Equipment and Safety Manual

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INTRODUCTION

Student construction of experiments is a valued part of the Herrick Lab tradition. This Manual is designed for Herrick Laboratory and is intended to be passed on to successive students, faculty and technical personnel, this process provides continuity and a basic level of safety knowledge. Don't hesitate to add legible notes of the unique features of your work for future researchers. Learning by 'trial and error' can be dangerous.

Any questions or comments regarding this manual should be directed to Ron Evans, Supervisor of Technical Services, Ray W. Herrick Laboratory, Purdue University. 765-494-2142 or e-mail evans@purdue.edu.

General Safety Information

All students and faculty members doing any experimental work in the Herrick Laboratories are required to under go a "SAFETY CHECK" of any of the following before operation:

1. New experimental apparatus or processes.
2. Any modification to existing apparatus.
3. Any change in apparatus operators.
4. Any change in chemicals or materials involved.
5. New student safety checks and up-dates to existing experimental setups.

A detailed discussion of SAFETY CHECKS are covered later in this document.

Recognize a hazard or unsafe practice. Learn the basics of hazard recognition. For instance, know the correct way to use tools, equipment and instruments and be able to determine when things need repair. Shop personnel are available to help you.

Know how to correct the situation. This does not necessarily mean 'fix it yourself'. It's important to know which individual is responsible for the equipment or part of the building in question.
Problems should be brought to the attention of Technical Services Shop personnel.

Bob Brown is our Building Deputy
Ron Evans and Bob Brown are Safety Coordinators

Act to correct the situation. This is the most important step of all. The knowledge that other people saw the hazard too is of no consolation to the person who was just injured by that hazard. Take the time to point out an unsafe practice to a fellow student. Students who work in each area of the Lab are often most familiar with the space. Please report potentially unsafe equipment or facilities to Technical Services. An E-Mail note is preferred along with a verbal report. If you do not get satisfaction from your initial contact, call Bob Brown or Ron Evans. Discontinue the use of defective or unsafe equipment as soon as the defect becomes known.

University Policies

Safety Policy

Purdue University is committed to a safe and healthy environment for all employees, students, and visitors. The University is also required by law to bring to your attention two significant legislative acts

dealing with safety.

1. The Williams-Steiger Occupational Safety and Health Act (OSHA) was signed into law in 1971. In 1973, the Indiana Occupational Safety and Health Act brought all state institutions under the safety and health guidelines set forth by federal OSHA laws.

2. Indiana Law P.L. 241 states: "Sec. 3.1- Every employer shall comply with the occupational health and safety standards promulgated under this chapter, and pursuant to any directions is such standards, keep his employees informed of their rights and obligations under the act."

3. NEC, the National Electric Code, is a regionally adoptable standard for the safe installation of electrical wiring and equipment in the United States.

Employer Responsibilities

1. Establish and maintain conditions of work which are reasonably safe and healthful for employees and free from recognized hazards that are causing or likely to cause death or serious physical harm to employees.

2. Comply with the specific safety and health standards issued by the Department of Labor.

Employee Responsibilities and Rights

1. Comply with safety and health standards, rules, regulations, and orders applicable to his or her conduct. This means attend RTK and safety instruction as soon as you join the lab.

2. May not be discharged or discriminated against in any way for filing safety and health complaints or otherwise exercising their rights under the act.

Accidents

If a serious injury occurs, immediately dial the '911' emergency phone number. All Public Safety personnel are trained first aiders and will also arrange for transport to a hospital or to the Student Health Center. Attempts to move an injured person can cause further injury, especially to the spine and neck. Never move a person suspected of serious injury unless it is a life threatening situation such as fire. Try to keep the victim warm and still.

Because of infection, minor cuts have the potential to become more serious. Wounds should be washed and dressed as soon as possible. First Aid kits are attached to the walls in both the East and West Wings. During normal hours help is available from the shop. You have the option to visit the Student Health Center which is open 24 hours.

Report accidents to Technical Services for further investigation and completion of the necessary documentation. 'Near miss' incidents which had the potential for serious injury should also be reported. The purpose is not to fix blame but to make the lab a safer place.

Fire and Fire Related Emergencies

If you discover a fire or fire related emergency such as abnormal heating of material, hazardous gas leaks, hazardous material or flammable liquid spill, smoke, or odor of burning, immediately follow these procedures:

* Activate the building fire alarm system (fire pull station). If not available or operational, verbally notify persons in the building

* Call 911 to notify the Fire Department

* Isolate the area and evacuate the building

1. Shut down equipment in the immediate area, if possible
2. Close doors to isolate the area
3. Use a portable fire extinguisher to:
4. Evacuate yourself
5. Assist others to evacuate
6. Control a small fire, if possible

NOTE: You are not required to use a fire extinguisher.

* Provide the fire/police teams with the details of the problem upon their arrival. Special hazard information you may know is essential.

If fire alarms are ringing in your building:

1. evacuate the building.
2. move at least 200 feet away from the building.
3. stay clear of driveways, sidewalks and other access ways to the building.
4. try to account for all employees and report any missing persons to the emergency personnel at the scene.
5. Assist emergency personnel, as requested.
6. Do not re-enter the building until directed to do so.

Drugs and Alcohol

Use of drugs or alcohol is forbidden in the Lab. Impaired reflexes and judgment can be deadly around electricity, power tools, and ladders.

UNIVERSITY HAZARD COMMUNICATION PROGRAM

The OSHA Hazard Communication Standard

Employees have the right to know the hazards of the chemicals and products in their work areas. The Hazard Communication Standard (29 CFR 1910.1200) was initially promulgated in 1983 to protect employees handling chemicals in the manufacturing sector (Standard Industrial Classification, SIC, codes 20-39). The standard was expanded to cover the non-manufacturing sector, including universities. In Indiana, the compliance date for the non-manufacturing sector was August 1, 1988. The standard was additionally updated in 1994.

The law applies to all University employees who work with or supervise operations involving hazardous chemicals. The law covers all hazardous chemicals, regardless of quantity.

The law requires that all employees be informed about the known hazards associated with the chemicals to which they may be exposed. The law also requires that information about the chemicals be readily accessible during all work shifts. This information is typically contained on Safety Data Sheets or SDSs (new universal standard).

For all University work areas, with the exception of laboratories, the following requirements must be met:

1. An inventory of hazardous chemicals in the work area shall be made.
2. Safety data sheets shall be obtained for all hazardous chemicals used or stored in the work area, and copies of these data sheets shall be maintained readily accessible to all employees during all work shifts.
3. All hazardous chemicals shall be properly labeled.
4. Employees shall be provided training on the right-to-know program and hazardous chemicals in their work area. This training shall include details on the written hazard communication program, information on SDSs and where they are located, information on the employer's labeling system, information on methods used to detect the presence or release of a hazardous chemical, and information on methods and equipment required to protect themselves from hazardous chemical exposures.

For laboratory areas, the hazard communication standard requires the following:

1. Labels on incoming materials shall not to be removed or defaced.

2. SDSs, which are received with incoming shipments, shall be maintained and made readily accessible to the laboratory employees.

3. Laboratory employees shall be informed of the known hazards of the chemicals in their work areas, of methods to detect the presence or release of a hazardous chemical, and of methods and equipment required to protect themselves from the hazard.

4. Laboratory employees must comply with the provisions of the Purdue University Chemical Hygiene Plan. Contact Radiological and Environmental Management (REM) for additional information (49-46371).

<u>Employee information and training must be provided at the time of initial assignment to a work area, or whenever a new hazard is introduced into the work area.</u>

Employee Rights and Responsibilities

Employees have the right to file a complaint with IOSHA if they feel they are being exposed to an unsafe work place practices or conditions. They also cannot be discharged, suspended, or otherwise discriminated against by their employer because of their filing a complaint, or exercising their rights under the law.

Employees have the responsibility to attend the training seminars on the Hazard Communication Standard and to stay informed about the chemicals used on the job. They have the responsibility to use work practices and protective equipment required for safe performance of their job. Finally they have the responsibility to inform their supervisors of accidents and conditions or work practices they believe to be a hazard to their health or to the health of other individuals.

Purdue University Right-to-Know Program

The Department of Radiological and Environmental Management (REM) is located in Hampton Hall of Civil Engineering (HAMP B173, extension 46371) and they are responsible for development, initial implementation, and oversight of the program for compliance with the law. REM can establish health and safety work rules for work areas or departments. Failure to observe work rules, regardless of their origin, can result in disciplinary action. Each department head is responsible for implementing and maintaining the program in their respective work areas (i.e., offices, stockrooms, farms, maintenance shops, building services, etc.). For more efficient implementation of the program, department heads should select one or more individuals to serve as coordinators. These coordinators are referred to as designated trained individuals or (DTI). Bob Brown and Ron Evans (shop personnel) are the DTIs for the Herrick Laboratory.

The DTIs are responsible for ensuring that chemical inventories are completed for each work area under their control and that SDSs are collected for each chemical on the inventory. DTIs are responsible for ensuring that SDSs are readily accessible to all employees working in the area during all work shifts. DTIs are responsible for ensuring chemicals are properly labeled in their work area. Finally, DTIs are required to provide appropriate training to the work area employees. For a complete description of the DTI's responsibilities and duties refer to the University's Right-To-Know Compliance Manual. Copies are available from the Herrick Lab Shop.

While Undergraduate students are not covered under the provisions of the Hazard Communication Standard, these students shall be made aware of chemical health and safety hazards in classroom situations and shall be provided with information and equipment to protect themselves from the hazards. Departments should provide student training at the beginning of each course in which hazardous chemicals are used. Specific safety instructions should be provided at the beginning of each class period.

Employee Training

Employees must know the known physical and health hazards associated with the chemicals in their work areas. Graduate Research Assistants are employees! They must be told about the University's Right-To-Know program and where a copy of the RTK Compliance Manual is located. They should know how to obtain SDSs and other hazard information and should know the labeling system used at the University.

Employees must also be informed about the measures they can take to protect themselves from the hazards associated with their work. This protection may include specific work practices, personal protective equipment, emergency procedures, and methods and observations which may be used to detect the release of a chemical.

Right-to-Know The DTI has primary responsibility for conducting employee training. General information on the Right-To-Know Program may be conveyed by the use of this booklet. Specific work area information will be provided by the DTI. Initial Comprehensive Training sessions are available on the WEB by accessing the website https://web.ics.purdue.edu/~hebentle/TrainLocal/Purdue%20HCP4.0/Purdue%20HCP4.0.htm.

For yearly renewal, visit this website for the Awareness Training https://web.ics.purdue.edu/~hebentle/TrainLocal/Purdue%20office%20HCP4.0/Purdue%20office%20HCP4.0.htm.
Upon completion of the online training, your quiz grades will be emailed to Bob Brown. Everyone new to the lab are also required **to attend a short one-on-one meeting with Bob Brown soon after arrival for further specific safety training and to sign a required Documentation of Training record for the University.**

If you have any questions concerning this or any other safety related item, please contact me in Rm 55 HERL, by email rbrown@purdue.edu, or at 494-2142

Employees must be provided effective information and training on the hazardous chemicals in their work area at the time of initial assignment, and whenever a new physical or health hazard the employees have not previously been trained about is introduced into their work area. Information and training may be designed to cover categories of hazards (e.g., flammability, carcinogenicity) or specific chemicals. Chemical-specific information must always be available through labels and SDSs. There is no grace period for conducting training.

Safety Data Sheets (SDS)

A Safety Data Sheet (SDS) is a document containing chemical hazard and safe handling information and is prepared in accordance with the OSHA Hazard Communication Standard. An SDS shall be obtained for each hazardous material listed on the chemical inventory where inventories are required.

Chemical manufacturers and distributors must provide the purchasers of hazardous chemicals an appropriate SDS for each hazardous chemical/product purchased.

If an SDS was not provided with the shipment of a hazardous chemical, the supervisory staff should request one in writing from the manufacturer or distributor in a timely manner. The supervisory staff shall assure the SDSs on file are current. SDSs must be readily accessible to all employees during all

work shifts.

SDS's for Herrick Laboratory are available 24 hours a day at the Safety bulletin board located near the Shop next to the Coke machine. Other copies are available from the shop. The Herrick Chemical Inventory is part of the SDS documentation. The inventory and SDS files are maintained on a weekly basis.

Each department within the Department of Radiological and Environmental Management (REM), is responsible for maintaining their own SDSs, and most of the time they are available online from the manufacturer. The supervisory staff shall also assure a work area SDS file is maintained for individual work areas. If you want to review an SDS, contact your supervisor, instructor, DTI, or REM. If you need an SDS for your work area file, contact the chemical supplier or REM.

Reading SDSs

Guidelines for reading and understanding an SDS section by section is included as part of your Right-to-Know Training Class. You can also find this information in Appendix C, page 36 of the Purdue Right-To-Know and Hazardous Materials Safety Manual. Copies are available from the Herrick Labs Shop. Computer based interactive training is available on-line at http://www.free-training.com. Your log-on, carryout time and quiz scores will be emailed to Bob Brown, and will become part of your personal safety training record.

Labels and Other Forms of Warning

It is University policy that all containers of hazardous chemicals be correctly labeled as described in this section.

Each original shipment container, portable container, and stationary process container shall include the appropriate hazard warning for each chemical, or mixture as a whole, based on the method of hazard determination (29 CFR 1910.1200(d)(2) Appendix B). Specifically, each original incoming container shall be labeled, tagged, or marked by the manufacturer /distributor with, at least, the following information:

* Identity of the hazardous chemical(s) (identity means the trade name or the chemical name as given on the SDS and as listed in the chemical inventory list).
* The appropriate hazard warning, including health, flammability, reactivity, and PPE data.
* Name and address of the chemical's manufacturer, importer, or other responsible party.

Chemical containers, both hazardous and non-hazardous, must be inspected by the immediate supervisor to ensure that they are properly labeled upon arrival at the University. Incorrectly labeled containers should be corrected immediately.

Alternatives and allowable exceptions to the above labeling requirement at Purdue University are:

* For stationary process containers (i.e. 55 gallon drums, 33 gallon drums, 5 gallon carboys), alternate identification methods may be used if the hazards of the chemical (as specified in 29 CFR 1910.1200(f)(4)) are effectively conveyed to the employee. Alternate methods of labeling are signs, placards, batch tickets (tags). A numbering or lettering system may be an acceptable form of identification on the above type of labels. However, all employees must know this method of identification, and know where to find the SDSs in their work areas during each work shift.

* Non-laboratory containers that are used for carrying, daily use, and/or storing chemicals (safety cans, plastic bottles, etc.) shall be labeled with the name of the material as found on the SDS or on the original shipment container. Hazard warnings do not have to be included if the primary container or SDS is located in the same area as the carrying, storing, or daily use containers, and if the primary container is identified with the appropriate hazard warnings (health, reactivity, flammability, PPE).

* Laboratory containers, including bottles, beakers, flasks, sample vials, etc., should be marked, labeled, or coded in all cases. This will aid in preventing any confusion about what chemical is in the container. The label should also be dated and should identify the owner of the material.

* Existing labels on incoming containers shall not be removed or defaced unless appropriately relabeled immediately with the required information. Damaged or illegible labels on any container shall be replaced.

* Labels and other forms of warnings must be legible, in English, and prominently displayed on the containers.

Hazardous Chemicals

The Hazard Communication Standard defines a hazardous chemical as any element, chemical compound, or mixture of elements and/or compounds which is a physical hazard or a health hazard.

A chemical is a physical hazard if there is scientifically valid evidence that it is a combustible liquid, a compressed gas, an explosive, a flammable, an organic peroxide, an oxidizer, pyrophoric, reactive (unstable material), or water reactive.

A chemical is a health hazard if there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. Included are:

* carcinogens
* reproductive toxins
* sensitizes
* neurotoxins (nerve)
* hepatotoxins (liver)
* agents that act on the hematopoietic system (blood)
* agents that damage the lungs, skin, eyes, or mucous membranes
* irritants
* corrosives
* radioactive material
* biohazards
* nephrotoxins (kidney)

A chemical is considered a carcinogen or potential carcinogen if it is so identified in any of the following:

* Nationals Toxicology Program, "Annual Report of Carcinogens (latest edition)
* International Agency for Research on Cancer, "Monographs" (latest edition)
* OSHA, 29 CFR 1910, Subpart Z, Toxic and Hazard Substances

A chemical is considered hazardous if it is listed in any of the following:

* OSHA, 29 CFR 1910, Subpart Z, Toxic and Hazardous Substances
* "Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment", ACGIH (latest edition)
* "The Registry of Toxic Effects of Chemical Substances", NIOSH (latest edition)

In most cases, the label will indicate if the chemical is hazardous. Look for key words like caution,

hazardous, toxic, dangerous, corrosive irritant, carcinogen, etc. Old containers of hazardous chemicals (before1985) may not contain hazard warnings. If you are not sure a chemical you are using is hazardous, review the Safety Data Sheet (SDS) or contact your DTI (Ron Evans or Bob Brown), or the Department of Radiological and Environmental Management (REM).

Chemical Inventory

For each work area, an inventory of the chemicals and/or chemical products used or stored shall be completed using Form HCP-4. The inventory shall include the storage location of the reported materials, and should include an estimation of the quantity used during the year. Chemical inventories should be updated on an annual basis. Copies of inventories should be provided to REM. For non-laboratory areas, chemical inventories shall be maintained in the work area with the RTK Compliance Manual.

Do not bring any chemicals into the Herrick Laboratories unless you have notified the DTIs (Ron Evans or Bob Brown)

Safe Handling of Chemicals

Know the safety and health hazards associated with the chemical(s) you are using. Consider the physical state (gas, liquid, or solid) of the material(s). Consider the process in which you are using the chemical(s), the facilities you have for storage of the materials, and the facilities and equipment you may need to handle an emergency. Know the procedures necessary for safe disposal of the chemicals.

Questions you should consider and answer for a safety check:

1. Is the material flammable, explosive, corrosive, or reactive?
2. Is the material toxic, and if so, how can I be exposed to the material (inhalation, skin or eye contact, accidental ingestion, accidental puncture)?
3. What kind of ventilation do I need to protect myself? What kind of personal protective equipment (i.e. gloves, respirator, and goggles) do I need to protect myself?
4. Will the process generate other toxic compounds or could it result in a fire, explosion, etc.?
5. Are my storage facilities appropriate for the type of materials I will be using? Can I properly segregate incompatible materials?
6. What possible accidents can occur and what steps can I take to minimize the likelihood and impact of an accident?
7. What are the proper procedures for disposal of the chemical(s)?

Once you evaluate the potential hazards associated with the chemical(s) and the process in which you wish to use them, you can design your process and work procedures to minimize or eliminate the hazards.

Disposal of Chemicals/Hazardous Materials

It is the policy of Purdue University to manage and handle chemical hazardous waste in accordance with applicable state and federal laws. Purdue University is also required by OSHA Laboratory Standard to ensure that the necessary work practices, procedures, and policies are implemented to protect laboratory employees from all potentially hazardous chemicals in use in their work place.

The guidelines which follow are not intended to supersede the information from REM in providing safe, practical methods for the management of chemicals throughout the Purdue University System, especially with regard to the removal of unwanted materials. Proper management of chemicals begins

with ordering and ends with the consumption or removal of the chemicals from your laboratory or work area. Unless approved by REM, disposal of chemicals via the sanitary sewer system is NOT permitted.

For materials that require removal, a pickup service is provided by the Department of Radiological and Environmental Management (REM). At the present time the University absorbs the disposal costs. However, researchers at Herrick Lab should plan and manage their research budgets to provide for the expense incurred in future Hazardous waste disposal. Contact Ron Evans or Bob Brown to facilitate removal of chemicals or products no longer needed in your research. This includes all rags or chemical soaked clean up materials. The major professor, researcher, or supervisor has the ultimate responsibility for ordering, identifying, and labeling all chemicals, including those that are no longer needed. They should follow all of the procedures in REM's guidelines and must provide proper instruction to personnel under their supervision.
For additional information or technical questions, contact REM at 49-46371. For questions regarding general University policy, contact the University Chemical Management Committee.

Safe handling of chemicals begins with proper planning and detailed knowledge about the hazards of the materials you are using. What information do you need?

* Are they flammable?
* Are they toxic?
* Are they carcinogens?
* What if a chemical comes in contact with your skin?
* How should they be transported?
* How should they be stored?
* What if there is a spill?
* How can unwanted chemicals be removed from your laboratory?

Answers to some of these questions are found in Safety Data Sheets (SDS's). Others are addressed in two Purdue University publications, Right to Know and Hazardous Materials Safety Manual (for non-laboratory areas), and Chemical Hygiene Plan and Hazardous Materials Safety Manual (for laboratories).

The Right To Know and Hazardous Materials Safety Manual contains additional information regarding inventory management.

Storage and Inventory Management

An annual inventory/inspection of all chemicals in every University facility is required. Inventories reduce the number of unknown chemicals and the tendency to stockpile materials. Inspect for container integrity and appropriate labels.

1. Chemicals should be segregated according to compatibility for laboratory storage. Carefully read the manufacturer's label and SDS sheet for information on safe storage and incompatibilities. Storage of materials by hazard grouping reduces risk of fire or explosive reactions should containers fail. This also assures safety for the chemical user and HERL personnel, as well as, regulatory compliance for the University.

2. Do not stockpile chemicals. Excess or outdated chemicals should not be allowed to accumulate and create an unsafe working environment. Send excess materials to REM for placement on the campus redistribution list. Mark the items usable on the pick-up request form.

3. Keep chemical waste containers closed at all times except when materials are being added or removed. Open containers allow evaporation and invite spills, and are viewed by federal and state inspectors as an improper means of storage.

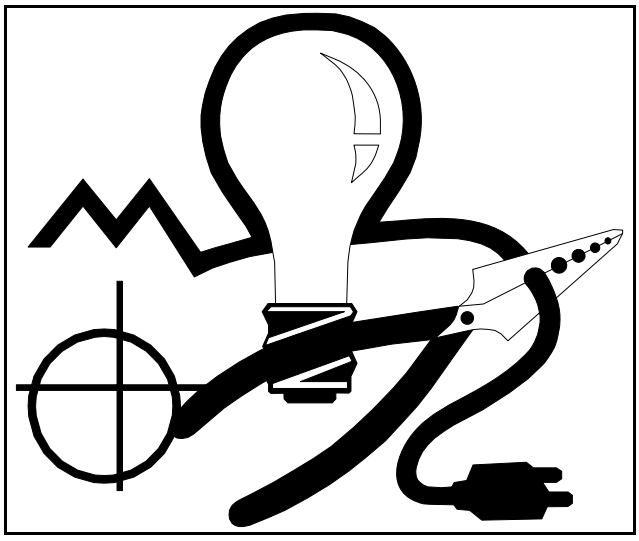
> *EPA annually conducts a surprise inspection of Purdue labs and work areas. Central to this inspection is proper labeling and storage of chemicals and hazardous materials. Violation of EPA regulations is punishable by fines of up to $25,000 per day. The Right To Know and other related safety documentation is also checked.*

4. Do not abandon chemicals when the research project is completed. Send all unused portions to REM for disposal. Indicate useable materials on the pick-up request. Check with associate research groups for interest in inventory items. Abandoned materials without the appropriate labeling become unknowns and are costly to dispose of. The principle investigator or major professor is responsible for oversight of this process.

ELECTRICAL DEVICES GENERAL

It takes very little electric current to kill--less than one-tenth of an ampere. With good contact, 115 volts is sufficient voltage to cause death. There have been fatal electric shocks where voltage as low as 60 to 70 volts was involved.

Never use electrical equipment when standing in or near water. In experiments which utilize water, and out-of-doors, a ground-fault circuit interrupter (GFI) will be installed in the circuit to prevent electrical shock. Portable ground-fault circuit interrupters are available from the shop for use in wet environments.



All electrical testing and maintenance shall be performed by the Herrick Lab Shop in accordance with NFPA 70 -National Electrical Code. All electrical equipment will be periodically inspected by shop personnel. Items found out of compliance with the following specifications will cause the shop to "RED TAG" your experiment.

Students are not permitted to perform any electrical modifications or repairs in circuits with voltages above 40 volts or currents greater than 15 amps. Students may work with low voltage DC and AC control circuits and data acquisition circuits and wiring. No electrical work should be performed on a live

circuit. Students must not attempt high voltage electrical repairs. If equipment has a frayed cord, causes even a minor shock, it must be removed from service and repaired. Report problems and defects to the shop so corrective action can be taken.

Switches, fuses, circuit breakers, and other control devices in areas where explosives or other flammable liquids or gasses exist shall be the type designed for use in these areas.

Suitable means should be provided for identifying all electrical equipment and circuits, especially if two or more voltages are used on the same experiment. Detailed schematic drawings and circuit diagrams for each experiment are required to be on file in the shop as part of the Safety Check.

* All electrical tools, equipment, and instrumentation should be properly grounded.
* Spliced or damaged electrical cords shall not be used until properly repaired.
* Electrical cords on instruments, power tools, and extension cords shall have heavy-duty rubber insulation.
* All electrical wiring will conform to NEC/ OSHA regulations.

Extension Cords

Extension cords are designed for temporary, not permanent, use. Use of thin, light duty extension cords increases the risk of fire and shock. Extension cords should have adequate current capacity for the equipment being used. Extension cords may be used for temporary (less than three months) use. Situations that require extension cords for longer than three months are considered permanent installations and must be addressed through upgrades to the building wiring systems. Extension cords should be no less than 16 gauge wire. Only "SO" type rubber covered type cord is approved. NO "ZIP cord" or "Home" type cords are allowed. Students must not attempt electrical repairs. Report problems to the shop!

House keeping is always a concern in the lab. Extension cords, "sloppy" data acquisition wiring, and cabling only increases the risk of equipment damage or injury. Do not place extension cords in traffic areas or under equipment. Cords on the floor of the lab should be taped to prevent falls. Stretching or pinching cords or cables between objects breaks interior electrical wires; this causes overheating which may result in fire. Refer to the following check list for common sense practice:

* Protect flexible cords and cables from physical damage.
* Provide slack in flexible cords to prevent tension on terminals.
* Check cords for cut, broken or cracked insulation.
* Extension cords are for temporary use. Install permanent wiring when use is not temporary.

Students must not attempt electrical repairs. If equipment has a frayed cord, causes even a minor shock, it must be removed from service and repaired. Report problems and defects so corrective action can be taken.

Coax Cables, Instrumentation Wiring, and Computer Cables

Electrical noise reduction should start with the design of the equipment and your test setup, not as a last ditch attempt to make sense out of "noisy" data signals. Always check both the physical and electrical condition of every cable you use for your research work. Make sure that cable connectors are tight to provide reliable ground returns. When solder connectors are used, inspect solder joints for "cold soldering" and corrosion. Stretching or pinching wires or cables between objects breaks interior conductors; this causes either a short or a high resistance. If vibration is present, use cable tie downs appropriately spaced to avoid cable fatigue.

Some simple general rules to apply to instrumentation circuits in respect to "noise". They are:

1. Minimize the noise voltage generated by currents from two or more circuits flowing through a common ground.
2. Avoid creating ground loops which are susceptible to magnetic fields and differences in ground potentials.
3. Electric fields are much easier to guard against than magnetic fields.
    * Keep instrumentation wiring and cabling separated from power and control circuit wiring.
    * A coax shield grounded at one or more points shields against electric fields.
4. Always use appropriate connectors/ never the "twist and tape method".

Terminal Connections

All electrical connections at the supply end for 24 volts or greater service must have strain relief and be enclosed. Do not mix splice connections of different voltages in the same box. Label the box with the voltage. Only standard NEC approved connectors (plugs & sockets) will be used and all voltage and current configurations will be followed to preclude accidental damage to equipment or people. All connectors (low voltage & high voltage) will be installed such that the male end is never "HOT" when exposed.

COMPRESSED GASES

Compressed Air

The Herrick Lab compressed air supply is fed by two 25 horse power and one 15 horse power air compressors, There are 12 2' X10' air receivers (storage tanks) providing a compressed air storage capacity of hundreds of cubic feet at 120 psi. Building air supply is maintained at 120psi. For most projects requiring compressed air a pressure reducing regulator is required. Our air supply is reasonably "dry", if moisture in the air supply is a problem either use compressed "dry" nitrogen or see the shop for special moisture removal devices. Building compressed air <u>should not be used for breathing.</u>

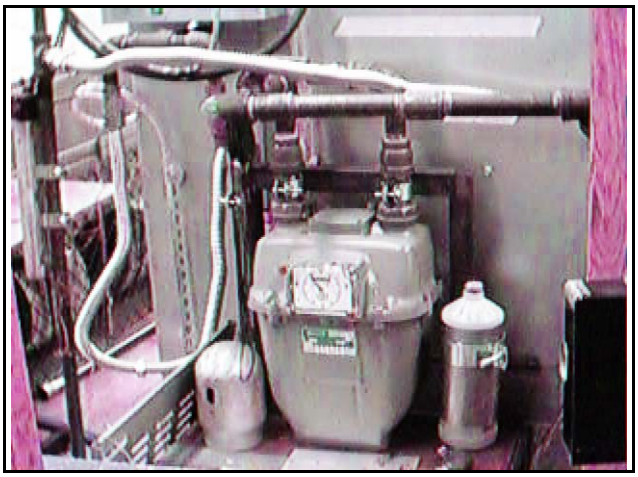
Compressed air can be dangerous. Never use compressed air to blow dirt from your clothes. Never point the compressed-air blowgun at another person. The Occupational Safety and Health Act (OSHA) requires that compressed-air blowguns discharge air at a pressure of not more than 30 psi (pounds per square inch) [2.2 kg/CM2 (kilograms per square centimeters.

When charging vessels with compressed air, never exceed the pressure rating of the vessel. An automobile tire when over inflated can cause severe injuries. <u>Be careful!</u>

Pay close attention to the condition of compressed air hoses and "quick-disconnects". A broken 1/2" air hose with a 120psi pressure will whip around with great speed and energy. It can injure you! Shut off hose connections at the manifold when air hoses are not in use. Report any leaks or other problems to the shop.

Compressed Gases

Many of our laboratory operations require the use of compressed gases. Compressed gases present a unique hazard. Depending on the particular gas, there is a potential for simultaneous exposure to both mechanical and chemical hazards. Gases may be combustible, explosive, corrosive, poisonous, inert, or a combination of hazards. If the gas is flammable, a danger of fire or explosion exists. Additional hazards of reactivity and toxicity of the gas, as well as asphyxiation, can be caused by high concentrations of even "harmless" gases such as nitrogen. Compressed gases in use at Herrick Lab may range from piped in Natural gas at a pressure of 10 inches of water to high pressure cylinders filled with highly reactive chemicals at pressures above 4,000 psi. Pressurized storage and dispensing cylinders (tanks) fall into two broad categories: low pressure and high pressure. Safety guidelines concerning experiments which use "city gas" will be covered in the Specific Experimental Lab Facilities Section.



Gas Lines

All gas lines leading from a compressed or "natural" gas supply should be clearly labeled to identify the gas, the experiment served, and the relevant emergency telephone numbers. The labels should be color coded to distinguish hazardous gases (such as flammable, toxic, or corrosive substances) (e.g., a yellow background and black letters). Signs should be conspicuously posted in areas where flammable compressed gases are stored, identifying the substances and appropriate precautions (e.g., HYDROGEN -

FLAMMABLE GAS -NO SMOKING - NO OPEN FLAMES).

CYLINDERS

Since the gases are contained in heavy, highly pressurized metal containers, the large amount of potential energy resulting from compression of the gas makes the cylinder a potential rocket or fragmentation bomb. In summary, careful procedures are necessary for handling the various compressed gases, the cylinders containing the compressed gases, regulators or valves used to control gas flow, and the piping used to confine gases during flow. Because high pressure gas cylinders are tall and narrow, they must be secured at all times to prevent tipping. Cylinders may be attached to a bench top, individually to the wall, placed in a holding cage, or have a non-tip base attached.

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

When new cylinders are received, they should be inspected. During this inspection, one should insure the proper cap is securely in place and the cylinder is not leaking. Cylinders shall have clear labels indicating the type of gas contained. If the cylinders are acceptable, they shall be stored in a proper location. If a leaking cylinder is discovered, move it to a safe place (it is safe to do so) and inform the shop. Under no circumstances should any attempt be made to repair a cylinder or valve.

Cylinder Storage

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

Oxygen cylinders, full or empty, shall not be stored in the same vicinity as flammable gases. The proper storage for oxygen cylinders requires that a minimum of 50 feet be maintained between flammable gas cylinders and oxygen cylinders or the

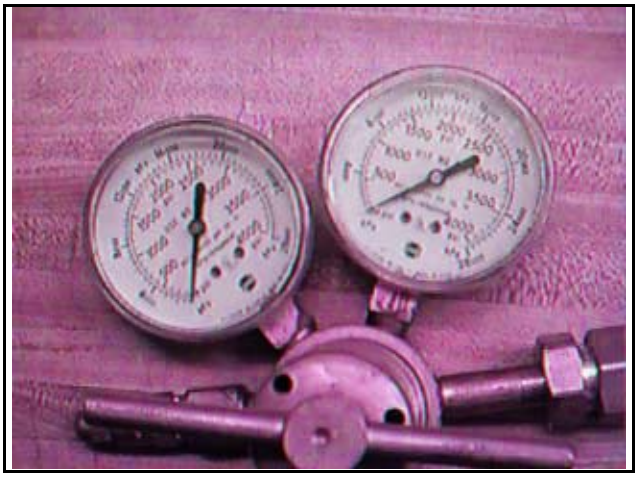
storage areas be separated, at a minimum, by a fire wall five feet high with a fire rating of 0.5 hours. Greasy and oily materials shall never be stored around oxygen; nor should oil or grease be applied to fittings.

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

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

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

Cylinders are equipped with either a hand wheel or stem valve. For cylinders equipped with a stem valve, the valve spindle key should remain on the stem while the cylinder is in service. Only wrenches or tools provided by the cylinder supplier should be used to open or close a valve. At no time should pliers be used to open a cylinder valve. Some valves may require washers; this should be checked before the regulator is fitted. Cylinder valves should be opened slowly. Main cylinder valves should never be opened all the way. When opening the valve on a cylinder containing an irritating or toxic gas, the user should position the cylinder with the valve pointing away from them and warn those working nearby.



Regulators are gas specific and not necessarily interchangeable. Always make sure that the regulator and valve fittings are compatible. If there is any question as to the suitability of a regulator for a particular gas, check with the shop. After the regulator is attached, the cylinder valve should be opened just enough to indicate pressure on the regulator gauge (no more than one full turn) and all the connections checked with a soap solution for leaks. Never use oil or grease on the regulator of a cylinder valve.

A cylinder should never be emptied to a pressure lower than 172 kPa (25 psi/in2) (the residual contents may become contaminated if the valve is left open). When work involving a compressed gas is completed, the cylinder must be turned off, and if possible, the lines bled. When the cylinder needs to be removed or is empty (see above), all valves shall be closed, the system bled, and the regulator removed.

The valve cap shall be replaced, the cylinder clearly marked as "EMPTY" and returned to a storage area for pickup.

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

Gas Cylinder Transportation

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

To protect the valve during transportation, the cover cap should be screwed on hand tight and remain on until the cylinder is in place and ready for use. Cylinders should never be rolled or dragged. When moving large cylinders, they should be strapped to a properly designed wheeled cart to ensure stability. Only one cylinder should be handled (moved) at a time.

SPACE FOR ADDITIONAL INFO AND VEHICLE TRANSPORT INFO INCLUDING ICC REGULATIONS

REFRIGERANTS

Background

Effective July 1, 1992, section 608 of the Clean Air Act prohibited individuals from knowingly venting ozone depleting compounds used as refrigerants into the atmosphere while servicing, maintaining, repairing or disposing of air conditioning or refrigeration equipment.

Introduction

EPA regulations concerning CFC & HCFC leakage apply to research projects in Herrick lab. In order to comply with EPA regulations and University policy it is necessary for the shop to keep accurate records of all refrigerants purchased and document their legal disposal or reclamation.

The University has developed procedures covering the disposal of refrigeration equipment. It will be necessary for the shop to remove all refrigerants, oil, capacitors etc. prior to the disposal of equipment. We are asked to keep records, including serial number, description, type of refrigerant charge, etc. and tag the equipment to indicate that it has been properly prepared for disposal.

If refrigerants are recycled or reclaimed, they are not considered hazardous under federal law. However, in some cases, lubricants and other materials removed from air conditioning or refrigeration equipment or experimental apparatus may be considered hazardous. For this reason, it is strongly recommended that the principal investigator include language in his/her contract with a sponsor which will provide for the following:

SDS Sheets for all materials provided by the sponsor. (This should include lubricants used in compressors or the gear boxes of sample units)

Sufficient funds should be included in the Proposal to cover the disposal costs of any hazardous materials and recovery of refrigerants used in the research.

While some of the replacement refrigerants have a zero ozone depletion potential (ODP), they do have a significant direct global warming potential (GWP). Therefore, containment and recycling are sound practices for all refrigerants. It will be the policy of the Herrick laboratory to recover ALL refrigerants used in this Laboratory. While some HFC refrigerants do not come under the same regulations covered by the EPA for CFC and HCFC refrigerants, a uniform policy will preclude accidental mishandling of refrigerants. See Addendum for refrigerant forms.

Legal Considerations:

The law authorizes the EPA to assess fines of up to $25,000 per day per violation for any violation covered under the Clean Air Act. In addition, the EPA may pay an award of up to $10,000, to any person who furnishes information or services which lead to a criminal conviction or a judicial or administrative civil penalty ousted as a result of a violation of the Act.

The best way for Herrick Lab to avoid a charge of intentional venting, is to ensure that everyone (the sponsor, professor, students, and shop personnel) understand the regulations and are trained and equipped to follow procedures and practices which are in full compliance with EPA and University Policies.

NOTE: The following Refrigerant safety information is only concerned with safety. Detailed refrigeration and refrigerant standard operating procedures (SOP's) will be covered in the section of this manual titled Specific Experimental Lab Procedures.

Refrigerant Safety

Exposures to refrigerants, or other substances, at very low temperatures can cause frostbite. Likewise, prolonged contact, splashing into the eyes, or release of pressurized gases or liquids pose hazards. Several preventive measures are recommended, including use of appropriate eye protection and gloves when there is a possibility of contact.

No discussion of refrigerant safety would be complete without emphasizing of the potential for asphyxiation. All of the fluorocarbon refrigerants are heavier than air and can displace it, thereby creating the possibility of suffocation with a major leak or spill. Fatal accidents have occurred with the familiar refrigerants, including a well-publicized incident involving an R- 22 leak in a mall skating rink. Many refrigerant vapors cannot be seen, tasted or smelled, so there is no natural warning.

Other refrigerants like ammonia can be smelled, seen and tasted and are lighter than air, but still can pose an asphyxiation hazard. Ammonia also can be corrosive to the skin and eyes in high concentrations. Most people can detect its odor at concentrations far below those at which it causes harm.

Most flammability concerns are limited to a few refrigerants like propane. Given the right conditions almost all refrigerants can cause a fire. Flammability increases with temperature and pressure, especially in the presence of combustible lubricants. Accidents have occurred with refrigerants that once were viewed as completely nonflammable. For example, R-22 can ignite in air mixtures at elevated temperatures and pressure. This is why compressed air should never be used in leak testing refrigeration systems.

Refrigerant Tanks

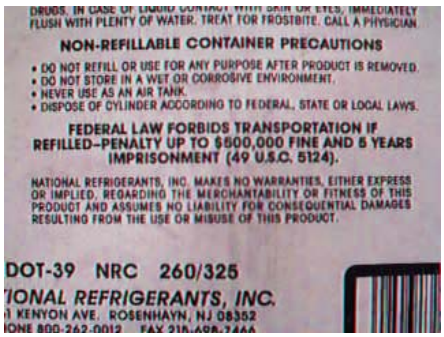
The temperature pressure relationship of many refrigerants is such that it may be dispensed and stored in low pressure vessels. This does not change the potential danger involved. Refrigerant tanks should be treated the same as any pressurized cylinder.

Some new refrigerant is sold in disposable dispensing tanks. These containers are much thinner than tanks intended for refilling. Disposable refrigerant tanks should NEVER be refilled or re-pressurized. Bring empty disposable tanks to the shop. Do not throw in trash! Refrigerant is commonly recovered and dispensed from special refillable 50 lb tanks designed to be used with our recycling equipment. Different recycling machines require tanks with different fittings. Detailed refrigeration and refrigerant standard operating procedures(SOP's) will be covered in the section of this manual titled Specific Experimental Lab Procedures.

FLAMMABLE MATERIALS:

Gasoline and other flammable liquids are used so much in the lab that people forget they are very dangerous if not handled properly. A spark or open flame in a closed place filled with gasoline vapor can cause an explosion. Even the spark from a light switch can ignite vapors and cause an explosion. Regardless of what you have learned about fuel/air ratios you must always be extremely careful with flammables. Accidents are not textbook examples!

If flammable vapors exist in an area you should keep the lab doors open and keep the ventilating system running. Wipe up the spilled liquid at once, and put the rags in a flammable rag can and bring the incident to the attention of the shop. They will insure the materials are properly disposed of.



Store gasoline and other flammables in an approved safety container. Never, never store flammables in a glass jug or plastic fuel can. All fuel cans should be stored in the appropriate

Flammable Storage Locker

There are three such lockers and a fuel storage shed at Herrick Lab. One locker is located in the East Wing engine Dyno area it is reserved exclusively for engine fuels, the second locker is located in the storage area in the front of the East wing, it is used for a variety of solvents and fuels. The third locker located in the West wing is reserved for paints and solvents. No oxidizing chemicals or acids should be stored in any of these lockers. See Ron Evans or Bob Brown if you have Flammable storage needs. Make sure all containers are properly labeled, see the shop for labels.

The fuel Storage shed is exclusively used for automotive test fuels. Fuels should be dispensed ONLY from the pump pictured. Barrels are grounded electrically to earth to preclude static electricity build ups and resultant fires. The key is available from the shop during normal hours.

Oily rags can also start fires. They can catch fire without a spark or flame. Oily rags and waste should be put into special closed metal containers. In these special containers, they can do no harm if they ignite from spontaneous combustion or another cause.

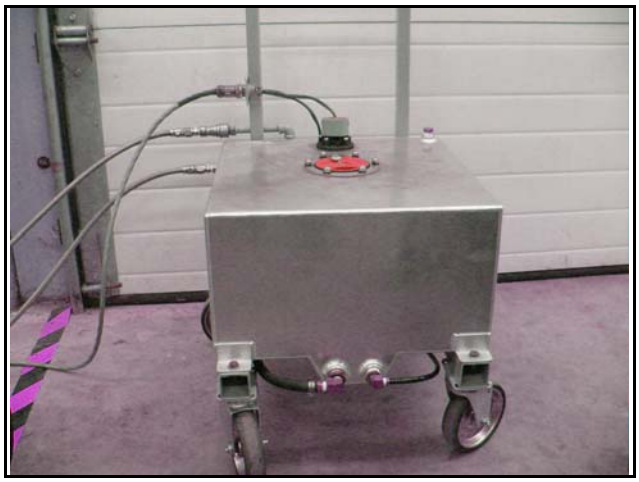
Gasoline and Fuel Handling

Handle gasoline (and all fuels) with care! Avoid spilling or overflowing secondary containers when refueling. To avoid static charge build up NEVER pump into a plastic container. Check grounding straps for a good connection and keep the pump nozzle in contact with the can or tank when pumping fuel.

Gasoline vapors are highly flammable and can ignite at temperatures as low as -45 degC. One cup (500ml) of gasoline, when vaporized and ignited, has the same explosive force as five sticks of dynamite!

Health Effects

(Read the SDS Sheets)
Exposure to gasoline and solvent fumes can cause headaches, dizziness and nausea. Gasoline and solvent vapors are moderately irritating to the eyes and respiratory passages. Exposure limits are 300-500 ppm (parts per million) Gasoline can be smelled at concentrations as low as .25ppm in open air. Ingesting liquid gasoline or breathing concentrated vapors can be fatal. Repeated contact with gasoline will cause drying of the skin (dermatitis). Most gasoline no longer contains lead so that eliminates one very dangerous poisoning possibility. Some currently used gasoline may contain methyl terirary butyl either (MTBE), menthol alcohol, ethyl alcohol or other oxygenating chemical that have been shown to have negative long term health effects! (Read the SDS Sheet)



Engine Experiments

To reduce the danger of refueling all engine experiments will be equipped with portable safety fuel tanks. Tanks will be fitted with self sealing quick disconnects, electrical plugs and approved fittings. The use of these tanks eliminates refueling inside the building. Total gasoline capacity is limited to 10 gallons.

Diesel tanks are similar but use different quick disconnects to preclude the possibility of interchanging diesel and gasoline. Tanks will be clearly marked to indicate the type of fuel to be used.

Safety Reminders

- Don't smoke within 10 feet of the gasoline storage shed.
- Absolutely no smoking or open flames in the engine lab.
- If you spill gasoline, ventilate the area at once, wipe up the spill with rags and put the rags and safety rag can out side the building. Notify the shop!
- If the spill or leak is large, notify the shop immediately!
- Don't clean your hands or anything else with gasoline or diesel fuel!!!
- If you spill gasoline on your clothing, slowly (to avoid static electric ignition) remove the garments and wash or shower with plenty of sudsy soap and water. Even after washing your clothing, they may still contain fuel vapor, don't put them in a dryer... you could create a fire.
- If you ingest gasoline, seek medical attention and do not induce vomiting.
- Any time you have handled any chemical, wash your hands BEFORE and AFTER using the rest room, eating, or smoking!

STANDARD OPERATING PROCEDURES

Cryogenic liquids

Cryogenic liquids (argon, nitrogen, helium, hydrogen and oxygen) and certain other liquefied gases are at extremely low temperatures (-60/C to -266/C). Very small amounts of these liquids produce large amounts of gas. Consult the product's SDS for specific guidelines regarding health and safety information, personal protective equipment and emergency recommendations.

Safety precautions that must be taken with compressed gases also apply to cryogenic liquids (see compressed gas standard). There are, however, additional precautions necessary when dealing with cryogenic materials.

Spills

Contact with cryogenic materials can rapidly freeze and destroy skin tissues. If exposed:

Contact a physician immediately.

Remove all clothing that may restrict circulation to the frozen area.
Flush affected area with warm, not hot, water. Water temperature should be between 40/C- 46/C. Do not use dry heat.
Do not rub frozen body parts, before or after warming.
Keep patient warm and resting.
Cover thawed body part with dry sterile gauze and large, bulky protective clothing.
Do not allow patient to drink alcohol or smoke.

Material Compatibility

Common materials such as carbon steel, plastic, and rubber may become brittle or fracture after contact with cryogenic liquids.

Storage/Handling

Cryogenic liquid containers are specially designed to reduce heat loss. This design consists of an inner container and an outer casing, which are separated by a vacuum and special insulation. This construction makes cryogenic containers more fragile than other compressed gas cylinders. For this reason cryogenic containers must be handled with extreme care:

1. Use dollies for moving cryogenic containers. Avoid rolling containers by holding the neck as it is the main support for the inner portion of the container.
2. Keep containers clean. Avoid contaminating them with materials which may create hazardous conditions upon contact with the cryogenic fluid or gas.
3. Report all leaking or improperly set relief valves, as well as safety valves with broken seals or with any frost, ice formation, or excessive corrosion to the shop.
4. Remove the container to a remote location and contact the shop if plugs of ice or foreign material develop in container vents or opening. Do not attempt to remove the plug.
5. Vent containers with an approved safety device which permits excess gas to escape.
6. Label containers clearly. (MUST ATTACH SDS SHEET)
7. Avoid heating or welding containers which contain a cryogen.
8. Do not store oxygen with any other gases except gaseous nitrogen or gaseous carbon dioxide. Do not store liquid nitrogen with helium, hydrogen or oxygen.

Personal Protective Equipment (PPE)

Use protective gloves when any material that comes in contact with cold liquids and their vapors is being handled. Gloves should be loose fitting, so that they can be removed quickly if liquids are spilled into them.

1. Wear safety glasses, if spraying or splashing is likely a face shield should be worn.
2. Cuffless trousers should cover the top of and remain outside of boots or work shoes.

GENERAL SAFETY PRECAUTIONS

1. Use and store cryogenic materials only in well ventilated areas. Cryogenic gases are capable of displacing air necessary for respiration and causing asphyxiation.
2. Never allow any unprotected part of the body to touch un-insulated pipes or vessels that contain cryogenic fluids.
3. Use tongs to withdraw objects immersed in a cryogenic liquid.
4. Perform operations slowly to minimize boiling and splashing when charging a warm condenser or

when inserting objects into a cryogenic liquid.

5. Remove all combustible materials from the area, especially oil or gasses when handling liquid oxygen. NO SMOKING signs MUST be posted.

6. Avoid wearing clothing or jewelry (watches, rings, etc.) which may trap a cryogenic fluid.

7. Change and air all clothing that has been splashed with liquid oxygen immediately. Material may absorb pure Oxygen and become highly flammable.

Drill Presses

* Clamp material to be drilled securely to the drill-table before starting the machine.

* Tighten the chuck of the drill press and remove the release key before starting the machine or your arm may be twisted around the spindle. Never leave the key in the chuck.

* Use drills properly sharpened to cut the right size.

* Run drills only at the correct speed and do not force or feed too fast. Broken drills can cause serious injury.

* If your work should slip from the clamp, never attempt to stop it with your hands. Stop machine to make any adjustment or repair.

* Drill presses should never be forced by exerting excess pressure on the feed lever.

* Drive belts should be covered.

Fork Lift Truck

These minimum operating procedures apply to all employees within the University and Herrick Laboratory who operate forklift trucks or motorized hand trucks as defined by OSHA 1910.178.

Training and Certification to Operate Requirement

Only trained and certified operators are permitted to operate a powered industrial truck. Training of operators has two parts. The first is the generic formal training and the second is the actual performance evaluation for certification of the truck that will be used in the field. Generic formal training will be conducted by REM.

The performance evaluation for certification in the field on the actual truck(s) used will be conducted by certified shop personnel.

Maintenance of Industrial Trucks

1. Any power-operated industrial truck not in safe operating condition must be removed from service. (RED TAG SHALL BE IN PLACE)

Authorized personnel must make all repairs.

2. Industrial truck(s) must be examined by the operator prior to each usage to ensure that its condition is safe for operation. Check for the following:

1. Signs of hydraulic oil leakage.
2. Loss of other vital fluids.
3. State of Charge.
4. Test operation of:
    a. brakes
    b. warning lights
    c. back-up horn
    d. other controls

3. Industrial truck(s) must be examined by the operator after to each usage and the following services performed:

1. Ignition key removed and returned to the shop.
2. Battery un-plugged and connected to charger.
3. Battery charger set to Daily Charge.
4. Parked with forks in a safe condition (lowered and under charger preferred)

Abrasive Wheeled Tools General

* Face shields and or safety glasses should always be used when grinding.

* Grinding wheels should be equipped with tool rests that hold the work firmly. The tool rest should be kept adjusted close to the wheel with a maximum opening of 1/8". Adjust the tongue to no more than 1/4" of the wheel.

* Bench and pedestal grinders should be permanently mounted or secured.

* The maximum RPM rating of each abrasive wheel must be compatible with the RPM rating of the grinder motor.

* Each electrically operated grinder should be effectively grounded.

* Each grinder should have an individual "On" and "Off" control switch.

* Abrasive wheels must not be stored where they would be exposed to high temperature or humidity, water or other liquids, freezing temperatures or any temperature low enough to cause condensation on the wheels when moved from the storage area to an area of higher temperature, or where they would be subjected to physical damage from falling tools or materials.

* Before new abrasive wheels are used they should be visually inspected and ring tested.

* Safety guards used on machines known as "right angle head" or "vertical portable" grinders must not have an exposure angle greater than 180 degrees, and the guard must be located so that it is between the operator and the wheel during use. The guard should be adjusted so that pieces of an accidentally broken wheel will be deflected away from the operator.

* The side of an energy wheel should not be used for grinding, unless it is a special type of wheel designed for that purpose.

* Grinding of large parts, prolonged grinding, grinding of potentially toxic materials, and cutting of wheels all require mechanical exhaust ventilation.

* Defective abrasive wheels (cracked, broken, out of balance) should not be used.

* Abrasive wheels which have been discarded should not be re-used.

* Flanges should be of such design as to satisfactorily transmit the driving torque from the spindle to the grinding wheel.

* Flanges may be made of steel, cast iron, or other material of equal or greater strength and rigidity.

* Flanges shall be designed with respect to rigidity so that when tightened, the radial width of bearing surface of contact on the wheel is maintained.

* Abrasive wheels must have cover guards.

Hand Tools

Hand tools are tools that are powered manually. Hand tools include anything from axes to wrenches. The greatest hazards posed by hand tools result from misuse and improper maintenance. The Herrick Lab Shop is responsible for the safe condition of tools and equipment. The shop will not issue or permit the use of unsafe hand tools. If you are not familiar with the proper use of a tool, ask! Shop personnel will be happy to train you in the proper use and handling of tools and equipment.

When using saw blades, knives, or other tools, you should direct the tools away from aisle areas and away from other people working in close proximity. Knives and scissors must be sharp; dull tools can cause more hazards than sharp ones.

Wrenches must not be used when jaws are sprung to the point that slippage occurs. Impact tools such as drift pins, wedges, and chisels, must be kept free of mushroomed heads. The wooden handles of tools must not be splintered.

Iron or steel hand tools may produce sparks that can be an ignition source around flammable substances. Where this hazard exists, spark-resistant tools made of non-ferrous materials should be used where flammable gases, highly volatile liquids, and other explosive substances are stored or used.

Five basic safety rules can help prevent hazards associated with the use of hand and power tools:

- Keep all tools in good condition with regular maintenance.
- Use the right tool for the job.
- Examine each tool for damage before use and do not use damaged tools.
- Operate tools according to the manufacturers' instructions.
- Provide and use properly the right personal protective equipment.

Ladders and Scaffolds

* Use care in placing a ladder. A ladder's feet should be one- fourth of its length away from the wall

against which it is leaning.

* Be sure your ladder is long enough for the job. A ladder's overall length is different than its usable length. The top three rungs of a ladder are not meant to be stood upon.

* Do not leave tools on top of a stepladder or on any other elevated place from which they may fall. Effective tool holders should be used.

* Place ladders only against solid footing and stationary backing.

* Always face the ladder when ascending or descending. Use both hands when going up or down a ladder.

* Use only ladders in good repair. Never use a broken or weak ladder or one with missing rungs.

* Metal ladders conduct electricity! If you plan to use a ladder near power lines, with electrical equipment, or to change a bulb, use a wooden or fiberglass ladder if at all possible.

* No uprights, braces, or supporting members of a scaffold should be removed, loosened, or weakened while any of the scaffold planking or flooring is in place.

* Do not work on a double extension ladder unless someone is holding the bottom.

* Do not use ladders in a strong wind.

* If you must set up a ladder in a traffic area, use a barricade or guard to prevent unexpected collisions.

* When using a step ladder, make sure it is fully open and its spreader is locked.

* To avoid shifting, tie down straight ladders as close to the support point as possible.

* If you need tools, carry them in a tool belt or raise and lower them with a hand line.

* Never reach or lean too far to one side--keep your belt buckle between the ladder rails to maintain your balance.

* Don't climb higher than the second tread from the top on a step ladder.

* Scaffolds and their components must be capable of supporting without failure at least 4 times the maximum intended load.

* An access ladder or equivalent safe access must be provided to all scaffolds.

* Slippery conditions on scaffolds should be eliminated once discovered.

Laser Standard Operating Procedures

All lasers are classified by the manufacturer and labeled with the appropriate warning labels. Any modification of an existing laser or an unclassified laser must be classified by the Herrick Lab/ME Safety committee prior to use. The following criteria are used to classify lasers:

1.Wavelength. If the laser is designed to emit multiple wavelengths the classification is based on the most hazardous wavelength.
2.For continuous wave (CW) or repetitively pulsed lasers the average power output (Watts) and limiting exposure time inherent in the design are considered.
3.For pulsed lasers the total energy per pulse (Joule), pulse duration, pulse repetition frequency and emergent beam radiant exposure are considered.

Class I Lasers
These are lasers that are not hazardous for continuous viewing or are designed in such a way that prevent human access to laser radiation. These consist of low power lasers or higher power embedded lasers. (i.e. laser printers)

Class 2 Visible Lasers (400 to 700 nm)
Lasers emitting visible light which because of normal human aversion responses, do not normally present a hazard, but would if viewed directly for extended periods of time. (like many conventional light sources)

Class 2A Visible Lasers (400 to 700 nm)
Lasers emitting visible light not intended for viewing, and under normal operating conditions would not produce a injury to the eye if viewed directly for less than 1000 seconds. (bar code scanners)

Class 3a
Lasers that normally would not cause injury to the eye if viewed momentarily but would present a hazard if viewed using collecting optics (fibre optics loupe or telescope).

Class 3b
Lasers that present an eye and skin hazard if viewed directly. This includes both intrabeam viewing and specular reflections. Class 3b lasers do not produce a hazardous diffuse reflection except when viewed at close proximity.

Class 4 Lasers
Lasers that present an eye hazard from direct, specular and diffuse reflections. In addition such lasers may be fire hazards and produce skin burns.

All Class 3b and Class 4 lasers are to have written Standard Operating Procedures (SOP). SOP's are to be approved by the Herrick Lab Safety Committee. SOP's will contain the following information:

1.Operating procedures.
2.Maintenance procedures.
3.Service procedures.
4.Alignment procedures.
5.The Nominal Hazard Zone (NHZ) for the above procedures as defined by the Safety Committee.
6.Protective eye ware and other personal protective equipment as prescribed by the safety committee.

Nominal Hazard Zone (NHZ)

In some applications open beams are required, making it necessary to define an area of potentially hazardous laser radiation. (i.e. Laser Vibrometer) This area is called the nominal hazard zone (NHZ) which is defined as a space within which the level of direct, scattered or reflected laser radiation exceeds the MPE. The purpose of a NHZ. The Safety check process will determine the NHZ and the control measures to protect the researcher and/or other persons from exposure to radiation above the MPE.
Control measures are devised to reduce the possibility of exposure of the eye or skin to hazardous levels of laser radiation. Substitution of engineering controls with administrative controls may be done with the approval of the Safety Committee.

1. Warning signs are required (Minim requirement)

2. Active warning device such as attention getting lights or beacons (Required if Eye protection is required)

Although commercial laser products manufactured in compliance with the Federal Laser Product Performance Standard will be certified by the manufacturer and will incorporate some engineering controls, the use of the additional controls shall be considered in order to reduce the potential for hazard associated with some applications of lasers and laser systems.

Engineering Safety Controls

1.access restriction
2.eye protection
3.area controls
4.barriers, shrouds, beam stops etc.
5.administrative and procedural controls
6.education and training

Lathes

* Make sure that all gear and belt guards are in place.

* Never leave a chuck wrench in a chuck.

* Keep your hands off chuck rims when a lathe is in operation.

* Do not attempt to screw the chuck onto the lathe spindle with the power on, as it may get cross-threaded and cause injury. Stop the machine, place a board under the chuck, and then screw on by hand.

* Steady rests should be properly adjusted to conform with the material being worked on.

* When filing work in a lathe, file with the right hand over lathe instead of left hand, and face the head stock. If left-handed, reverse lathe and file from back side of lathe.

* See that tailstock, tool holder, and work are properly clamped before turning on power.

* Never attempt to adjust a tool while the lathe is running.

* Never apply a wrench to revolving work or parts.

* Always use a brush to remove chips--never your hands.

* When possible, use pipe sleeves to cover work protruding from the end of the lathe.

* Before removing your work from the lathe, remove the tool bit.

Lockout Safety

For the protection of faculty, students, and staff, the following lockout standard is intended primarily for use when locking and tagging equipment for electrical work. However, the information in this standard applies to all types of power for equipment operation. The aim of a lockout is to establish zero energy state in the machine. Zero energy state means all types of power including electricity, air under pressure, oil or water under pressure, and steam are dissipated so that operation of any controls will not produce movement. Use of power, such as steam under pressure, for heating does not remove it from this category. It is still power, capable of doing injury or damage, and subject to the lockout standard.

When ?

Shop is working on or near machines or equipment in which the unexpected movement of parts or the charging of electrical conductors would subject them to injury. When the shop or safety commitee member observes an unsafe conditon exists on any experimental apparatus, laboratory equipment or shop equipment. The following precautions must be taken:

I. The power supply to electrical installations, equipment or conductors shall be disconnected, locked out of service and tagged before any work is done, and while it is being done, on or near live exposed parts of the installations, equipment or conductors.

II. If more than one person is involved in the work the person who disconnected and locked out the device WILL communicate the purpose and status of the disconnecting and locking out to the LAB.

III. If a tag is used as a means of communication, the tag,
   (a) shall be made of non-conducting material;
   (b) shall be secured to prevent its inadvertent removal;
   (c) shall be placed in a conspicuous location;
   (d) shall state the reason the switch is disconnected and locked out;
   (e) shall show the name of the worker who disconnected and locked out the switch; and
   (f) shall show the date on which the switch was disconnected and locked out.

HOW?

1. *Identify All Energy Sources*. An initial survey must be made to identify all the equipment's sources of power or energy (including stored energy sources such as electrical capacitors or

elevated movable components) so that each energy source can be isolated.

2. *Notify People Affected* Everyone who would normally use the equipment being serviced must be informed of the lockout procedures being used and told not to attempt to start or energize the equipment.
3. *Shut Down the Equipment* Using appropriate equipment shutdown procedures, turn off all operating controls or return them to the neutral position.
4. *Lockout Equipment* All maintenance personnel are issued a suitable lock (or locks). The lock has the individual worker's name and other identification on it he/she has the only key to the lock.
5. *Test Lockout Effectiveness* The main valve or main electrical disconnect must be tested to be sure that the power to the machine is off.

Machine Tool Safety General

All machine tools are potentially dangerous. The dangers can be overcome however by knowledge of safe practice, experience in use, and the application of some common sense rules. But the potential danger is always there.

Some basic rules of machine use

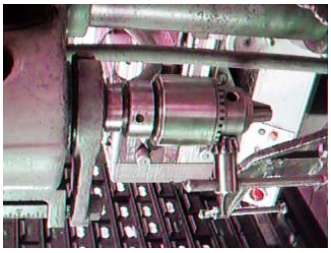
Machine tools can be used safely when the operator has:

* an awareness of the design of the machine and an understanding of it's appropriate use
* an understanding of machine setting with regards to safety principles such as guards, and holding the work piece, specific to the machine being used
* an understanding of the correct speed the machine should work at with regards to the work undertaken and the material being cut, and the feed rate at which the work piece should be cut at
* an understanding of personal safety and the safety of others in the working environment
* an awareness of the contributing safety factors in machine use, i.e., with regards to dust, swarfe and the use of coolants
* a sensitivity to the cleanliness and tidiness of the machine and it's immediate environment
* a knowledge of the specific section of the Health and Safety at Work Act (1974) under which the machine and it's use falls.

Personal Protective Equipment

* Safety glasses should be worn at all times when in the shop.
* Hearing protection should be used in a noisy environment. If you're unsure whether hearing protection is needed, check with Ron Evans or Bob Brown.
* When handling rough stock, gloves should be worn. However, when performing any machining operations, gloves become a hazard because they can be caught in rotating parts.
* Sturdy, thick, slip-proof shoes should be worn.
* Wear short-sleeved shirts whenever possible. If long-sleeved shirts are necessary, make sure that they are not loose fitting.

Tools, Lathes, Drill Press, Mill, Band Saws



* Do not remove or make ineffective any safeguards unless authorized. Guards removed for repairs should be replaced promptly.
* Machines must be shut down before cleaning, repairing, or oiling. Disconnect or use Lock Out techniques.
* Keys or adjusting tools must never be left so that they may creep, be thrown, or fall when a machine is started.

Machine Tool Safety Lathes, Drill Press, Milling Machine

* When drilling or tapping material see that it is securely fastened by blocks or clamps so that it cannot spin or climb the drill. In no case should the operator rely on his hands to secure the material from turning.
* Use a brush, special tool, or hook to remove chips, shavings, or other material from work.
* Transparent guards should be kept clean.
* Keep fingers clear of a machine's point-of-operation by using special tools or devices, such as push sticks, hooks, or pliers.

* Revolving shafts, although apparently smooth, will catch loose or ragged clothing, gloves, jewelry, hair, or wiping rags. Proper clothes and caution are always necessary when working around any revolving machinery. Shirt sleeves should be rolled up. Neckties should not be worn.

* Safety glasses must be worn whenever flying chips, particles of material, liquids, chemicals, or sparks may cause eye injury.

Portable Power Tools

Students and Staffs using portable electric tools must be aware of several dangers. Among the most serious hazards are electrical burns and shocks. Under certain conditions, even a small amount of electric current can result in fibrillation of the heart and death. An electric shock also can cause the user to fall off of a ladder or other elevated work surface and be injured due to the fall.

- To protect the user from shock and burns, electric tools must have a three-wire cord with ground and be plugged into a grounded receptacle, be double insulated, or be powered by a low-voltage battery. Three-wire cords contain two current-carrying conductors and a grounding conductor.

- Double-insulated tools are available that provide protection against electrical shock without third-wire grounding. On double-insulated tools, an internal layer of protective insulation completely isolates the external housing of the tool.

- Appropriate personal protective equipment, such as safety goggles and gloves, must be worn to protect against hazards that may be encountered while using hand tools.

- Workplace floors shall be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.

- Power tools must be fitted with guards and safety switches; they are extremely hazardous when used improperly. The types of power tools are determined by their power source: electric, pneumatic, liquid fuel, hydraulic, and powder-actuated.

Welding, Cutting, and Brazing

* Signs reading "DANGER--NO SMOKING, MATCHES, OR OPEN FLAMES" or the equivalent should be posted.

* Grounding of the machine frame and safety ground connections of portable machines should be checked periodically.

* Electrical power to the welder should be shut off when no one is present.

* Welding is to be done only by those employees who are qualified as welders.

* Red should be used to identify acetylene (and other fuel-gas) hoses, green for oxygen hoses, and black for inert gases and air hoses.

* Always stand to one side and away from the gauge faces and front of the regulator when opening the cylinder valve. In case of an explosion, you will not be cut by flying glass.

* Never open an acetylene cylinder valve more than one-half (1/2) turn. Always keep the key on the acetylene cylinder valve. In case of a flashback or fire from a leaky cylinder connection, a gloved hand can withstand the heat long enough to close the valve.

* Oxygen is not a substitute for compressed air. Never use oxygen equipment around oily gloves, clothes or oily surfaces. Oil or grease in presence of oxygen, under pressure, will ignite violently.

* Suitable fire extinguishing equipment should be available for instant use.

* Fire watchers should be assigned when welding or cutting is performed in locations where a serious fire might develop.

* A lighted torch should not be turned on concrete. Concrete always contains some moisture which may cause the concrete to explode.

* Cylinders have exploded from what seemed to be slight jars. Be sure your cylinders are chained or strapped securely.

* Never use acetylene from a cylinder in a horizontal position. In this position, the acetone is drawn out of the cylinder with the acetylene.

* Use the cylinder valve--not the regulator--to turn the gas off. The regulator is not designed to be used as a shut-off valve.

* Do not watch the electric arc without welding lenses. Ultra- violet and infra-red rays are thrown off in concentrated form and can burn unprotected eyes.

* Eye protection helmets, hand shields, and goggles meeting the appropriate standards are required.

* Local exhaust ventilation is recommended for most welding, cutting, and brazing. It is required when the following base metals, fluxes, coatings, platings, or filler metals are used:

- beryllium
- cadmium
- chromium
- fluorides
- lead
- mercury
- zinc
- inert gas welding
- oxygen cutting of stainless steel

Silver soldering requires local exhaust ventilation due to cadmium in the solder.

* When working in confined spaces, environmental monitoring tests should be taken and means provided for quick removal of welders in case of an emergency (see section on confined space safety).

Woodworking Machines

* Saws used for ripping should be equipped with anti-kick back devices and spreaders.

* A dull saw is dangerous. It retards speed and may break.

* A ripsaw should not be used for crosscutting, nor should a crosscutting saw be used for ripping.

* Woodworking machinery must be frequently checked by the Shop Foreman for defects.

* Saws must be sharp (not cracked), properly mounted, and have a blade guard.

* Check planer, shaper, jointer, knives, bolts, nuts, clamps, and guards.

* Stop a machine before leaving it. Another person may be injured by it.

* Radial arm saws should be arranged so that the cutting head will gently return to the back of the table when released.

ADDENDUM (Frequently used forms)

Professor_____

Student _____

SAFETY CHECK LIST FOR
EXPERIMENTAL INSTALLATIONS
AT HERRICK LABS

This form must be completed and filed with the HERL Safety Committee before the initiation of the experimental

A. General Information

1. Project Title: _____

   Project Account Number: _____

2. Professor in Charge of Project _____

   Professor's Office Number: _____ Telephone: _____ E-mail: _____

3. Operator's (Student):_____

   Operator's (Student) Office Number: _____Telephone: _____ Home Phone: _____

   E-mail:_____

PROPRIETARY PROJECT **(CIRCLE ONE) Yes No**

B. **Safety Variables** (maximum possible value should be given)

Pressure (psi): _____max

Sound Level (db): _____max

Combustibles: _____max
(fuels, solvents, gases, etc.).

Flowrate/quantity stored in system _____max

SDS's on file for all chemicals _____

Toxic materials (lbs. and type): _____max

Toxicity (ppm): _____max

Rotating Machinery (RPM): _____max

C. **General Experimental Equipment Checks:**

		Student	Technician	Professor	Safety Committee	Comments
1.	Pressure vessel installed properly. [examples : current date proof test, a) overpressure protection relief valves or example burst diaphragms, b) cleanliness such as oxygen service, etc.]					
2.	Piping or tubing properly installed (examples: pressure rating, tied down if containing high pressure flanges and fittings proper rating, meets cleanliness for example oxygen service, etc.)					
3.	Flexible hoses (hydraulic or gas) properly installed (examples: pressure rating, current date proof test, tied down if containing high pressure, meets cleanliness for example oxygen service, etc.)					

		Student	Technician	Professor	afety Committe	Comments
4.	Exhaust and venting systems installed properly (examples: no leakage, vented to a inter-lock, etc.)					
5.	Personnel safety equipment work or installed properly (examples: ear protection, respiratory protection, protective clothing, gloves, shoes, eye protection hood or safety glasses, etc.)					
6.	Fuels, solvents paints and toxic stored and handled properly (examples: quantity stored limited by state and university regulations, etc.)					
7.	Equipment safety shield installed properly (examples: belt guards, rotating shaft guards, optical barriers for lasers etc.)					
8.	Electrical wiring installed properly (examples: equipment properly grounded, circuits fused, high voltage shielded or interlocked, etc.) No loose wires.					
9.	Laser properly installed (examples: warning signs or lights posted, door interlocks if high energy laser is used, etc.)					
10.	Fire extinguisher equipment location established (examples: proper extinguishing material, and extinguisher charged, etc.)					
11.	Gas cylinders installed and stored properly (examples: chained to wall or rack, capped when not in use, etc.)					
12.	Laboratory area properly certified for intended use.					
13.	Laboratory area properly secured against accidental entry (examples: signs indicating hazard, doors secured, personnel barriers if hazardous area exists during the conduction of the experiment). These items for laser covered in Item 9 above.					
14.	Special considerations					

Written or posted operation checklist prepared (examples: apparatus start up, run, and shutdown procedures, night and weekend securing procedures, posting of critical shut-off locations for fire department, etc.). [Professor in charge and building safety coordinator or committee initials] _____

Number of people present while running equipment _____

Approved hours of operation _____ a.m. _____ p.m.

Please initial (professor in charge and building safety coordinator/committee member _____

Safety Instructions

The student and/or technician have been instructed in all matters of safety. If applicable proof of university "Right-to-Know" or Chemical Hazard Training is required for operator and faculty member.

Major Professor sign: _____

Copies to: All Signers
Herrick Safety Committee

Herrick Lab

REFRIGERANT BALANCE SHEET

NEW REFRIGERANT

*Section 608 of The CLEAN AIR ACT requires materials balance records be maintained on refrigerants. You **MUST** accurately record all materials dispensed from this container.*

Refrigerant_____ Quantity_____ Source_____

Date Purchased_____ Account #_____

DATE	Lbs.	OZ.	Project/Equipment	Technician
			Gross Weight Full	

Herrick Lab

REFRIGERANT TRACKING INFORMATION

RECOVERED & RECYCLED REFRIGERANT

*Section 608 of The CLEAN AIR ACT requires materials balance records be maintained on refrigerants. You **MUST** accurately record all materials dispensed from this container.*

Please indicate the quantity recovered & source and the quantity installed & equipment recharged. Place an R after technicians initial for recovered refrigerant and a I for refrigerants installed.

THIS TANK CONTAINS_____REFRIGERANT

DATE	Lbs.	OZ.	Project/Equipment	Technician
Tare weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				
Cylinder weight				

Attach additional sheets as needed.
CFC form #2 HERL Technical Services