

February 1, 1995

MEMORANDUM

TO: VICE PRESIDENTS, DEANS, DIRECTORS AND DEPARTMENT HEADS

FROM: G. WAYNE CLOUGH

SUBJECT: INSTITUTE SAFETY POLICY

I view no administrative responsibilities to be of greater importance than that of preserving life, and I recognize the administration's obligation to provide the Tech community with the safest possible environment. Fulfilling this responsibility requires the attention and cooperation of all individuals with administrative authority to ensure that:

- proper instruction and safe work practices are provided on a continuing basis;
- classroom and laboratory procedures are reviewed regularly; and,
- performance is supervised personally.

I urge each of you to follow and permit the use of only those practices and procedures which will ensure the maintenance of a safe working environment. Toward this end, I ask that each of you give your personal attention to the development of a safety program in accordance with your unique organization's needs.

The Associate Vice President for Facilities is responsible for safety at all Institute facilities. The Director of Environmental Safety is designated as the principal Institute administrator for providing direction and guidance for the overall campus safety program. He is available to assist you directly in assessing your safety needs, and to aid you in developing a safety program for your organization.

I am confident that your efforts in this important area will contribute materially to a reduction in on-campus accidents and injuries.

Please disseminate this information to the members of your organization.

JMP/sg

ACKNOWLEDGMENTS

The following publications were utilized in preparation of this manual:

- “Laboratory Safety Manual,”* University of Massachusetts
“Laboratory Safety Manual,” University of Georgia
“Safety in Academic Chemistry Laboratories,” American Chemist Society
“Prudent Practices for Handling Hazardous Chemicals in Laboratories,” National
Research Council
“Handbook of Laboratory Safety,” Chemical Rubber Company
“Guide for Safety in the Chemical Laboratory,” Manufacturing Chemists Association
“Laboratory Safety Manual,” University of Florida
“Chemical Technicians’ Ready Reference Handbook,” Shugar/Shugar/Bauman/
Bauman
“Safety in Working with Chemicals,” M.E. Green/A. Turk
Georgia Public Employee Hazardous Chemical Protection and Right-to-Know
Act of 1988 as amended (45-22-1)
Georgia Department of Labor, Chapter 300-3-19, Public Employee Hazardous
Chemical Protection and Right-to-Know Rules

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I. Introduction

This manual has been developed by the Georgia Institute of Technology, Department of Environmental Health & Safety (DEHS) to assist Institute departments in the recognition, evaluation and control of hazards associated with Institute laboratory operations. It is intended to establish basic safe operating practices so that faculty, students, and staff may carry out effective teaching and research programs in a safe and healthy environment. This manual is not intended, however, to be either a complete or final listing of potential hazards or safe practices. Because of the diverse nature of work being conducted in Institute laboratories, additional procedures or information may be necessary. Individuals having questions are urged to call upon the Department of Environmental Health & Safety for assistance.

II. Areas of Responsibility

- A. The *principal investigator* (P.I.) or supervisor has the primary responsibility for controlling hazards in his/her laboratory. This shall include: instructing laboratory personnel on potential hazards, training employees in safe practices, correcting work errors and dangerous conditions, encouraging a positive attitude towards safety, investigating the circumstances surrounding each accident, and taking steps to avoid recurrence.
- B. The *laboratory worker* shall be responsible for complying with oral and written safety rules, regulations, and procedures required for the assigned task.
- C. The *Department of Environmental Health & Safety* shall be responsible for assisting individuals and providing technical advice. The DEHS shall assist investigators in determining and following safe practices, coordinate safety activities, and provide education in safety. The Department shall have enforcement authority in dealing with unsafe practices.

III. Right To Know

A. Purpose

In order to comply with the Georgia Public Employees Hazardous Chemical Protection and Right To Know Act of 1988 as amended, Georgia Department of Labor, Chapter 300-3-19 Public Employee Hazardous Chemical Protection and Right To Know Rules, and the University System of Georgia Hazardous Chemical Protection Communication (Right To Know) Plan, this written Hazardous Chemical Protection Communication Plan is established for the Georgia Institute of Technology.

B. Definitions

1. **Member unit** means any of the 34 colleges and universities governed by the Board of Regents of the University System of Georgia.
2. **Member unit Right to Know Coordinator** means an individual who is assigned the responsibilities associated with the title in the written member unit Hazardous Chemical Protection Communications (Right To Know) Plan.
3. **University System Right To Know Coordinator** means the individual who is assigned the responsibilities associated with that title as described below.
4. **Work area** means a room inside a building or structure, an outside area, or other defined space in a work place where hazardous chemicals are produced, stored, or used and where employees are present in the course of their employment.
5. **Work place** means an establishment or business of an employer at one geographic location at which work is performed by a state employee and which contains one or more work areas. In the case of an independent contractor or sub-contractor, the work place shall be defined as all work areas wholly owned or controlled by such independent contractor or sub-contractor.

C. Policy

All work units of the Georgia Institute of Technology are included within this program. The written program is available for review at the office of the Institute Right To Know Coordinator, located at 490 Tenth Street, Room 316.

D. Right To Know Coordinator

The Georgia Institute of Technology Right To Know Coordinator is Steve Millspaugh, 4-9381, who shall:

1. Act as liaison between the University System Right To Know Coordinator and the Institute on hazardous chemicals issues;
2. Resolve questions regarding applicability of the Chapter 300-3-19 rules to individual work places and work areas of the Institute;
3. Make arrangements for and/or provide appropriate and adequate Right To Know Training to all employees of the Institute;
4. Ensure that a written work place specific hazard communication program be developed for each work place in the Institute. This work place specific program will include a list of hazardous chemicals used, stored, or manufactured in the particular work place, and will be available to all employees in the work place;
5. Disseminate updated information so that all employees of the Institute will have access to current Material Safety Data Sheets for those hazardous chemicals used in their work area, via their supervisors;
6. Ensure that employees are made aware of and are properly trained in the uses and hazards associated with chemicals to which they are exposed in their work area;
7. Ensure that employee training on and notification of the use of hazardous chemicals in the work area are adequately documented in each employee's personnel file;
8. Ensure that employees are provided with personal protective equipment appropriate to each work environment, and receive adequate training in the use and maintenance of this equipment;
9. Accumulate hazardous chemical inventory information for the Institute;
10. Review, at least annually, the hazardous chemical labeling practices in the work areas where secondary storage containers are used.

E. Procurement of Hazardous Chemicals

Unless there are alternate procedures established by the Institute Right To Know Coordinator to advise the Coordinator of the acquisition of a hazardous chemical, any person procuring a hazardous chemical **MUST** forward a copy of the purchase order to the Institute Right To Know Coordinator, or otherwise communicate in writing that the procurement did occur.

It is the responsibility of the person approving the purchase of the chemical to determine whether a chemical or product used is a hazardous chemical under the law.

F. Material Safety Data Sheets

A Central file of **MSDS** is maintained at the office of the University System Right To Know Coordinator in the Public Safety Building at the University of Georgia and is available to supervisors by computer modem, *via the Georgia Institute of Technology Right To Know Coordinator*, 24-hours each day by telephoning **GIST 241-0143**. For urgent access to any MSDS after normal business hours, an additional **MSDS** file, accessible by computer modem, is available at **GIST 241-3675**.

Department heads and supervisors throughout the Institute, in keeping with their obligation to ensure a safe work environment, are responsible for maintaining ready accessibility of **MSDS**'s for employees in their work areas for review during each work shift.

G. Container Labeling

The person ordering a chemical or product containing a hazardous chemical should verify that all containers received for use will:

be clearly labeled as to the contents; display the appropriate hazard warnings; and list the name and address of the manufacturer.

1. Secondary Containers

The work shift supervisor in each section should ensure that all secondary containers are labeled with either an extra copy of the original manufacturer's label or with a label containing:

the identity of the contents, and either an NFPA or HMIS hazard warning label, *properly filled out*.

If the secondary container is intended only for short-term storage (one week or less), it shall be labeled *at a minimum* with the name of the contents and date of filling. Vials and test tubes may have hazard labels affixed to the rack or container in which they are held, rather than on each vial or test tube, so long as every vial or test tube in the rack or container presents the same hazard.

2. Unlabeled Containers

If an employee finds a container in the work area, and it is unlabeled or carries a defaced label and is thought to contain a hazardous chemical, the employee should immediately notify a supervisor. If the supervisor is unable to identify the container, the supervisor should call the Institute Right To Know Coordinator for assistance.

H. Employee Training

1. Current Employees

Currently-employed persons must have received required Right To Know training no later than 30 June 1992.

2. New Employees

Prior to starting work, each new employee of the Institute will attend a Right To Know training session which will present **BASIC TRAINING**. That basic training may normally be scheduled during New Employee Orientation, and may include a showing of the video program “*Your Right To Know*,” approved by the Department of Labor for such training. The videotape program provides an overview of the hazardous chemical protection laws, regulations, and policies in place in The University System, and a summary of employee rights in hazardous chemical protection. Any additional Right To Know policies established for the Institute will be presented at this time.

3. Employees Handling Hazardous Chemicals

The immediate supervisor of any employee who will routinely be exposed to any hazardous chemical must ensure that before beginning work, each such employee receives additional **CHEMICAL-SPECIFIC TRAINING** on:

- any such chemicals present in work place operations;
- physical and health effects of the chemicals;

- methods and observations techniques used to determine the presence or release of the chemical in the work area;
- how to lessen or prevent exposure to these chemicals by proper work practices and use of personal protective equipment;
- emergency procedures to be followed in the event of exposure;
- procedures for safe disposal of waste chemicals.

4. Documentation of Training

After participating in either **BASIC TRAINING** or **CHEMICAL-SPECIFIC TRAINING**, a written record of the training given must be made. Such records must be maintained for three years.

5. Training for Increased Hazard

Prior to the introduction of any new chemical hazard or significant increase of an existing hazard in a work area, the immediate supervisor of affected employees must ensure that additional necessary **CHEMICAL-SPECIFIC TRAINING** is provided and recorded.

I. Supervisory Responsibilities

Department heads are responsible for advising their employees of any operations occurring in their work areas where hazardous materials are present.

The **Institute Right To Know Coordinator** is responsible for ensuring that all hazardous chemicals remaining on the Institute property as a result of the departure of a faculty or staff member, or the vacating or reassignment of an assigned space, shall be managed in accordance with appropriate procedures.

J. Informing Contractors

A **Contractor** doing work at the Institute may:

1. Expose employees of the Institute to hazardous chemicals used by the Contractor;
2. Expose employees and sub-contractors of the Contractor to hazardous chemicals used by the Contractor;

3. Expose employees and sub-contractors of the Contractor to hazardous chemicals used by the Institute.

Therefore, any contract with the Insitute which may involve hazardous chemical exposure *should require the contractor to:*

1. Notify the work place manager at the member unit work site at least 30-days prior to the commencement of work of any hazardous chemicals which will be used or stored at the work site by the contractor or its sub-contractor. (This 30-day requirement may be waived in the event of an emergency.) The work place manager will then:
 - a) Disseminate this information to member unit employees whose work place is at the work site;
 - b) Obtain from the Contractor, **MSDS's** for those hazardous chemicals and maintain them readily available to Institute employees during the Contractor's presence at the work site;
2. Provide documentation to the work place manager that its employees and its sub-contractors have been provided with information and training on hazardous chemicals being used by the contractor or its sub-contractors at the work site.

K. Hazardous Chemical Lists

The Institute Right To Know Coordinator shall supply to the **University System Right To Know Coordinator** in June and December of each year, a list, by name and manufacturer, of all hazardous chemicals or products present in the member unit's work places. This list shall include all chemicals labeled as flammable, explosive, combustible liquid, corrosive, reactive, oxidizer, toxic, water reactive, pyrophoric, or an organic peroxide.

1. Appendix 1 Hazardous Chemicals List

The **Institute Right To Know Coordinator** shall publish every January and July a list of those hazardous chemicals and products containing hazardous chemicals which are found at the Institute.

Publication of this list is required as part of this written **Hazardous Chemical Protection Communication Plan**.

IV. General Laboratory Safety Guidelines

A. Signs and Labels

1. Emergency Telephone Numbers

A sign, available from the DEHS (4-4635), shall be affixed to the outside of every laboratory and chemical storage area. This sign should list the names and phone numbers of those individuals to be contacted in the event of an emergency.

2. Hazard Warning Signs

Clearly visible signs should be posted indicating the nature of any hazard (e.g., biohazards, carcinogens, flammable solvents, radioactive materials, and lasers) contained in the laboratory or storage area.

Maintenance personnel must enter rooms on campus periodically during the course of their duties. Some investigators conduct experiments which must not be disturbed or they use techniques which may be harmful to individuals who are not apprised of the danger. When such experiments are being conducted, appropriate warning signs such as *DO NOT ENTER - EXPERIMENT IN PROGRESS* or *DO NOT ENTER - LASER IN USE*, etc., should be clearly displayed on all entrances.

3. Emergency equipment (Section III, B) as well as chemicals and waste containers (Section III, E) shall be labeled.

B. Safety Equipment and Emergency Procedures

1. Laboratory workers shall be required to know the locations of, and how to use emergency equipment. They shall also be required to be familiar with emergency procedures.

Signs shall be posted to identify the locations of safety showers, eyewash stations, exits, and fire extinguishers.

2. Safety Equipment

- a. Fire Extinguishers

All chemical laboratories shall have an appropriate type fire extinguisher of adequate size. (If you have questions about fire extinguishers, call the Institute Fire Marshall at 4-2990.)

Water extinguishers are effective against burning paper and trash (Class A fires). They *should not* be used on electrical, liquid or metal fires.

Carbon dioxide extinguishers are effective against burning liquids, such as hydrocarbons, and electrical fires (Class B and C fires). They are recommended for fires involving delicate instruments and optical systems because they do not damage such equipment. They are less effective against paper, trash or metal fires and *should not* be used against lithium aluminum hydride fires.

Dry power extinguishers are effective against burning liquids and electrical fires (Class B and C fires). They are less effective against paper and trash or metal fires. These extinguishers are generally used where large quantities of solvents are present.

“Met-L-X” extinguishers and others that have special granular formulations are effective against burning metal (Class D fires). Included in this category are fires involving magnesium, lithium, sodium, and potassium; alloys of reactive metals; and metal hydrides, metal alkyls, and other organo-metallics. These extinguishers are less effective against paper and trash, liquid or electrical fires.

b. Safety Showers and Eyewashes

A safety shower and an eyewash fountain must be located within 25-feet of the laboratory work area. The maximum travel time to an eyewash should be 10 to 15-seconds. In the event that a permanent installation is not readily available, a “temporary” eyewash should be obtained. This shall consist of an eye/face wash that attaches directly to the faucet. Portable eye/face units should be used only when other installations are not possible. A non-toxic additive should be mixed in the water to eliminate the formation of bacteria. Eye wash bottles are considered to be ineffective and should never be relied upon!

Every laboratory worker should know the location of, and how to use the safety shower in order to be able to locate it with eyes closed, if necessary.

c. First-Aid Kit

A first-aid kit shall be located in a clearly visible place in each laboratory. This kit should include, but is not limited to, the following:

CONTENTS PER KIT

1 pk	Merthiolate swabs
1 pk	Wound cleansing scrubbers
1 pk	Scissors and forceps
3 ea	Ammonia inhalants
1 rl	Dermicel first-aid tape
5 ea	4" x 4" gauze pads
10 ea	2" x 2" gauze pads
1 ea	Triangular bandage
4 ea	5" x 9" Surgipad combine dressing
10 ea	Band-aids
2 ea	Compression bandages
2 ea	2" x 5 yds. gauze rolls

Information on purchase of first-aid kits may be obtained from DEHS.

3. Emergency Procedures

a. Emergency Reporting Procedures

- (1) Report the nature of the emergency to the appropriate agency:

for medical emergency and/or police ----- dial 4-2500.
for **fire** ----- pull nearest alarm and call the campus police at 4-2500.

Include the following information when reporting an emergency:

- your name
- telephone number
- building
- floor
- room number
- condition of any injured individuals (e.g., unconscious, burned, or trapped)
- type of fire, if any

- (2) Notify others in the area.
- (3) Meet ambulance, fire crew, or campus police.
- (4) Do not move seriously injured people unless they are in danger of further injury.

b. First Aid

In case of medical emergency or while waiting for assistance:

- (1) Summon medical help, if you have not already done so. If there is a fire, use proper extinguishers--cut off electrical circuits and/or gas lines. Close doors.
- (2) Do not move any injured person unless absolutely necessary.
- (3) Keep the injured person warm.
- (4) If clothing is on fire, help the individual to the floor and roll him/her around to smother the flames, or if a safety shower is immediately available, douse the person with water. (Running to a not immediately accessible safety shower or other source of water will only serve to fan the flames and intensify the clothing fire.) Fire blankets are intended primarily as a first-aid measure for prevention of shock rather than against smoldering or burning clothes. By wrapping a person who is on fire, heat is retained and the clothing may continue to smolder, resulting in serious burns. In addition, if the person who is wrapped in the safety blanket is

standing, a chimney effect may occur—smoke from the smoldering clothing would continue to rise past the person's face.

- (5) ***If chemicals have been spilled over a large area of the body***, quickly remove all contaminated clothing while using the safety shower. Immediately flood the exposed areas with cold water for at least 15 minutes; resume if pain returns. Wash off chemicals by using a ***mild detergent or soap*** (preferred) and water; do not use neutralizing chemicals or salves.

If chemicals have been spilled on a confined area of the skin, immediately flush with cold water and wash by using a mild detergent or soap (preferred) and water. Remove any jewelry in the affected area. If a delayed action of the chemical is possible (e.g., methyl and ethyl bromides) obtain medical attention promptly.

If a chemical has been splashed into the eyes, immediately wash the eye and inter surface of the eyelid with copious amounts of water for 15 minutes. Check for and remove any contact lenses at once (contact lenses are prohibited in the laboratory). An eyewash fountain should be used if available. Forcibly hold the eye open to wash thoroughly behind the eyelids. Where no eyewash is available, the injured individual should be placed on his/her back and water gently poured into the eye. The eye must be held open.

- (6) In case of ingestion of a toxin, dilute the poison by having the victim drink large amounts of water (do not give liquids to an unconscious or convulsing victim). Attempt to learn what the ingested substances were. Save the label or container for transportation with the victim to the medical facility.

c. Accident Reports

EMPLOYEES (INCLUDING STUDENT EMPLOYEES) -- In the event of a laboratory accident, a Supervisor's Accident Investigation Report and an Employer's First Report of Injury shall be completed by the laboratory supervisor with the assistance of the injured employee. Sample copies of these forms are enclosed. Once completed, these forms should be forwarded to the Office of Human Resources, and a copy sent to DEHS.

STUDENTS (NOT EMPLOYED) AND VISITORS -- In the event of a laboratory accident, a Supervisor's Accident Investigation Report should be completed by the laboratory supervisor with the assistance of the injured

party. Once completed, this form should be forwarded to the Department of Environmental Health & Safety.

C. Protective Clothing and Equipment

Eye protection shall be worn at all times in all laboratories where other than purely instrumental studies are being conducted. Ordinary prescription glasses will not provide adequate protection from injury to the eyes. The minimum acceptable protection are hardened glass or plastic safety glasses.

Safety goggles or face shields shall be utilized where there is a possibility of splashing chemicals, violent reactions or flying particles. Specific goggles shall be worn for protection against laser hazards, and ultraviolet or other intense light sources.

Contact lenses should not be worn in the lab without proper eye protection (e.g., safety goggles, face shields, etc.).

1. Gloves

Skin contact is a potential route of exposure to toxic materials. Dermatitis, erythema, burns, and absorption of toxic and/or carcinogenic chemicals are some of the consequences of exposing skin to hazardous liquids. Therefore, proper protective gloves shall be worn when working with toxic or corrosive materials, or with materials of unknown toxicity. Gloves should be selected on the basis of the material being handled and their suitability for the particular laboratory operation.

Chemical resistance is the most common type of glove evaluation. It is a qualitative and subjective rating and refers to the ability of the material to resist decomposition or disintegration. It **does not** indicate the chemical protection afforded by the glove. Chemical permeation, on the other hand, does. Permeation is the process by which a hazardous liquid may pass through the glove material to the inside. Because the glove material is not physically destroyed, the individual may not be aware that breakthrough has occurred and that he/she is being exposed. The period of adequate protection, (i.e., the breakthrough time plus some interval of time during chemical permeation), can only be determined by testing the glove with the chemical to be handled.

When selecting gloves:

- determine the physical properties of the chemical to be used, its toxicity and, if possible, its ability to be absorbed through skin.

- determine which glove materials have the highest breakthrough times and lowest penetration rates. Consult the manufacturer or the Department of Environmental Health & Safety. Remember, no one glove is suitable for handling all chemicals.
- determine the glove that offers the best resistance to chemical degradation.

2. Footwear

Solid toed shoes shall be worn at all times. Open toed shoes or sandals offer little or no protection against chemical spills or broken glass.

3. Other Clothing

Laboratory personnel shall not wear loose (e.g., saris, dangling neckties, and overlarge or ragged laboratory coats), skimpy (e.g., shorts and/or halter tops), or torn clothing. If there is a possibility of contamination, personal clothing that will be worn home should be covered by protective apparel.

D. Health and Hygiene

1. Food Handling

Contamination of food, drink, and smoking materials are potential routes of exposure to hazardous materials. For this reason, food or beverage shall not be taken into any laboratory where there is a toxicity hazard. Glassware or utensils that have been used for laboratory operations should never be utilized to prepare or consume food. Laboratory refrigerators and cold rooms should not be used for the storage of foods; separate, clearly labeled equipment should be employed.

Smoking shall be prohibited except for specifically approved areas. Nonsmoking areas shall be posted as such.

2. Hand Washing

Hands shall be washed often, even when gloves are being utilized. Avoid the use of solvents for washing. They remove the natural protective oils from the skin and can cause irritation and inflammation. In some cases, the solvents might even aid skin absorption of a toxic chemical.

3. Pipetting

No solutions shall be pipetted by mouth.

E. Housekeeping

Work areas shall be kept clean and free from obstructions. Cleanups should follow the completion of any operation or be done at the end of the day. Aisles, hallways, and stairways shall not be used for storage areas.

All reagents stored in other than their original container shall be labeled clearly as to the contents, date, and name of the person storing the solutions. Chemicals stored in the laboratory should be inventoried periodically and unneeded items either disposed of or returned to the storeroom. Containers should also be examined for deteriorating labels. The quantity of chemicals stored in the laboratory shall be kept as low as possible.

Old or outdated solutions should be disposed of (see Section IV, K). The laboratory supervisor should arrange for the removal or safe storage of all hazardous materials which personnel have on hand when they are about to terminate, graduate or transfer.

All spills and broken glassware shall be cleaned up immediately (see Section IV, H).

Never store bottles or equipment on shelves over laboratory benches unless there are restraining lips on the shelves. Storage of bottles on benches is undesirable because of their propensity to be knocked over. Storage in hoods is also inadvisable because this practice interferes with the airflow in the hood (see Section IV, B), clutters up the working space, and increases the amount of material that could become involved in a fire.

Wastes shall be placed in appropriate receptacles and properly labeled. Broken glassware, pipettes and syringes shall be placed first into puncture proof containers.

F. Working Alone and Unattended Operations

Persons working after hours or alone shall make arrangements with other persons in the building to check with each other periodically. Experiments which are hazardous shall not be performed by a worker who is alone in a laboratory.

Unattended operations which may continue for several hours or overnight should be approved by the laboratory supervisor. Many of these operations utilize water as the coolant in condensers. Either a decrease or increase in water pressure can have serious consequences. Lower pressure, typical in the early morning as water usage increases, can result in a slower flow and inadequate cooling. Higher pressures can cause leaks, separation of connections and flooding.

When setting up unattended operations, regulate the water pressure automatically via the installation of a water pressure regulator. The regulator should be protected by an appropriate filter to prevent clogging. Monitor the water flow so that in the event of interruption, electricity and water supply can be turned off. The latter is necessary because a break in a connection can result in flooding. Position the monitor at some point after the water has passed through the apparatus and is on its way to the drain.

Operations should be designed to be safe, and plans should be made to avoid hazards in the event of a failure in power, water, gas or some other service. Room lights should be left on and an appropriate warning sign should be placed on the door.

G. Refrigerators

Three types of refrigerators are available for use:

1. The *ordinary household refrigerator* is not equipped with explosion-safe controls or door switches and should not be used to cool flammable liquids because sparks from controls or door switches may ignite the vapor-air mixture.
2. The *explosion-safe refrigerator* is constructed with its controls mounted outside the storage compartment. This type refrigerator is suitable for storing flammable liquids.
3. The *explosion-proof refrigerator* also has its controls mounted on the outside, but in addition, the controls are of an explosion-proof design. This type is needed only where both the internal and external environment present a fire or explosion hazard.

Every refrigerator should be clearly labeled to indicate whether or not it is suitable for storage of flammable liquids. Flammable liquids stored in a refrigerator shall be in closed containers.

Laboratory refrigerators shall not be used for storage of food or beverage unless used solely for that purpose and labeled as such.

H. Heating Equipment

1. Steam Heated Devices

Steam heated devices rather than electrically heated devices or bursen burners shall be used whenever possible. (Steam heated devices do not present shock or spark hazards and can be left unattended with assurance that their temperature will not rise beyond 100 degrees C.)

2. Electrically Heated Devices

Only *hot plates* that have their heating elements enclosed in a glass, ceramic, or insulated metal case should be used in laboratories. Laboratory workers should be aware of the possible spark hazard from the on-off switch of older hot plates.

Heating mantles should be checked for breakage in the fiberglass cloth coating and to assure that no water or other chemicals are spilled into the mantle. Laboratory workers should be careful not to turn a variable transformer so high as to exceed the input voltage recommended for the mantle by the manufacturer.

Oil baths should always be monitored via a thermometer or other device to ensure that their temperature does not exceed the flash point of the oil being used. Smoking, caused by the decomposition of the oil or of organic materials in the oil, represents another hazard. A laboratory worker using an oil bath heated above 100 degrees C should be careful to guard against the possibility that water (or some other volatile substance) could fall into the hot bath. Such an accident can splatter hot oil over a wide area. The oil bath should never be supported on an iron ring because of the possibility of accidental tipping.

3. Burners

Where burners are used, distribute the heat with a wire gauze pad. As with all heating equipment, burners should not be left on when not in use. Workers should understand the hazards of burners before proceeding with an experiment.

I. Glassware

Careful handling and storage procedures should be used to avoid damaging glassware. Damaged items should be discarded or repaired.

Hand protection should be utilized when inserting glass tubing into stoppers or when placing rubber tubing on glass hose connections. To insert glass tubing:

1. Fire polish the ends of the glass tubing;
2. Wet the glass and stopper hole with glycerin or water;
3. Wrap a cloth around the glass;
4. Hold hands close together and rotate the glass back and forth; and
5. Never attempt to push the glass into the stopper or tubing.

On occasion it will be necessary to enlarge or bore a hole in a stopper. When utilizing a cork borer:

1. Select the appropriate size rubber or cork stopper;
2. Select a borer of slightly smaller size than the hole to be bored;
3. Sharpen the borer;
4. Supporting the stopper with a cloth pad for palm protection, begin boring at the narrow end;
5. Twist the borer while applying steady pressure;
6. Check the alignment of the borer after each twist;
7. Remove the borer when halfway through the stopper;
8. Remove any plug in the borer; and
9. Begin boring from the other end of the stopper, carefully checking the alignment.

To remove glass tubing and/or thermometers from stoppers:

1. Lubricate the tubing with water or glycerin;
2. Wrap the tubing with a towel;
3. Gently twist the tubing, pulling lightly;
4. If the tubing is stuck to the stopper, gently insert the end of a rat-tailed file between the tubing and stopper, and rotate gently, while lubricating with glycerin; and
5. If this method fails, cut the stopper away.

When loosening stopcocks, stoppers or any other glass-to-glass connections which are frozen, it is important to remember that glass is fragile. Utilize one of the following:

1. Gentle tapping: with a wooden handle of a spatula, gently tap the frozen stopcock or stopper in the direction that it will come out. Work over a desk top covered with cushioning material.
2. Heating: immerse the frozen connection in hot water. Then use technique #1.
3. Stopcock removing clamp: affix the clamp to the frozen stopcock and gently twist. This method should be performed carefully and in combination with technique #2.

V. Chemical Safety

A. Transporting Chemicals

Transporting chemicals may not only be dangerous to the individual undertaking the transport, but to innocent bystanders unaware of the potential hazard.

When chemicals are carried, they should be placed in a safety container, acid-carrying bucket, or other appropriate container to protect against breakage and spillage. When they are transported on a wheeled cart, the cart should have wheels large enough to negotiate uneven surfaces without tipping or stopping suddenly.

Hazardous chemicals should be transported on freight elevators, wherever possible, so as to avoid exposure to persons on passenger elevators. When a passenger elevator must be used:

1. the chemicals should be labeled and carried in safety containers.
2. the chemicals should not be transported during busy times, such as change of classes.

B. Chemical Fume Hoods

Chemical fume hoods are intended to remove vapors, gases, and dusts of toxic, flammable, corrosive or otherwise dangerous materials. With the sash lowered, laboratory fume hoods can also afford workers protection from such hazards as chemical splashes or sprays and fires. However, they are not designed to withstand explosions.

The following factors and guides should be observed in the daily operation of fume hoods:

1. Before performing hazardous operations, make simple checks to determine that the hood is working (e.g., a small piece of paper held at the face of the hood will be sucked inward). Check the hood's manometer, if one has been installed.
2. When work is being conducted within the hood, position the sash so that protection from splashes, flying debris, etc., is provided. Normally, this is a 12-16" work opening.
3. Experimental procedures should be conducted well inside the hood. Moving an apparatus 5-10cm back from the front edge into the hood can reduce the vapor concentration at the face by 90%.
4. Hoods are not intended for the storage of chemicals. Materials stored in them should be kept to a minimum and in a manner that will not interfere with airflow.
5. Hoods should be considered as backup safety devices that can contain and exhaust toxic, offensive, or flammable materials. They should not be regarded as a means of disposing of chemicals.

The use of perchloric acid requires specially designed Perchloric Acid Fume Hoods. For the specifications of a Perchloric Acid Fume Hood, as well as the requirements and procedures for installation, repair, removal, and relocation, consult the Facilities or the Department of Environmental Health & Safety.

C. Flammable Liquids

1. General Information

Flammable substances are the most common hazardous materials found in the laboratory. The propensity to vaporize, ignite, burn or explode varies with the specific type or class of substance. An indicator of the flammability of a solvent is its *flash point*, the lowest temperature at which a liquid gives off vapor in sufficient concentration to form an ignitable mixture with air. This information is usually available on the label affixed to the chemical container or in tables of chemical data. *Flammable liquids* are defined as those liquids which have flash points below 100 degrees F (37.7 degrees C). *Combustible liquids* have flash points between 100 degrees F (37.7 degrees C) and 210 degrees F (93.3 degrees C).

Among the most hazardous liquids are those that have flash points at room temperature or lower, particularly if their range of flammability is broad (flash points and flammability limits of some common chemicals appear in Table 1).

For a fire to occur, three conditions must exist: 1.) a concentration of flammable vapor that is within the flammable limits of the substance; 2.) an oxidizing atmosphere, such as air; and; 3.) a source of ignition. Elimination of one of these three will prevent the start of fire or extinguish an existing fire. Air cannot usually be excluded. Therefore, the problem usually involves preventing the coexistence of flammable vapors and an ignition source. Because spillage of a flammable liquid is always a possibility, strict control of ignition sources is mandatory.

When flammable materials are being used in a laboratory, close attention should be given to all potential sources of ignition. The vapors of all flammable liquids are heavier than air and capable of traveling considerable distances. This possibility should be recognized, and special note should be taken of ignition sources at a lower level than that at which the substance is used.

2. Handling

The following guidelines should be observed in *handling* flammable materials:

TABLE 1

Flash Points, Boiling Points, Ignition Temperatures, and
Flammable Limits of Some Common Laboratory Chemicals *

Limit Chemical	Class	Flash Point (° C)	Boiling Point (° C)	Ignition Temperature (° C)	Flammable (percent by volume in air)	
					Lower	Upper
Acetaldehyde	1A	-37.8	21.1	175.0	4.0	60.0
Acetone	1B	-17.8	56.7	465.0	2.6	12.8
Benzene	1B	-11.1	80.0	560.0	1.3	7.1
Carbon disulfide	1B	-30.0	46.1	80.0	1.3	50.0
Cyclohexane	1B	-20.0	81.7	245.0	1.3	8.0
Diethyl ether	1A	-45.0	35.0	160.0	1.9	36.0
Ethyl alcohol	1B	12.8	78.3	365.0	3.3	19.0
n-Heptane	1B	-3.9	98.3	215.0	1.05	6.7
n-Hexane	1B	-21.7	68.9	225.0	1.1	7.5
Isopropyl alcohol	1B	11.7	82.8	398.9	2.0	12.0
Methyl alcohol	1B	11.1	64.9	385.0	6.7	36.0
Methyl ethyl ketone	1B	-6.1	80.0	515.6	1.8	10.0
Pentane	1A	-40.0	36.1	260.0	1.5	7.8
Styrene	1B	32.2	146.1	490.0	1.1	6.1
Toluene	1B	4.4	110.6	480.0	1.2	7.1
p-Xylene	1C	27.2	138.3	530.0	1.1	7.0

* From: *“Prudential Practices for Handling Hazardous Chemicals in Laboratories”*
National Academy Press (1981)

TABLE 2

Flammable Liquids - Maximum Size of Containers

<u>Container Type</u>	<u>Class 1A¹ Liquids</u>	<u>Class 1B² Liquids</u>	<u>Class 1C³ Liquids</u>
Glass ⁴	1 pt	1 qt	1 gal
Approved Metal or Plastic	1 gal	5 gal	5 gal
Safety Cans	2 gal	5 gal	5 gal
Metal Drums (ICC Spec)	60 gal	60 gal	60 gal

¹Class 1A - Flash point below 73° F, boiling point below 100° F.

²Class 1B - Flash point below 73° F, boiling point at or above 100° F.

³Class 1C - Flash point at or above 73° F, and below 100° F.

⁴Exceptions may be made to this regulation, upon application to DEHS for storage of Class 1A and 1B liquids in glass containers not to exceed 1 gallon.

- a. Flammable materials should be handled only in areas free of ignition sources.
- b. “NO SMOKING” signs should be posted and obeyed wherever flammable liquids are handled or stored. Never smoke or use an open flame near flammable liquids.
- c. Flammables should not be heated with an open flame. Some other type of heat source, such as a steam bath, water bath, or heating mantle should be used.
- d. Transfer flammable liquids with caution. The friction of flowing liquids may be sufficient to generate static electricity which in turn may cause a spark and ignition. Therefore, ground or bond all such large containers before pouring from them. (You may contact DEHS for the details of this procedure.)
- e. Flammable liquids should be dispensed and used in a hood or well-ventilated area so that flammable vapors will not accumulate.
- f. Substitute nonflammable liquids whenever possible.

3. Storage

The following guidelines should be observed in *storage in flammable materials*:

- a. Storage of flammable materials should comply with Institute codes and regulations.
- b. Keep only small quantities of flammable materials available for immediate use.
- c. An approved safety can with a self-closing cover, vent, and flame arrester is the best container for storing flammable liquids or waste solvents in small quantities. An ordinary five-gallon container does not provide adequate protection in cases of fire.
- d. Refrigerators and cooling equipment used for storing flammable liquids should be explosion-safe (see Section III, G). These are externally wired thereby removing possible internal sources of ignition.

D. Highly Reactive Chemicals and Explosives

1. General

When chemical reactions are considered safe it is generally because the reaction rate is relatively slow or can be easily controlled. Certain reactions proceed, however, at such a fast rate and generate so much heat that they may result in explosion. Care should be taken to ensure there is sufficient cooling and surface area for heat exchange.

Many chemical reactions may involve hazards like those mentioned above, but can be handled safely if some preliminary planning has been done. Planning an experiment should include knowledge of the reactivity, flammability, and toxicity of the chemicals used in and produced by the experiment. This information may be obtained from such sources as the "*Fire Protection Guide on Hazardous Materials*" (NFPA), "*Handbook by Reactive Chemical Hazards*" (L. Bretherick), or by calling the DEHS at 4-4635.

Researchers should consult the laboratory supervisor or principal investigator when planning an experiment in which hazardous materials are used or hazardous conditions may occur. Such planning shall include selection of the proper safety procedures, clothing and equipment as well as consideration of the possibility of a power failure, equipment breakdown, or fire and the precautions that can be taken to minimize the consequences.

2. Specific Chemicals

a. Peroxides

Organic peroxides are a class of compounds that have unusual stability problems that make them among the most hazardous substances handled in laboratories. As a class, organic peroxides are considered to be powerful explosives. They are sensitive to heat, friction, impact, and light as well as to strong oxidizing and reducing agents. All organic peroxides are flammable. Types of compounds known to form peroxides are listed in Table 3. Specific chemicals that can form dangerous concentrations of peroxides are listed in Table 4.

TABLE 3
Peroxide Forming Structures

Structure	Examples
1. $\begin{array}{c} \diagup \text{C}-\text{O}- \\ \\ \text{H} \end{array}$	Ethers, acetals
2. $\diagup \text{C}=\text{C} \diagdown$	Olefins with allylic hydrogen, chloroolefins and fluoroolefins, terpenes, tetrahydronaphthalene
3. $\begin{array}{c} \diagup \text{C}=\text{C}-\text{C}=\text{C} \diagdown \\ \text{and} \\ \diagup \text{C}=\text{C}-\text{C} \text{ CH} \end{array}$	Dienes, vinyl acetylene
4. $\begin{array}{c} \text{H} \\ \\ \text{C}=\text{C}- \\ \\ \text{H} \end{array}$	Vinyl Monomers
5. Alkali metals	Potassium
6. Alkali metals alkoxides and amides	Sodamide
7. $\begin{array}{c} \diagup \text{C}- \\ \\ \text{H} \end{array}$	Paraffinic and alkylaromatic hydrocarbons, particularly those with tertiary hydrogen
8. Organometallic	Grignard reagent
9. $\begin{array}{c} \text{O} \\ \\ -\text{C}-\text{H} \\ \text{and} \\ \text{O} \text{ H} \\ \quad \\ -\text{C}-\text{C}- \\ \quad \end{array}$	Aldehydes, ketones. Anhydrous acetaldehyde will autoxidize at 0° or below under ultraviolet light catalysis to form peracetic acid which may react with more acetaldehyde to give the explosive acetaldehyde monoperacetate.
10. $\begin{array}{c} \text{O} \quad \text{H} \\ \quad \\ -\text{C}-\text{N}-\text{C}- \\ \quad \end{array}$	Ureas, amides, lactams

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TABLE 4

Examples of
Peroxidizable Compounds

Common Compounds That Form Peroxides During Storage

Ethyl ether	Isopropyl ether
Tetrahydrofuran	Divinyl acetylene
Dioxane	Vinylidene chloride
Acetal	Potassium metal
Methyl i-butyl ketone	Sodium amide
Ethylene glycol dimethyl- ether (glyme)	Styrene
Vinyl ethers	Butadiene
Dicyclopentadiene	Tetraflouroethylene
Diacetylene	Chlorotrifluoroethylene
Methyl acetylene	Vinyl acetylene
Cumene	Vinyl acetate
Tetrahydronaphthalene	Vinyl chloride
Cyclohexene	Vinyl pyridine
Methylcyclopentane	Chlorobutadiene (chloroprene)

by H.L. Jackson, W.B. McCormack,
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Suggestions for safe use and storage of ether and other peroxidizable materials:

- (1) All peroxidizable materials should be stored in a cool place, away from light. Metal cans are preferable; do not store ethers in ground glass-stoppered bottles.
- (2) Ethers and peroxidizable materials should be ordered only in small quantities and should be dated upon receipt and when opened. They should be discarded within a year after receipt if unopened, or within six months if opened.
- (3) Ethers shall always be handled in a hood to assure proper ventilation. This will protect individuals from inhaling the vapors and prevent accumulation of explosive concentrations of the vapor. For methods of peroxide detection and removal, consult DEHS.

b. Incompatibles

Certain combinations of chemicals are particularly dangerous and should be avoided. Table 6 indicates the compatibility of various chemicals.

c. Other chemical hazards that may result in explosions or fires include:*

Acetylenic compounds are explosive in mixture of 2.5-80% with air. At pressures of two or more atmospheres, acetylene (C_2H_2) subjected to an electrical discharge or high temperature decomposes with explosive violence. Dry acetylides detonate on receiving the slightest shock.

Aluminum chloride ($AlCl_3$) should be considered a potentially dangerous material. If moisture is present, there may be sufficient decomposition (HCl vapor) to build up considerable pressure.

Ammonia reacts with iodine to give nitrogen triiodide, which is explosive, and with hypochlorites to give chlorine.

Benzoyl peroxide, when dry, is easily ignited and sensitive to shock. It decomposes spontaneously at temperatures above 50 degrees C.

Carbon disulfide is both very toxic and very flammable; mixed with air, its vapors can be ignited by a steam bath or pipe, a hot place, or a glowing light bulb.

*From "Prudent Practices for Handling Hazardous Chemicals in Laboratories,"
National Academy Press (1981).

Chlorine may react violently with hydrogen or with hydrocarbons when exposed to sunlight.

Chromium trioxide-pyridine complex ($\text{CrO}_3\text{-C}_5\text{H}_5\text{N}$) may explode if the CrO_3 concentration is too high. The complex should be prepared by addition of CrO_3 to excess $\text{C}_5\text{H}_5\text{N}$.

Diazomethane (CH_2N_2) and related compounds should be treated with extreme caution. They are very toxic, and the pure gases and liquids explode readily. Solutions in ether are safer from this standpoint.

Dimethyl sulfoxide [$(\text{CH}_3)_2\text{SO}$] decomposes violently on contact with a wide variety of active halogen compounds. Explosions from contact with active metal hydrides have been reported. Its toxicity is still unknown, but it does penetrate and carry dissolved substances through the skin membrane.

Dry ice should not be kept in a container that is not designed to withstand pressure. Containers of other substances stored over dry ice for extended periods generally absorb carbon dioxide (CO_2) unless they have been sealed with care. When such containers are removed from storage and allowed to come rapidly to room temperature, the CO_2 may develop sufficient pressure to burst the container with explosive violence. On removal of such containers from storage, the stopper should be loosened or the container itself should be wrapped in towels and kept behind a shield. Dry ice can produce serious burns.

Drying agents---“Ascarite” should not be mixed with phosphorus pentoxide (P_2O_5) because the mixture may explode if it is warmed with a trace of water. Because the cobalt salts used as moisture indicators in some drying agents may be extracted by some organic solvents, the use of these drying agents should be restricted to gases.

Diethyl, diisopropyl, and other ethers sometimes explode during heating or refluxing because of the presence of peroxides. Ferrous salts or sodium bisulfite can be used to decompose these peroxides, and passage over basic active alumina will remove most of the peroxidic material. In general, however, old samples of ethers should be discarded.

Ethylene oxide ($\text{C}_2\text{H}_4\text{O}$) has been known to explode when heated in a closed vessel. Experiments using ethylene oxide under pressure should be carried out behind suitable barricades.

Halogenated compounds---Chloroform (CHCl_3), carbon tetrachloride (CCl_4), and other halogenated solvents should not be dried with sodium, potassium or other active metal; violent explosions are usually the result of such attempts. Many halogenated compounds are toxic.

Hydrogen peroxide (H_2O_2) stronger than three percent can be dangerous; in contact with the skin, it may cause severe burns. Thirty percent H_2O_2 may decompose violently if contaminated with iron, copper, chromium or other metals or their salts.

Liquid-nitrogen-cooled traps open to the atmosphere rapidly condense liquid from the air. Then, when the coolant is removed, an explosive pressure buildup occurs, usually with enough force to shatter glass equipment. Hence, only sealed or evacuated equipment should be so cooled.

Lithium aluminum hydride (LiAlH_4) should not be used to dry methyl ethers or tetrahydrofuran; fires from this are very common. The products of its reaction with CO_2 have been reported to be explosive. Carbon dioxide or bicarbonate extinguishers should not be used against LiAlH_4 fires, which should be smothered with sand or some other inert substance.

Oxygen tanks---serious explosions have resulted from contact between oil and high-pressure oxygen. Oil should not be used on connections to an O_2 cylinder.

Ozone (O_3) is a highly reactive and toxic gas. It is formed by the action of ultraviolet light on oxygen (air) and, therefore, certain ultraviolet sources may require venting to an exhaust hood.

Palladium or platinum on carbon, platinum oxide, Raney nickel and other catalysts should be filtered from catalytic hydrogenation reaction mixtures carefully. The recovered catalyst is usually saturated with hydrogen and highly reactive and, thus, will inflame spontaneously on exposure to air. Particularly in large-scale reactions, the filter cake should not be allowed to become dry. The funnel containing the still-moist catalyst filter cake should be put into a water bath immediately after completion of the filtration.

Another hazard in working with such catalysts is the danger of explosion if an additional catalyst is added to a flask in which hydrogen is present.

Parr bombs used for hydrogenations have been known to explode. They should be handled with care behind shields, and the operator should wear goggles.

Perchlorates---the use of perchlorates should be avoided wherever possible. Perchlorates should not be used as drying agents if there is a possibility of contact with organic compounds or in proximity to a dehydrating acid strong enough to concentrate the perchloric acid (HClO₄) to more than 70% strength (e.g., in a drying train that has a bubble counter containing sulfuric acid). Safer drying agents should be used.

Seventy percent HClO₄ can be boiled safely at approximately 200 degrees C, but contact of the boiling undiluted acid or the hot vapor with organic matter, or even easily oxidized inorganic matter (such as compounds of trivalent antimony), will lead to serious explosions. Oxidizable substances must never be allowed to contact HClO₄. Beaker tongs, rather than rubber gloves, should be used when handling fuming HClO₄.

Perchloric acid evaporations should be carried out only in fume hoods designed specifically for this purpose. Please consult the Facilities Division or the Department of Environmental Health & Safety.

Permanganates are explosive when treated with sulfuric acid. When both compounds are used in an absorption train, an empty trap should be placed between them.

Peroxides (inorganic)---when mixed with combustible materials, barium, sodium, and potassium peroxides form explosives that ignite easily.

Phosphorus (P) (red and white) forms explosive mixtures with oxidizing agents. White P should be stored under water because it is spontaneously flammable in air. The reaction of P with aqueous hydroxides gives phosphine, which may ignite spontaneously in air or explode.

Phosphorus trichloride (PCl₃) reacts with water to form phosphoric acid, which decomposes on heating to form phosphine, which may ignite spontaneously or explode. Care should be taken in opening containers of PCl₃, and samples that have been exposed to moisture should not be heated without adequate shielding to protect the operator.

Potassium (K) is in general more reactive than sodium, it ignites quickly on exposure to humid air and, therefore, should be handled under the surface of a hydrocarbon solvent such as mineral oil or toluene (see Sodium).

Residues from vacuum distillations (e.g., ethyl palmitate) have been known to explode when the still was vented to the air before the residue was cool.

Such explosions can be avoided by venting the still pot with nitrogen, by cooling it before venting, or by restoring the pressure slowly.

Sodium (Na) should be stored in a closed container under kerosene, toluene or mineral oil. Scraps of Na or K should be destroyed by reaction with n-butyl alcohol. Contact with water should be avoided because Na reacts violently with water to form H_2 with evolution of sufficient heat to cause ignition. Neither carbon dioxide nor bicarbonate fire extinguishers should be used on alkali metal fires.

Sodium azide may react violently with benzoyl chloride plus potassium hydroxide, bromine, carbon disulfide, chromium oxychloride, copper, lead, nitric acid, dimethylsulfate and dibromomalonitrile. It is especially important that sodium azide not be allowed to come in contact with heavy metals (for example, by being poured into a lead or copper drain) or their salts; heavy metal azides detonate with notorious ease.

Sulfuric acid (H_2SO_4) should be avoided, if possible, as a drying agent in desiccators. If it must be used, glass beads should be placed in it to help prevent splashing when the desiccator is moved. The use of H_2SO_4 in melting point baths should be avoided (silicone oil should be used). To dilute H_2SO_4 , add the acid slowly to cold water.

Trichloroethylene (Cl_2CCHCl) reacts under a variety of conditions with potassium or sodium hydroxide to form dichloroacetylene, which ignites spontaneously in air and detonates readily even at dry-ice temperatures. The compound itself is highly toxic and suitable precautions should be taken when it is used as a degreasing solvent.

TABLE 5

Examples of Incompatible Chemicals*

<u>Chemical</u>	<u>Is Incompatible With</u>
Acetic acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates
Acetylene	Chlorine, bromine, copper, fluorine, silver, mercury
Acetone	Concentrated nitric and sulfuric acid mixtures
Alkali and Alkaline earth metals (such as powdered aluminum or magnesium, calcium, lithium, sodium, potassium)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, halogens
Ammonia (anhydrous)	Mercury (in manometers, for example), chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid (anhydrous)
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrates, sulfur, finely divided organic or combustible materials.
Aniline	Nitric acid, hydrogen peroxide
Arsenical materials	Any reducing agent
Azides	Acids
Bromine	See Chlorine
Calcium oxide	Water
Carbon (activated)	Calcium hypochlorite, all oxidizing agents
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, powdered metals, sulfur, finely divided organic or combustible materials
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, alcohol, flammable liquids in general
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, benzene, finely divided metals, turpentine.
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulfide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids (organic or inorganic)
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Everything
Hydrocarbons (such as butane, propane, benzene)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide
Hydrocyanic acid	Nitric acid, alkali

*From: *“Prudent Practices for Handling Hazardous Chemicals in Laboratories”*
National Academy Press (1981)

TABLE 5 (Continued)

Examples of Incompatible Chemicals*

<u>Chemical</u>	<u>Is Incompatible With</u>
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, alcohols, acetone, organic materials, aniline, nitromethane, combustible materials
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous), hydrogen
Mercury	Acetylene, fulminic acid, ammonia
Nitrates	Sulfuric acid
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, copper, brass, any heavy metals
Nitrites	Acids
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver, mercury
Oxygen	Oils, grease, hydrogen, flammable liquids, solids or gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oils
Peroxides, organic	Acids (organic or mineral), avoid friction, store cold
Phosphorus (white)	Air, oxygen, alkalis, reducing agents
Potassium	Carbon tetrachloride, carbon dioxide, water
Potassium chlorate	Sulfuric and other acids
Potassium perchlorate (see also chlorates)	Sulfuric and other acids
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Selenides	Reducing agents
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds, fulminic acid
Sodium	Carbon tetrachloride, carbon dioxide, water
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Ethyl or methyl alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfides	Acids
Sulfuric Acid	Potassium chlorate, potassium perchlorate, potassium permanganate (similar compounds of light metals, such as sodium, lithium)
Tellurides	Reducing agents

*From: *“Prudent Practices for Handling Hazardous Chemicals in Laboratories”*
National Academy Press (1981)

E. Toxic Substances

Toxicity is the capability of a chemical to produce injury. Almost any substance is toxic when taken in doses exceeding “tolerable” limits. **Hazard** is the probability that an injury will occur or rather the prospect that an individual will receive a toxic dose.

The effects of a toxic chemical may be qualified into several categories. **Local toxicity** is the effect a substance has on the body tissues at the point of contact. **Acute toxicity** is the effect a substance has after only one or a few short, relatively large exposures. **Chronic toxicity** is the effect a substance has as a result of many small exposures over a long period of time.

An individual may be exposed to a chemical substance via a number of different routes:

1. Inhalation
2. Ingestion
3. Contact with skin or eyes

Inhalation of toxic vapors, mists, gases or dusts can result in poisoning by absorption through the mucous membrane of the mouth, throat, and lungs, and can cause serious local effects. Because of the large surface area of the lung (90 square meters total surface) along with its continuous blood flow, inhaled gases or vapors may be very rapidly absorbed and carried into the circulatory system. The rate of absorption will vary with the concentration of the toxic substance, its solubility and the individual inhalation rate. The degree of injury from exposure to a toxic substance depends on the toxicity of the material, its solubility in tissue fluids and the concentration and duration of exposure.

Ingestion of chemicals used in the laboratory may result in significant injury. The relative acute toxicity of a chemical can be determined by its oral LD₅₀, that quantity of material which when ingested will cause the death of 50% of the test animals. This LD₅₀ is expressed usually in milligrams per kilogram of body weight.

To prevent ingestion of chemicals, laboratory workers should wash their hands immediately after using any toxic substance and before leaving the laboratory. Food and drink should not be stored or consumed in areas where chemicals are being used. Cigarettes, cigars, and pipes should not be used in other than specifically designated “safe” areas. Chemicals should not be tasted, and pipetting and siphoning of liquids should never be done by mouth.

Skin contact is the most frequent route of exposure to chemical substances. A common result of skin contact is localized irritation, but some materials can be

absorbed through the skin sufficiently to produce systemic poisoning. Contact of most chemicals with the eyes will result in pain and irritation. A considerable number of chemical substances are capable of causing burns or loss of vision. Alkaline materials, phenols and strong acids are particularly corrosive and may cause permanent loss of vision. Furthermore, the vascular network of the eyes may permit the rapid absorption of many chemicals.

All persons in the laboratory should wear safety glasses to prevent eye contact with chemicals. However, face shields, safety goggles, shields, and similar devices will provide better protection. Protection against skin contact may be obtained by use of gloves, laboratory coats, tongs, and other protective devices.

Before initiating work with a chemical substance, the researcher or laboratory worker should be familiar with the types of toxicity, the toxic dose, and the hazards of the chemical. It is also important to realize that two or more substances may act synergistically to produce a toxic effect greater than that of either substance alone. Furthermore, chemical reactions involving two or more substances may form products significantly more toxic than the starting materials. Therefore, the entire experimental procedure should be evaluated.

The Department of Environmental Health & Safety is available to help researchers in planning experiments with toxic materials.

TABLE 6

COMBINED TABULATION OF TOXICITY CLASSES*

Commonly Used Term	LD ₅₀ Single Oral Dose for Rats (g/kg)	4-hr Vapor Exposure Causing 2 to 4 Deaths in 6-rat Groups (ppm)	LD ₅₀ Skin for Rabbits (g/kg)	Probable Lethal Dose for Man
Extremely toxic	0.001 or less	Less than 10	0.005 or less	Taste (1 grain)
Highly toxic	0.001 to 0.05	10 to 100	0.005 to 0.043	1 tsp (4 cc)
Moderately toxic	0.05 to 0.5	100 to 1,000	0.044 to 0.340	1 oz (30 gm)
Slightly toxic	0.5 to 5.0	1,000 to 10,000	0.35 to 2.81	1 pint (250 gm)
Practically nontoxic	5.0 to 15.0	10,000 to 100,000	2.82 to 22.6	1 quart
Relatively harmless	>15.00	>100,000	>22.6	>1 quart

*Hodge, H.C., and Sterner, J.H., American Industrial Hygiene Association Quarterly 10:4,93, Dec 1943.

Reprinted with permission, from: Handbook of Toxicology, Vol. 1, "Acute Toxicities" J.W. Spector, ed. Philadelphia, Pa.: W.B. Saunders Company 1956

F. Corrosives

Corrosives consist of four major classes: strong acids, strong bases, dehydrating agents and oxidizing agents. Inhalation of the vapors of these substances can cause severe bronchial irritation. These chemicals erode the skin and the respiratory epithelium and are particularly damaging to the eyes.

1. Acids and alkalis should be stored separately in a cool ventilated area, away from metals, flammables, and oxidizing materials. The storage area should be checked regularly for spills and leaks and there should be suitable spill cleanup materials available. Protective clothing should be worn whenever acids or alkalis are handled.

Suggestions for safe use and storage:

- a. Always pour acids into water, never the reverse.
- b. Cap bottles securely and store them securely, but do not store acids and alkalis together.
- c. Clean up spills promptly. Do not leave residues on a bottle or lab bench where another person may come in contact with them (see Section IV, H).
- d. Wear protective garb when handling acids or alkalis. This shall include rubber gloves, apron, and eye protection.
- e. If you have been splashed with acids or alkalis, follow emergency procedures indicated in Section III, B.

Four acids deserve special attention because of the hazards they pose. These are: nitric acid, perchloric acid, picric acid, and hydrofluoric acid.

Nitric acid is corrosive and its oxides are highly toxic. Because nitric acid is also an oxidizing agent, it may form flammable and explosive compounds with many materials (e.g., ethers, acetone and combustible materials). Paper used to wipe up nitric acid may ignite spontaneously when dry. Nitric acid should be used only in a hood and should be stored away from combustible materials.

Perchloric acid forms highly explosive and unstable compounds with many organic compounds and even with metals. Unstable perchlorate compounds may collect in the duct work of fume hoods and cause fire or violent explosions. Therefore, perchloric acid should be used with extreme caution and only in a fume hood designed for its use—a perchloric acid hood has corrosion-resistant duct work and washdown facilities. Minimum quantities of perchloric acid should be kept on hand and the container stored in a perchloric acid hood on a glass tray that is deep enough to hold the contents of the bottle. Perchloric acid should not be kept for more than one year since explosive crystals may form.

Picric acid can form explosive compounds with many combustible materials. When the moisture content decreases, picric acid may become unstable and may explode from being shaken. Picric acid should be dated, stored away from combustible materials and not kept for extended periods (e.g., longer than one year).

Hydrofluoric acid is extremely corrosive and will even attack glass. All forms—dilute or concentrated solutions or the vapor—can cause serious burns. Inhalation of HF mists or vapors can cause serious respiratory tract irritation that may be fatal. Burns from hydrofluoric acid heal slowly and with great difficulty. Therefore, hydrofluoric acid should be used in a suitable fume hood while gloves, safety glasses and lab coat are being worn. Care should be taken to avoid contacting hydrofluoric acid with metals or ammonia since toxic fumes may result.*

2. Oxidizing agents present fire and explosion hazards on contact with organic compounds and other oxidizable substances.

Suggestions for safe use and storage:

- a. Oxidizing agents should be stored separately from flammable liquids, organics, dehydrating agents and reducing agents.
- b. Strong oxidizing agents should be stored and used in glass or other inert containers. Corks and rubber stoppers should not be used.
- c. Oxidizing agents should be used with caution in the vicinity of flammable materials.

*From: “*Laboratory Safety Manual*,” University of Massachusetts

3. ***Dehydrating agents*** include concentrated sulfuric acid, sodium hydroxide, phosphorus pentoxide and calcium oxide. In order to avoid violent reactions and spattering, these chemicals should be added to water, never the reverse. Because of their affinity for water, these substances cause severe burns on contact with skin.

G. Metals

1. Alkali metals

“Alkali metals (e.g., sodium and potassium) react violently with water and decompose the water to give off hydrogen, which may be ignited by the heat of reaction. Alkali metals can also ignite spontaneously in air, especially when the metal is in powdered form and/or the air is moist.

Suggestions for safe use and storage:

- a. Store alkali metals under mineral oil or kerosene. Avoid using oils containing sulfur since a hazardous reaction may occur.
- b. Use only special, dry powder fire extinguishers on alkali metal fires.
- c. Any waste alkali metals should be placed in a labeled, leak-proof container, covered with mineral oil and disposed of via the DEHS waste pick-up service.”*

2. Metal powders

Finely powdered metals that come in contact with acids may ignite and burn. Metal powders can also create a dust explosion hazard when the powders become airborne in an area where a spark or flame is present. In addition, metal powders are subject to rapid oxidation, which may result in a fire or explosion.

*From: “*Laboratory Safety Manual*,” University of Massachusetts

H. Chemical Spills

1. General

Chemical spills can be handled effectively if some preplanning has been conducted. Individuals should become familiar with proper clean-up procedures before a spill occurs. This preplanning should include consideration of:

- a. Potential location of the spill;
- b. Quantities of material that might be released;
- c. Chemical and physical properties of the material (e.g., its physical state, vapor pressure, and air or water reactivity);
- d. Hazardous properties of the material; and
- e. The types of personal protective equipment that might be needed.

2. Spill kits

Clean-up material shall be available in the laboratory. These materials shall include:

- a. Neutralizing agents such as sodium carbonate or sodium bisulfate.
- b. Absorbents such as vermiculite. Paper towels, rags, and sponges may be used, but caution should be exercised because some chemicals may ignite upon contact with them.
- c. Vacuum line and needle-nose pipette, and trap, for mercury spills.

Commercial spill kits are available that have instructions, absorbents, reactants, and protective equipment. For additional information on commercial spill kits, call DEHS.

3. Emergency procedures

If a spill does occur, the following general procedures may be used, but should be tailored to individual needs.

- a. Attend to any person who may have been contaminated.
- b. Notify individuals in the area about the spill.

- c. Evacuate nonessential personnel.
 - d. If the spilled material is flammable, turn off ignition and heat source.
 - e. Avoid breathing vapors of spill material; if necessary, use a respirator.
 - f. Leave on or establish exhaust ventilation if it is safe to do so.
 - g. If a spill is large or involves a highly toxic material or carcinogen, call DEHS.
4. Spill clean-up procedures
- a. Flammable liquids: All flames should be extinguished and spark-producing equipment turned off. The spilled liquid should be absorbed and the absorbing material should be placed in a plastic bag and kept away from sources of ignition. This material should be disposed of in the same manner as all hazardous chemical waste (see Section III, K).
 - b. Toxic chemicals: All flames should be extinguished, all spark-producing equipment turned off, and all experiments shut down. The room should be evacuated until it is decontaminated. In the case of volatile liquids or poisonous gases, respiratory protection should be worn when entering the room. Call DEHS for information on how to deal with a toxic chemical spill.
 - c. Acids or alkalis: Do not neutralize the spilled liquid unless you are sure that the resulting reaction will not release hazardous fumes or cause explosion. Otherwise, neutralize the spilled liquid and absorb it.
 - d. Mercury: Droplets and pools of mercury metal can be pushed together and then collected by suction using an aspirator bottle with a long capillary tube or a vacuum device made from a filtering flask, a rubber stopper, and several pieces of flexible and glass tubing. Cover droplets of mercury in nonaccessible crevices with calcium polysulfide and excess sulfur. Dispose of this material in the same manner as hazardous chemical waste.
 - e. Alkali metals: Smother the spill with a special, dry powder extinguisher.

For additional information, contact DEHS.

I. Cryogenics

The principal hazards of cryogenic materials are burns from contact with skin; pressure build-up in unvented spaces; and fire, explosion, or asphyxiation which can result from the evaporation of cryogenes.

Suggestions for safe use and storage:

1. Eye protection should be worn whenever cryogenic liquids are handled. Where splashing is a possibility, face shields should be used. Appropriate gloves, shoes, and clothing should be worn.
2. In case of a splash, immediately flood exposed areas and clothing.
3. Avoid wearing watches, rings, bracelets or other jewelry.
4. Although many gases in the cryogenic range are not toxic, they are all capable of causing asphyxiation by displacing the air necessary to support life. Therefore, they should be used only in well-ventilated areas.
5. Venting should be provided to avoid quick and violent pressure changes when cryofluid vaporizes.
6. Handle combustible cryogenes such as liquid hydrogen and liquid natural gas in the same way combustible gases are handled: provide ventilation, keep away from open flames and other ignition sources, prohibit smoking, and vent gases to a safe location.
7. Exposed glass portions of the container should be taped to minimize the flying glass hazard if the container should break or explode.

J. Compressed Gas Cylinders

The following rules should be observed in using compressed gas cylinders:

1. All gas cylinders should be labeled to identify their contents. Do not rely on color codes.
2. Know the properties of the chemical contents of gas cylinders.
3. Handle gas cylinders carefully.
4. Store and use in well-ventilated areas, away from heat or ignition sources. Store oxygen away from flammable gases. Reactive gases should be used separately.
5. Cylinders must be chained or strapped in place to prevent them from falling over. Metal cylinder caps for valve protection should be kept on at all times when the cylinders are not in use.
6. Transport cylinders only via hand truck.
7. Do not use cylinders without a pressure regulator. Before connecting the regulator to the cylinder valve outlet, make sure the connections are compatible. If the inlet of the regulator does not fit the cylinder valve outlet, ***do not force it!*** It may not be the right one. Contact the supplier or producer of the gas or regulator if advice is needed on the selection of a regulator.
8. Check regulators periodically to ensure proper and safe operation.
9. Inspect regulator inlets and cylinder valve outlets for foreign matter.
10. A regulator, valve or other equipment that has been used with another gas should never be used with oxygen.
11. Close cylinder valves when not in use. Do not rely on a regulator to stop the gas flow overnight.
12. Close valves on empty cylinders and mark the cylinder “empty.”
13. Never attempt to refill a cylinder.

K. Waste Disposal

The Resource Conservation and Recovery Act is intended to promote the protection of human health as well as that of the environment. In order to accomplish this goal, a “cradle to grave” tracking system for all hazardous waste has been developed. This tracking system, as dictated by Environmental Protection Agency (EPA)/Department of Transportation (DOT) regulations, requires the specific identification of all materials that are, or might be, hazardous wastes. The principal investigators have the primary responsibility for their operations, including the proper handling of hazardous waste. Their cooperation is essential for the Institute to comply with these regulations.

Many commonly used laboratory chemicals, such as acetone, benzene, chloroform, ethyl ether, formaldehyde, toluene and xylene are included in this classification. For information regarding the identification and disposal of hazardous wastes, consult the Institute Hazardous Waste Policy or call DEHS.

Please note that non-halogenated organic solvents are combined to be shipped off as liquids. Because of this fact, halogenated organics such as carbon tetrachloride, chloroform, etc., should be stored separately and not mixed with other solvents.

VI. Hazardous Waste Policy

A. Applicability

This policy is applicable to all Institute faculty, staff, students, and Institute of Paper Science & Technology Center.

B. General

Federal, state, and local governments have imposed strict regulations concerning the management, storage, and disposal of hazardous chemicals. Compliance with these laws, good safety practices, and the necessity to avoid future liabilities, dictate that the Institute follow a conservative approach in handling this material.

The DEHS is charged with ensuring that all hazardous waste generated at Georgia Institute of Technology is handled properly.

The term “**hazardous waste**” as used in this policy means any substance no longer of use to the possessor whose chemical properties do, or may, endanger personnel, material, or the environment if handled improperly. Hazardous waste includes, but is not limited to those items specifically identified as “**hazardous waste**” under federal and state statutes. If a question exists on how waste should be handled either contact the DEHS or assume it to be hazardous.

C. Waste Minimization

Government regulations and internal cost effectiveness require that as little hazardous waste be generated as possible. The following guidelines are intended as a checklist to accomplish this waste minimization – they are not intended to restrict required activities.

Before beginning a project determine the hazards associated with the material. Where possible substitute less hazardous substances.

Use small batch or micro-level reactions where possible.

Order and maintain the minimum amount of any specific chemical.

Certain chemicals are difficult and/or costly to dispose of and should be given special consideration. Some types are:

- Any heavy metal (mercury, barium, cadmium, chromium, beryllium, silver, selenium, tellurium, etc.) either elemental or in compounds.

- Chlorophenols, dioxins, and cyanides.
- Compressed gases (to include lecture bottles) or containers with liquid under pressure (especially if the substance is poisonous). Where possible arrange with the supplier to accept return of used containers.
- Manufacturers samples. Either arrange for the manufacturer to accept return of unused material or ensure they provide an ample description of the product and its characteristics.

D. Accumulation of Waste

Excess amounts of waste should not be allowed to accumulate.

Each laboratory/activity will conduct as least an annual survey and dispose of unneeded/ expired material.

At the end of any project or prior to the departure of an individual all material will be clearly identified and unneeded/expired material disposed of.

E. Segregation of Waste

To the extent feasible, waste should be segregated and not combined. Mixing of different type wastes poses dangers and imposed cost penalties.

F. Containers

Waste containers must be compatible with the waste collected, kept closed unless material is being added, capable of being transposed, and appropriately labeled. Do not use containers over 5 gallons/20 liters without prior consultation with the DEHS.

Containers which have been emptied using normal practices, (e.g., pouring, are not considered hazardous except for poisons) these containers should never be reused and are considered hazardous even when empty.

G. Labeling

Waste collection containers must be clearly labeled with:

1. The word “**WASTE**” in a conspicuous location.
2. The type waste being accumulated in the container, (e.g., oil, halogenated solvent, hydrochloric acid).

Before the waste is picked-up by DEHS the following must be on the label:

- a. The name and phone number of an individual who can answer questions concerning the waste.
- b. The actual contents of the container – provide chemical names not abbreviations, process descriptions, or brand/product names.

Labels are available on request from the DEHS.

H. Collection

The DEHS is responsible for picking up hazardous chemical waste from individual activities. Activities desiring a waste pick-up will notify DEHS with the type, amount, location, and contact person/phone number.

We will, in most cases, respond to telephonic requests, written requests are preferred, and in the case of certain activities may be required.

Arrangements may be made for periodic pick-ups of waste without individual requests or for consolidation of waste from a number of activities at one site.

I. Contact

Direct questions to the Hazardous Waste Officer, DEHS at 4-6224 or 4-4635.

VII. Hazardous Materials Storage and Disposal Policy

The DEHS Hazardous Materials Handling Team is having some problems picking up certain materials which are improperly packed or stored. Boxes containing broken glass are falling apart due to the fact that liquids are also being discarded in these containers. Also, “*SHARPS*” are being stored in improper containers.

Hazardous materials which are being stored for pick-up and disposal must be packaged as follows:

- A. Biohazardous materials: Red bag inside an appropriate biohazard box, properly labeled.
- B. “*SHARPS*”: Needles, razor blades, etc. should be put in appropriate “*SHARPS*” containers. These containers should be made of thick plastic and should have a lid. A plastic milk bottle would suffice. These filled “*SHARPS*” containers should then be put in a biohazard box for disposal.
- C. All spent liquids or solids should be stored in properly labeled containers ready for pick-up and disposal.
- D. Broken Glass: Broken glass can be discarded in the dumpster.
- E. Empty Bottles: These can be discarded in the dumpster.

If there is a question whether residuals in broken glass or empty containers are hazardous, they should be collected and labeled separately. All broken glass should be collected in a puncture proof, leak proof, and properly labeled container.

If you should require any additional information, please do not hesitate to contact the DEHS at 4-4635.

VIII. Policy and Procedures for Biohazardous Waste

A. Policy

The Georgia Institute of Technology supports a comprehensive program for the management and control of biohazardous waste, in keeping with applicable laws, regulations, and codes. The protection of faculty, staff, students, and visitors, the environment and the community is maintained by minimizing the risk of exposure to biohazardous waste and discarded materials during all stages of existence, from the point of generation within the Institute, to the point of final disposal. Efforts to minimize the waste stream volume and maximize recycling are an integrated and ongoing part of the Biohazardous Waste Management Program.

B. Basis

Proper engineering and work practice controls, personal protective equipment and clothing, training, medical surveillance, signs, labels, and procedures will reduce or prevent potential risks of exposure to hazards when collecting, handling, transferring, and disposing of biohazardous wastes. These potential hazards may be classified as risk of exposures to pathogens and contaminated materials; risk of physical injury from needles, “*SHARPS*” and broken glass; and risk of chemical exposures. The Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), the National Fire Protection Association (NFPA), and Georgia Department of Natural Resources establish requirements and/or recommend actions that address all aspects of waste management and related activities. When in place and in practice, these measures control hazards, minimizing the risk of injury or exposure in waste operations.

C. Roles and Responsibilities

1. **The Department of Environmental Health, and Safety:** This department has the overall operational responsibility for the scheduling, coordination, documentation, and day-to-day operations required to segregate, collect, transfer, process, and dispose of all chemical wastes. The department is also responsible for maintaining and providing expertise to all levels of staff concerning waste management, hazards, hazard control design, and hazard control verification, in accordance with all applicable laws, regulations, guidelines, policies, and standards. Biohazardous materials will only be handled by the department once all proper engineering, work practice controls, signs, labels, and safety procedures are in place. For additional information, contact the DEHS at 4-4635.

2. **The Biosafety Committee:** The committee will review and make recommendations concerning biohazardous materials, policies, procedures, and biohazardous waste management. Committee activities are characterized by, but not limited to: the periodic review and recommendation for revision of Institute and departmental procedures; review and recommendations for resolution of issues identified through analysis of the biohazardous waste management system, employee on-the-job injury incidents and exposures; review, evaluate, update and revise the Biohazardous Safety Policy and procedures, as applicable.
3. **Faculty, Staff and Students:** All faculty, staff, and students dealing with biohazardous materials are to be knowledgeable in the application of this policy and to practice the procedures for the proper handling of biohazardous waste materials as defined by this policy.

D. Procedures

1. **Waste Categories, definition and separation:** The following waste category definitions, collection, separation, labeling, and containment methods meet the regulatory requirements and establish the basis for procedural handling of biohazardous waste:
 - a. Waste which has no known Biohazardous, Radiological, or Chemical contamination, risk or exposure hazard and is acceptable, without treatment or processing, can be disposed of at a permitted “Sanitary Landfill.” This waste requires no special containment, handling or labeling precautions, except those required to prevent spillage of liquids, accidental lacerations, or back strains. If bagged, this waste shall be collected in plastic trash bags. Consolidation and movement of this type of waste may be accomplished by any practical means for disposal in the local trash receptacle.
 - b. Wastes which may be potentially contaminated with pathogenic or infectious materials shall be autoclaved. Faculty, staff, or students collecting and handling these type of wastes are required to use the appropriate Personal Protection Equipment (PPE) and are to observe the safety regulations set forth by the Biosafety Committee for the handling of regulated materials. These wastes shall be put into autoclavable bags labeled with the “Biohazard Symbol.” These wastes shall not be mixed with other types of waste. Once autoclaved, this bag will be placed in a plastic trash bag for disposal.

Waste consisting of used “*SHARPS*” and needless which have been contaminated with potentially pathogenic or infectious materials will be

collected at the point of generation in **Approved Needle Boxes** or “*SHARPS*” **Containers**, labeled with the “Biohazard Symbol.”

Human organs and animals, and animal parts will be collected at the point of origin in approved biohazard bags.

Blood, body fluids, and dilute chemical wastes which have been contaminated with pathogenic or infectious substances will be autoclaved prior to pick-up.

Biohazardous and chemical waste gases must pass through a certified vent system in accordance with OSHA, NFPA, EPA, and Georgia DNR requirements. Contaminated equipment such as Biomedical devices and equipment, freezers, laboratory equipment, etc. must be decontaminated prior to anyone working on it, or prior to offering the equipment for resale or salvage. All biohazard markings shall be removed at the time the equipment is for resale.

2. **Waste Containment, Placement, Storage, Transport**

- a. It is the responsibility of faculty, staff, and students working with biohazardous materials to ensure that all waste is appropriately contained, placed, stored, and transported.
 - b. Waste shall not be placed or stored in the corridor for later pick-ups. All waste biohazard materials must be properly stored in an area designated as a temporary holding area.
 - c. Regulated and unregulated waste shall not be collected, stored, transported or otherwise mixed in the same collection container. If unregulated and regulated waste become mixed, the unregulated waste shall be considered contaminated, and will be disposed of as regulated waste.
 - d. Contaminated “*SHARPS*” and needles are to be discarded into closable, puncture resistant, leak proof on sides and bottom, labeled or color coded containers in accordance with the Georgia Institute of Technology “*SHARPS*” Policy.
 - e. To prevent faculty, staff, or student injuries, spills, and contamination, waste bags must always be lifted by the tied end, placed upright in collection boxes and never dragged on the floor during transfer.
3. The “Principal Investigator” shall communicate in writing to his/her lab personal procedures and methods required for reporting of any accident involving a

biohazardous material. All accidents must also be reported to the DEHS at 4-4635.

4. **Training Requirements:** Waste handling procedure training is required for all faculty, staff, or students who perform tasks involving the handling of biohazardous materials.
 - a. Each unit that generates biohazardous materials may request an “Orientation Training” by the Biosafety Committee. Training shall include procedures for handling, storing, and/or disposal of biohazardous waste. Specific, detailed training related to the faculty, staff, or students tasks and potential exposures to biohazardous materials is the responsibility of the project's PI.
 - b. Faculty, staff, and students must be made aware of the OSHA Bloodborne Pathogen Standard and the Georgia Right-to-Know Hazard Communication Standard.
 - c. Training shall include the health and physical risks and any potential hazards inherent to their work environment.
 - d. Training shall include lines of communication to follow when reporting waste and hazardous materials management issues as they pertain to reporting of inappropriate placement of waste, spills management, and/or exposures to biohazardous materials.
 - e. Training shall include the use of personal protective equipment, barrier precautions, and other protective measures required when handling biohazardous waste materials.
 - f. There shall be an annual review of the Department/Unit waste management procedures by the Biosafety Committee and the DEHS. Periodic or at least annual reinforcement of Departmental/Unit waste management procedures is recommended. Documentation of Departmental/Unit training programs will be handled by each department.

Any questions regarding the policy and procedures outlined herein shall be directed to the Georgia Institute of Technology Biosafety Committee or the DEHS at 4-4635.

IX. Georgia Institute of Technology “SHARPS” Policy

A. General

“*SHARPS*,” if not disposed of properly, can cause injury or threat to human life by transmission of an infectious disease or infection. While it is true that most “*SHARPS*” are associated with cultures and stocks of infectious agents and associated biologicals, pathological waste, human or animal blood, excretions, exudates, or secretions; many other items have the potential for infecting or injuring humans and their environments. Items that have the capability to transmit or cause human infections through inhalation, ingestion, or skin absorption will be handled as “*SHARPS*.”

B. Definition

“*SHARPS*” are identified as any item that can lacerate or puncture the skin.

EXAMPLES:

- * Hypodermic needles
- * Syringes (with or without the needle attached)
- * Broken pipettes (unbroken pipettes will be regarded as “*SHARPS*” if they contain biological, chemical, or infectious agents)
- * Scalpel blades
- * Broken vials (unbroken vials will be regarded as “*SHARPS*” if they contain biological, chemical, or infectious agents)
- * Broken test tubes (unbroken test tubes will be regarded as “*SHARPS*” if they contain biological, chemical, or infectious agents)
- * Needles with attached tubing
- * Culture dishes (regardless of presence of infectious agents)
- * Non-specific broken glassware such as beakers, flasks, cylinders, etc. (unbroken glassware will be regarded as “*SHARPS*” if they contain biological, chemical, or infectious agents)
- * Microscope slides and cover slips
- * Knives
- * Box cutters
- * Razor blades

C. Disposal

All “*SHARPS*” must be disposed of by placing them in an appropriate “*SHARPS*” container. When “*SHARPS*” containers are full, contact the DEHS for disposal. For any additional information, contact the DEHS at 4-4635.

X. Laser Policy

A. General

Control measures for the safe use of lasers have been established by the American National Standards Institute (ANSI) and presented in Safe Use of Lasers (ANSI Z136.1-1993), which describes the different types of laser hazards and the appropriate measures to control each type.

Lasers are classified according to their relative hazards:

Class 1 lasers: These include laser printers, compact disc players, and unfocused laser diodes which are either completely enclosed or have such a low output of power that even a direct beam in the eye could not cause damage.

Class 2a & 2b lasers: These include supermarket scanners and visible laser bar code scanners. These are visible light lasers with a power of less than 1 milliwatt (mW). These can be a hazard if a person stares into the beam and resists the natural reaction to blink or turn away.

Class 3a lasers: These lasers have powers between 1 and 5 mW and can present an eye hazard if a person stares into the beam and resists the natural reaction to blink or turn away, or views the beam with focusing optical instruments.

Class 3b lasers: These are visible, ultraviolet, and infrared lasers with powers in the 5 to 500 mW range and can produce eye injuries instantly from both direct and specularly reflected beams.

Class 4 lasers: These are visible, ultraviolet, and infrared lasers with continuous powers in excess of 500 mW or pulse energies in excess of a threshold that depends on wavelength and pulse duration. Class 4 lasers present all of the hazards of Class 3 lasers and may also produce eye or skin damage from diffuse scattered light.

Class 3 and Class 4 lasers should be operated only in posted laser-controlled areas. No one but the authorized operator of a laser system should ever enter a posted laser-controlled laboratory when the laser is in use.

B. Controls

1. Personal Protection Control

- a. Eye
 - b. Exposed Skin
 - c. Inhalation
2. Area Control
- a. Avoidance of specular reflectance
 - b. Protection from laser plume and air contamination
 - c. Proper ventilation
 - d. Avoidance of electrical shock

C. Eye Protection

The first concern in laser protection continues to be the eyes. Full protection of the eyes means not only from impact of the direct beam, but also from the significant amount of reflection from surfaces. Eye protection is divided essentially into the following phases:

1. The design of laser systems to develop as much as possible the closed system technique.
2. The avoidance, as much as possible, of highly reflectant surfaces on and adjacent to the target areas.
3. Personal protection in the form of protective devices for the eyes.
4. Constant reappraisal of all proposals for area and personal protection.
5. Continued eye examinations and good records for all operating personnel. Continued eye examination and good records are important, especially to determine the long-term effects of exposure.

Personal protection for the eyes requires goggles or safety glasses specifically designed for laser work which have sufficient protective material and which are so fitted that stray light cannot come in from any angle. Laser safety glasses and goggles must meet ANSI Z136.1, Z136.2, Z136.3, Z87.1, DIN 58215, DIN 58219, NFC 43801, and/or EN 207-208 standards. To determine which standards apply, laser type, wavelength, and optical density required must first be identified.

D. Skin Protection

The direct impact of high-energy lasers may cause considerable damage to the skin, especially where it is pigmented. A temporary injury to the skin may be painful and treated symptomatically. Injury to larger areas of the skin are far more serious as they may lead to serious loss of body fluids, toxemia, and systemic infections. Injury to the skin can result either from thermal injury following temperature elevation in skin tissues or from a photochemical effect (e.g., “sunburn”) from excessive levels of actinic ultraviolet radiation. The threshold of injury depends upon exposure duration. The warmth sensation resulting from absorption of radiation energy normally provides adequate warning for an avoidance reaction to prevent thermal-injury of the skin from almost all sources except the nuclear fireball and some high-powered, far-infrared lasers. Avoiding direct exposure of the skin is the best protection.

E. Air Pollution and Inhalation Hazards

Air contamination is also a problem, especially as it relates to the use of liquid nitrogen coolants, nitrogen purges, spectroscopy and fragments from the laser plume. The concentration of nitrogen vapor could become significant in confined spaces with a consequent reduction of oxygen concentration. The increasing use of water-cooled lasers in preference to the nitrogen-cooled type may reduce the frequency of the use of nitrogen. Liquid nitrogen produces burns when handling in a careless manner.

Ozone is produced at times from the flash lamps and concentrations of ozone could build up with high repetition rate lasers.

A new field of chemistry is the study of the chemical lasers. When these contain toxic materials, the researcher must be aware of their hazards. An example of a chemical laser hazard is the new laser containing selenium oxychloride, with an output of 10,600 Å.

Raman laser spectroscopy and Brillouin scattering present potential and actual hazards with laser impacts of such materials as benzene, nitrobenzene, toluene, and carbon disulfide. There may be air contamination from these toxic materials or new compounds formed after impact. Plume fragments from living tissues may disseminate viable cancer tissue in the air. High-power-output studies should be done under a hood or with adequate exhaust systems. Even with low-output systems, flammability of the solvent on impact may produce potential fire hazards. It is best to use traps over the laser head to contain plume fragments.

F. Associated Hazards

1. Atmospheric Contamination:

- a. Vaporized target material from high energy laser cutting, drilling, and welding operation. Materials involved may include asbestos, carbon monoxide, carbon dioxide, ozone, lead, mercury, and other metals.
- b. Gases from flowing-gas lasers or byproducts of laser reactions, such as bromine, chlorine, hydrogen cyanide, and many others.
- c. Gases or vapors from cryogenic coolants.
- d. Vaporized biological target materials from high energy lasers used in biological or medical application.

2. Ultraviolet Radiation:

Either direct or reflected from flash lamps and CW laser discharge tubes. Ultraviolet radiation is generally only of concern when quartz tubing is used. Consult ACGIH TLV for Ultraviolet Radiation.

3. Chorioretinal Injury Resulting From Glare:

From high luminance visible radiation emitted from unshielded pump lamps.

4. Electrical Hazards:

The potential for electrical shock is present in most laser systems. Pulsed lasers utilize capacitor banks for energy storage and CW lasers generally high high-voltage direct current or radio-frequency electrical power supplies. Solid conductor grounding rods (connected first to a reliable ground) shall be utilized to discharge potentially live circuit points prior to maintenance.

5. Cryogenic Coolants:

Cryogenic liquids may cause burns; examples are: liquid nitrogen, liquid helium, and liquid hydrogen.

6. Other Hazards:

The potential for explosions at the capacitor banks or optical pump systems exists during the operation of some high-power lasers or laser systems. The possibility

of flying particles from target areas in laser cutting, drilling, and welding operations may exist. Explosive reactions of chemical laser reactants or other gases used within the laser is a concern in some cases.

7. X-Rays:

Potentially hazardous x-radiation may be generated from high voltage (over 15 kV) power supply tubes.

XI. Protective Measures in the Laser Laboratory

Safety measures for the protection of the operating personnel include:

- A. A warning light system initiated on charging of any high energy laser in the laser room, which causes red lights at the benches to flash intermittently in any adjoining rooms and in the laser room, and a large warning sign outside the laboratory to be illuminated.
- B. A muted bell system which commences chiming on charging of the laser capacitor banks and continues until the laser is discharged.
- C. Individual door locks triggered by the laser charging circuits which prevent opening of the doors except in an emergency.
- D. A master override switch in the office or other adjoining rooms so that personnel can leave these rooms in an emergency whether the laser is firing or not. This switch is self-illuminated at all times.
- E. Black curtains or screens which may be pulled around the laser benches to screen personnel from the laser flash.
- F. Use of specifically designed antilaser flash goggles or safety glasses for personnel working close to the laser head, as well as for visitors being exposed to the laser.
- G. Avoidance of specular surfaces by rough finishing of the walls and painting with flat charcoal black paint.
- H. Avoidance of any open electrical connections.
- I. Proper air conditioning of the rooms.

XII. Warning Signs

- A. Labels: The classification labeling in accordance with 21CFR1040, the Federal Laser Product Performance Standard, may be used to satisfy the labeling requirements in the section.
- B. Signal Words: The signal word “CAUTION” shall be used with all signs and labels associated with Class 2 and Class 3a lasers and laser systems. The signal word “DANGER” shall be used with all signs and labels associated with Class 3b and Class 4 lasers and laser systems.

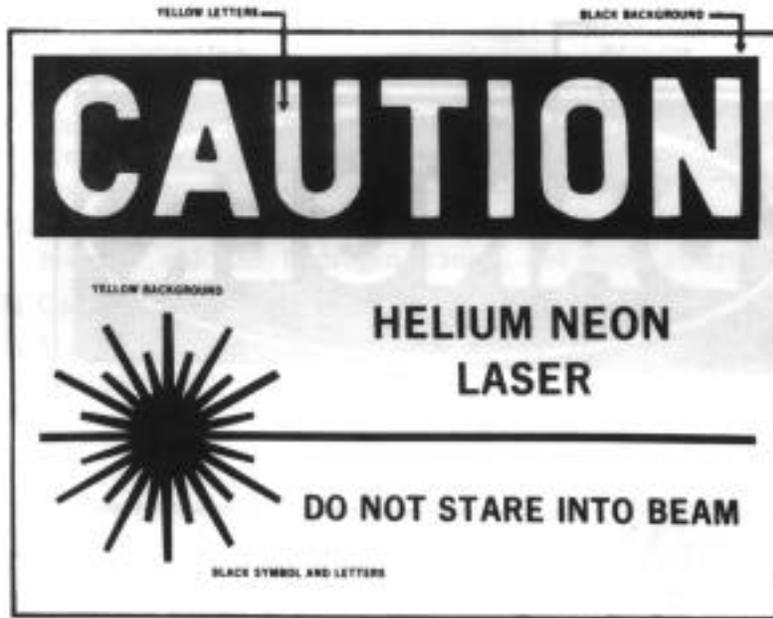
NOTE: A Class 2a laser or laser system shall have a label affixed which instructs: “Avoid Long Term Viewing of Direct Laser Radiation.” This label need not bear the warning symbol or signal words, but must be visible during operation and bear the designation “Class 2 Laser.”

- C. Appropriate space shall be left on all signs and labels to allow the inclusion of pertinent information. Such information may be included during the printing of the sign or label, or may be handwritten in a legible manner to include the following information:
 - a. Above the tail of the sunburst special precautionary instructions or protective actions required by the reader such as:
 - For Class 2 “Laser Radiation – Do Not Stare Into Beam”
 - For Class 3a “Laser Radiation – Do Not Stare Into Beam or View Directly With Optical Instruments”
 - For Class 3b “Laser Radiation – Avoid Direct Exposure To Beam”
 - For Class 4 “Laser Radiation – Avoid Eye or Skin Exposure to Direct or Scattered Radiation”
 - b. Above the tail of the sunburst on signs, additional precautionary instructions or protective actions required by the reader should be provided such as: invisible, knock before entering, do not enter when light is on, restricted area, etc.
 - c. Below the tail of the sunburst on signs, type of laser, (Ruby, Helium-Neon, etc.) or emitted wavelength, the pulse duration, if appropriate, and the maximum output.

- d. At the lower right on signs, the class of the lasers or laser systems.

Placarding of potentially hazardous areas should be accomplished in accordance with local standard operating procedures. Attachments A and B are examples of appropriate signage.

Attachment A

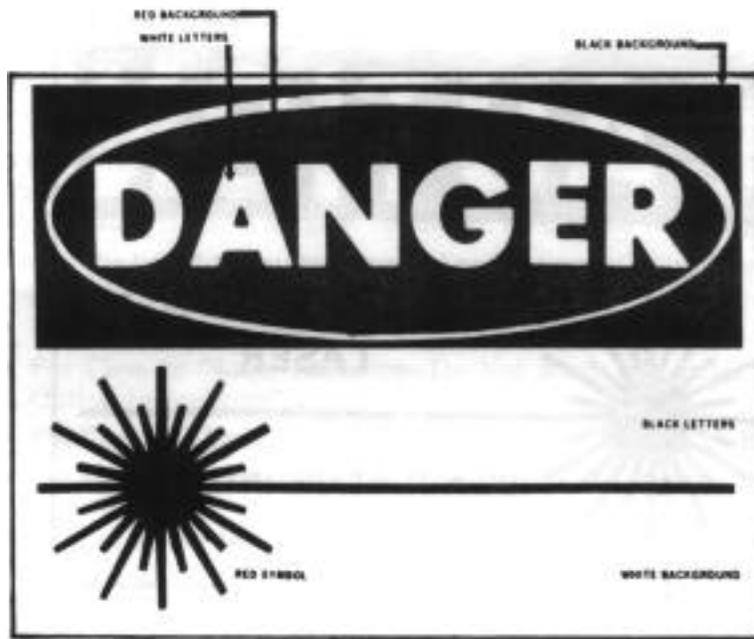


Laser for Class 2 (visible) lasers only:



Laser for Class 3a visible laser having a total power output below 5mW but a maximum beam irradiance less than $2.5 \text{ mW}\cdot\text{cm}^{-2}$

Attachment B



Labels and Signs for Class 3b and 4 lasers only: (Blank format)



Class 3b and Class 4 laser only: with sample hazard control information filled in.