) LEAVE the area of danger. This is of paramount importance to enable rescuers to do what is necessary to sustain life. If the area includes other people's work space, make sure they leave, too. If you can safely turn off equipment as you go, do so.
- 2) CALL the campus emergency number from the nearest safe area. Calling takes precedence over everything except evacuation in all emergencies. This also applies for seemingly minor emergencies; it is far better to make an occasional unnecessary call than to fail to call and needlessly endanger life or health.

For ALL emergencies:

Busch 6-911

Calmly state: your name; the location and nature of the emergency; whether an ambulance or fire fighting equipment is needed; any hazards that might threaten persons on the scene or responding; and a phone number and location at the scene where you can be reached.

After calling, stay off the phone. The only exception is in cases of poisoning, when you may need to call the Poison Control Center: 1-800-962-1253.

- 3) PROTECT the life and health of anyone who may be injured. The First Aid advice given in this Guide is contingent on rescue equipment and qualified personnel being 2 or 3 minutes away. In a number of isolated experiment stations this is not so; suitable modifications to the emergency procedures should be made.

After calling, do what you can to continue to preserve life, but do no more than the necessary first aid procedures unless you are specifically trained to do so. Subsequent steps will depend on the nature of the emergency and your assessment of its severity. In each of the following situations, be sure you are in a safe place, summon help quickly, and try to protect the lives of those involved.

b. Injury

Ideally, only people with first aid training should render first aid (call 732-932-4902 for more information on first aid training). In an emergency, however, untrained help may be better than none. Stay calm, do only what you must before help arrives, and follow these priorities:

- 1) REMOVE THE VICTIM FROM THE AREA OF DANGER—fire, spill, fumes, etc. If the victim is not conscious - DO NOT ENTER THE AREA - proceed immediately to step 2, “Call for help.”

[NOTE: If the victim is in contact with electricity, he or she becomes “the area of danger”. Avoid direct physical contact with the injured and the source of power; disconnect the power, or push/pull the victim away from the circuit with a non-conductive material (board, rope, etc.)].

- 2) CALL FOR HELP **6-911**

Always initiate the process to get trained medical help before you take any other extensive action. For a serious injury (very heavy bleeding, chemical in eyes, etc.), you will often need to stabilize the situation briefly before calling. Common sense will dictate this potentially difficult decision, but in no case should calling be delayed except for the most immediate life-threatening situation.

If two people are available, one can go for help while the other begins first aid.

- 3) REESTABLISH AIRWAY for breathing, if breathing has stopped.

Check for an object blocking the airway; remove it if possible. Only if there is no blockage should artificial respiration be attempted; otherwise the victim could be injured further.

Lift the victim’s neck and tilt head back to open airway. Pinch the victim’s nostrils and cover the mouth with yours. Blow your breath into the victim’s mouth until you see the chest rise. Remove your mouth and let the victim exhale while you breathe in.

Repeat 15 times per minute until the victim starts breathing or help arrives. DO NOT STOP, even if you think there is no hope.

- 4) CONTROL BLEEDING by applying direct pressure to the wound, using a clean cloth or your hand. If possible, elevate the injured area above the heart. Keep the victim warm and lying down. Never use a tourniquet except for amputated or crushed limbs.
- 5) REESTABLISH CIRCULATION through cardio-pulmonary resuscitation (CPR). Only those trained in this procedure should attempt it. Training is available through the Division of Fire and Emergency Services. Call (732) 932-4902 for more information.
- 6) Treat for CHEMICAL CONTACT.

If the chemical was ingested, call the campus emergency number and then the Poison Control Center (1-800-962-1253). Follow their instructions. If for some reason you cannot reach professional advice, do not give the victim water, milk, or anything else unless so directed by a Material Safety Data Sheet (MSDS), Hazardous Substance Fact Sheet (HSFS), or other text. Do not induce vomiting if the victim complains of pain or a burning sensation in the mouth or throat, or if the ingested substance is known to be caustic, a cleaning fluid, or a petroleum product. Induce vomiting only if directed to do so by Poison Control. To induce vomiting, place the victim’s head below the hips, mouth down or to the side, and place a finger at the back of the victim’s throat.

If the chemical was inhaled and the victim is conscious, call the campus emergency number and then carry or drag the victim to fresh air. Do not let the victim walk unassisted or engage in any unnecessary activity that will increase the circulation of poison in the bloodstream. If you need to use artificial respiration, be careful you do not inhale the poison from the victim. If the

victim is not conscious, do not enter the area; the victim may have been overcome by gases in the area, or by a lack of oxygen in the space. There have been many documented instances, some on University campuses, of would-be rescuers becoming additional victims.

If the chemical was splashed in the eye, immediately seek an eyewash, safety shower, or spigot. The eye must be washed for at least 15 minutes with the eyelids held apart to allow maximum exposure of the eyeball. While washing, check for contact lenses by looking into the eye, and by asking the victim (while contact lenses are prohibited in laboratories where chemicals are used, rules are sometimes broken). Ask the victim to remove them if possible. Otherwise, contacts may be removed under gentle water pressure. Do not attempt to remove contacts by hand or with any other object. Emergency personnel are trained to do this. Be careful not to rub the eyes.

If chemicals are on the skin, follow the recommendations under the First Aid section of the MSDS. If such information is not readily available, wash the affected area with continuous clean water for 15 minutes. Remove any clothing contaminated with chemicals; be careful that the rescuer does not become contaminated as well.

Be aware of the possibility of inadvertent injection or unnoticed introduction of chemicals into the body. Many solids, oily liquids, or water solutions can enter through cuts in the skin. In addition, many oily liquids and oil soluble solids will be absorbed by the skin. Keep victim quiet and wait for medical assistance.

7) Treat for SHOCK.

Though in appearance less dramatic than the above injuries, shock can kill just as quickly. If a person goes into severe shock, treatment for shock takes priority over all first aid except for reestablishing airway, control of bleeding, and CPR.

Symptoms of shock include paleness, cold and clammy skin, weakness, nausea/vomiting, shallow breathing, rapid pulse, cold sweat, chills and shaking.

If possible, remove the cause of shock (e.g., control heavy bleeding). Keep victim warm and lying down. Elevate legs if no spinal or head injuries are suspected. Keep airway open and give non-alcoholic liquids if the victim can swallow and does not have a "belly wound."

c. Fires and Explosions

- 1) LEAVE the area of danger—usually the building. When needed, use a fire extinguisher to clear a safe path, or "shoot your way out". Do not stay to fight large fires.
- 2) CALL the campus emergency number. The emergency number should be called, or the building alarm sounded, for all unintentional fires, without exception.
- 3) Be sure that others in the area of the fire are notified as well, whether verbally or through the fire alarm. If you hear a fire alarm (a loud bell or horn), immediately leave the building, making sure that others do too.
- 4) On your way out, turn off equipment and move explosive materials away from possible heat, ONLY IF THERE IS SAFE TIME TO DO SO. Your leaving quickly is THE HIGHEST PRIORITY.
- 5) In determining the nearest safe place, be aware of the possible spread of toxic gases and fumes, including the likely direction of spread (for example, gases heavier than air will accumulate in low places). When the Fire Department arrives, tell them which chemicals are involved.
- 6) If a person's clothing is on fire, he or she must not be allowed to run, as this will fan the flames and cause a more serious burn. Douse with water or wrap in a fire blanket, coat, or whatever is available to extinguish the fire. Roll the person on the floor if necessary. After calling the emergency number, place clean, wet, ice-packed cloths on the burned areas, wrap the person warmly to avoid shock, and wait for assistance.

- 7) The primary purpose for fire extinguishers is to “shoot your way out” in order to reach safety; fire fighting is always better done by those with the equipment and training to do it. Know in advance which type of extinguisher is appropriate for which type of fire (consult the data on the extinguisher); be sure to use the appropriate extinguisher, and direct discharge at the base of the flames. Training on the proper use of fire extinguishers is available through the Division of Fire and Emergency Services. Call (732) 932-5325 for more information.
- 8) A fire contained in a small vessel can usually be smothered by covering the vessel with an inverted beaker or watch glass. Do not use dry paper towels or cloths. Remove nearby flammable materials while the fire burns itself out.

d. Chemical Spills

Procedures for handling spills in laboratories are given in Appendix 2. The flow chart which is included should be copied and posted in the laboratory. If there has been any chemical contamination of personnel or clothing, follow Emergency Procedures for Chemical Contact (see section b.6, above).

e. Identifying Hazardous Substances in Emergencies

To help identify hazardous substances involved in an emergency, REHS has established a Caution Sign program which provides for door signs bearing the room supervisor’s name and phone number and a listing of potential hazards in the room. Caution signs may be obtained or updated by calling REHS at (732) 932-2550 (2-2550). A copy of the Caution Sign program is given in Appendix 3.

f. Reporting Accidents

In the event of a laboratory accident, an Accident Report Form must be completed by the supervisor or instructor and sent to Risk Management and REHS. This form contains valuable information to help determine causes and prevent future accidents in the laboratory, and should be completed for all laboratory accidents, no matter how minor.

A copy of the form is given in Appendix 4. Anyone needing additional copies of the form can contact Risk Management or REHS. Additional information is available in the University Health/Safety Manual.

g. Power Failures

If your laboratory loses power during an emergency, leave the building as quickly as possible by following your departments building evacuation plan. Call the campus emergency number from the nearest safe area to report the power failure and await assistance.

2. General Laboratory Behavior

a. Safety Rules

- 1) Know the location of laboratory exits.
- 2) Know the location and use of the safety showers and eyewashes.
- 3) Know the location and use of fire extinguishers.
- 4) Know the location and use of spill kits, when available.
- 5) Know the location of the nearest phone which can be used in an emergency.
- 6) Know the potential hazards of the materials, facilities, and equipment with which you will work. If you are uncertain ask your instructor, your supervisor, your Unit Safety Committee, or REHS.
- 7) Use the proper safety equipment for your procedure. This could include a fume hood, glove box, biosafety cabinet, shield, or other equipment.

- 8) Do not wear contact lenses in laboratories where chemicals are used.
 - 9) Wear eye protection in the laboratory. Splash goggles are required for wet chemical work or work with dusts and powders.
 - 10) Wear other personal protective gear where laboratory or experimental conditions dictate. This includes laboratory aprons, lab coats, gloves, gauntlets, glass blowers' goggles, face shields, dust masks, respirators** Anyone requiring respiratory protection must participate in Rutgers Respiratory Protection program. Contact REHS at 22550 for more information., and other equipment.
 - 11) Wear clothes that protect the body against chemical spills, dropped objects, and other accidental contact. Thus, bare midriffs, shorts, open shoes, sandals, and high heels are prohibited.
 - 12) Confine long hair when in the laboratory. Remove or secure ties or other articles of clothing or jewelry that might become entangled in equipment.
 - 13) Do not eat, drink, smoke or apply cosmetics in the laboratory. Do not store food or drink in the laboratory, or use laboratory equipment for eating or drinking.
 - 14) Do not pipet by mouth. Use only mechanical pipeting devices.
 - 15) Wash hands frequently when handling chemicals and before leaving the laboratory. Beware of contamination of clothing or of door knobs, frames, etc. Remove any protective gear before leaving the laboratory; this includes gloves and laboratory coats.
 - 16) Follow written protocols or instructions. Perform only authorized experiments. (See Sec. E, "Laboratory Operations Which Require Prior Approval".)
 - 17) Do not move or disturb equipment in use without consent of the user.
 - 18) For reasons of safety and security, it is prudent to avoid working alone in the laboratory, particularly after hours. The laboratory supervisor is responsible for determining and implementing procedures to provide for emergency notification and periodic checks of an individual working "alone" in the laboratory. The extent of the procedures are dependent on the nature of the laboratory work and the degree of potential hazard.
 - 19) Do not play in the laboratory.
 - 20) Follow good housekeeping practices—clean up as you go, and keep work areas, aisles and exits uncluttered.
 - 21) Do not deface labels on chemical containers. Make sure all container labels correctly identify their contents.
 - 22) Report all accidents and injuries immediately to your laboratory instructor, supervisor, or Chemical Hygiene Officer.
 - 23) Report unsafe conditions to your instructor, supervisor, Chemical Hygiene Officer, Unit Safety Committee, or REHS.
- b. Additional Rules for Students
- 1) Read and follow the Safety Rules listed previously.
 - 2) Know who is in charge of your laboratory.
 - 3) Perform only authorized experiments, and be sure you understand the procedures involved before you begin. If anything unexpected, dangerous, threatening, or unmanageable happens, immediately call your instructor.
 - 4) Do not use unfamiliar equipment without instruction and permission.
 - 5) Behave and dress appropriately for conscientious work in a potentially hazardous place. Never play in the laboratory.
 - 6) Report all accidents and injuries, however small, to your instructor.
- c. Additional Rules for Instructors and Supervisors
- 1) Take responsibility, in attitude and action, for the safety conditions of your laboratory.
 - 2) Observe all rules and see that they are enforced.

- 3) Set an example by wearing protective equipment and by following proper laboratory procedures to promote safe work habits.
 - 4) Carefully review all laboratory experiments for possible safety problems before the experiments are assigned to students.
 - 5) Make both preventative and remedial safety measures part of your instruction. Be sure all students and laboratory workers are familiar with emergency procedures and equipment.
 - 6) Be alert for unsafe conditions. Inspect often and intelligently; take effective corrective action promptly.
 - 7) Assume responsibility for visitors and require that they follow the same rules as students and other laboratory workers.
 - 8) Keep a current file of publications on laboratory safety. Encourage its use. See Section D on Employee Information and Training.
- d. Rules for Custodial Workers
- 1) You may sweep, mop, wash the floors and remove normal trash from any laboratory, including a radiation laboratory.
 - 2) Rooms which have a Caution Sign and any of the nine different stickers on the door may contain materials or equipment which, if used improperly, may cause harm.
 - 3) Do not touch any material, container, or waste container with a biohazard symbol or radiation symbol on it.
 - 4) You must not touch, disturb, move, or handle any containers of any chemicals or materials except those issued to you by your department. If you need chemicals or other laboratory materials moved in order to perform your duties, have the room supervisor arrange for this to be done, or contact your supervisor.
 - 5) If the contents of any containers (other than those issued to you) are spilled, **DO NOT TOUCH THEM OR ATTEMPT TO CLEAN THEM UP.** Tell your supervisor, who will then contact emergency personnel.
 - 6) Wear safety glasses if there are persons working in the laboratory.
 - 7) Do not eat, drink, smoke, or apply cosmetics in a laboratory.
 - 8) If you have any questions, contact the room supervisor first, your supervisor next, or finally, REHS.

e. Rules for Maintenance Workers

- 1) Before working in a laboratory, or on a chemical fume hood, inform the room supervisor what you will be doing, and when you will be working. The room supervisor's name should be posted on the main laboratory door.
- 2) The room supervisor is responsible for assuring that your work area within the room is free from physical, chemical, and/or biological hazards. Your work area may include hoods, sinks, cabinets and benches, bench tops, floors, and/or equipment. You may be required to repair, move, remove, replace, paint, etc. as part of your duties.
- 3) Do not handle or move chemicals in the laboratory. If you need chemicals moved in order to perform your duties, have the room supervisor arrange for this to be done.
- 4) Generally, you should not move or handle equipment in the laboratory. If your work requires you to move, remove, or replace a piece of equipment, have the room supervisor assure you that the equipment is free of any physical, chemical and/or biological hazards.
- 5) Do not eat, drink, smoke, or apply cosmetics in the laboratory.
- 6) In situations where the hazard cannot be totally removed, specific work procedures will be developed in conjunction with the room supervisor, and REHS. If there is a chance your work may bring you in contact with chemical hazards (e.g. working on laboratory sinks, working in areas where there is a chance of chemical contamination) or when working in rooms where chemical experiments are taking place, have the room supervisor provide you with the necessary protective equipment, including gloves, goggles, etc.
- 7) When working on a fume hood, ask the room supervisor if the hood was used for perchloric acid or radioactive materials. Contact REHS before performing maintenance on any part of a perchloric acid or radioactive materials fume hood system (including: hood, base, duct, fan, stack, etc.). Lubricate perchloric acid hood fans with fluorocarbon grease only.
- 8) If you are working in a room labeled with a radiation symbol, refer to the handout "Maintenance Staff - Procedures For Dealing With Equipment In Laboratories Using Radioactive Materials".
- 9) If you have any questions, contact the room supervisor first, your supervisor next, or finally REHS.

3. Safety Systems

a. Personal Protective Equipment

- 1) Eye Protection

Splash Goggles

Eyes are particularly sensitive to any contact with chemicals; therefore, **splash goggles must be worn at all times** in laboratories where liquid chemicals, dusts, or powders are being used. Safety glasses do not offer sufficient protection from fumes or particles entering from the side.

Shields

Standing shields and face shields protect the face and neck. Shields of good rigidity and strength which protect the face and neck should be used for vacuum work, when working with low or high pressure systems, or where mild explosions may be anticipated.

- 2) Respiratory Protection

Dust masks, cartridge respirators, self-contained breathing apparatus, or any other type of respiratory protection should not be necessary in a properly designed laboratory. If you

believe you may nevertheless require such protection, contact REHS for information and recommendations.

3) Skin and Body Protection

Gloves

Gloves protect the hands against contact with chemicals and also against abrasion and extremes of heat and cold. Check gloves before use, for worn spots, cracks, and other signs of wear. When removing gloves, be careful to avoid touching the outside of the gloves with your bare hands; also avoid touching door knobs, light switches, etc., with the gloves. Always remove gloves (and all other protective gear) before leaving the laboratory.

Different kinds of gloves offer different levels and types of protection. Gloves made of cotton or cotton with leather protect against abrasion, sharp objects, and glass; however, they offer virtually no wet chemical protection, and may actually absorb chemicals and keep them in contact with the skin. Surgical type gloves made of rubber or synthetics offer some hand protection and also allow dexterity. For more substantial protection against some acids and most other corrosives, heavy rubber gloves are available with various lengths of forearm protection. Heavy rubber gloves do not effectively protect against a number of concentrated acids, organic solvents, or PCBs. These substances require gloves made of a synthetic material, for example neoprene nitrile rubber or Viton, depending on the chemical being used. Insulated gloves should be used when dealing with temperature extremes. Proper fit and comfort must also be considered when selecting gloves.

Aprons and Lab Coats

Aprons and lab coats protect the body as gloves do the hands. Heavy duty rubber aprons should be used for protection against strong acids and bases. As discussed above, heavy rubber will not protect against all materials, in which case a synthetic material must be used. Vinyl aprons are recommended for general use; cloth lab coats are also useful, but mainly for protecting clothing.

As with gloves, lab coats and aprons should remain in the laboratory. Many of the substances which are found in the laboratory can be inadvertently taken home on lab coats and aprons.

Shoes

Sturdy closed shoes should be worn in the laboratory at all times to protect against spills and splashes which reach the floor. Leather shoes offer better protection against corrosion than canvas shoes; open-toed shoes are prohibited in the laboratory.

4) Hearing Protection

Standards for hearing protection and acceptable noise levels have been established by PEOSHA regulations. If you feel that a noise hazard is present in your laboratory, contact REHS for evaluation and recommendations.

b. Fire Protection

Fire Extinguishers

Everyone working in a laboratory must know the location and correct use of fire extinguishers. Although extinguishers are capable of putting out small, contained fires, their primary purpose is to allow you to “shoot your way out”—to establish and maintain a safe exit path as you leave.

It is important to use the right kind of extinguisher for the fire. The classes of fires are identified by letter:

A—ordinary combustible solids including paper, wood, coal, rubber, and textiles.

B—flammable and combustible liquids, including gasoline, diesel fuel, alcohol, motor oil, grease, and flammable solvents.

C—electrical equipment.

D—combustible or reactive metals (such as sodium and potassium), metal hydrides, or organometallics (such as alkylaluminums).

Each fire extinguisher is clearly marked by the letter(s) of the class of fire that it can extinguish. Because using the wrong kind of extinguisher can be very dangerous, the time to read the extinguisher is before the fire, at your leisure.

Fire extinguishers are supplied and maintained by the University Fire Department. If you have any questions, call the Fire Department non-emergency number (732-932-3077).

c. Laboratory Equipment

1) Fume Hoods

Fume hoods are a common means of control of exposure to toxic substances. The variety of hood used should depend on the materials involved; for example, hydrofluoric acid will etch glass, perchloric acid requires a stainless steel hood interior and duct, and wash-down system and radioisotopes may require stainless steel ducts. REHS can advise as to the variety of hood that will be appropriate, and will also perform periodic hood tests.

A chemical fume hood is designed to operate most effectively at an optimum air velocity, usually 80 - 100 linear feet per minute. While it is good practice to work with the sash as low as possible, this measurement is made with the sash fully open to ensure protection at any sash height. This air velocity will result in a laminar air flow pattern which will capture most fumes and vapors likely to be given off within the hood. Lower air velocities may be insufficient to capture and remove most fumes and vapors. Higher velocities can lead to a turbulent air flow which does not capture the fumes and vapors as well. Higher or lower air velocities may be acceptable in certain cases with REHS approval. REHS annually surveys all fume hoods within the University to determine if they are operating at acceptable levels. If your fume hood does not have an inspection sticker, or if you have a new hood, please contact REHS.

The following are guidelines for safe fume hood use, and are to be followed when using a fume hood. All laboratory supervisors should periodically review these procedures with all laboratory personnel.

- a) Use the fume hood with the sash as low as possible, at or below the indicated operating height. The operating height should be clearly marked by arrows on either side of the sash track. These marks are placed on a hood when it is surveyed by REHS. If your fume hood does not have an operating height sticker on it, call REHS as the hood probably has not been surveyed. If you need to move large pieces of equipment into or out of the hood, raise the sash for as long as is necessary, and lower it as soon as possible. Do not work on the hood with the hood sash fully open. The fume hood operates more effectively with the sash at the operating height. Additionally, this will allow the sash to serve as a physical barrier between your face and the contents of the fume hood.
- b) Do not store chemical or equipment which are not currently being used, in the hood.
- c) Raise large pieces of equipment up on blocks approximately 2", to allow air to pass under the equipment and allow more even air flow through the hood.
- d) Do not place equipment or chemicals very close to the slot openings in the baffles at the rear of the hood, or very close to the front edge of the hood. Putting items in those spots will interfere with even air flow through the hood. Keep materials at least six inches back from the front edge.
- e) Keep the sash glass clean, and never obstruct your view through it with paper, notices, decals, or other items.

- f) Avoid sudden movement past the face of the hood when it is operating. Simply walking briskly past the hood can disrupt air currents, and pull vapors out of the hood.
- g) Keep your head outside the fume hood. Do not walk into a “walk-in” hood when it is operating. “Walk-in” hoods are designed to hold large pieces of equipment and are not to be literally “walked-into”.
- h) NEVER use perchloric acid in a fume hood not specifically designed for this purpose. A properly designed perchloric acid hood has a stainless steel liner, with a stainless steel duct that runs vertically to the roof. It is designed with a water wash-down system to periodically remove dangerous perchloric acid residues. Using perchloric acid in a conventional fume hood can leave explosive residues on the hood, duct, or fan.
- i) If your hood is equipped with a flow indicating device, check to see that it is functioning properly before use. If your hood is not equipped with a flow-indicating device, you can periodically check it with a hand-held velocity meter or by hanging a small (approximately 1” x 4”) piece of tissue, Kimwipe, or similar light-weight paper from the bottom of the hood sash. This should be drawn in when the hood is operating normally and will hang straight down, when the hood is operating marginally or not at all. If your fume hood is not operating properly, first check to see that it is on and that the rear slots are not blocked. If that is not the problem, then call your campus Facilities Operations and Maintenance or Physical Plant immediately to arrange to have it repaired.

Keep in mind that a chemical fume hood is an important piece of laboratory safety equipment. Using and maintaining a fume hood properly will help protect you and your fellow workers from potential chemical hazards in the laboratory. If you have questions about fume hood use, or need training on the proper use of a chemical fume hood, please contact REHS.

2) Glove Boxes

Where highly toxic substances must be contained, or reactive substances must be handled in an inert or dry atmosphere, it may be necessary to use a completely enclosed unit such as a glove box.

3) Eyewashes

An emergency eyewash unit should be located in every laboratory and should deliver a gentle flow of clean, aerated water. The eyewash must be kept free of obstructions.

When a chemical has splashed into the eye, irrigate the eye immediately. Flush the eye with a copious amount of water under gentle pressure. If the victim is wearing contact lenses, have him or her remove them at once if possible. Forcibly hold the eye open to wash thoroughly behind the eyelids. The victim must be given prompt medical attention regardless of the severity of the injury. Continue irrigating for 15 minutes before transport to a hospital or health center.

Eyewash units and safety showers are installed and maintained by Facilities Operations and Maintenance, and tested annually. REHS and the using department determine the need and location for new showers and eyewash stations. If there is a need in your department, your Unit Safety Committee should contact REHS.

4) Safety Showers

Each laboratory should have a safety shower in an easily accessible location, often in a corridor. The shower area must be kept clear of obstructions.

In case of chemical contamination over a large part of the body, the contaminated clothes must be removed immediately and the person doused with water continuously for 15 minutes or until medical help arrives. A blanket can be used for warmth and modesty during dousing. Someone should be sent at the beginning of this procedure to summon medical attention.

5) Ground Fault Circuit Interrupters

A ground fault circuit interrupter is an electrical device that protects against leakages of electrical current to ground. If even a minor leakage is detected, the device opens the circuit, preventing possible electrocution. Ground fault circuit interrupters can be portable—placed within the laboratory where needed—or installed in the circuit box itself by Facilities Operations and Maintenance. These devices are required where damp or wet conditions are likely.

6) Spill Containment

Use absorbent paper on the bench top to contain small spills. Absorbent paper will also help reduce possible contamination of the laboratory furniture and apparatus. Procedures using larger amounts of liquid should be performed in or over spill trays. Spill kits of absorbent material should be available for containment and neutralizing of large spills. Be sure to use each kit only for the materials designated on the kit container. All spills requiring the use of a kit should be reported to the campus emergency number.

4. Preparing For Laboratory Work

Before beginning any laboratory work, a plan should be made describing: goals; chemicals and equipment needed; and the sequence of steps to be followed, including safety measures.

a. Chemicals

Full descriptions of chemicals used in the laboratory can be found on Material Safety Data Sheets (MSDSs) or Hazardous Substance Fact Sheets (HSFSs), which contain information on physical characteristics, hazards, disposal, and routine and emergency precautions. There is a sheet for virtually every chemical marketed, available from chemical suppliers, University RTK Central Files (available in Libraries), REHS, and a number of computer based information systems. HSFSs are available from the NJ Department of Health for each of the substances regulated by the New Jersey Worker and Community Right-to-Know law. The Right-to-Know law requires, among other things, that persons who may be exposed to chemicals be trained in general and specific chemical hazards and chemical safety. MSDSs and HSFSs should be used as part of this training. An MSDS or HSFS should be acquired for every chemical used and should be kept on file for reference. The information on the MSDS or HSFS should be given to every laboratory worker who will be handling the chemical in question. Design your procedure to use the least hazardous chemicals and the minimum possible quantity of each chemical that will still allow meaningful results. Using smaller quantities of chemicals means that less can be spilled or volatilized, and that less must be treated and/or disposed as hazardous waste.

b. Equipment

Specific information must be obtained about any equipment to be used. Most equipment is sold with this information, ranging from one page instruction sheets to complete books. This information must be read thoroughly and followed exactly for safest use of the equipment. When used equipment is sold or donated to the University, recipients must obtain operating instructions if at all possible.

c. Written Procedures

Developing a protocol is basic to the experimental process, and should result in a written set of procedures. Writing the procedures allows the researcher or instructor to go through the experiment in the planning stage, and identify areas where special precautions may be necessary. The written protocol will provide workers with step-by-step instructions, minimizing the chance of errors. A good written protocol will allow for modifications and will include safety precautions (e.g.,

“wear splash goggles,” “pour acid into water,” “perform this operation in fume hood”). Written procedures should also include MSDSs or HSFSSs for all chemicals used in the experiment. In addition, a laboratory notebook should be kept during the procedure, documenting each action and its result. In the event of an accident, a set of written procedures and laboratory notebook may indicate what went wrong, and possibly why.

d. Setting Up

Just before beginning the work, review the written procedures, following the expected sequence of the experiment. Review the materials to be used as to their degree and nature of hazard, including flammability, volatility, reactivity, etc.

All equipment and supplies should be in place before actual work begins, including proper protective equipment (e.g., hoods, glove boxes, gloves, aprons, safety goggles, shields, and lab coats). The work area should be uncluttered and orderly. Where areas of possible contamination and exposure might exist, take precautionary measures, such as lining the work surface with absorbent paper. Also, have on hand all the necessary equipment to deal with a spill or accident (more absorbent paper, spill-control kits, etc.)

5. General Laboratory Equipment Setup

a. Preparing the Work Space

Work space should be uncluttered. Only necessary materials, equipment, protocols, instructions, notebook, and pen or pencil should be present. Books, unnecessary materials, and scraps of paper should be removed and stored properly. Keep measuring equipment, such as glass cylinders, where it will not be easily knocked over. Do not place equipment on the floor of a working area where it may trip others or be knocked over.

Use only equipment that is free of flaws (cracks, chips, inoperative switches, frayed cords, etc.). Ensure that all necessary guards are in place before using equipment. Examine glassware carefully. All defective glassware should be returned to the stockroom for replacement, or should be discarded safely. All defective electrical equipment must be repaired before use, or discarded.

Set up clean, dry apparatus, firmly clamped and well back from the edge of the laboratory bench. Keep burners and open flames a safe distance from solvents and reagent bottles. Allow enough space for the equipment used, and enough working space to avoid crowding other workers and disturbing their apparatus. Select vessels of the proper capacities for each experiment.

Place a tray or absorbent paper under the apparatus to confine spilled liquids.

All equipment must be properly supported to prevent unnecessary movement and to maintain proper alignment during the experiment. Apparatus attached to a ring stand should be positioned so that the system's center of gravity is over the base and not to one side. Securely attach clamps to stands. Set up the equipment with adequate space and configuration for removing burners or baths. Orient equipment so that stopcocks, hoses, and other attachments will not be loosened by gravity. Use a retainer ring or spring where necessary.

Use a fume hood if the experiment is expected to evolve noxious odors, or toxic or flammable gases, vapors, or fumes. Do not use perchloric acid, hydrofluoric acid, or radioisotopes in hoods that are not specifically approved for those materials.

Use a protective shield when conducting a reaction which may result in a mild explosion or when using a vacuum system (which may implode). Use a face shield that is sufficiently large and strong to protect your face and neck, or use a standing shield. A standing shield is indicated if an explosion is likely. Standing shields must be adequately stabilized with weights or fasteners to prevent their being knocked over by an explosion, and should be secured near the top. Eye protection must be worn even when using the shields.

b. Glassware

Pyrex or borosilicate glassware is recommended for all laboratory glassware except for special experiments which use ultraviolet or other light sources. The only soft glass provided in the laboratory should be reagent bottles, measuring equipment, stirring rods, and tubing. Any sizable nonspherical glass equipment to be evacuated, such as suction flasks, should be specially designed with heavy walls. Dewar flasks and large vacuum vessels should be taped or otherwise screened or contained in a metal jacket to avoid flying glass from an implosion. Thermos bottles, with thin walls, are not adequate substitutes for Dewar flasks.

Large bottles and jars containing acids or corrosive chemicals should only be moved in suitable acid bottle carriers, such as those made of rubber.

Cuts from glass constitute the most common laboratory accident, and potentially one of the most dangerous, as the open cut provides a way for toxic chemicals to enter the bloodstream directly. Do not begin any operation of cutting, bending, or inserting glass into a stopper or hose without understanding the complete procedure and each separate step.

- 1) When cutting glass tubing, be sure to hold the tubing firmly, and to make a single steady stroke with a sharp file. When breaking the tubing at the cut, cover the tubing with cloth and hold it in both hands, well away from the body. Push out on the tubing but do not deliberately bend the glass with your hands. Wetting the nick will help open the fracture. Be sure that you are well away from others in the laboratory. Be especially careful in cutting a short piece from a long piece of tubing, since the long end may whip around and injure a nearby person.
- 2) When boring a stopper, be sure the borer is sharp and one size smaller than that which will just slip over the tube to be inserted. In the case of a rubber stopper, lubricate with water, or preferably glycerol or ethylene glycol. Holes should be bored by slicing through the stopper, twisting with moderate forward pressure, grasping the stopper only with the fingers and keeping the hand away from the back of the stopper. Place the stopper on a wooden board or block to avoid damaging the cutting edge of the borer. Keep the index finger of the drilling hand against the barrel of the borer and close to the stopper in order to stop the borer when it breaks through. Preferably drill only part way through, then finish by drilling from the opposite side. Discard a stopper if a hole is irregular or does not fit the inserted tube snugly, if the stopper is cracked, or if it leaks.
- 3) Stoppers should fit so that $1/3$ to $1/2$ of the stopper is inserted into the joint. Corks should first be softened by rolling and kneading. With hands close together to minimize being cut in case the vessel breaks, gently but firmly twist the stopper in place. Avoid exerting any pressure on inserted glass tubes. When available, ground glassware is preferable. Glass stoppers and joints should be clean, dry, and lightly lubricated. Stuck glass stoppers can be removed using commercially available bottle stopper remover. Students should ask instructors for assistance when glass connections, stoppers, or corks are stuck.
- 4) Fire polish all glass tubing and rods, including stirring rods. Unpolished glass has a razor-sharp edge which will not only lacerate the skin, but will cut into a stopper or rubber hose, making it difficult to insert the glass properly. After fire polishing or bending glass, allow ample time for it to cool; grasp it gingerly at first, in case it is still hot.
- 5) To remove a glass tube from a stopper, use a lubricated, dulled cork borer or the tang of a small file, inserted between tube and stopper. Lubricate as separation progresses. Sometimes it may be useful to roll the stopper with a block of wood under enough pressure to flex the rubber. If none of these procedures works, remove the tube by cutting the stopper with a single edged razor blade or an X-ActoR knife. If this is not feasible, discard the stopper and tube.
- 6) When inserting glass tubing or rods into rubber hoses, fire polish both ends of the glass to be inserted. Lubricate the glass with water, or preferably glycerol or ethylene glycol. Wrap a cloth around the glass and hold it close to the hose (not more than 5 cm). Protect the hand holding the hose with a cloth or glove. Insert the glass into the hose with a slight twisting motion, avoiding too much pressure and torque.

c. Electricity

Electricity becomes a hazard in the laboratory when the current passes through a person or through a flammable or explosive material. Care with electrical connections, particularly with grounding, and not using frayed electrical cords can reduce such dangers.

Equipment in the laboratory must have grounded (three-prong) plugs or be double insulated. Temporary wiring and the use of extension cords should be avoided. All wiring must meet the National Electric Code specifications. Where wet conditions are likely, ground fault circuit interrupters must be installed. All switches that are not directly and obviously attached to a piece of equipment should be labeled to show the equipment they control; in-line cord switches are discouraged.

If, when you touch a piece of electrical equipment, you feel a shock or “tingle,” you should disconnect it and report it for repair immediately. Shorts in circuitry get worse, and delay greatly increases the hazard. If you suspect a piece of equipment to be electrically dangerous, have it checked by a qualified electrician. Never attempt to repair any electrical equipment with the current on. Equipment that is faulty or broken must be unplugged and moved or taped in such a way that it cannot be accidentally plugged in or turned on. The equipment should be clearly labeled as unsafe and not to be used while awaiting repair.

d. Vacuum Operations

Because of the pressures involved, equipment used in vacuum operations must be carefully inspected frequently and regularly. Apparatus must be assembled so as to avoid strain, and heavy assemblies must be supported from below as well as by the flask neck. Vacuum apparatus should always be placed well back from the edge of the bench top or hood sill, where it will not be accidentally struck. Inspect frequently for signs of fatigue or wear.

1) Shielding

Either standing shields or face shields should be used in all vacuum operations, especially when the apparatus contains flasks of 1 liter or larger.

2) Vacuum Desiccators

Vacuum desiccators should be enclosed in a box or approved shielding device (such as “desigard”) for protection in case of an implosion. When opening a desiccator that has been under vacuum, make sure that atmospheric pressure has been completely restored. A “frozen” vacuum desiccator lid can be loosened by a single-edge razor blade inserted as a wedge and then tapped with a wooden block to raise the lid.

3) Water Aspirators for Vacuum

Water aspirators for vacuum are used mainly for filtration purposes; use only equipment that has been approved for this purpose. Never apply a vacuum to a flat bottom flask unless the flask is a heavy walled filter flask designed for the purpose. Place a trap and a check valve between the aspirator and the apparatus so that water cannot be sucked back into the system if the water pressure should fall unexpectedly while filtering. These recommendations also apply to rotary evaporation operations where water aspirators are being used for vacuum.

4) Vacuum Pumps

A cold trap should be placed between the apparatus and the pump so that volatiles from a distillation do not get into the pump oil or out into the atmosphere of the laboratory. Exhausts

from pumps should be vented properly. All pumps must also have a belt guard to prevent hands or loose clothing from being pulled into the belt pulley.

e. Pressure Operations

As with vacuum operations, the equipment used in high pressure procedures must be regularly and frequently inspected for any signs of wear or fracture. Each pressure vessel should be clearly stamped or labeled with its basic allowable working pressure, the allowable temperature at this pressure, and the material of construction. Always use a pressure relief disk or other suitable device in pressure systems. The relieving pressure and setting data should be printed on a tag attached to installed pressure-relieving devices, and the setting mechanisms should be sealed.

Before any pressure equipment is altered, repaired, stored, or shipped, it should be carefully vented and cleaned. When assembling such apparatus, avoid strain and excessive force. Threads must match correctly. Never use oil or hydrocarbon-based lubricant on apparatus that will contain oxygen. Kel-F oils or greases (polychlorotrifluoroethylene oils or greases) are the proper lubricants for these systems. In assembling copper tubing, avoid sharp bends and allow flexibility. Check for hardening and cracking in the copper; renew if necessary.

All reactions under pressure must be shielded, and prominent signs should be placed to warn others of high pressure hazard.

f. Heating

1) Open Flame

Wherever possible, use heating mantles, heating tapes, or laboratory hot plates in place of gas (Bunsen) burners. When using a heating mantle, always operate below the maximum allowable voltage for that mantle. It is obvious that open flame must never be used where explosive or flammable chemicals are present, but the presence of such chemicals may be unsuspected or sudden. If a burner must be used, distribute its heat with a flame retardant wire gauze, or by moving the burner about underneath the container being heated. Test tubes being heated in this way should be held with a test tube holder at about a 45 degree angle and heated gently along the side, not at the bottom, to minimize superheating which may cause the contents to be ejected. Avoid pointing a test tube toward yourself or any nearby person.

2) Hot Oil Baths

Hot oil used for heating purposes is often overlooked as a hazard, yet it carries serious dangers: (1) spattering caused by water falling into hot oil, (2) smoking caused by decomposition of the oil or of organic materials in the oil, and (3) fire caused by overheated oil bursting into flame. Operating baths should not be left unattended unless a high temperature cut off is installed. Precautions should be taken to contain any spills of hot oil caused by breakage or overturning of the baths. Fiberboard, cardboard, or other combustible components must not be used in heated apparatus.

In evaluating a hot oil bath setup, carefully consider the size and location of the bath, the operating temperature and temperature-control device, the type of oil used (silicone oil is suggested for most heating baths), the ventilation available, and the method of cooling the hot oil. A label on the bath should include the name of the oil and its safe working temperatures. Silicone oil is a safe non-flammable fluid which can be used in heating baths to 250°C (about 480°F) without decomposition.

3) Temperature Control

The rates of all reactions increase as the temperature increases. Highly exothermic reactions may become dangerously violent unless provisions are made for cooling, for example, by

bringing a cooling bath up around a flask. Virtually all reactions require some temperature control, and thus apparatus should be assembled in such a way that either heating or cooling can be quickly applied or withdrawn. A suitable thermometer should be used in a boiling liquid where a strong exothermic reaction is likely so that there will be warning and time to apply cooling.

Boiling stones or boiling sticks should be used in unstirred vessels of boiling liquid (other than test tubes) to prevent superheating and “bumping”. Do not reuse boiling stones or sticks. Do not add them or any other solid material to a liquid which is near its boiling point since this is likely to cause splattering or boil over.

g. Cooling

1) Flowing Water

When cooling with flowing water, beware of differences in water pressure when operations have to be left unattended for long periods, particularly overnight. In such situations, you may need to use an automatic water regulator installed in the line to keep the flow even, as well as a water flow monitor that will shut down all equipment if the flow is interrupted. Wire all rubber or plastic tubing to metal or glass connections to prevent the tubing from detaching, thus avoiding the risk of a flood.

2) Cooling Baths

When ice water is not cool enough as a bath, salt and ice may be used. For even lower temperatures, dry ice may be used with an organic liquid, such as acetone, ethanol, or ethylene glycol. Ethylene glycol, with a flash point of 111oC (230oF), is the best of the three listed above, considering flammability. When choosing a liquid for use with dry ice, you must consider the viscosity, flammability, volatility, solubility in water, and the possibility of toxic vapors.

Few, if any, liquids are free from all of these hazards. Your choice must also be made based on the temperature requirements of your procedure and the limitations of your equipment.

3) Cryogenics

Cryogenic equipment setups involve hazards due to extremely low temperatures, and also hazards associated with the high pressure gases that are often part of such setups (see the following section on Compressed Gases). Be careful to control ignition sources and to monitor the formation of very high or very low concentrations of oxygen.

Safe management of the hazards associated with extremely low temperatures requires thorough understanding of the unique conditions created. For example, the extreme cold of liquid nitrogen can make metals and other materials brittle. Uninsulated equipment can condense oxygen from the air to yield dangerously high concentrations of liquid oxygen, which can explosively ignite many combustibles. On the other hand, liquid nitrogen, left open, reduces the oxygen content of air as the oxygen condenses and the nitrogen evaporates. A person working in an inadequately vented area could lose consciousness without warning, and will die without rescue. Good ventilation is essential in all cryogenic operations, along with an understanding of the low-temperature behavior of the substances involved.

Contact of liquefied gases with eyes or skin produces serious burns. Damaged tissue should be flooded with a gentle stream of water, not warmer than body temperature (using an eyewash, for example). The affected area should then be dried very gently (excluding eyes) and protected until medical assistance arrives. To avoid contact with liquefied gases, wear goggles, face shield, and insulated gloves that fit loosely enough to throw off in case of a spill.

The body should be completely covered, with no skin exposed. Wear no jewelry, and avoid clothing with cuffs or pockets that could trap and hold a cryogenic liquid close to the skin.

Put objects into a cryogenic liquid slowly, and pour liquids into containers slowly in order to minimize the inevitable boiling and splashing.

For the same reason, dry ice should be added to liquid slowly and in small amounts, to avoid foaming and boil over. Handle dry ice with dry leather or insulated gloves, and never lower your head into a dry ice chest, as the oxygen content may be inadequate and suffocation can result.

Dewar flasks and cold traps should be taped to prevent flying glass in case of breakage. Avoid pouring cold liquid over the edge of a Dewar flask, as it may break and implode.

h. Compressed Gases

Gases are supplied in cylinders under great pressures, some as much as several thousand pounds per square inch. If the valve is broken off at the cylinder neck, the cylinder becomes a potentially deadly rocket, propelled with great momentum and high speed. Gas cylinders have been documented to cause extensive property damage, injury, and death. For this reason, all gas cylinders, full or empty, must always be strapped or chained to a sturdy support to prevent the cylinder from falling and breaking off the valve. All cylinders of compressed gas should be treated as high energy sources and therefore regarded as potential explosives.

In addition, released gas can rapidly displace the breathing air in a room, causing suffocation. Many gases are toxic or corrosive and can cause injury if inhaled or contacted in even small amounts. Many gases are reactive with other materials or gases. Oxygen, in greater than normal concentrations, greatly increases the risk of fire and explosion.

Compressed gas cylinders have certain safety features, including special valves, fittings, and caps. For example, many gases have special valves that prevent the inadvertent mixing of incompatible gases. The best protection, though, lies in following the guidelines developed over years of experience with the hazards of compressed gas.

1) Use

Begin with thorough knowledge of the substances and equipment involved. Always know the identity of the gas in a cylinder; if for some reason a cylinder is unlabeled, return it to the vendor; do not guess. Know the properties and potential of the gas to be used, and the procedures for using it. Be careful not to exceed the design pressure of the apparatus. Always wear safety goggles when handling or using compressed gases.

Carefully inspect fittings, regulators, and apparatus for damage before using. Do not use damaged equipment. Use only regulators, gauges, and connections with matching threads and which are designed to be used with the gas and cylinders involved. Never lubricate, modify, force, or tamper with a cylinder valve.

Only those tools approved by the cylinder vendor should be used on cylinder connections. Do not modify or alter cylinders or their attachments. Use cylinders and manifold systems only with their appropriate pressure regulators.

Use cylinders only in well ventilated areas. Corrosive gases should be used only in locations with access to safety showers and eyewash stations. Corrosive, toxic, and flammable gases should be used only in fume hoods designed for use with the particular gas or group of gases. Use flammable gases only after proper bonding and grounding connections have been made.

Do not expose cylinders to temperatures higher than about 50°C (122°F). Some rupture devices on cylinders will release at about 65°C (149°F). Some small cylinders, including those not fitted with rupture devices, may explode if exposed to high temperatures.

Open cylinder valves slowly. Rapid release of a compressed gas will cause an unsecured gas line to whip dangerously and also may build up a static charge which could ignite a combustible gas. Never direct high pressure gases at a person, or use compressed gas or compressed air to blow away dust or dirt; resultant flying particles can be dangerous. Close cylinder and bench valves when the cylinder is not in use; the pressure regulator is not sufficiently strong to assure safe closure.

Do not extinguish a flame involving a highly combustible gas until the source of the gas has been shut off. Otherwise, it can re-ignite, causing an explosion.

Always use a trap to prevent back siphonage of liquid chemicals, and a check valve to prevent back flow of gases into the cylinder. When gas is passed from a cylinder into a vessel containing a liquid, contamination of the cylinder gas with other chemicals is a real possibility. Such contamination makes the gas unsuitable for future use and may result in explosion with resultant injury, damage, or even death. Use of a safety trap to contain liquid and a check valve to prevent back flow of gas will eliminate this possibility. These are installed immediately after the pressure regulator, and before the vessel containing the liquid. The safety trap should have a volume of about one and one half times the total liquid volume in the system.

Never bleed a cylinder completely empty. Always leave a residual pressure (about 25 psig) to keep contaminants out. Promptly remove the regulators from empty cylinders, being sure to bleed the gas from the regulator first. Replace the protective caps at once. Mark the cylinder "EMPTY" in removable printing. Never refill a cylinder.

2) Used Cylinders

Handle used cylinders as you would full cylinders. Keep them strapped or chained at all times. Store the used cylinders separately from full cylinders so there is no chance of confusing them. Mark all used cylinders "MT" or "EMPTY" in removable writing (such as chalk), or tear the attached tag to indicate empty.

3) Leaking Cylinders

Cylinders that are leaking or otherwise damaged are an immediate danger. If they can be transported safely, they should be taken to an open place separate from all other cylinders to await vendor pickup.

Be very careful, however, in moving any cylinder that is leaking. Avoid inhaling gases while carrying or loading such a cylinder, and try to avoid spreading gases in corridors and stairwells. In the case of toxic or flammable gases, call the emergency number for help.

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4) Transportation

Do not move a cylinder unless the cap is in place.

Generally, cylinders must be transported on a hand truck to which they can be strapped or chained. Cylinders may be rolled on edge only for very short distances. Use an elevator, if possible, to move cylinders to upper or lower floors. If stairs must be used, move cylinders on a hand truck which is equipped for stairs.

When handling cylinders, always consider them to be full. Do not allow them to strike each other, or to be dropped, cut, scraped, or otherwise damaged.

5) Storage

Keep only those cylinders currently in use in the laboratory. All cylinders, in use or in storage, must be secured to a sturdy object, such as a wall, bench, or stand, using a strong strap or chain.

Store full and used (empty) cylinders only in isolated areas that are ventilated and protected from direct sunlight, rain, snow, damp ground, heat, fire, and electrical contact. Temperatures in storage should be maintained between -20°F and 120°F unless the manufacturer indicates otherwise. Storage can be indoors or outdoors under shelter. Never store or use cylinders in corridors, stairwells, or in high traffic areas.

Cylinders of the same gas should be stored together. Oxidizers should be separated from flammables and combustibles by 20 feet of space, or by a one-hour rated firewall and five feet of space. In addition, store used (empty) and full cylinders separately and clearly indicate whether they are full or empty.

Keep caps on all cylinders except when connected for use, and keep cylinders upright, whether in use or storage. Consult the University Health/Safety Manual for additional information on storage of gas cylinders.

6. Handling Chemicals

Following are guidelines and principles for safety in the direct manipulation of chemicals—holding, pouring, mixing, transporting, storing, and so on. The list of situations covered is far from exhaustive; emphasis is instead on the most common ways in which chemicals are handled in the laboratory. Safety precautions for use of laboratory equipment can be found in Safety Systems, Section 3, and General Laboratory Equipment Setup, Section 5.

a. Personal Contact

The primary safety goal in handling chemicals is to prevent the chemicals from entering your body. It cannot be said too often that protective gear must be worn at all times, and precautions for avoiding personal contact with the chemicals must always be in mind.

- 1) Avoid direct contact of any chemical to the hands, face, and clothing. Be aware of what you touch; be careful not to touch gloves to your face, for example. After any skin contact, and always before you leave the laboratory, wash face, hands, and arms. Leave all equipment in the laboratory.
- 2) Never taste chemicals or sniff from chemical containers.
- 3) Never eat, drink, smoke, or apply cosmetics in the laboratory.
- 4) Dispense and handle hazardous materials only in areas where there is adequate ventilation.
- 5) If you believe that significant ingestion, inhalation, injection, or skin contact has occurred, call the emergency number on your campus and follow the Emergency Procedures given earlier in this Guide.

b. Handling Containers

Clearly label all chemical containers. The Laboratory Standard requires that labels on incoming chemical containers not be removed or defaced. Do not use any substance from an unlabeled or improperly labeled container. Printed labels that have been partly obliterated or scratched over, or crudely labeled by hand, should be relabeled properly. Unlabeled chemical containers are a violation of the NJ Right-to-Know Act and should be disposed of promptly and properly.

Carefully read the label before removing a chemical from its container. Read it again as you promptly recap the container and return it to its proper place. Names of distinctly different substances are sometimes nearly alike; mistakes are easy to make and can be disastrous.

When picking up a bottle, first check the label for discoloration, and if it is clean, grasp it by the label. Spilled chemical will show up on the label better than on the glass; holding the container by the label will protect you from prior spills, and protect the label from present ones. After use, wipe the bottle clean.

If a stopper or lid is stuck, use extreme caution in opening the bottle. Friction caused by removing tops may cause explosions with some substances (such as hydroperoxides formed from ethers or picric acid contaminated with heavy metals).

Support beakers by holding them around the side with one hand. If the beaker is 500 ml or larger, support it from the bottom with the other hand; also, consider using a heavy-duty beaker slowly on the clean surface of the bench. If the beaker is hot, use beaker forceps or tongs, and place the beaker on a heat-resistant pad.

Grasp flasks by the center neck, never by a side arm. If the flask is round bottomed, it should rest on a proper sized cork ring when it is not clamped as part of a reaction or distillation assembly. Large flasks (greater than 1 liter) must be supported at the base during use.

Never look down the opening of a vessel, in case of unforeseen volatility or reaction.

c. Pouring

Do not pour toward yourself when adding liquids or powders. Stoppers too small to stand upside down on the bench should be held at the base and outward between two fingers of the pouring hand.

Use a funnel if the opening being poured into is small. If a solid material will not pour out, be careful when inserting anything into the bottle to assist removal. Students should seek advice from instructors before proceeding.

Always add a reagent slowly; do not "dump" it in. Observe what takes place when the first small amount is added and wait a few moments before adding more.

When combining solutions, always pour the more concentrated solution into the less concentrated solution or water. Stir to avoid violent reactions and splattering. The more concentrated solution is usually heavier and any heat evolved will be better distributed. This procedure is particularly applicable in preparing dilute acid solutions. Be sure to wear goggles and use the hood when diluting solutions.

Make sure the stopcock is closed and has been freshly lubricated before pouring a liquid into an addition or separatory funnel. Use a stirring rod to direct the flow of the liquid being poured. Keep a beaker under the funnel in the event the stopcock opens unexpectedly.

Wear an apron and gloves, in addition to goggles, whenever pouring bromine, hydrofluoric acid, or other very corrosive chemicals, to avoid painful chemical burns.

d. Pipeting

NEVER pipet by mouth. Use an aspirator bulb, or another mechanical Pipetting device. Constantly watch the tip of the pipet and do not allow it to draw air.

e. Storage

Keep as few chemicals as possible on the bench top. All chemicals not immediately needed should be properly stored.

Do not store incompatible materials together or in close proximity. Use safety cans with flame arrestors for quantities of flammable solvent larger than 4 liters, and be sure to leave a space at the top of a closed container for expansion of liquid and vapors. If chemical purity requirements preclude metal containers, glass containers may be used. Containers no larger than one pint (500 ml) should be used to store NFPA Class IA liquids, including, but not limited to: acetaldehyde, diethyl ether, ethyl chloride, methyl formate, low boiling petroleum ether, pentane and propylene oxide.

Store large containers of reagents on low shelves, preferably in a tray adequate to contain spills or leakage.

Dispense corrosive liquids in small containers, no larger than 500 ml, preferably in chemically resistant coated containers. Never take more than is immediately needed.

1) Refrigerators

Ordinary household refrigerators constitute a hazard when used for storage of flammable or unstable chemicals. These units produce conditions which can lead to explosion. Domestic (household- type) refrigerators may not be used for flammable chemical storage unless suitably modified to eliminate all possible contact between vapors and electric spark or arcing. Explosion proof refrigerators are preferred.

When searching for an item in a refrigerator used for chemical storage, be careful not to inhale vapors that may have built up in the cabinet.

All chemicals, including those stored in refrigerators, should be sealed and labeled with the name of the material, the date it was placed in storage, and the name of the person storing it there. Refrigerators should be cleaned on a regular schedule, and old chemicals should be properly discarded.

Food must NEVER be stored in any refrigerator used to store chemicals.

2) Storage of Flammable Chemicals

Keep flammables in use in the laboratory in safety cans specifically designed for that purpose at all times. In the event that such cans are not available, glass bottles may be used with the proper precaution. The containers used by the manufacturer must meet certain standards for shipping. These same containers are not always suitable for routine use. The shipping container must be sealable and of suitable shape and strength for transport. This transport is usually within another container - carton, crate, etc. Do not use screw caps to close bottles containing volatiles (such as diethyl ether, low-boiling petroleum ether, methylene chloride, and pentane) as pressure build up can cause failure in a bottle which is not new and which may have internal strains which come from normal use. In such situations, use corks or neoprene stoppers. Use a one-holed cork fitted with a drying tube if moisture must be excluded. To relieve pressure build up, use a cork fitted with a check valve. Keep all flammables away from direct sunlight and sources of heat.

Storage of Flammable Liquids

Flammable storage limits for laboratories are given in the following Table.

Maximum Allowable Storage of Flammables¹ in Laboratories²

Total Quantity Instructional or Class I,II,III Tot.	Total Quantity Instructional or Class I,II,III Tot.	Quantity Outside Of Safety Cabinets/safety Cans	Quantity Outside Of Safety Cabinets/safety Cans
40 gal	10 gal	80 gal	20 gal

NOTE: 1 Class I = Liquids with flash point <100°F Class II = Liquids with flash point >100°F and <140°F Class IIIA = Liquids with flash point >140°F and <200°F Class IIIB = Liquids with flash point >200°F

NOTE: 2 Based on labs >200 ft². For labs <200 ft², use half the quantities given above. Larger quantities may be allowed with REHS approval.

The maximum container size is given in the table below.

Maximum Allowable Container Capacity (NFPA) 45.7* Flammable Liquids Combustible Liquids Container Type IAIB ICII IIIA Glass 1 pt 1 qt 1 gal 1 gal 5 gal Metal (other than DOT Drums) or approved plastic 1 gal 5 gal 5 gal 5 gal 5 gal Safety Cans 2 gal 5 gal 5 gal 5 gal 5 gal Metal Drums (DOT) n/a 5 gal 5 gal 60 gal 60 gal In instructional laboratory work areas, no container for Class I or II liquids shall exceed a capacity of 1 gallon, except that safety cans may be of 2 gallon capacity.

- Exceptions:
- Glass containers as large as 1 gal. (3.785 L) may be used if needed and if the required purity would be adversely affected by storage in a metal or an approved plastic container, or if the liquid would cause excessive corrosion or degradation of a metal or approved plastic container.
- Drums of not more than 60 gallons (227 L) capacity are permitted in a separate area inside the building if the inside area meets the requirements of NFPA 30, Flammable and Combustible Liquids Code.

Storage Cabinets

Only (1) storage cabinet may be located in a laboratory. Cabinets shall be labeled in conspicuous lettering, "FLAMMABLE—KEEP FIRE AWAY".

Flammable storage cabinets are designed to protect the contents from external fires. For this reason, the door(s) must be kept closed except when removing or replacing the cabinet's contents. These cabinets do not necessarily protect people from solvent vapors during normal use of the cabinet. There are vent kits available for flammable storage cabinets, however these cabinets are fire tested with the vent holes closed. The NFPA Flammable & Combustible Liquids Code Handbook recommends against venting these cabinets as this practice may defeat the designed purpose. Where particularly noxious or toxic chemicals are being used, cabinets may be vented, with prior REHS approval.

The interior of the cabinet is capable of withstanding the effects of vapors from solvents, but not of other materials such as corrosives. As these materials are incompatible with most flammables, only flammable storage cabinets are designed with a lip to contain a two-inch depth of a spilled liquid.

3) Storage of Acids

Acid storage cabinets are designed to withstand corrosion, contain spills, keep like materials together, and protect the contents from physical damage. If ordinary cabinets used for acid storage show signs of deterioration, consider relocating the acids to a specially designed cabinet. As acids are incompatible with alkalis, flammables, and other classes of chemicals, only acids may be stored in these cabinets.

Dichromate cleaning solution is an unsuspected source of pressure build up explosions in the laboratory. Although storage of this common cleaning solution in the glass shipping container is a common laboratory practice, it has led to several serious incidents. Occasionally, the dichromate solution will contain sufficient amount of organic material from previous glass cleanings to evolve a large enough quantity of carbon dioxide to explosively rupture a screw topped glass bottle. To prevent a possible explosion, and subsequent potential injury, a stopper is recommended. See the recommendation given above for storage of flammables.

f. Chemical Inventories

The NJ Right-to-Know law requires that all laboratories that have not received research and development exemptions prepare, maintain, and update a list of all chemicals present in the laboratory. The list should include, for each container, the chemical name(s) of the contents, the CAS Number (Chemical Abstracts Service Number), the quantity and the container type. This list is also useful for acquiring the MSDSs and HSFSSs needed and to carry out work both safely and in compliance with the PEOSHA standards. For example, identification of a substance as a Particularly

Hazardous Substance and a carcinogen and taking the appropriate precaution in its use, would not be possible without compiling this list. For more information, see Section G, "Provisions for Employee Protection when working with Particularly Hazardous Substances."

In the case of shared spaces, information on chemicals present should be provided by a user to another user, upon request.

g. Transportation

Bottles of one gallon or more should be transported in bottle slings or bottle carriers that could completely contain the substance in the event of breakage. This is particularly important in transporting corrosive, toxic, or flammable liquids. If you need to move several such containers at once within a building, use bottle carriers and a properly designed cart. All containers should be tightly capped during transport.

Smaller bottles can be carried by their handles, or by grasping the label and placing the little finger under the base of the bottle. Never try to balance a bottle by holding it solely from underneath. Approach all doors with caution.

If you do drop and break a container, you have the responsibility of calling the emergency number to report the spill and to request assistance in cleanup.

New Brunswick 911 (or 6-911 from University Centrex phones) Newark (973) 353-5111 Camden (609) 225-6111

For off-campus locations, please list emergency number here:

7. Chemical Hazards

This section contains descriptions of the general categories of chemical hazard, and the principles of safety associated with each. This section purposefully does not contain advice for handling specific chemicals. Safe work in a chemical laboratory requires very detailed knowledge of the nature, potential, and compatibilities of each substance used; cursory or selective description in this Guide would be misleading and, as a result, unsafe. Anyone planning an experiment or procedure should acquire and review a Material Safety Data Sheet (MSDS) or Hazardous Substance Fact Sheet (HSFS) for each substance, and also for all likely products and byproducts. MSDSs and HSFSs for each chemical present in the laboratory must be available to every laboratory worker within five days of a written request. They are available from REHS, Building 4127, Livingston Campus, upon request.

They are also available from the reference desks of the University libraries listed below:

LIBRARY OF SCIENCE AND MEDICINE, BUSCH
ALEXANDER LIBRARY, CAC
MABEL SMITH DOUGLASS LIBRARY, DOUGLASS
DANA LIBRARY, NEWARK
CAMDEN LIBRARY, CAMDEN

The following categories provide a structure for thinking about—and planning protection against—common chemical hazards. In actual practice, such hazards do not group themselves in neat categories, but usually occur in combination and/or sequence. The categories and concepts are provided as an aid to awareness, and as encouragement for consistent safe planning and practice.

a. Flammability

Flammability is one of the most common chemical hazards. The exact degree of hazard, however, depends on the specific substance and the conditions you expect to use it in. To handle a flammable substance safely, you must know its flammability characteristics: flash point, upper and lower limits of flammability, and ignition requirements. This information appears on each MSDS or HSFS.

- 1) Flash Point

For a liquid, the flash point is the lowest temperature at which the liquid gives off enough vapor to form an ignitable mixture with air and produce a flame when a source of ignition is present. Many common laboratory solvents and chemicals have flash points that are lower than room temperature.

- 2) Ignition Temperature

The ignition (or autoignition) temperature of a substance—solid, liquid, or gas—is the minimum temperature required to initiate self-sustained combustion. Some ignition temperatures can be quite low (for example, carbon disulfide at 90°C (194°F)).

- 3) Autoignition

Autoignition or spontaneous combustion occurs when a substance reaches its ignition temperature without the application of external heat. This characteristic is particularly important to keep in mind in the storage and disposal of chemicals.

- 4) Limits of Flammability

Each flammable gas and liquid (as a vapor) has a limited range of flammable concentration in mixtures with air. The lower flammable limit (or lower explosive limit) is the minimum concentration below which a flame is not propagated when an ignition source is present—such a mixture would be too lean to burn. The upper flammable limit (or upper explosive limit) is the maximum concentration of vapor in air above which a flame is not propagated—such a mixture is too rich. The flammable range (or explosive range) lies in between the two limits.

Listed measurements of all these characteristics—flash points, ignition temperatures, limits of flammability—are derived through tests conducted under uniform and standard conditions that may be very different from actual practice. For example, concentrations of vapor in air in a laboratory are rarely uniform, and point concentrations can be quite high. It is good practice to set maximum allowable concentrations at 20 percent of the listed lower limit of flammability within closed systems. (It is important to note that, generally, this 20 percent limitation is still well above the maximum concentration considered to be safe for health considerations.)

- 5) Precautions with Flammable Liquids

Flammable liquids do not burn; their vapors do. For a fire to occur, there must be 1) a concentration of vapor between the lower and upper flammable limits, 2) an oxidizing atmosphere, usually air, and 3) a source of ignition. As it is unlikely that air can be excluded, and unrealistic (given the constant possibility of a spill) to assume that the vapor concentration can be controlled, the primary safety principle for dealing with flammable liquids is strict control of ignition sources.

Ignition sources include electrical equipment, open flames, static electricity, and, in some cases, hot surfaces. Others working in the laboratory should be informed of the presence of flammable substances so that ignition sources can be eliminated. Obviously, it is very important to know which of those sources is capable of igniting a substance you are using.

Remember that most flammable vapors are heavier than air, and will spread out horizontally for considerable distances until an ignition source is contacted.

If possible, flammable liquids should be handled only in areas free of ignition sources. Heating should be limited to water and oil baths, heating mantles, and heating tapes.

Static-generated sparks can be sudden ignition sources. When transferring flammable liquids in metal equipment, take care that metal lines and vessels are bonded together and grounded to a common ground.

Ventilation is very important. A fume hood should be used when flammable liquids are allowed to stand in open containers or are handled in any way.

6) Precautions with Flammable Gases

Leakage of compressed or liquefied gases can quickly produce a flammable or explosive atmosphere in the laboratory. This is obviously true where the gases themselves are flammable and under high pressure, but may also be true in the use of non-pressurized liquefied gases. For example, even relatively safe liquefied gases such as liquid air or liquid nitrogen, if kept in open vessels for too long, will generate concentrations of liquid oxygen which can contribute to an explosion. Proper care with compressed gas cylinders and cryogenic setups is essential (see General Laboratory Equipment Setup, Section 5).

b. Explosiveness

Ignition of flammable vapors or gases can occur with such speed that an explosion results. There are other substances that are explosive in themselves—in response to heat, mechanical shock, or contact with a catalyst. With some substances, very tiny amounts of impurity are sufficient to begin a reaction that quickly becomes explosive.

1) Precautions

Acquire a Material Data Safety Sheet (MSDS) or Hazardous Substance Fact Sheet (HSFS) for each chemical you are using. It is crucial that you know its potential including its compatibilities with other substances.

Be alert to any unusual change in the appearance of a reaction mixture. Rapid unexpected temperature rise or fuming are signals for emergency measures such as removing the heat source, quickly applying a cooling bath, or leaving the room.

Explosive compounds should be protected from the conditions to which they are sensitive (mechanical shock, heat, light, etc.). Check your MSDS/HSFS to see what those conditions are. Such substances should be brought to the laboratory only as required, and only in the smallest quantities absolutely necessary. Reactions involving or producing explosives should be designed on as small a scale as possible, and should be done behind a suitable barricade.

Special care should be taken that equipment is maintained (for example, that oil is routinely changed in vacuum pumps) and that heating methods used do not cause, or increase the potential for ignition.

Other laboratory workers must be notified when an explosive hazard is present, through direct announcement and conspicuous warning signs.

Highly exothermic or potentially explosive reactions must never be left unattended.

2) Personal Protection

In addition to protection otherwise required in the laboratory, wear face shields, and heavy gloves at all times when handling known explosive substances. Laboratory coats of a flame-resistant material or treatment may help reduce minor injuries from flying glass or flash. When serious explosive hazard is anticipated, shields and barricades will be necessary, along with devices for manipulating equipment at a safer distance long-handled tongs, stopcock turners, mechanical arms, etc.). Some experiments at Rutgers have required specially designed rooms be constructed for the safety of the researchers. Contact REHS if you plan to run an experiment with a significant explosion potential.

c. Toxicity

Toxicity is the potential of a substance to cause injury by direct chemical action with the body tissues. Whether the effect is acute or chronic, the only way to avoid such injury is to prevent or greatly minimize contact between toxic chemicals and body tissues.

1) Measurement

The dose, or amount of chemical, you are exposed to determines the body's response. In the workplace, there are certain guidelines or regulations which limit your exposure to hazardous substances. These guidelines, which are set by various regulatory or professional organizations are referred to as "workplace exposure limits".

A workplace exposure limit is the airborne concentration of a material below which most persons can be exposed for long periods of time without adverse effect. These limits are based on an 8-hour time-weighted-average (TWA) over a working lifetime. Permissible Exposure Limits (PEL) are those set by PEOSHA. Workplace exposure limits may be expressed as Threshold Limit Values (TLV) or Workplace Environmental Exposure Limits (WEEL).

Time-Weighted Average (TWA) is the average concentration of a substance integrated over a period of time (e.g. a normal 8-hour workday).

A Short-Term Exposure Limit (STEL) is the maximum concentration limit for a continuous 15 minute exposure period, provided that the daily TWA is not exceeded. Because workplace exposure limits are generally expressed as average concentrations, excursions above these values are permitted. The exposure levels during such excursions must be below the STEL. However, there are certain levels which must never be exceeded even instantaneously. These are known as the ceiling levels for a TLV, or TLV-C.

All these measurements, though often based on data from animal research, refer to the exposure and resistance of a healthy adult. These levels do not necessarily apply to pregnant women, their unborn fetuses, or adults who are ill or under special stress. In such situations the individual and his/her supervisor or instructor must carefully consider all pertinent information. REHS can be consulted in such matters.

2) Acute Toxicity

Acute toxic effects are usually produced by a single large dose, generally well above the TLV, received in a short period of time. The effects are immediate, and may be partially or totally reversible. Acute toxic effects include:

Simple asphyxiation: the body does not receive enough oxygen (for example, when gaseous nitrogen has displaced the air in a room).

Chemical asphyxiation: the body is prevented from using oxygen (for example, when carbon monoxide instead of oxygen is absorbed in the blood).

Anesthetic: causes dizziness, drowsiness, headaches, and coma (for example, by the vapors of many organic solvents).

Neurotoxic: the brain's control of the nervous system is slowed down or changed (for example, by concentrations of lead and mercury).

Corrosive: body tissue is directly damaged by reaction with chemicals (for example, by strong acids or bases—see separate subtopic below).

Allergic: repeated exposure to a chemical produces sensitizing, until there is an allergic reaction at the contact site (usually skin).

3) Chronic Toxicity

Chronic toxicity refers to adverse or injurious effects that can result from prolonged exposure to a substance, sometimes at dose levels just above the TLV. Damage may not appear for many years—perhaps generations—and is often irreversible. As a result, this class of hazard is both very difficult and very important to guard against. The body can filter and process levels of toxicity that might seem surprisingly high, but over extended periods of time, even with the dose very low, the filtering process may fail, and damage may occur.

Types of chronic toxic effects include:

Carcinogenicity: produces cancer (for example, asbestos and vinyl chloride are known to produce cancer in humans).

Mutagenicity: alters cell genes; subsequent generations show genetic damage.

Teratogenicity: harms developing fetus.

Reproductive toxicity: interferes with the reproductive system in men or women.

Specific organ toxicity: damages specific organs (for example, carbon tetrachloride can cause liver damage).

4) Precautions

The precautions to take against contact with toxic substances are repeated many times throughout this Guide. With chemicals of low acute toxicity, it may be tempting to be less rigorous; yet it is precisely those chemicals which most require continual caution—an unvarying habit of safety.

You must protect your body against all forms of chemical contact: absorption, inhalation, ingestion, and injection. Never eat, drink or smoke in the laboratory; wear the appropriate protective gear, and always remove it before you leave the laboratory. Make sure you carefully wash your hands before leaving the laboratory. Remember that the chemicals you bring home on your clothes will have a more powerful effect on growing children and elderly people than on most adults.

In order to know what level of personal protection will be adequate, keep up to date on recent tests for substances you are using. MSDSs are updated regularly, and you should consult the most recent data each time you begin a new procedure. The best precaution is to treat all chemicals as toxic.

d. Corrosives

Corrosiveness is a form of acute toxicity sufficiently common and hazardous to merit separate discussion. Corrosive chemicals include strong acids, strong bases, oxidizing agents, and dehydrating agents. When they come in contact with skin, eyes, or, through inhalation, the surface tissues of the respiratory tract, they react with the tissues they touch and cause local injury.

1) Liquid Corrosives

A liquid corrosive will act on the skin rapidly or slowly depending on concentration and length of contact. These chemicals react directly with the skin: dissolving or abstracting from it some essential components; denaturing the proteins of the skin; or disrupting the skin cells. Mineral acids, organic acids, and bases are among the typical liquid corrosives.

When handling liquid corrosives, contact with them must be scrupulously avoided. Wear goggles, rubber or suitable synthetic gloves, and a face shield. A rubber or synthetic apron and rubber boots may also be necessary. Since many liquid corrosives also release irritating vapors, procedures using these materials should be performed in a fume hood.

2) Solid Corrosives

Solid corrosives interact with the skin or other surfaces when dissolved by the moisture there. Damage then occurs both from the corrosive action and from the heat of solution. Because they are solid, these chemicals are relatively easy to remove; but because they may not react immediately and may not be painful at first (as with the caustic alkalis), they may cause much damage before being detected.

Solid corrosives are most commonly dangerous in a finely divided state. Dust control and good exhaust ventilation are essential, as well as goggles, gloves, and other protective clothing. In case of chemical contact, much care must be taken during the emergency shower irrigation to remove all particles of solid matter that might be lodged in the skin or clothes.

3) Gaseous Corrosives

Gaseous corrosives pose the most serious health hazard of all corrosives because of possible damage to the lungs, including spasm, edema, pneumonia, and even death. Different corrosive gases affect different parts of the lung (for example, ammonia affects the upper respiratory tract, while phosgene affects the lung, causing pulmonary edema), but all are to be avoided.

It is thus crucial that corrosive gases not be inhaled. Careful design and the use of fume hoods is essential. Skin and eyes must also be protected, as gases contact all exposed parts of the body.

e. Impurities and Combinations

MSDSs contain information on pure chemicals, known mixtures, and proprietary materials—unfortunately there are no such sheets for other materials found in the laboratory, including solutions, mixtures of unknown or uncertain composition, and byproducts of reactions, all common in the laboratory. Impurities, synergistic effects, formation of unexpected products and byproducts, insufficiently clean equipment, and the combination of vapors from your experiment with that of your neighbor's can all produce sudden and unanticipated hazards.

There is no absolute protection against all contingencies, but it helps to wear protective gear, to clean equipment scrupulously, to be aware of experiments in progress in nearby areas, and to be completely familiar with emergency procedures.

8. Cleanup And Waste Disposal

a. Cleanup

Cleaning up should be a continual process, performed during as well as after an experimental procedure. Cleaning should include yourself and your clothing, laboratory surfaces, equipment, and containers. Wash hands frequently while working in the laboratory; when you leave, remove protective gear and inspect clothing. Care with gear and clothing will prevent taking chemicals home with you; care with equipment and containers will help avoid future contamination and surprise mixtures. Such care requires planning as well as good housekeeping. Cleanup and disposal methods should be part of your written procedures.

When washing glassware, work with a few items at a time, and allow them to drain where they will not fall over. If anything falls, let it fall rather than risk severe cuts by grabbing it as it breaks. If glass has broken into a sink containing water, drain the water and then use gloves when picking out broken pieces.

Clean vessels or equipment with appropriate materials (water, soap, acid, etc.). Do not proceed unless you are sure which materials to use; check Material Data Safety Sheets (MSDSs), Hazardous Substance Fact Sheets (HSFSs), or other references for advice on proper cleaning

materials to use with the specific substance to be cleaned up. Follow directions carefully. If you have any questions, call REHS.

b. Waste Disposal

Rutgers University has programs for the management of waste generated in University laboratories. Details of the programs are given in the following Appendices:

Appendix 5 Policy for the Disposal of Laboratory Glass

Appendix 6 Policy for the Disposal of Chemicals

Appendix 7 Policy for the Disposal of Regulated Medical Waste

B. CRITERIA TO DETERMINE AND IMPLEMENT CONTROL MEASURES

1. Determination

Whenever possible, MSDSs or HSFSs for chemicals used in the laboratory will be reviewed prior to the use of a chemical. These data, along with information on the conditions under which the chemical is to be used, will generally be used to determine the degree of protection required. In certain circumstances, REHS will conduct exposure monitoring to determine adequacy of controls and to determine if additional control measures are necessary. The following criteria will be used to determine and implement control measures:

- a. Occupational exposure limits [usually an OSHA Action Level (AL) or Permissible Exposure Limit (PEL)], an ACGIH Threshold Limit Value (TLV), or other equivalent standard—Generally, substances with lower exposure limits require higher levels of protection.
- b. Vapor pressure—Generally, substances with higher vapor pressures require higher levels of protection.
- c. Exposure potential—This will be determined by reviewing experimental procedures. Exposure potential is generally increased with increased temperature or pressure, when working with open rather than closed systems, during transfer of materials, during the use of hazardous substances with live animals, etc. Exposure can occur via inhalation, skin contact (with liquid, solid or vapor) or through accidental ingestion. Generally, greater exposure potential requires higher levels of protection.
- d. Exposure monitoring results—REHS can use results of personal or area exposure monitoring to make judgments on appropriate control strategies.

2. Implementation

Once the required degree of control is determined, control measures will be selected from one of the following categories:

a. Engineering Controls

Engineering controls reduce an exposure at its source. Engineering controls are the method of choice for reducing exposures and will be used whenever possible/practicable. Examples of some engineering controls include:

- 1) Substitution of hazardous materials or operations with those which are less hazardous
 - 2) Use of Laboratory fume hoods
 - 3) Use of glove boxes or other enclosures
 - 4) Use of local exhaust ventilation (e.g. “elephant trunks”, slotted exhaust hoods, and canopy hoods).
- b. Administrative Controls

Administrative controls are work practices which are designed to control exposures. Administrative controls will be used in conjunction with engineering controls or when engineering controls are impractical or infeasible. Examples of administrative controls include:

- 1) Limiting time of exposure to maintain levels below acceptable exposure limits
- 2) Utilizing good housekeeping procedures to reduce exposures.
- c. Personal Protective Equipment

Personal protective equipment does not reduce the source of exposure, but rather protects the individual. Personal protective equipment will be used in addition to engineering controls, while engineering controls are being installed or when engineering controls are impractical or infeasible. Some examples of personal protective equipment include:

- 1) Respirators—This includes dust masks, as well as other types of respiratory protective equipment). Because all respirator users must participate in Rutgers respiratory protection program, you must call REHS if you think you have a need for respiratory protection.
- 2) Gloves, aprons, boots, and other skin protection
- 3) Goggles, face shields.

C. DOCUMENTATION THAT FUME HOODS AND OTHER PROTECTIVE EQUIPMENT ARE FUNCTIONING PROPERLY

1. Fume Hoods

All renovated/retrofitted or newly installed fume hoods will be equipped with a flow indicating device. In the absence of such a device, other methods can be used to determine if a fume hood is functioning (e.g. checking the face velocity with small hand-held velocity meter, or by hanging a small piece of tissue, or a “tell-tail” from the sash).

REHS will annually survey all laboratory fume hoods to determine if they are functioning in accordance with University requirements. REHS will post a copy of the survey results on the fume hood and will maintain a copy of the results on file. The Department Chair will also be informed in writing of the results of the survey. Any fume hoods found not to be operating in accordance with these requirements DUE TO THE USER’S ACTIONS (e.g. hood cluttered) will be referred to the user for correction. All other hood malfunctions will be reported to Campus Facilities Operations and Maintenance for repair. Under certain circumstances, fume hoods will be placed out of order by REHS until such repairs can be made.

2. Safety Showers and Eyewashes

All safety shower and eyewash units will be inspected annually by campus Facilities Operations and Maintenance and Maintenance Departments. Safety shower and eyewash units found not to be operating in accordance with University requirements will be repaired immediately. If repairs cannot be made immediately, they will be placed out of order until such repairs are completed.

All inspected units will be tagged with the date of inspection and the initials of the person completing the inspection.

3. Biological Safety Cabinets

All biological safety cabinets at Rutgers University are certified annually or whenever they are relocated. Certification is performed by an outside vendor under contract.

To certify new or relocated cabinets, a request must be made through REHS. REHS notifies the certification contractor of the location of the unit and schedules the certification.

The cost of the initial certification of new or relocated units is the responsibility of the principal investigator. The cost of annual recertification is paid for by REHS.

D. EMPLOYEE INFORMATION AND TRAINING

The intent of the Information and Training Program is to inform workers of the physical agents and hazardous chemicals in their laboratory, and the nature of the risks associated with handling these materials. Before working with any of these hazardous materials, lab workers will be informed of the conditions under

which the materials may be harmful or may cause injury. They will be trained in the proper control methods (engineering, personal protective equipment, etc.) and appropriate procedures necessary to control occupational exposure to hazards in the laboratory. This training is designed to satisfy the requirements of the Public Employees OSHA Occupational Exposure to Hazardous Chemicals in the Laboratories Rule (the Laboratory Standard) and the NJ Worker and Community Right-To-Know (NJ RTK) Act.

The information and training will be provided to University laboratory employees in two separate training sessions. First, a general orientation session will be provided, scheduled, and documented by REHS. The session covers the topics outlined below, under "General Orientation (Classroom Training)". Second, a "hands-on" training session specific to the employee's work area must be scheduled by the employee's Department and given by their lab supervisor or Chemical Hygiene Officer. This session must cover the items listed below, under "Laboratory Training (Hands On/Specific to Work Area)". REHS will provide blank attendance forms to document this "hands-on" training session. However, a copy of the completed Department attendance form must be sent to REHS for compliance documentation.

1. General Orientation (Lecture) - to be provided by REHS
 - a. Regulatory Review - the contents of the Laboratory Standard and the NJ RTK Act will be reviewed, and a copy will be made available in the CHP.
 - b. CHP - The contents of the Chemical Hygiene Plan will be reviewed.
 - c. Physical and Health Hazards - the physical and health hazards of chemical exposure will be reviewed, including, but not limited to: biohazards, carcinogens, compressed gases, corrosives, cryogenic materials, embryotoxins, explosives, flammables, mutagens, oxidizers, poisons, radioactive materials, reactive materials, sensitizers, and teratogens.
 - d. Methods of Determining Exposure - the following methods of determining exposure will be reviewed:
 - 1) Exposure monitoring
 - 2) Evaluation of work practices
 - 3) Use of senses: sight with emphasis on sense of smell and focusing on the odor threshold of materials with poor warning properties.
 - e. Permissible Exposure Limits (PELs) - PELs and other occupational exposure limits will be reviewed. Also, a copy of OSHA Air Contaminants Standards, 29 CFR 1910.1000 is included in the CHP in Appendix 8. If a material is considered hazardous but has no PEL, REHS will help establish controls for working with the material safely.
 - f. Central Files - Employees will be informed that the University maintains, for hazardous materials in the workplace, Material Safety Data Sheets (MSDSs) and Hazardous Substance Fact Sheets (HSFSs) in the Rutgers Environmental Health and Safety (REHS) Department and in all major campus libraries. Employees will be informed of the location and availability of these hazard information resources. Additional reference materials, available in individual departments, on the hazards, safe handling, and storage of hazardous materials will also be discussed.
 - g. Chemical Exposure Prevention - the following exposure prevention mechanisms will be reviewed:
 - 1) Engineering Controls:
 - Substitution - Substitute less hazardous materials for more hazardous material, whenever possible.
 - Isolation/Enclosure - Enclose the lab experiment or procedure; (e.g. utilize glovebox).
 - Ventilation - Remove airborne toxic materials from workers breathing zone through use of local exhaust ventilation (e.g. fume hoods).
 - 2) Administrative Controls - minimize exposure through good housekeeping procedures, by minimizing exposure time, through good work practices.

- 3) Personal Protective Equipment - use of personal protective equipment will be discussed, including: eye and face protection, skin protection (e.g. gloves, aprons, lab coats), and respiratory protection.
2. Laboratory Training (“Hands-On”/Specific to work area) to be provided by laboratory supervisor or principal investigator
 - a. CHP Availability - The location and availability of the Chemical Hygiene Plan (CHP) for individual labs will be reviewed.
 - b. SOPs - Standard Operating Procedures developed for that specific lab will be reviewed.
 - c. Emergency Procedures - Emergency procedures and equipment for the lab (e.g. Location and use of eyewash, safety showers, fire extinguishers, exit routes, etc.) will be reviewed.
 - d. Safety Equipment - Safety equipment used in the lab (e.g. fume hoods, face shields, gloves, etc.) will be reviewed.
 - e. Designated Areas - Designated areas and any special procedures for handling extremely hazardous substances will be reviewed.
 - f. Signs and Symptoms of exposure - Signs and symptoms associated with exposure to materials in the laboratory will be reviewed. In addition, the methods and observations that can be used to detect the presence or release of hazardous materials in the laboratory will again be covered in the hands-on training.

E. LABORATORY OPERATIONS WHICH REQUIRE PRIOR APPROVAL

In general, prior approval must be obtained when a laboratory procedure presents a significant risk of injury, illness, or exposure to hazardous substances. The risk is considered significant when there are very large quantities of particularly hazardous substances involved or the experimental procedures exacerbate the potential for a hazardous condition. Obviously, these conditions must be applied on a case-by-case basis.

Prior Review and Approval by a Principal Investigator

For routine operations, other than those detailed under “Prior Review and Approval by a Unit Safety Committee,” the principal investigator, or someone designated^{AA}. The principal investigator may designate the responsibility for this review to a senior laboratory person. This person must have not only the responsibility for safety in the laboratory, but must also have the authority to enforce and implement safety procedures and policies in the laboratory. by the principal investigator, may review and approve operations by completing the “Safety Review and Approval Checklist,” copy attached. Only principal investigators or their designees who have attended University-sponsored Laboratory Standard Training may review and approve these laboratory operations^{BB}. Until the guidelines become fully operational, this requirement will be waived for those individuals who have not yet received this training, but have attended Rutgers University NJ Right-to-Know training..

Prior Review and Approval by a Unit Safety Committee

The following would require prior approval by the Unit Safety Committee before proceeding with a particular experiment or activity:

- When it is likely that occupational exposure limits^{CC} At Rutgers University, these occupational exposure limits include either Threshold Limit Values (TLVs), which are established by the American Conference of Governmental Industrial Hygienists (ACGIH) or Permissible Exposure Limits (PELs) promulgated by Federal OSHA, whichever is LOWER. could be exceeded or that other harm is likely
- When there is a failure of any of the equipment used in the process that did or could have resulted in injury, illness, or exposure of a laboratory worker to a hazardous material, the Unit Safety Committee must grant approval before the procedure may be undertaken again.
- When any laboratory workers become ill or suspect that they or others have been exposed due to any experimental procedure.

Principal investigators who wish to obtain prior approval from the Unit Safety Committee must provide to the committee the information on the "Request for Prior Approval" form, copy attached. If animals are to be used in this research activity, you must obtain approval from the Rutgers Institutional Review Board for the Use and Care of Animals.

SAFETY REVIEW AND APPROVAL CHECKLIST

Name of Operation:

Location:

Principal Investigator:

Department:

Date ____/____/____

List all individuals who have been trained in this procedure:

General

Provide a brief description of the activity which will be carried out. Activities can include, but are not limited to: a particular reaction, a reaction system, use of a particular chemical, use of addition of new components to a new or old system, initiation of a new research project, or the addition of a new chemical to an old procedure. If available, a copy of the written procedure may be attached to satisfy this requirement.

Question Answer Yes or No

1. Have you identified and addressed all hazards associated with materials, equipment and procedures?

Summarize the hazards which may be encountered, including: toxicity, flammability, pressure, vacuum, temperature extremes, noise, explosivity, etc.

2. Are there written procedures for what you are doing?
3. Are current copies of the most recent MSDSs for the material available?

The information on the MSDS should be reviewed with all individuals who will be involved in this procedure. The MSDS must be readily available.

4. Have all individuals been trained and do they understand the written procedures?
5. Has the potential for emergency situations been addressed (e.g. runaway reaction, loss of temperature control, etc?)
6. Are shut-offs for bottled gases or other critical valves/shut-offs located where they can readily and safely be reached and closed?
7. Are specific emergency shut-down instructions posted and visible?

Post emergency shut-down procedures for all overnight and unattended operations. Ensure that there is a current Caution Sign posted on the laboratory door.

8. Is appropriate protective equipment (e.g. gloves, goggles, face shields, lab coats, etc.) available and being used?

For assistance on selecting proper protective equipment at 932-2550.

9. Are all individuals familiar with what to do in the event of accidental contact (e.g. inhalation, ingestion, skin contact)?

This information is available on the MSDS.

10. Are all individuals familiar with what to do in the event of a spill or other emergency?

This information may be found on an MSDS. Additional information may be obtained by contacting REHS.

11. Are you using the least hazardous materials and minimum practical quantities for your needs?
12. Is appropriate safety equipment available and in working order (e.g. fume hoods, glove boxes etc.)?

If any question above is answered with a "NO", please explain, below. Also, add any additional comments below.

Request for Prior Approval by the Unit Safety Committee

Request for Prior Approval by the Unit Safety Committee

Date of Request _____

Principal Investigator

Department Chair

Department

Building - Room

Phone

CHEMICAL TO BE USED

Name CAS No.

Synonyms

Location of Use

Use Condition

Location of Storage

Period/Frequency of Use

Quantity of be Procured

PERSONNEL PROPOSED FOR THIS PROJECT

EXPERIMENTAL PROCEDURES

Briefly describe the procedures that will involve the use of this material.

CONTROL PROCEDURES

Describe controls that will be employed to protect the individuals participating in this research.

DECONTAMINATION AND DISPOSAL

Decontamination Procedures (surfaces, materials, instruments, equipment, etc.):

Disposal Procedures (wastes and unused stock):

EMERGENCY PROCEDURES

In the event of overt personnel exposure (inhalation, ingestion, inoculation):

In the event of environmental contamination (spill):

In the event of environmental contamination (spill):

MONITORING PROCEDURES (if required by the USC)

Medical and/or personnel monitoring procedures for evidence of personnel exposure

Monitoring procedures to detect environmental contamination

F. MEDICAL CONSULTATIONS AND EXAMS

1. Medical Consultation

A laboratory worker will be offered a medical consultation or examination at no cost under the following circumstances:

- a. If it is likely that the worker will be or has been exposed to a substance at a level in excess of either the OSHA recommended Action Levels, or in their absence, Permissible Exposure Limit (PEL) or the Threshold Limit Value (TLV) recommended by the ACGIH. REHS should be consulted for assistance in assessing the exposure or potential for exposure.
- b. If a laboratory worker develops signs or symptoms associated with exposure to a chemical being used.
- c. In the event of an exposure to chemicals through a spill, explosion, or other accident.

2. Procedure

- a. All medical consultations are provided at no cost through the University Health Center located at each campus. The attending University physician will decide if the person needs to be referred to an area hospital or other such medical facility for further treatment. Off-campus facilities should contact the Occupational Health physician at Hurtado Health center for assistance in arranging for medical surveillance.
- b. In case of exposure to a chemical spill, accident, explosion, etc., or onset of symptoms associated with a chemical being used, the supervisor of the laboratory shall refer the employee to the appropriate health center. If the center is closed or not easily accessible, he/she should be sent to the Emergency Room of the nearest hospital.
- c. The supervisor shall collect as much information as possible about the person, chemical(s) involved, MSDSs and HSFs, symptoms, exposure monitoring results, and other relevant data, and present this information to the physician, if needed.
- d. The physician in charge will inform the employee about the medical examination results, related conditions, tests required, and any follow-up required.
- e. REHS will be advised of the results of relevant tests conducted by the attending University physician.

3. Medical Records

- a. The University physician shall keep written records of all such medical examinations. These records must be maintained for the length of employment plus thirty years.
- b. Such records must contain, but are not limited to, physicians' opinions, recommendations, results of any tests performed and any follow-ups.
- c. Upon written request, such records shall be made available for review by the employee or an authorized representative.
- d. All such records shall be maintained and made available for review in accordance with the OSHA standard 29 CFR 1910.20.

G. PROVISIONS FOR EMPLOYEE PROTECTION WHEN WORKING WITH PARTICULARLY HAZARDOUS SUBSTANCES ; (CARCINOGENS, REPRODUCTIVE TOXINS, SUBSTANCES THAT HAVE A HIGH DEGREE OF ACUTE TOXICITY, AND CHEMICALS OF UNKNOWN TOXICITY)

Consideration will be given to adopt the procedures described in this section as appropriate, when performing laboratory work with any select carcinogen, reproductive toxin, substance that has a high degree of acute toxicity, or a chemical whose toxic properties are unknown.

1. The following definitions apply:
 - a. Select carcinogen: Any substance defined as such in 29 CFR 1910.1450 and any other substance described as such in the applicable MSDS.
 - b. Reproductive toxin: Any substance described as such in the applicable MSDS.
 - c. Substances with a high degree of acute toxicity: Any substance for which the LD50 data described in the applicable MSDS cause the substance to be classified as a "highly toxic chemical" as defined in ANSI Z129.1.** ANSI Z129.1 includes chemicals in any of the following categories:
 - 1) A chemical that has a median lethal dose (LD50) of 50 mg. or less per kg. of body weight when administered orally into albino rats weighing between 200 - 300 grams each, or
 - 2) A chemical that has a median lethal dose (LD50) of 200 mg. or less per kg. of body weight when administered by continuous contact for 24 hours (or less, if death occurs within 24 hours) with the bare skin of albino rabbits weighing between two and three kg. each, or
 - 3) A chemical that has a median lethal concentration (LC50) in air of 200 ppm by volume or less of gas or vapor, or 2 mg. per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less, if death occurs within one hour) to albino rats weighing between 200 and 300 grams each, provided such concentrations and/or conditions are likely to be encountered in a reasonably foreseeable manner.
 - d. Chemical whose toxic properties are unknown: A chemical for which there is no known statistically significant study conducted in accordance with established scientific principles that establish its toxicity.
 - e. For the purposes of this CHP, chemicals in the above four categories will be referred to as "particularly hazardous."
 - f. Designated area: A hood, glove box, portion of a laboratory, or an entire laboratory room designated as the only area where work with quantities of particularly hazardous chemicals shall be conducted.
2. Establish a "designated area" in the laboratory for use of the particularly hazardous substance. Designated areas shall be posted and their boundaries clearly marked. Only those persons trained to work with particularly hazardous chemicals will work with those chemicals in a designated area. All such persons will:
 - a. Use the smallest amount of chemical that is consistent with the requirements of the work to be done.
 - b. Use high-efficiency particulate air (HEPA) filters or high-efficiency scrubber systems to protect vacuum lines and pumps.
 - c. Store particularly hazardous chemicals or remove them from storage.
 - d. Decontaminate a designated area when work is completed.
 - e. Prepare wastes from work with particularly hazardous chemicals for waste disposal in accordance with specific disposal procedures consistent with the Resource Conservation and Recovery Act (RCRA). (For further information on specific disposal requirements, contact REHS)
3. Store all particularly hazardous chemicals in locked and enclosed spaces with slight negative pressure compared to the rest of the building.
4. Because the decontamination of jewelry may be difficult or impossible, avoid wearing jewelry when working in designated areas.
5. Wear long-sleeved disposable clothing and gloves known to resist permeation by the chemicals used when working in designated areas. (For further guidance on selection of protective clothing, contact REHS.)

6. Conduct a “dry run” of procedures involving particularly hazardous substances.

APPENDIX 1**OCCUPATIONAL EXPOSURE TO HAZARDOUS CHEMICALS IN LABORATORIES 29 CFR 1910.1450**

Occupational Exposure to Hazardous Chemicals in Laboratories Rule

(Laboratory Standard)

Regulatory Overview

In February, 1993, New Jersey's Public Employees OSHA adopted 29 CFR 1910.1450, Federal OSHA's "Occupational Exposure to Hazardous Chemicals in Laboratories Rule", (also known as the Laboratory Standard). An overview of the Laboratory Standard, as well as a full copy of the regulation is given in Appendix 1. The purpose of this Guide is to provide a model for the development and implementation of a Chemical Hygiene Plan (CHP) for each university laboratory, as required by the Laboratory Standard.

At Rutgers University, the Laboratory Standard applies to all employees and students engaged in the "laboratory use" of hazardous chemicals. It applies to research and teaching laboratories which are carrying out small-scale operations (those which can be handled safely and easily by one person) using multiple chemicals and procedures, where the procedures are neither a part of, nor simulate, a production process.

Generally, the Laboratory Standard requires:

- 1) **EXPOSURE LIMITS:** For OSHA - regulated substances, adherence to Action Levels, or, in their absence, Permissible Exposure Limits (PELs) for laboratory employees.
- 2) **EXPOSURE DETERMINATION:** Initial monitoring and, when necessary, periodic monitoring of employee exposures to OSHA - regulated substances when there is a reason to believe that an Action Level, or in its absence, a PEL, has been exceeded. Employees must be notified within 15 days of the results of the monitoring.
- 3) **CHEMICAL HYGIENE PLAN:** A Chemical Hygiene Plan must be developed. When implemented, the plan must be capable of protecting employees from health hazards associated with chemicals in the laboratory and must keep exposures below occupational exposure limits.
- 4) **EMPLOYEE INFORMATION AND TRAINING:** Employees must be provided with information and training regarding the requirements of the Laboratory Standard and the Chemical Hygiene Plan, and the hazards of chemicals present in the work area. This training must be provided when an employee is initially assigned to a laboratory area, or when new hazards are introduced.
- 5) **MEDICAL CONSULTATIONS/EXAMINATION:** Laboratory employees shall be provided with medical examinations under the following conditions:
 - When an employee develops signs or symptoms or exposure to a hazardous chemical in the laboratory.
 - When monitoring reveals exposure in excess of an Action Level or PEL.
 - When an event, such as a spill or explosion takes place, where there is a likelihood of exposure.

These examinations shall be provided at no cost to the employee.

- 6) **HAZARD DETERMINATION:** Labels on incoming chemical containers must not be removed or defaced. Material Safety Data Sheets (MSDSs) which are received must be maintained and must be readily accessible to employees. For substances created in the laboratory, a hazard determination must be made.
- 7) **RESPIRATORY PROTECTION:** When respirators are required, they must be maintained and used in accordance with 29 CFR 1910.134.
- 8) **RECORDKEEPING:** Results of exposure monitoring as well as medical consultations and exams must be kept in accordance with 29 CFR 1910.20.

Insert 29 CFR Section 1910.1450

APPENDIX 2**PROCEDURES FOR HANDLING CHEMICAL SPILLS****RESPONSE ACTIONS TO SPILLS/DISCHARGES**

In the event of a spill or discharge of a chemical, one must evaluate whether: 1) the chemical poses a hazard to personnel within the area or the environment, and 2) the chemical can be easily and safely cleaned up.

The attached charts detail response actions for spills or discharges which occur indoors (Spill Chart I) and those which occur outdoors (Spill Chart II). The following instructions are to be used in conjunction with the appropriate chart.

If the spilled material poses a hazard to the personnel in the area or the environment, immediately notify all to evacuate the area and/or building (evacuation procedures are described in Section IV of the Rutgers University Contingency Plan); this can be done verbally or by sounding the fire alarms that are located throughout the building. After evacuation, University Police must be notified as soon as possible.

If the chemical does not pose a threat to the personnel in the area but cannot be easily cleaned up, immediately place paper towels or other absorbents to stop or block the flow (only for liquid), notify the people in the immediate area, then notify University Police and then REHS.

When calling, be sure that you have all the pertinent information to give to the Police.

This would include:

1. The chemical substance involved in the release, if known.
2. An estimate of the quantity.
3. The time and duration of the release, if known.
4. The location of the release, where and onto what surface.
5. Any known or anticipated acute or chronic health risks associated with the spill/discharge, if known.
6. Proper precautions to take as a result of the release, including evacuation, if known.
7. The names and telephone numbers of the person(s) to be contacted for further information.

Radioactive substances are not covered under the federal spill-reporting requirements; if radioactive substances are released to the environment, contact REHS, who will notify the EPA Radiological Response Coordinator.

NOTIFICATION AFTER 5:00 PM

Contact University Police, who will notify a representative of the Rutgers Environmental Health and Safety (REHS) Department. The main function of REHS is to coordinate all actions pertaining to the spill incident. REHS will coordinate and manage the containment and clean-up of the spilled or discharged material and contact the various agencies requiring immediate verbal notification.

EMERGENCY TELEPHONE NUMBERS

New Brunswick and Piscataway Campus Police: 6-911 or 932- 7211 (24 hours) Newark Campus Police: (973) 353-5111 or dial 80 Camden Campus Police: (609) 225-6111 or dial 8 REHS: 932-2550 (8 AM to 5 PM) INSERT SPILL CHART I
INSERT SPILL CHART II

APPENDIX 3

CAUTION SIGN PROGRAM

Insert Caution sign, 3 pages and 1 blank.

APPENDIX 4

ACCIDENT REPORT FORM

Insert 2 page Accident form.

APPENDIX 5**APPENDIX 5 POLICY FOR DISPOSAL OF LABORATORY GLASS**

The purpose of this policy is to ensure the safe disposal of all laboratory glass, which includes preventing injuries to anyone who must handle discarded glass. This policy applies to all laboratory glass, intact as well as broken, except for radioisotope-contaminated glass and Regulated Medical Waste (RMW) contaminated glass, which are covered under the radioactive waste and RMW disposal procedures, respectively.

A. Procedure

Place all glass, intact as well as and broken, into a specially marked rigid container designed for this purpose (refer to "Specifications" section, below). A properly labeled thick-walled, rigid cardboard container may be substituted. The container must be able to withstand penetration by the sharps it contains, and must be lined with a leak-resistant liner (e.g. a polyethylene or polypropylene bag). Seal the container and clearly mark it "BROKEN GLASS" to describe its contents.

Rinse all empty hazardous chemical containers three times with small amounts of a suitable solvent or appropriate detergent solution (triple-rinsing) before discarding. The solvent may be any liquid which is effective (e.g., water or water-detergent solutions effectively clean water-soluble substances and water-dispersible substances; mineral spirits is useful in dissolving many oily materials). Collect the rinsate for disposal as a hazardous material (Refer to the POLICY FOR THE DISPOSAL OF CHEMICALS). Then deface or remove all labels. After this step, they may be discarded as ordinary trash.

Seal filled glass-disposal containers before placing them for disposal. Ordinary, uncontaminated, discarded glass, when packed in its special container, may be disposed of with the regular trash. If a container of ordinary non-contaminated glass is so heavy or bulky that special handling is required, call Custodial Services for proper disposal. They can be reached by dialing the Service Desk Number under the appropriate Campus Maintenance Section of Facilities.

Do not put glass originating in the laboratory into a recycling container.

B. Specifications—Glass disposal containers

1. Table Model 8" x 8" x 10", with cover. Fisher Catalogue No. 12-009-7B
2. Floor Model 12" x 12" x 27", with cover. Fisher Catalogue No. 12-009-7A

These items are available for purchase from the University Fisher Scientific Representative.

APPENDIX 6**APPENDIX 6 POLICY FOR THE DISPOSAL OF CHEMICALS POLICY FOR THE DISPOSAL OF CHEMICALS****A. POLICY FOR DISPOSAL OF CHEMICALS**

The collection of all unwanted chemicals is routinely coordinated by Rutgers Environmental Health and Safety (REHS). You are encouraged to recycle chemicals that are usable within your department. REHS will also collect and offer chemicals for recycling. A recyclable chemical inventory will be distributed periodically.

These procedures must be followed for disposal of unwanted chemicals. They apply to chemicals that REHS does not authorize for disposal with the regular trash, or, in a very few instances, those which may be poured down the drain. Refer to the drain disposal policy for a list of chemicals that can be disposed of via the sanitary sewer system. The policy discussed below, however, does not apply to radioactive, biohazardous, or Regulated Medical Waste (RMW) disposal, each of which is covered by a separate policy.

1. Procedures

- a. Chemicals must be collected in individual, leakproof, sealed containers. Glass containers may be safely used for virtually anything, except hydrofluoric acid, acidic fluoride salts, and very strong alkalis. The chemicals must be compatible with the container material (e.g. acids must not be placed in a steel container, alkalis must not be placed in an aluminum container).
- b. Select the smallest container available that will properly hold the material, allowing sufficient headspace above the surface of the liquid to allow room for expansion. This makes for economy and efficiency. Five gallon pails and fifty-five gallon drums are available from REHS, as required. Do not use your own pails or drums without prior approval from REHS; they may not meet US Department of Transportation requirements.
- c. All containers must be identified and labeled with the chemical name of the substance. Trade names, acronyms, abbreviations, codes, or formulas are not acceptable.
- d. All 'spent' chemical waste (waste which cannot possibly be recycled as a result either of several substances having been mixed together or a substance being contaminated) must have a HAZARDOUS WASTE LABEL affixed to its container prior to use. HAZARDOUS WASTE LABELS can be obtained by calling REHS. These labels must not be put on bottles containing pure chemicals, as these materials may be recycled. (A copy of this label is attached.)
- e. Each component of a mixture of chemicals in a container must be identified on its label, along with its corresponding concentration. The units of concentration must be on the label together with their numerical values. When the solute is either a liquid or a gas, concentrations may not be expressed simply as 'percent' but must be given as either a 'weight percent' or a 'volume percent'.
- f. Substances which are unidentified (unknowns) cannot be accepted for collection by REHS. This stems from regulations requiring waste haulers to accept only identified materials. Responsibility for establishing the identity of an 'unknown' rests with the department wishing to dispose of it. REHS will, on request, furnish the names of state-certified analytical laboratories.
- g. When the 'spent' chemical waste container becomes full, enter the "accumulation start date" on the Hazardous Waste Label. The New Jersey Hazardous Waste Regulations define "accumulation start date" as the date at which the container is completely full and storage of the container has begun. The New Jersey Department of Environmental Protection requires that full containers of 'spent' waste be removed to an approved Storage and Disposal Facility within 90 days after this date. The date upon which each period of accumulation for storage (as defined above) begins must be clearly marked, and the label must be easily visible for inspection.
- h. Removal of unwanted chemicals will be arranged by REHS. Complete and submit a REQUEST FOR HAZARDOUS WASTE DISPOSAL form to REHS, Building 4127, Livingston Campus. (See copy of form attached.) A REHS staff representative will then schedule the removal of the chemicals from your laboratory.
- k. Broken or intact hypodermic needles or syringes that are contaminated by chemicals or that have been used in chemical laboratories only for 'chemical procedures', such as removal of a solution from a vial through a septum or

adding liquid to a gas chromatograph must be disposed of, according to law, by the procedure described in POLICY FOR THE DISPOSAL OF REGULATED MEDICAL WASTE as over-classified medical waste.

2. Laboratory/central Waste Storage Requirements

- a. Daily inspections (working days only) of the chemical hazardous waste containers in both the laboratory or in designated central waste storage areas must be performed, looking for leaks and for deterioration caused by corrosion and other factors. Inspection sheets for inspecting designated central waste storage and laboratory areas can be obtained by calling REHS at (732) 932-2550.
- b. Containerized hazardous waste must be segregated in storage by waste type. Containerized hazardous waste must not only be segregated in and before transportation according to general waste type, e.g. flammables, poisons, and acids, but must be so arranged that incompatible substances cannot mix. Incompatibles must be kept apart. Incompatible substances are those pairs of substances that, when mixed, either react violently or evolve flammable or poisonous gases or vapors.

Below are a few general principles that must be followed in the safe storage and shipping of chemicals:

- 1) Keep acids and bases apart.
 - 2) Keep acids apart from cyanides or sulfides.
 - 3) Acids should never be put into steel containers, e.g. cans or drums.
 - 4) Glass bottles and jars are inert to nearly any chemical except for hydrofluoric acid and some acidic fluorides. (They are also somewhat etched by concentrated aqueous solutions of strong alkalis.)
 - 5) Organic acid halides, organic acid anhydrides, inorganic acid anhydrides, e.g. phosphoric anhydride (phosphorous pentoxide) and anhydrous strongly acidic salts (such as aluminum chloride, ferric chloride) must all be treated as water-reactives and strong acids. They must be kept apart from both alkalis and water.
 - 6) Oxidizing agents must be kept apart from reducing agents; they often react violently when mixed. Oxidizing agents include hydrogen peroxide, chromium trioxide, potassium permanganate, sodium chlorate, and sodium nitrate. Three particularly potent oxidizing agents are perchloric acid, nitric acid, and sodium dichromate-sulfuric acid mixtures (e.g., ChromergeR). Reducing agents include metals and nearly all organic compounds and solvents.
 - 7) Water-reactives must be stored apart from water, aqueous solutions, and acids. Care must be taken so that the containers in which they are shipped do not break or leak.
 - 8) Air-reactive chemicals must be packed in containers that are sealed off from the atmosphere. Quite often these containers are sealed glass ampules or bulbs. Particular care must be taken when packing and unpacking them or handling them so they are not broken. In the case of certain air-reactive gases, the container is usually a compressed gas cylinder or lecture bottle; air-reactive liquids and solids are often sent in sealed glass ampules. and solids
 - 9) Explosive materials and shock-sensitive substances present special risks that require special packaging, shipping, and handling. Consult with REHS before handling or shipping them for disposal.
- c. Every container must be arranged so that its identification label is readily visible.
 - d. Hazardous waste must not be placed in an unwashed container in which an incompatible waste has previously been stored.

For more information on chemical disposal, call REHS (732) 932-2550.

Page ___ of ___ DATE OF PICK-UP _____ DESTINATION OF PICK-UP _____

REQUEST FOR HAZARDOUS WASTE DISPOSAL

Requester Bldg Date

Telephone Department List

Substance Location: Building Room Campus

A. NAME OF CHEMICAL(S) B. HAZARD C. QUANTITY OTHER (NO FORMULAS) CLASS INFORMATION

Send to: Rutgers Environmental Health & Safety (REHS) Department Building 4127 Livingston Campus
hf\hazmat- 9/92, 5/93

REQUEST FOR HAZARDOUS WASTE DISPOSAL

Instructions for Completing

- I. The Requester is the person who is responsible for the generation of the waste.
 - II. This request form is to be completed by the requester.
 - III. A. The correct chemical name or names should be written on the form and the waste labels to identify the material. Chemical formulas and trade names are not acceptable. i.e. Methylene Chloride, not CH₂Cl₂.
- B. For mixtures of liquids, all constituents must be listed on the form as well as the waste label and add up to 100%. Solutions of solids or gases in liquids must be expressed in concentrations of either weight percent, molarity (moles per liter), or normality (equivalents/liter).
- C. List each hazard presented by the substance, by using the corresponding letter shown below:
- C - Corrosive O - Oxidizer
 - E - Explosive P - Poison
 - F - Flammable R - Reactive
- D. Fill in the unit used to record the amount of substance listed, such as gram, ml, liter, gallon, pound.

PLEASE XEROX THIS FORM FOR FUTURE USE

When a supply of labels is needed or when questions arise, call 932-2550.

The completed form should be folded and returned to Rutgers Environmental Health and Safety Department at this address:

RUTGERS, THE STATE UNIVERSITY RUTGERS ENVIRONMENTAL HEALTH & SAFETY LIVINGSTON BUILDING
4127 NEW BRUNSWICK, NJ 08903-5077

SWS/pv hf\hazmat-1 4/86, 5/93

3. Disposal of empty containers and other equipment

Empty bottles or cans that have contained hazardous substances and are to be discarded must be rinsed three times with a suitable solvent. Destroy or deface the label so as to make it illegible and destroy the cap to prevent its reuse. Place in a proper waste container (glass, metal, etc.), separate from regular room trash. They must not be placed in recycling bins. No item of laboratory glassware or any chemical container may ever be put in the ALUMINUM AND GLASS Recycling Bins.

Broken glass and other sharp or hazardous objects must be placed in their own appropriate specially marked rigid containers. Hypodermic needles and syringes (including those used to introduce samples for gas chromatographic analysis) and scalpel blades must be disposed of in a container specially designed for this purpose. Discarded glassware, broken as well as unbroken, must be put into special puncture-resistant cartons marked "Broken Glass." These special containers prevent sharp objects from poking through and protect physical plant personnel and others

who must handle the trash. Waste paper baskets and plastic trash bags are to be used only for waste paper and other office trash.

It must be emphasized that no item of laboratory glassware or any chemical container may ever be put in the ALUMINUM AND GLASS Recycling Bins. The only glass permitted in those Recycling Bins are jars and bottles that have contained only edibles—food and beverages.

B. POLICY FOR DRAIN-DISPOSABLE SUBSTANCES

Research and instruction in laboratories continually produces small amounts of aqueous wastes. In such cases, laboratory workers must decide whether to pour particular solutions down the drain or keep them for pick-up by REHS personnel. This guide will help them make such decisions.

1. General

Generally, unwanted chemicals are collected by REHS for disposal. This is done in accordance with Section A. "Policy for the Disposal of Chemicals." Certain materials are suitable for drain disposal. These should be carefully considered to ensure they do not cause damage to the plumbing system or cause other problems such as odors in a building. Materials which are suitable for drain disposal are listed in the table which follows. Other materials are prohibited from drain disposal without prior approval from REHS. If you have questions about the suitability of other materials for drain disposal, or about the proper disposal of any laboratory material, please contact REHS at 932-2550.

2. Drain disposal of dilute acids and alkalis

Acids and alkalis which have been rendered neutral by the experimental process may be discarded by drain disposal. Proper care must be taken to adjust the solutions to a pH of between 6 and 9. Generally, 1N hydrochloric acid can be used to neutralize alkaline materials and 1N sodium hydroxide can be used to neutralize acid materials. Remember to SLOWLY add the acid to the water or alkali, not vice versa. Drain disposal is properly done in the following manner:

- a. Protective gear (gloves, laboratory apron, and safety goggles) must be worn.
- b. Before pouring the solution, turn on the tap to get a good flow of water to wash it down. Also, make sure that the sink and drain lines are washed free of any substances that will generate noxious gases when mixed with the solutions. Such substances include cyanides, sulfides, bisulfides, sulfites, bisulfites, nitrates, and nitrites.
- c. Pour the solution down the drain slowly, making sure that before, during and after pouring, the tap is turned on to provide a strong flow of water that aids in washing it down the drain.

TABLE 1

DRAIN-DISPOSABLE SUBSTANCES , list of

SOLUTIONS ADJUSTED TO A pH OF 6-9 POLYHYDROX- ALCOHOLS hydrobromic acid sodium hydroxide 1,2-propylene glycol hydrochloric acid potassium hydroxide glycerol (glycerine) hydriodic acid ammonium hydroxide mannitol nitric acid potassium carbonate sorbitol phosphoric acid (potash) phosphorous acid sodium carbonate sulfuric acid (soda ash) acetic acid sodium pyrophosphate formic acid trisodium phosphate

ALL NATURALLY-OCCURRING ALL VITAMINS AMINO ACIDS ALL SUGARS l-ascorbic acid (vitamin C) alanine arabinose choline cysteine fructose inositol glycine galactose nicotinic acid (niacin) histidine glucose pantothenic acid leucine lactose pyridoxine (vitamin B6) lysine maltose riboflavin (vitamin B2) serine sucrose thiamine (vitamin B1) tryptophan tyrosine

CHEMICALS* COMMONLY USED ON THE FARM AND IN THE HOUSEHOLD (No pesticides of any kind) acetylsalicylic acid casein sodium bicarbonate (aspirin) citric acid (sour salt) alum corn syrup sodium bisulfate (sodium aluminum sulfate) dextrin sodium bitartrate ammonium alum gelatin sodium carboxy - (ammonium aluminum

sulfate) methylcellulose magnesium sulfate sodium chloride borax (sodium tetra- (Epsom salt) sodium citrate borate decahydrate) potassium aluminum sulfate sodium dihydrogen (potassium alum) phosphate boric acid sodium hypochlorite calcium chloride potassium bitartrate sodium mono- (cream of tartar) hydrogen phosphate calcium phosphate, monobasic sodium nitrate calcium superphosphate sodium potassium calcium triple superphosphate tartrate (Rochelle salt) sodium silicate sodium sulfate

(Glauber's salt) urea * for any chemical containing sodium, the corresponding potassium or ammonium compound may be substituted.

APPENDIX 7**POLICY FOR THE DISPOSAL OF REGULATED MEDICAL WASTE (RMW)**

The following instructions are for generators of Regulated Medical Waste (RMW). These instructions are summarized from "The Policy for the Disposal of Regulated Medical Waste." All generators of RMW must attend a RMW Orientation session provided by Rutgers Environmental Health and Safety (REHS).

A. Definition of RMW

The NJ Regulated Medical Waste Act of 1989 defines RMW as solid waste generated from one of the processes listed below, which ALSO fits the description of any of the seven classes of waste listed below.

RMW is any solid waste generated:

- in the diagnosis, treatment or immunization of humans or animals,
- in research pertaining to the above, OR
- in the production or testing of biologicals¹ AND which also fits into any of the seven classes listed below:
 - Class 1: Cultures and Stocks
 - Class 2: Pathological Wastes
 - Class 3: Human Blood & Blood Products
 - Class 4: Sharps
 - Class 5: Animal Waste
 - Class 6: Isolation Waste
 - Class 7: Unused Sharps

B. Overclassified RMW

Overclassified RMW is material which resembles RMW, which does not meet the