Cornell University

Chemical Hygiene Plan

Guide to Chemical Safety for Laboratory Workers

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Environmental Health and Safety

Revised October, 1999

A revision history for this document is on the reverse of this page.

Cornell Chemical Hygiene Plan

Revision History

January, 1991	Release of Original Document
February, 1992	Revised Document
February, 1994	Revised Document
May, 1995	Revised Poison Inhalation List
May, 1997	Revised Standard Operating Procedures
August, 1997	Revised Cornell University Select Carcinogens
May, 1998	Revised Procedures for Chemical Waste Disposal
October, 1999	Revised Document

If you want to know if you have the most current version, check our Web site at:

http://www.ehs.cornell.edu/lrs/chemical%20hygiene%20plan/chp.htm

In an *EMERGENCY* call 911

How to report an emergency:

If you believe there is an immediate danger to the health or safety of yourself or others (for example, a fire, a large chemical spill, or a medical emergency) call the **Cornell Police at 911**.

How to report an injury, *as a follow-up, not during the actual emergency*:

If any employee is injured on university-owned or occupied space, a Cornell University Accident Report must be completed within 24 hours of the time of the accident. This form, with instructions for its completion, is available from your department administrator. Note that Cornell employees injured at work must be evaluated at Gannett Health Center.

Concern	Resource
Information on fire, chemical, radiation, biological, occupational, or campus safety and training programs	Environmental Health and Safety (EH&S): Normal business hours: 255-8200 Nights and week-ends: 255-1111 E-mail: dehs-mailbox@cornell.edu Web site http://www.ehs.cornell.edu
Chemical Information Requests and Material Safety Data Sheets (MSDSs)	EH&S, Veronica Parsons-Zieba, 254-4693 (vjp4)
OSHA Laboratory Standard, Chemical Hygiene Plan, Laboratory Safety	EH&S, Tom Shelley, 255-4288 (tjs1)
Radiation Safety Concerns	EH&S, Tom McGiff, 2555-8200 (tjm3)
Occupational Health & Safety	EH&S, Jim Grieger, 255-8200 (jrg5)
Biological Safety	EH&S, Frank Cantone, 255-8200 (fac2)
Asbestos	EH&S, Mike DeLance, 255-8200 (mrd3)
Personal Protective Equipment	EH&S, Mike Vitucci, 255-8200 (mv15)
Chemical Waste Disposal	EH&S, Mike Lonon, 255-8200 (ml107)
Excess Chemicals Exchange Program	http://www.chem.cornell.edu/~jht1/
Questions about Pesticides	Pesticide Management Education Program, 255-1866
Security	Cornell Police, 255-1111
Medical Problems	Gannett Health Center, 255-5155
Health Education Programs	Health Education Office, 255-4782
Agricultural Facilities/ CALS Occupational Health	Mary-Lynn Cummings, 255-2557 (mc101) www.cals.cornell.edu/OfficeResearch/OEH/EnvHealth.html

Introduction

The Occupational Safety and Health Administration (OSHA) requires a safe work environment for all types of employment. OSHA has adopted a health standard to protect laboratory workers from chemical hazards in their workplace. 29 CFR 1910.1450, "Occupational Exposure to Hazardous Chemicals in Laboratories," mandates health and safety practices and procedures in laboratories that use hazardous chemicals. The Standard became effective May 1, 1990 and it requires that a Chemical Hygiene Plan be developed for each laboratory workplace. Cornell EH&S has taken responsibility for maintaining an institutional Chemical Hygiene Plan. Each laboratory may adopt or modify this plan or write their own plan.

The purpose of the Laboratory Standard is to protect laboratory employees from harm due to chemicals while they are working in a laboratory. Most laboratories at Cornell that use chemicals are subject to the requirements of the Laboratory Standard. In addition to employees who ordinarily work full time within a laboratory space, for the purposes of the Standard, "laboratory employee" may include employees such as office, custodial, maintenance and repair personnel, and others, who as part of their duties regularly spend a significant amount of their time within a laboratory environment. OSHA considers graduate students who get paid for working in a lab as employees and thus they are also subject to the requirements of the Laboratory Standard.

A hazardous chemical is defined by OSHA as a substance for which there is statistically significant evidence, based on at least one scientific study, showing that acute or chronic harm may result from exposure to that chemical. This broad definition clearly applies to most of the chemicals typically used in laboratories.

The Laboratory Standard is a performance standard. That is, there are few specific requirements to carry out certain procedures in a certain way; instead, specific results to be achieved are denoted but the manner by which the results are to be accomplished is not delineated. The primary emphasis is on administrative controls necessary to protect workers from overexposure to hazardous substances in laboratories.

The Cornell University Chemical Hygiene Plan is developed and coordinated by Environmental Health and Safety. Environmental Health and Safety and the individual laboratories that are regulated by the Standard will share the burden of compliance with the Standard. Many laboratories at the University have developed safety manuals and procedures that already address chemical safety in laboratories. The Lab Standard should not require changes that are a burden to laboratories.

Questions about the Cornell University Chemical Hygiene Plan should be directed to Environmental Health and Safety (EH&S), 125 Humphreys Service Building, Ithaca, N.Y. 14853 (phone 255-8200).

The Chemical Hygiene Plan

Standard Operating Procedures

There are over three thousand research laboratories at Cornell University and most of these involve the use of hazardous chemicals. Many departments have developed comprehensive safety and health manuals. These manuals address specific safety rules, regulations, and standard operating procedures for laboratory workers in the department or college. Most of the laboratories have referred to widely known and accepted laboratory safety practices referenced in *Prudent Practices in the Laboratory,* published by the National Research Council, or *Safety in Academic Chemical Laboratories,* published by the American Chemical Society.

Environmental Health and Safety (EH&S) will assist laboratories in developing general and specific standard operating procedures for chemical use in laboratories. Due to the large variety of research and the number of laboratories involved, it will be the responsibility of each laboratory, department, or college to ensure that their practices and procedures are adequate to protect their workers who use hazardous chemicals. It will be the responsibility of the principal investigator or department head to ensure that written safety procedures are developed for work in their labs and that controls and protective equipment are adequate to prevent overexposure. In many cases, standard operating procedures for laboratory safety have been developed and implemented for years and few changes will be necessary to comply with the Lab Standard. Existing standard operating procedures may need to be evaluated to ensure that they address the health and safety requirements for the chemicals in use.

Control Measures

The exposure to hazardous chemicals in the laboratory shall be controlled through the use of good general laboratory practices, standard operating procedures specific to an individual laboratory or department, engineering controls, and personal protective equipment.

General laboratory practices: Environmental Health and Safety provides laboratories with information about general laboratory work practices and rules that are recognized as effective control measures to minimize exposure to hazardous chemicals in the laboratory. The information is referenced from *Prudent Practices in the Laboratory* and *Safety in Academic Chemistry Laboratories.* These general procedures include guidelines on use of chemicals, accidents and spills, personal protection, use of fume hoods, and other good laboratory practice information.

Specific laboratory practices: Individual departments or laboratories must develop additional written safety procedures whenever necessary to protect laboratory workers from specific chemical hazards that are unique to their particular area of research. Particular attention should be given to control measures for operations that involve the use of select carcinogens or acutely toxic chemicals. Environmental Health and Safety can assist researchers in developing safety procedures for specific hazards.

Engineering controls: There are a variety of engineering controls that can be used in the laboratory to control exposures to hazardous chemicals. Some of the engineering controls that will be used in laboratories at Cornell may include dilution ventilation, local exhaust ventilation (fume hoods), and proper storage facilities.

Personal protective equipment: Personal protective equipment will be available to laboratory workers for use to reduce exposures to hazardous chemicals in the laboratory. Common personal protective equipment such as goggles, gloves, face shields, and aprons are recommended for use with hazardous chemicals. Other personal protective equipment such as respirators will be available and recommended for use if necessary. (See Section 10.) Environmental Health and Safety will assist in the proper selection, use, and care of personal protective equipment. Personal protective equipment will be readily available and most equipment is provided at no cost to the employee.

Other: Other control methods that will be used to determine and reduce employee exposures to hazardous chemicals in the laboratory may include exposure monitoring, testing eyewash and emergency shower facilities, developing emergency procedures, proper container selection, and substitution of less toxic chemicals whenever possible.

Fume Hoods

The fume hood inspection program at Cornell consists of an initial comprehensive inspection followed by annual standardized inspections for all campus fume hoods. This initial inspection will provide extensive baseline information including but not limited to hood usage, type of hood, room and building information, as well as average face velocity measurements. Follow-up inspection for proper use and face velocity measurements will be done routinely each year or when requests for inspections are made. After each inspection, hoods will be labeled with inspection stickers regarding face velocity measurements and safety operating tips. All inspection information will be recorded on a standard form and will be kept on file at Environmental Health and Safety.

The fume hood inspections consist of three parts:

1. Recording of information identifying building, room, hood usage, type of hood, person in charge, etc.

2. Measurement of hood average face velocity.

3. Determination of acceptability of hood and discussion of results with hood operator and/or person in charge.

Whenever possible, a dry ice capture test will be performed on the hood being evaluated. The results of this procedure will be posted near the face of the hood.

Hoods will be classified as acceptable or unacceptable based on the face velocity measurement. An average face velocity of 80 fpm or greater (hood sash fully open) is acceptable. The hood will be considered unacceptable if it cannot achieve an 80 fpm average with the sash at two feet (2.0') opening or greater. If a hood is found to be unacceptable, a warning sign indicating that the hood has been

inspected and found not to provide optimum protection will then be attached to the center of the sash window or another suitable but conspicuous location. Instructions are included explaining proper procedures to have the hood repaired or maintenance service performed. EH&S will coordinate fume hood repairs with the Facilities and Campus Services shops to ensure a timely and accurate repair process. Upon completion of these services, Environmental Health and Safety must be contacted to re-inspect the hood.

The proper functioning and maintenance of other protective equipment used in the lab is the responsibility of a variety of service groups. Maintenance Management, Facilities Engineering, Environmental Health and Safety, and other groups provide and service equipment such as fire extinguishers, eyewash/shower facilities, spill response equipment, and mechanical ventilation. Periodic inspections and maintenance by these groups ensure proper functioning and adequate performance of the equipment.

Information and Training

Cornell will provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area. This training and information will come from a variety of sources.

Environmental Health and Safety has been providing training programs for laboratory workers for several years. These programs include information on chemical safety, Right-to-Know, Hazard Communication, the Lab Standard, radiation safety, spill response, eye protection, and how to obtain additional safety information.

The program "Chemical Safety for Laboratory Workers" is currently being presented each month to newly hired laboratory personnel. These programs are publicized by e-mail and a letter sent to every new Cornell employee. Anyone who has not yet attended is encouraged to attend. This "Chemical Safety for Laboratory Workers" training program is also currently being given for new graduate students and undergraduate students working with chemicals in laboratories.

Notebooks of Material Safety Data Sheets (MSDSs) for chemicals commonly used in laboratories are located in each department, and new MSDSs for new chemical purchases are sent on to the departments as they are received at EH&S. Employees are encouraged to consult these MSDS notebooks, or to call or write to EH&S for additional MSDSs. Chemical information request forms are included in these notebooks, in the training program handouts, and on our Web site for the convenience of employees. The EH&S Web site also gives information to employees for obtaining MSDSs from various internal and external Web sites.

Environmental Health and Safety will provide information to laboratories, including the Chemical Hygiene Plan, Material Safety Data Sheets (MSDSs), OSHA Permissible Exposure Limits, and specific topical information from employee requests. Environmental Health and Safety personnel are available on a daily basis to answer questions and provide information to employees about chemical safety in laboratories.

Other sources of information and training may come from informal group or individual discussions with a supervisor, posted notices, and handout booklets. Properly labeled containers will give immediate warning information to workers about specific chemical hazards. Many departments have safety committees and safety manuals that provide information on laboratory safety. Employees are encouraged to contact their department safety representative and EH&S for information about safety in laboratories.

Prior Approval for High Hazard Work

Environmental Health and Safety can assist in identifying circumstances when there should be prior approval before implementation of a particular laboratory operation. Due to the large variety of research being conducted in laboratories at the University, it is impossible to apply one prior approval process that can include all laboratories. Instead, high hazard types of activities should be identified by the principal investigator or person responsible for the work, and any type of approval process should be addressed in the laboratory's or Department's standard operating procedures.

Environmental Health and Safety will assist in providing information to researchers about work with select carcinogens, highly toxic gases, and other high hazard chemicals. General guidelines and recommendations for the safe handling, use and control of high hazard materials can be provided through MSDSs, and reference sources such as *Prudent Practices in the Laboratory*, and *Safety in Academic Chemistry Laboratories*. In certain instances, prior approval from a research related committee may be required before beginning an operation or activity.

Currently, there are some circumstances where prior approval is required before work can begin. These include:

- Research using live vertebrate animals - Institutional Animal Care and Use Committee (3-3516).
- Biohazards - College of Veterinary Medicine Biohazards Committee (Veterinary College, 3-3966), Environmental Health (non-Veterinary College biohazards, 5-8200).
- Recombinant DNA use - Recombinant DNA Committee (5-5014).
- Use of Radioactive Materials - Environmental Health and Safety (5-8200).

Medical Consultation and Medical Examinations

Medical consultation and medical examinations will be made available to laboratory workers who work with hazardous chemicals, as required. All work related medical examinations and consultations will be performed by or under the direct supervision of a licensed physician and will be provided at no cost to the employee through the Gannett Health Center.

The opportunity to receive medical attention will be provided to employees who work with hazardous chemicals under the following circumstances:

- Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory.

- Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the Permissible Exposure Limit) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements.

- In the event of a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee will be provided an opportunity for a medical consultation. The consultation shall be for the purpose of determining the need for a medical examination.

All records of medical consultation, examinations, tests or written opinions shall be maintained at Gannett Health Center in accordance with 29 CFR 1910.20. The Gannett Health Center is located at 10 Central Avenue and the phone number is 255-5155. Exposure monitoring records of contaminate levels in laboratories will be maintained in Environmental Health and Safety at 125 Humphreys Service Building. The phone number at EH&S is 255-8200.

Personnel Responsible for the Chemical Hygiene Plan

Environmental Health and Safety will provide technical information and program support to assist in compliance with the OSHA Laboratory Standard. Environmental Health and Safety will maintain the Chemical Hygiene Plan (CHP) and the institutional Chemical Hygiene Officer responsibilities will reside within EH&S. However, it will be the responsibility of the individual supervisor (usually the principal investigator), department or college to be in compliance with the components of the plan.

Provisions for Additional Employee Protection for Work with Particularly Hazardous Substances

The Chemical Hygiene Plan includes provisions for additional employee protection for work with particularly hazardous substances. Research involving the use of particularly hazardous substances, such as select carcinogens, reproductive toxins, or acutely toxic chemicals may require prior review to ensure that adequate controls are in place which will protect the worker. Environmental Health and Safety will assist with the review and make recommendations for additional employee protection.

Additional employee protection may require the use of additional provisions such as:

- Establishment of a designated area

- Use of containment devices such as fume hoods or glove boxes

- Procedures for safe removal of contaminated waste

- Decontamination procedures

- Personal and area air monitoring

- Leak detection systems

The provision for additional controls may require the expertise and recommendations of various groups including EH&S, Facilities Engineering, technical committees, and outside consulting companies. These groups have all been previously involved with review and implementation of controls for high hazard research. All additional provisions for work with particularly hazardous materials must be incorporated into the standard operation procedures for those materials.

GENERAL PRINCIPLES FOR WORK WITH LABORATORY CHEMICALS

The following are general principles that can be applied to almost all uses of hazardous chemicals in laboratories:

1. It is prudent to minimize all chemical exposures: Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals shall be adopted, rather than specific guidelines for particular chemicals. Skin contact with chemicals should be avoided as a cardinal rule.

2. Avoid underestimation of risk: Even for substances of no known significant hazard, exposure shall be minimized; for work with substances which present special hazards, special precautions shall be taken. One should assume that any mixture may be more toxic than its most toxic component and that all substances of unknown toxicity are potentially toxic.

3. Provide adequate ventilation: The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by the use of hoods and other ventilation devices.

4. Institute a chemical hygiene program: Follow the Cornell Chemical Hygiene Plan. This must be a regular, continuing effort, not merely a standby or short-term activity. The Chemical Hygiene Plan recommendations shall be followed in academic teaching laboratories as well as by full-time laboratory workers.

5. Observe exposure limits: The Permissible Exposure Limits (PELs) of OSHA and the current Threshold Limit Values (TLVs) of the American Conference of Governmental Industrial Hygienists shall not be exceeded. The Permissible Exposure Limits and Threshold Limit Values can be obtained by contacting the Department of Environmental Health and Safety at 255-8200.

GENERAL RULES FOR WORK WITH LABORATORY CHEMICALS

The following are general safety and health rules that must be followed for essentially all laboratory work with hazardous chemicals. It is required that laboratories review and comply with these basic safety rules. Laboratories may need to modify these rules to provide additional controls to protect employees from chemical and physical hazards associated with the particular operation being conducted.

Accidents and spills:

Eye Contact: Promptly flush eyes with water for at least 15 minutes. Use both hands to hold the eyelids open so that the entire surface of the eye may be rinsed. Seek immediate medical attention.

Inhalation or Ingestion: Seek medical attention.

Skin Contact: Promptly flush the affected area with water and remove any contaminated clothing. If symptoms persist after washing for 15 minutes or longer, seek medical attention.

If medical attention is necessary, call **911** or contact the Gannett Health Center at 255-5155.

For large spills call **911**. For spill clean-up assistance for incidental spills and disposal of chemical waste, contact Environmental Health and Safety at 255-8200.

In the event of a fire call **911**. If you extinguish a small fire with a portable fire extinguisher it must be reported to Environmental Health and Safety at 255-8200.

Avoidance of "routine" exposure:

Develop and encourage safe habits. Avoid unnecessary exposure to chemicals by any route (inhalation, absorption through skin, or ingestion).

Do not smell or taste chemicals.

Inspect gloves and test glove boxes before use.

Do not allow the release of toxic substances in cold rooms and warm rooms, since these generally have contained, recirculated atmospheres.

Children in Labs:

Children are not permitted in Cornell University laboratories and other areas where hazardous materials and equipment are used. Access to these areas is restricted to authorized Cornell faculty, staff, students, and other individuals conducting business on campus.

Supervisors of laboratories and areas where hazardous materials and equipment is used or stored are responsible for ensuring that children are not allowed in these areas.

Choice of chemicals:

Use only those chemicals for which controls are available to minimize exposure to employees and students.

Substitute less hazardous chemicals for high hazard chemicals whenever possible.

Use the smallest possible quantities of chemicals feasible for a protocol.

Whenever possible, do not generate mixed hazardous wastes, for example, radioactivity with a flammable solvent.

Search existing inventories and use chemicals in stock before purchasing new chemicals.

Eating, smoking, etc.:

To prevent exposure to hazardous chemicals through ingestion, eating, drinking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present is prohibited.

Smoking is prohibited in all lab areas at Cornell.

Personal hygiene is very important. Wash your hands thoroughly after using any chemicals or other laboratory protocols and especially before eating or drinking.

Prohibit storage, handling or consumption of food or beverages in storage areas, refrigerators, glassware or utensils that are also used for laboratory operations. Refrigerators for the storage of food must be labeled, “For Food Storage Only. No Chemicals or Samples.”

Equipment and glassware:

Handle and store laboratory glassware with care to avoid damage.

Inspect all glassware for damage prior to each use. Do not use damaged glassware.

Use extra care with Dewar flasks and other evacuated glass apparatus. Shield or wrap them to contain chemicals and fragments should an implosion occur.

All high vacuum glassware should be taped when possible to minimize shrapnel in the event of an implosion.

Use equipment only for its designed purpose.

Horseplay:

Practical jokes or other behavior that might confuse, startle, or distract another worker is prohibited.

Mouth suction:

Do not use mouth suction for pipeting or starting a siphon! Even if you don't get any liquid in your mouth, you are sucking the fumes.

Personal apparel:

Confine long hair, loose clothing, and jewelry.

Wear shoes at all times in the laboratory. Avoid wearing sandals, perforated or open toed shoes.

Wear a lab coat when working with chemicals. Shorts should not be worn in a lab when using corrosives or other chemicals that present a skin contact hazard.

Personal protection:

Appropriate eye protection must be worn by all persons, including visitors, where chemicals are stored or handled.

Wear appropriate gloves when the potential for contact with toxic materials exists. Inspect the gloves before each use, wash them before removal, and replace them periodically. Discard disposable gloves immediately following overt contamination with highly toxic materials. EH&S can provide information on the resistance to chemicals of common glove materials, as well as assistance in the selection of the proper glove type. (See Section 11.)

Use appropriate respiratory equipment only when air contaminant exposure levels are not sufficiently controlled by engineering, work practice, or administrative controls. (See Section 10.)

Remove laboratory coats immediately on significant contamination. Contaminated lab coats must be designated as such before being removed to a commercial laundry to protect workers in such establishments.

Planning:

Seek information and advice about hazards, plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation.

Protocols using highly hazardous materials, equipment or methods must have prior approval from your supervisor or safety committee.

Unattended operations:

Leave lights on and place an appropriate warning sign on the door (listing the nature of the experiment in progress, your name, and a contact number). Provide for the containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation.

Whenever possible, use automatic shutoff devices on long term or unattended operations, such as a loss of cooling water shutoff, over-temperature shutoff, etc.

Use of the fume hood:

Use the fume hood for operations that might result in the release of toxic chemical vapors, fumes or dust. Benchtop use of chemicals that present an inhalation hazard is prohibited.

Confirm adequate hood performance before use; check the telltale. Conduct a dry ice capture test when using new materials for the first time or whenever substantial changes have been made to an experimental setup in a hood.

Keep the hood sash lowered to the height recommended by EH&S. Keep materials stored in hoods to a minimum and do not allow them to block vents or airflow.

When conducting long-term experiments with acutely toxic materials do not use a hood with an automatic night or timed setback.

Vigilance:

Be alert to unsafe conditions and see that they are corrected when detected.

Waste disposal:

Comply with all waste disposal procedures provided by EH&S. (See Section 7.)

Working alone:

Avoid working alone when using hazardous chemicals or processes.

Use a buddy system or a notification protocol with Cornell Police or others in a facility if you must work alone.

OSHA Laboratory Standard

Original Text

1910.1450 ***Occupational exposure to hazardous chemicals in laboratories***.

Becomes effective May 1, 1990.

(a) Scope and application.

(1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

(i) For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) routinely exceeded from an OSHA regulated substance with exposure monitoring and medical surveillance requirements, paragraphs (d) and (g)(1)(ii) of this section shall apply.

(3) This section shall not apply to:

(i) Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.

(ii) Laboratory use of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

(A) Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

(b) Definitions

"Action level" means a concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Carcinogen" (see "select carcinogen").

"Chemical Hygiene Officer" means an employee who is designated by the employer, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the Chemical Hygiene Plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

"Chemical Hygiene Plan" means a written program developed and implemented by the employer which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

"Combustible liquid" means any liquid having a flash point at or above 100 °F (37.8 °C), but below 200 °F (93.3 °C), except any mixture having components with flash points of 200 °F (93.3 °C), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

"Compressed gas" means: (i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 °F (21.1 °C); or (ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 °F (54.4 °C) regardless of the pressure at 70 °F (21.1 °C); or (iii) A liquid having a vapor pressure exceeding 40 psi at 100 °F (37.8 °C) as determined by ASTM D-323-72.

"Designated area" means an area which may be use for work with "select carcinogens," reproductive toxins or substances which have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory or a device such as a laboratory hood.

"Emergency" means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment which results in an uncontrolled release of a hazardous chemical into the workplace.

"Employee" means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

"Explosive" means a chemical that causes a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

"Flammable" means a chemical that falls into one of the following categories:

(i) **"Aerosol, flammable"** means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame projection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening:

(ii) **"Gas, flammable"** means:

(A) A gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or

(B) A gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.

(iii) **"Liquid, flammable"** means any liquid having a flash point below 100 °F (37.8 °C), except any mixture having components with flash points of 100 °F (37.8 °C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) **"Solid, flammable"** means a solid, other than a blasting agent or explosive as defined in 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard.

A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

"Flashpoint" means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite when tested as follows:

(I) Tailgate Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24-1979 (ATM D 56-79))- for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 °F (37.8 °C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (see American National Standard Method of Test for Flash Point by Pensky-Martens Closed Tester, Z11.7-1979 (ASTM D93-79)- for liquids with a viscosity equal to or greater than 45 SUS at 100 °F(37.8 °C), or that contain suspended solids, or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of Test for Flash Point by Setaflash Closed Tester (ASTM D3278-78)).

Organic peroxides, which undergo auto accelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

"Hazardous chemical" means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

Appendices A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether or not a chemical is to be considered hazardous for purposes of this standard.

"Laboratory" means a facility where the "laboratory use of hazardous chemicals" occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis.

"Laboratory scale" means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. "Laboratory scale" excludes those workplaces whose function is to produce commercial quantities of materials.

"Laboratory-type hood" means a device located in a laboratory, enclosed on five sides with a moveable sash or fixed partial enclosure on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition provided that the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

"Laboratory use of hazardous chemicals" means handling or use of such chemicals in which all of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"

(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in anyway simulate a production process; and

(iv) "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

"Medical consultation" means a consultation which takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

"Organic peroxide" means an organic compound that contains the bivalent -O-O- structure and which may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

"Oxidizer" means a chemical other than a blasting agent or explosive as defined in 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

"Physical hazard" means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water-reactive.

"Protective laboratory practices and equipment" means those laboratory procedures, practice and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

"Reproductive toxins" means chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

"Select carcinogen" means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP) (latest edition); or

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC) (latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m3;

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

"Unstable (reactive)" means a chemical which is the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

"Water-reactive" means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.

(c) Permissible exposure limits.

For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

(d) Employee exposure determination

(1) Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

(2) Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

(3) Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

(4) Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing, either individually or by posting results in an appropriate location that is accessible to employees.

(e) Chemical hygiene plan--General.

(Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan.)

(1) Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

(i) Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

(ii) Capable of keeping exposures below the limits specified in paragraph (c) of this section.

(2) The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

(3) The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection:

(i) Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

(ii) Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

(iii) A requirement that fume hood and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

(iv) Provision for employee information and training as prescribed in paragraph (f) of this section;

(v) The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

(vi) Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

(vii) Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer and, if appropriate, establishment of a Chemical Hygiene Committee; and

(viii) Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

(A) Establishment of a designated area;

(B) Use of containment devices such as fume hoods or glove boxes;

(C) Procedures for safe removal of contaminated waste; and

(D) Decontamination procedures.

(4) The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

(f) Employee information and training.

(1) The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

(2) Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

(3) Information. Employees shall be informed of:

(i) The contents of this standard and its appendices which shall be made available to employees;

(ii) The location and availability of the employer's Chemical Hygiene Plan;

(iii) The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

(iv) Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

(v) The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical suppler.

(4) Training.

(i) Employee training shall include:

(A) Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

(B) The physical and health hazards of chemicals in the work area; and

(C) The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

(ii) The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g) Medical consultation and medical examinations.

(1) The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

(i) Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

(ii) Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

(iii) Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

(2) All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

(3) Information provided to the physician. The employer shall provide the following information to the physician:

(i) The identity of the hazardous chemical(s) to which the employee may have been exposed;

(ii) A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and

(iii) A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(4) Physician's written opinion.

(i) For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

(A) Any recommendation for further medical follow-up;

(B) The results of the medical examination and any associated tests;

(C) Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous chemical found in the workplace; and

(D) A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

(ii) The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

(h) Hazard identification.

(1) With respect to labels and material safety data sheets:

(i) Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

(ii) Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

(2) The following provisions shall apply to chemical substances developed in the laboratory:

(i) If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

(ii) If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.

(iii) If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard(29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.

(i) Use of respirator.

Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

(j) Recordkeeping.

(1) The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

(2) The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.20.

(k) Dates.

(1) Effective date: This section shall become effective May 1,1990.

(2) Start-up dates.

(i) Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.

(ii) Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

(l) Appendices.

The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.

Appendix A to 29 CFR 1910.1450

National Research Council Recommendations
Concerning Chemical Hygiene in Laboratories (Non-Mandatory)

A. General Principals for Work with Laboratory Chemicals
1. Minimize all Chemical Exposures
2. Avoid Underestimation of Risk
3. Provide Adequate Ventilation
4. Institute a Chemical Hygiene Program
5. Observe the PELs and TLVs

B. Responsibilities
1. Chief Executive Officer
2. Supervisor of Administrative Unit
3. Chemical Hygiene Officer
4. Laboratory Supervisor
5. Project Director
6. Laboratory Worker

C. The Laboratory Facility
1. Design
2. Maintenance
3. Usage
4. Ventilation

D. Components of the Chemical Hygiene Plan
1. Basic Rules and Procedures
2. Chemical Procurement, Distribution, and Storage
3. Environmental Monitoring
4. Housekeeping, Maintenance and Inspections
5. Medical Program
6. Personal Protective Apparel and Equipment
7. Record
8. Signs and Labels
9. Spills and Accidents
10. Training and Information
11. Waste Disposal

E. General Procedures for Working With Chemicals
1. General Rules for all Laboratory Work with Chemicals
2. Allergens and Embryotoxins
3. Chemicals of Moderate Chronic or High Acute Toxicity
4. Chemicals of High Chronic Toxicity
5. Animal Work with Chemicals of High Chronic Toxicity

F. Safety Recommendations
G. Material Safety Data Sheets

Foreword

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted from "Prudent Practices for Handling Hazardous Chemicals in Laboratories" (referred to below as "Prudent Practices"), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Ave., NW., Washington DC 20418.

"Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from "Prudent Practices", organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix should consult "Prudent Practices" for a more extended presentation and justification for each recommendation.

"Prudent Practices" deals with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical hygiene" being substituted for the word "safety". However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

Corresponding Sections of the Standard and this Appendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard	**Relevant appendix section**
(e)(3)(i) Standard operating procedure for handling toxic chemicals.	C, D, E
(e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures.	D
(e)(3)(iii) Fume hood performance	C4b
(e)(3)(iv) Employee information and training (incl. emergency procedures).	D10, D9
(e)(3)(v) Requirements for prior approval of laboratory activities	E2b, E4b
(e)(3)(vi) Medical consultation and medical examinations.	D5, E4f

(e)(3)(vii) Chemical hygiene responsibilities..... B
(e)(3)(viii) Special precautions for work with particularly hazardous substances. E2, E3, E4

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A-D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in "Prudent Practices" are given in parentheses.)

A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, "Prudent Practices" expresses certain general principles, including the following:

1. It is prudent to minimize all chemical exposures.

   Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).

2. Avoid underestimation of risk.

   Even for substances of no known significant hazard, exposure should be minimized; for work with substances which present special hazards, special precautions should be taken (10,37,38). One should assume that any mixture will be more toxic than its most toxic component (30,103) and that all substances of unknown toxicity are toxic (3,34).

3. Provide adequate ventilation.

   The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32,198).

4. Institute a chemical hygiene program.

   A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).

5. Observe the PELs, TLVs.

   The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6,11,21) including the:

1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7,11).
2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).
3. Chemical hygiene officer(s), whose appointment is essential (7) and who must:

   (a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);

   (b) Monitor procurement, use, and disposal of chemicals used in the lab (8);

   (c) See that appropriate audits are maintained (8);

   (d) Help project directors develop precautions and adequate facilities (10);

   (e) Know the current legal requirements concerning regulated substances (50); and

   (f) Seek ways to improve the chemical hygiene program (8,11).
4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:

   (a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21,22);

   (b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21,171);

   (c) Know the current legal requirements concerning regulated substances (50,231);

   (d) Determine the required levels of protective apparel and equipment (156,160,162); and

   (e) Ensure that facilities and training for use of any material being ordered are adequate (215).
5. Project director or director of other specific operations, who has primary responsibility for chemical hygiene procedures for that operation (7).
6. Laboratory worker, who is responsible for:

   (a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7,21,22,230); and

   (b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:

   (a) An appropriate general ventilation system (see C(4) below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);

   (b) Adequate, well-ventilated stockrooms/storerooms (218,219);

   (c) Laboratory hoods and sinks (12,162);

   (d) Other safety equipment including eyewash fountains and drench showers (162,169); and

   (e) Arrangements for waste disposal (12,240).

2. Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continuing appraisal and be modified if inadequate (11,12).

3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).

4. Ventilation

   (a) **General laboratory ventilation**. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing an increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).

   (b) **Hoods**. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200,209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.

   (c) **Other local ventilation devices**. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct(207).

   (d) **Special ventilation areas**. Exhaust air from glove boxes and isolation rooms should be passed though scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).

   (e) **Modifications.** Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate(12,193,204).

(f) **Performance**. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (94).

(g) **Quality**. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194,195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfpm) (200,204).

(h) **Evaluation**. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6,12,14,195), and reevaluated whenever a change in local ventilation devices is made (12,195,207). See pp.195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan

1. Basic Rules and Procedures (Recommendations for these are given in section E, below).

2. Chemical Procurement, Distribution, and Storage

(a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215,26). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).

(b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19). Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

(c) Distribution. When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).

(d) Laboratory storage. Amounts permitted should be as small as practical. Storage of bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-6, 229).

3. Environmental Monitoring.

Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections

(a) Cleaning. Floors should be cleaned regularly (24).

(b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6,21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

(c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Safety showers should be tested routinely (169). Other safety equipment should be inspected regularly (e.g., every 3-6 months) (6,24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).

(d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

5. Medical Program

(a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).

(b) Routine surveillance. Anyone whose work involve regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11,50).

(c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). Se pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

(a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);

(b) An easily accessible drench-type safety shower (162,169);

(c) An eyewash fountain (162);

(d) A fire extinguisher (162-164);

(e) Respiratory protection (164-169), fire alarm and telephone for emergency use (162) should be available nearby; and

(f) Other items designated by the laboratory supervisor (156,160).

7. Records

(a) Accident records should be written and retained (174).

(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).

(c) Inventory and usage records for high-risk substances should be kept as specified in sections E(3)(e) below.

(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisor, and laboratory workers (28);

(b) Identity label, showing contents of containers (including waste receptacles) and associated hazards (27,48);

(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and (d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents

(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drill (172).

(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).

(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).

(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8,28).

10. Information and Training Program

(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5,15).

(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154,169). Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6). Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).

(d) Frequency of Training: The training and education program should be a regular, continuing activity--not simply an annual presentation (15).

(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

11. Waste Disposal Program.

(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).

(b) Content (14,232,233,240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).

(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not opened (24,27). Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).

(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14,238,241). Indiscriminate disposal by pouring waste chemicals down the drain (14,231,242) or adding them to mixed refuse for landfill burial is unacceptable (14). Hoods should not be used as a means of disposal for volatile chemicals (40,200). Disposal by recycling (233,243) or chemical decontamination (40,230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals:

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the subprograms mentioned above, these should include the rules listed below.

1. General Rules

The following should be used for essentially all laboratory work with chemicals:

(a) Accidents and spills:

Eye Contact: Promptly flush eyes with water for a prolonged period (15 minute) and seek medical attention (33,172).

Ingestion: Encourage the victim to drink large amounts of water (178).

Skin Contact: Promptly flush the affected area with water(33,172,178) and remove any contaminated clothing (172,178). If symptoms persist after washing, seek medical attention (33).

Clean-up. Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24,33). See pp. 233-237 for specific clean-up recommendations.

(b) Avoidance of "routine" exposure:

Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23);

Do not smell or taste chemical (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199).

Inspect gloves (157) and test glove boxes (208) before use.

Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).

(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22,24,32,40); wash hands before conducting these activities (23,24). Avoid storage, handling or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23,24,226).

(e) Equipment and glassware: Handle and store laboratory glassware with care to avoid damage; do no use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23,26).

(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).

(g) Horseplay: Avoid practical jokes or the behavior which might confuse, startle or distract another worker (23).

(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23,32).

(i) Personal apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) Personal housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

(k) Personal protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22,23,33,154).

Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given on p.159).

Use appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-165), inspecting the respirator before use (169). Use any other protective and emergency apparel and

equipment as appropriate (22,157-162). Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).

Remove laboratory coats immediately on significant contamination (161).

(l) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22,23).

(m) Unattended operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27,128).

(n) Use of hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-199). As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13). Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200).

Keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200). Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).

(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).

(p) Waste disposal: Assure that the plan for each laboratory operation includes plans and training for waste disposal (230).

Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22,24).

Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of wastewater treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).

(q) Working alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

2. Working with Allergens and Embryotoxins

(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).

(b) Embryotoxins (34-35) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed using appropriate protective apparel (especially gloves) to prevent skin contact.

Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made. Store these substances, properly labeled, in an adequately ventilated area and in an unbreakable secondary container. Notify supervisors of all incidents of exposure or spills and consult a qualified physician when appropriate.

3. Work with Chemicals of Moderate Chronic or High Acute Toxicity (Examples: diisopropylflurophosphate (41), hydrofluoric acid (43) , hydrogen cyanide (45)).

Supplemental rules to be followed in addition to those mentioned above (Procedure B of "Prudent Practices", pp. 39-41):

(a) Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

(b) Applicability: These precautions are appropriate for substances with moderate chronic or high acute toxicity used in significant quantities (39).

(c) Location: Use and store these substances only in areas of restricted access with special warning signs (40,229). Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance (39); trap released vapors to prevent their discharge with the hood exhaust (40).

(d) Personal protection: Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

(e) Records: Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40,229).

(f) Prevention of spills and accidents: Be prepared for accidents and spills (41).

Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39).

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surface with removable, absorbent, plastic backed paper (40). If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40). Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethyl mercury and nickel carbonyl (48), Benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).)

Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of" Prudent Practices" pp. 47-50).

(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49,50). Decontaminate the controlled area before normal work is resumed there (50).

(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) Medical surveillance: If using toxicologically significant quantities of such a substance a regular basis (e.g., 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

(h) Signs and labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233-4).

(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48,227,229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48,229).

(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap

the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49,50,233).

5. Animal Work with Chemicals of High Chronic Toxicity

(a) Access: For large scale studies, special facilities with restricted access are preferable (56).

(b) Administration of the toxic substance: When possible, administer the substance by injection or gavage instead of in he diet. If administration is in the diet, use caging system under negative pressure or under laminar airflow directed toward HEPA filters (56).

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55,56).

(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration, if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from "Prudent Practices" do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35-36).

2. Electrically powered laboratory apparatus: (179-92).

3. Fires, explosions: (26,57-74,162-164,174-175,219-220,226-227).

4. Low temperature procedures: (26,88).

5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27,75-101).

G. Material Safety Data Sheets

Material safety data sheets are presented in "Prudent Practices" for the chemicals listed below.

(Asterisks denote that comprehensive material safety data sheets are provided).

*Acetyl peroxide (105)
*Acrolein (106)
*Acrylonitrile (107)
Ammonia (anhydrous) (91)
*Aniline (109)
*Benzene (110)
*Benzo(a)pyrne (112)
*Bis(chloromethyl) ether (113)
Boron trichloride (91)
Boron trifluoride (92)
Bromine (114)
*Tert-butyl hydroperoxide (148)
*Carbon disulfide (116)
Carbon monoxide (92)
*Carbon tetrachloride (118)
*Chlorine (119)
Chlorine trifluoride (94)
Chloroform (121)
Chloromethane (93)
Diethyl ether (122)
Diisopropyl flurophosphate (41)
Dimethylformamide (123)
Dimethyl sulfate (125)
Dioxane (126)
Ethylene dibromide (128)
*Fluorine (95)
*Formaldehyde (130)
*Hydrazine and salts (132)
Hydrofluoric acid (43)
Hydrogen bromide (98)
Hydrogen chloride (98)
Hydrogen cyanide (133)
Hydrogen sulfide (135)
Mercury and compounds (52)
Methanol (137)
*Morpholine (138)
Nickel carbonyl (99)
*Nitrobenzene (139)
Nitrogen dioxide (100)

N-nitrosodiethylamine (54)
Peracetic acid (141)
Phenol (142)
Phosgene (143)
Pyridine (144)
Sodium azide (145)
*Sodium cyanide (147)
Sulfur dioxide (101)
*Trichloroethylene (149)
Vinyl chloride (150)

Appendix B to 29 CFR 1910.1450

References (Non-Mandatory)

The following references are provided to assist the employer in the development of a Chemical Hygiene Plan. The materials listed below are offered as non-mandatory guidance. References listed here do not imply specific endorsement of a book, opinion, technique, policy or a specific solution for a safety or health problem. Other references not listed here may better meet the needs of a specific laboratory.

(a) Materials for the development of the Chemical Hygiene Plan:

1. American Chemical Society, Safety in Academic Chemistry Laboratories, 4th edition, 1985.
2. Fawcett, H.H. and W.S. Wood, Safety and Accident Prevention in Chemical Operations, 2nd edition, Wiley-Interscience, New York, 1982.
3. Flury, Patricia A., Environmental Health and Safety in the Hospital Laboratory, Charles C. Thomas Publisher, Springfield IL, 1978.
4. Green, Michael E. and Turk, Amos, Safety in Working with Chemicals, Macmillan Publishing Co., NY, 1978.
5. Kaufman, James A., Laboratory Safety Guidelines, Dow Chemical Co., Box 1713, Midland, MI 48640, 1977.
6. National Institutes of Health, NIH Guidelines for the Laboratory Use of Chemical Carcinogens, NIH Pub. No. 81-2385, GPO, Washington, DC 20402, 1981.
7. National Research Council, Prudent Practices for Disposal of Chemicals from Laboratories, National Academy Press, Washington, DC,1983.
8. National Research Council, Prudent Practices for Handling Hazardous Chemicals in Laboratories, National Academy Press, Washington, DC, 1981.
9. Renfrew, Malcolm, Ed., Safety in the Chemical Laboratory, Vol.IV, J.Chem.Ed., American Chemical Society, Easton, PA, 1981.
10. Steere, Norman V., Ed., Safety in the Chemical Laboratory, J.Chem.Ed., American Chemical Society, Easton, PA. 18042, Vol.I,1967, Vol.II,1971, Vol.III,1974.
11. Steere, Norman V., Handbook of Laboratory Safety, The Chemical Rubber Company Cleveland, OH, 1971.
12. Young, Jay A., Ed., Improving Safety in the Chemical Laboratory, John Wiley & Sons, Inc. New York, 1987.

(b) Hazardous Substances Information:

1. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes, P. O. Box 1937 Cincinnati, OH 45201 (latest edition).

2. Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service, U.S. Government Printing Office, Washington, DC, (latest edition).

3. Best Company, Best Safety Directory, Vols. I and II, Oldwick, N.J., 1981.

4. Bretherick, L., Handbook of Reactive Chemical Hazards, 2nd edition, Butterworths, London, 1979.

5. Bretherick, L., Hazards in the Chemical Laboratory, 3rd edition, Royal Society of Chemistry, London, 1986.

6. Code of Federal Regulations, 29 CFR part 1910 subpart Z. U.S.Govt. Printing Office, Washington, DC 20402 (latest edition).

7. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, World Health Organization Publications Center, 49 Sheridan Avenue, Albany, New York 12210 (latest editions).

8. NIOSH/OSHA Pocket Guide to Chemical Hazards. NIOSH Pub. No. 85- 114, U.S. Government Printing Office, Washington, DC, 1985 (or latest edition).

9. Occupational Health Guidelines, NIOSH/OSHA NIOSH Publication No.81-23 U.S. Government Printing Office, Washington, DC, 1981.

10. Patty, F.A., Industrial Hygiene and Toxicology, John Wiley & Sons,Inc., New York, NY (Five Volumes).

11. Registry of Toxic Effects of Chemical Substances, U. S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. Revised Annually, for sale from Superintendent of Documents, U.S. Govt. Printing Office, Washington, DC 20402.

12. The Merck Index: An Encyclopedia of Chemicals and Drugs, Merck and Company Inc. Rahway, N.J., 1976 (or latest edition).

13. Sax, N.I. Dangerous Properties of Industrial Materials, 5th edition, Van Nostrand Reinhold, NY., 1979.

14. Sittig, Marshall, Handbook of Toxic and Hazardous Chemicals, Noyes Publications, Park Ridge, NJ, 1981.

(c) Information on Ventilation:

1. American Conference of Government Industrial Hygienists, Industrial Ventilation, 16th edition, Lansing, MI, 1980.

2. American National Standards Institute, Inc., Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1979 American National Standards Institute, N.Y. 1979.

3. Imad, A.P. and Watson, C.L. Ventilation Index: An Easy Way to Decide about Hazardous Liquids, Professional Safety, pp.15-18, April 1980.

4. National Fire Protection Association, Fire Protection for Laboratories Using Chemicals NFPA-45, 1982.

Safety Standard for Laboratories in Health Related Institutions, NFPA 56c, 1980.

Fire Protection Guide on Hazardous Materials, 7th edition, 1978. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

5. Scientific Apparatus Makers Association (SAMA), Standard for Laboratory Fume Hoods, SAMA LF7-1980. 1101 16th Street, NW., Washington, DC 20036.

(d) Information on Availability of Referenced Material:

1. American National Standards Institute (ANSI), 1430 Broadway, New York, NY 10018.

2. American Society for Testing and Materials (ASTM), 1916 Race Street, Philadelphia, PA 19103.

(Approved by the Office of Management and Budget under control number 1218-0131)

CHEMICAL WASTE DISPOSAL PROCEDURES

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Environmental Health and Safety

May, 1998

CHEMICAL WASTE DISPOSAL PROCEDURES

Introduction

Procedures for the handling of chemical waste are undergoing significant and continuous changes commensurate with society's heightened awareness and concern for the environment. These changes are resulting in ever increasing regulations and a corresponding escalation of incurred costs for disposal. **In general, current regulations and laws hold the University responsible for any adverse effects from these chemicals forever, regardless of the manner in which they were disposed of or where they are.** In 1997 Cornell disposed of approximately 44 tons of chemical waste.

The New York State Department of Environmental Conservation (DEC) has jurisdiction over the disposal program, as a result of New York's legislative action to assume authorization to implement the Resource Conservation and Recovery Act (RCRA) in conjunction with federal regulatory programs initiated by the Environmental Protection Agency (EPA). The Department of Transportation (DOT) regulations govern the labeling, packaging and transportation of chemical waste. Environmental Health and Safety is the federally registered university department charged with the management of such waste. Federal and state regulations provide criminal penalties for the abandonment, misrepresentation, or improper disposal of hazardous waste.

In the event of a chemical spill or emergency the Environmental Health and Safety Hazardous Materials Team (HazMat Team) should be contacted by calling the Campus Police at **911**.

*This document deals solely with the disposal of waste that is <u>not</u> radioactive. For assistance or information on disposal of radioactive material, including both licensed material (material authorized under a Cornell Radioactive Permit) and non-regulated radioactive material such as uranium and thorium salts, contact Environmental Health and Safety at 255-8200. Please note the following: 1) A detailed description of chemical composition must be provided for all liquid radioactive waste; and 2) procedures that produce mixed waste including **<u>both</u>** radioactive and hazardous chemical material must be approved in advance by the Cornell Radiation Safety Committee.*

These procedures and suggestions are presented for the following purposes:

1.) *To ensure that the University is in compliance with all federal, state and local laws applicable to the management and disposal of hazardous materials.*

2.) *To reduce the impact of hazardous materials on the environment by implementing a waste minimization program.*

3.) *To reduce the University's costs and liability associated with the management and disposal of hazardous waste.*

4.) *To provide staff at Cornell University with a comprehensive reference source for proper preparation (packing, labeling, etc.) of hazardous materials designated for on- or off-site disposal.*

The book, *Prudent Practices in the Laboratory, Handling and Disposal of Chemicals,* National Academy Press, 1995, has attained a status as the standard authority on questions related to the technical aspects of the treatment and disposal of chemical waste. Laboratories should have a copy available for the use of researchers. *Prudent Practices* can be ordered through the Cornell Campus Book Store.

How to approach questions of treatment and disposal often requires judgment which is best exercised by scientists in the laboratory, but adherence to the regulations is a must.

Experiments that will produce a large volume of hazardous waste or any quantity of particularly difficult hazardous waste should be discussed with Environmental Health and Safety and planned for well in advance. A member of the EH&S HazMat team can be reached at 255-3761, 8:00 AM to 4:00 PM Monday thru Friday.

The companies which pick up chemical waste come to Cornell about four times a year. They stay for about five days and monitor the packaging of waste (at an average cost of $35,000 per visit). They examine each labeled bottle and, in some cases, make an analytical test to decide whether or not they are willing to accept the material. By taking the waste, the company is sharing the responsibility for the materials, so it is understandable that they have a conservative outlook. If material is not accepted for shipment, the problem is left with the University. Rejected material will be returned to the generating laboratory for further identification.

REDUCTION OF WASTE

The level of hazardous waste can be reduced by limiting the purchase of chemicals to the quantities that will be used. The RCRA regulations stress this approach and DEC has mandated that the University implement a program to reduce the volume of hazardous waste generated. Disposal facilities charge $50 or more (depending on the type of chemical) to dispose of a gallon of waste solvent, *so the cost of disposal often exceeds the original purchase price.*

Faculty and staff still continually ask Environmental Health and Safety to dispose of new, factory-sealed jars of chemicals. Lab workers, faculty and staff are urged to make available to others the excess chemicals in their laboratories. The Department of Chemistry and Chemical Biology maintains a chemical recycling program for the campus. Contact John Terry at 255-4389 or check their Web site at: http://www.chem.cornell.edu/jht1/

Experiments in teaching and research labs should be done on as small a scale as is feasible.

CONSOLIDATION OF SOLVENTS

Current regulations prohibit the disposal of hazardous waste chemicals in landfills, so all such materials are shipped for incineration or treatment.

Laboratory workers are urged to consolidate solvents as much as possible. A large percentage of chemical waste is shipped in 55-gallon drums known as labpacks. These drums contain bottles of solvent or chemicals (about 15 one-gallon bottles) along with absorbent material. Some material, if in sufficient quantity, is shipped as bulk liquid in the 55-gallon drums. If permitted by regulations, the latter procedure is far less costly.

The charge for disposal of labpacks is based on the number of drums of waste, whether the drum is completely filled with solvents or contains (as in most cases) partially filled bottles packed according to DOT regulations. Thus, *the cost of the disposal of a partially filled bottle is the same as the cost of one which is full*. Given this situation, partially filled bottles become very expensive for the amount of material being shipped. In part, this explains the high disposal cost per gallon of material. In order to reduce this empty but costly space, *compatible* solvents may be combined in a single container. When solvents are thus combined, the approximate volume percent of each solvent should be noted on the disposal tag. However, *halogenated solvents should not be combined for disposal with solvents which do not contain halogens*, because of differences in handling and ultimate disposal techniques. *Solutions of halogenated and non-halogenated solvents will be considered as halogenated solvents and disposed of accordingly.*

MATERIALS WHICH ARE NOT LEGALLY DISPOSABLE

As a prerequisite to shipping chemical waste, the identity of the material must be established. In the case of materials for which no information is available, Environmental Health and Safety will absorb the cost to have one or two samples characterized by a competent laboratory. The cost incurred to identify larger numbers of samples is the responsibility of the generating department.

A recurring problem is "orphan" waste. Orphan waste material is waste (with no information) left behind by students, staff and faculty who have left Cornell University. Some suggestions for dealing with this problem can be found in *Prudent Practices.* The best method of dealing with such "orphan" waste is to prevent its occurrence by having as much chemical waste removed as possible before a generator leaves. (Some departments have spent thousands of dollars on dealing with "orphan" wastes.)

Trade names or initials are not sufficient identification. Environmental Health and Safety has Material Safety Data Sheets on most trade name products. These sheets have sufficient information to allow identification, and, thereby, disposal of such products.

EXPLOSIVE AND HIGHLY REACTIVE CHEMICALS

Few laboratory chemicals are explosive but, at times, potentially explosive materials can be generated in synthetic work or merely by storage. Picric acid (2,4,6, trinitrophenol), a potentially explosive compound, is sometimes used in laboratories. It is usually purchased containing 10-15 percent water, in which state it is relatively safe. However, if allowed to dry, it should be treated as a dangerous explosive and Environmental Health and Safety should be notified. *Prudent Practices* has a list of shock-sensitive compounds which includes, among others, acryl and alkyl nitrites, alkyl perchlorates, azides, diazo compounds, dry diazonium salts, peroxides, hydroperoxides, and poly nitro alkyl/aromatic compounds. Many common laboratory chemicals can form explosive peroxides on exposure to air over time. A list of such chemicals can be found in *Prudent Practices.* The compounds on this list should be dated when opened and disposed of in specified periods of time. For example, diisopropyl ether is particularly susceptible to peroxide formation and, if its use is required, it should be completely used or disposed of within three months of opening. If older stocks of isopropyl ether are discovered, Environmental Health and Safety should be notified before handling.

Ether, dioxane and tetrahydrofuran are susceptible to peroxide formation. Once opened, stocks of these chemicals should be used within six months. After six months they must be tested for peroxide formation. Test strips for determining the amount of peroxides in solvents are available from the Chemistry Department stockroom. If the amount of peroxide is over 80 parts per million, the material should be discarded. (Note: No one knows if 80 ppm is reasonable; it's the number used in the University of Wisconsin manual.) *If a peroxide bearing solvent is not discarded after six months the peroxide must be destroyed using the appropriate procedures*. Recently, chemical manufacturers have been printing expiration dates on stocks of peroxide-forming chemicals, and the materials should be disposed of after this period has expired. *Prudent Practices* deals with the treatment and disposal of potentially explosive materials. Some water-reactive and pyrophoric compounds may also be decomposed using simple procedures. Such procedures are available in *Prudent Practices* and other references. These procedures must be carried out in the laboratory in which the material is generated and in the container in which the waste was originally accumulated. For assistance call Environmental Health and Safety at 255-8200.

Another class of materials which <u>cannot</u> be disposed of without pre-treatment is those which evolve gases. Any waste material which requires vent-caps <u>cannot</u> be accepted by Environmental Health and Safety.

HEAVY METALS

The EPA has banned heavy metals from land disposal. Alternate methods of treatment and disposal are under investigation but, none of these have received final approval from EPA.

At the moment limited disposal methods are available for mercury and other heavy metal compounds, and these materials currently picked up by Environmental Health and Safety. Metallic are mercury will be recycled by EH&S. The mercury should be separated from the glassware apparatus, such as thermometers and manometer ***by the researcher, using proper precautions.*** All heavy metal compounds should be kept separate from other materials to facilitate disposal.

NON-CHEMICAL PARAPHERNALIA

Plastic ware, disposable gloves, glassware, paper towels, tools, pumps, and the like, which are contaminated with chemical waste, cannot be disposed of by Environmental Health and Safety. Such items must be decontaminated and reused, or disposed of as ordinary trash. The appropriate method of decontamination is the responsibility of the laboratory. ***The resulting rinsate solution will be accepted for disposal as chemical waste.*** For disposing of empty bottles, EPA regulations require that containers be rinsed three times with a **30-second drain time between rinses** before being discarded or reused.

Hypodermic syringes and needles are considered regulated medical waste, and must be disposed of according to state and federal regulations. See the College of Veterinary Medicine document, "Disposal of Medical Waste," for instructions on the disposal of "sharps." All syringes, needles and other "sharps" should be placed in an approved rigid, leak-proof, and puncture-resistant container. The Veterinary College also takes dry materials (paper products, bench paper, gloves, etc.) contaminated with trace amounts of mutagens, reduced osmium tetroxide and other materials. For additional information, including obtaining a copy of "Disposal of Medical Waste," call the Office of the Director of Biosafety, NYSCVM, 253-3900, or the Incinerator Operator at 253-3288.

DISPOSAL OF NONHAZARDOUS LABORATORY WASTE CHEMICALS AS TRASH

The following table, adapted from *Prudent Practices*, lists solid chemicals which are not considered hazardous and are therefore suitable for disposal with regular trash. However, neither custodians nor trash collectors can readily distinguish between hazardous and nonhazardous wastes. Therefore, the packaging of such waste for disposal must be secure, and its transfer to the dumpster carried out by laboratory personnel.

A. *Organic Chemicals*

Enzymes
Sugars and sugar alcohols
Starch
Naturally occurring amino acids and salts
Citric acid and its Na, K, Mg, Ca, NH_4 salts
Lactic acid and its Na, K, Mg, Ca, NH_4 salts

B. *Inorganic Chemicals*

Silica
Sulfates: Na, K, Mg, Ca, Sr, NH_4
Phosphates: Na, K, Mg, Ca, Sr, NH_4
Carbonates: Na, K, Mg, Ca, Sr, NH_4
Oxides: B, Mg, Ca, Sr, Al, Si, Ti, Mn, Fe, Co, Cu
Chlorides: Ca, Na, K, Mg, NH_4
Borates: Na, K, Mg, Ca

C. ***Laboratory Materials Not Contaminated with Hazardous Chemicals***

Chromatographic adsorbent
Glassware
Filter papers
Filter aids
Rubber and plastic protective clothing

Other examples of nonhazardous biochemicals include polysaccharides, nucleic acids and naturally occurring precursors, and dry biological media.

INSTRUCTIONS FOR PACKAGING:

1. **Package securely for the dumpster** by using at least two layers of packaging so that material cannot spill during collection.

2. Leave label on innermost container.

3. Label outer container "Non-hazardous" waste.

4. **Place containers in the dumpster yourself**, since custodians do not handle even nonhazardous laboratory chemicals.

PROCEDURES FOR THE PREPARATION OF HAZARDOUS WASTE CHEMICALS FOR DISPOSAL BY ENVIRONMENTAL HEALTH & SAFETY

1. Call EH&S at 255-8200 to request new numbered two-part stick-on 5"x4" disposal stickers.

2. Complete the two-part stick-on label with all of the spaces filled in (i.e., bldg. and room number, name of requester, telephone number, chemical type, chemical name and weight or volume of all ingredients in each container). No trade names please. (Some ingredients may take more room than can be written on the numbered label. If this is the case, please tape (1) one additional copy of the ingredients on a small piece of paper to the container and send a second copy to EH&S along with the tear off portion of the label.) Due to the large number of laboratories serviced, we no longer accept telephone calls for routine chemical pick-ups unless it is an emergency situation. After receiving copies of the labels at EH&S, we will respond on a first come first served basis. **Please make sure that the date on the label is the date that you send the labels to EH&S via campus mail.**

Additional information on completing the label is as follows:

Building & Room: Indicates the area where the hazardous waste is generated, and directs EH&S personnel to the pickup.

Name and Telephone Number: Identifies the individual faculty or staff member generating the hazardous waste and assuming responsibility for its description. This information is important if questions about the material subsequently arise and must be answered.

Date: Both federal and state legislation stipulate 90 days as the length of time EH&S may possess the hazardous waste, subsequent to removing it from the individual laboratories and prior to final shipment to an approved disposal facility. Therefore, individual faculty and staff members should fill in the date on which EH&S was notified to pick up the chemicals.

Type: Identifies the general characteristics of the hazardous waste chemicals and indicates which classes of waste should not be mixed or packaged together to facilitate disposal procedures.

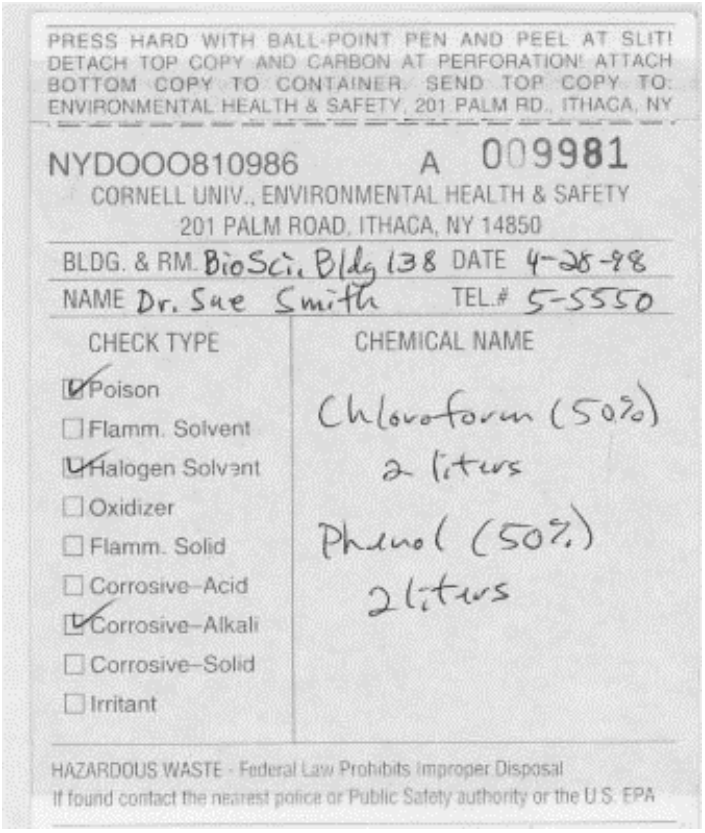
Chemical Name: Precisely identify the exact composition of the hazardous waste in each container. Both federal and state legislation prohibit the use of code numbers, trade names and initials in the transportation and disposal of hazardous waste. Hazardous waste consisting of multiple elements or compounds requires the identification of each constituent, *and the percentage by volume it occupies in the container* if known. *Note: The weight (in grams) or volume (in milliliters) of all ingredients in each container must be listed in this section, along with the chemical name and percent composition.*

Waste oils containing PCBs *must indicate the parts per million (ppm) of PCBs.* If this is unknown, the material can be tested by calling 255-3761 and obtaining a computerized sample number and sampling bottle to analyze the oil.

Unknown chemicals and chemical waste can be identified by a competent testing laboratory. However, it is the responsibility of the generator of the waste to field test the material before it is sent in to be analyzed so that the testing lab has as much information on the unknown material as possible. For example, if you know the pH or water and solvent solubility of the material, or if the history of use of the material is known, this is valuable information for the testing lab. Please supply this information with the sample. Call 255-3761 to obtain a computerized sample number and sampling bottle to analyze the unknown chemical or waste.

3. Use only screw top chemical glassware or plasticware for disposal. Soda pop, glass or plastic milk bottles, Clorox bleach bottles, or rubber/glass stoppered containers will not be allowed for waste disposal. Any waste bottle/ container that emits a noxious smell or is cracked or damaged in any way must be placed in an overpack container or transferred to a new bottle/container.

4. Place all containers in a **Department of Transportation** (DOT) approved box which has markings located on one side of the box (i.e., **UN/4G/X,Y** or **Z/S/DATE OF MANUFACTURE/USA**, etc.). The DOT boxes have a styrofoam insert for four 4-liter bottles. If the waste containers/bottles are smaller than the 4 liter space, please place as many smaller containers/ bottles in the space as you can. Cardboard pieces must be placed between the smaller bottles to prevent breakage during transportation to the chemical waste facility. These boxes are not supplied by EH&S; however, if you have difficulty locating boxes, we will assist in locating them and will communicate to you where you can pick them up.



PRESS HARD WITH BALL-POINT PEN AND PEEL AT SLIT! DETACH TOP COPY AND CARBON AT PERFORATION! ATTACH BOTTOM COPY TO CONTAINER. SEND TOP COPY TO: ENVIRONMENTAL HEALTH & SAFETY, 201 PALM RD., ITHACA, NY

NYDOOO810986 A 009981

CORNELL UNIV., ENVIRONMENTAL HEALTH & SAFETY
201 PALM ROAD, ITHACA, NY 14850

BLDG. & RM. BioSci. Bldg 138 DATE 4-28-98

NAME Dr. Sue Smith TEL.# 5-5550

CHECK TYPE	CHEMICAL NAME
☑ Poison	Chloroform (50%)
☐ Flamm. Solvent	2 liters
☑ Halogen Solvent	
☐ Oxidizer	Phenol (50%)
☐ Flamm. Solid	2 liters
☐ Corrosive–Acid	
☑ Corrosive–Alkali	
☐ Corrosive–Solid	
☐ Irritant	

HAZARDOUS WASTE - Federal Law Prohibits Improper Disposal
If found contact the nearest police or Public Safety authority or the U.S. EPA

Sample of the numbered two-part stick-on 5”x4” disposal sticker.

DISPOSAL OF LABORATORY WASTES TO SANITARY SEWER

Guide for Drain Disposal of Laboratory Chemicals

1.0 INTRODUCTION

This guide was prepared by Cornell's Environmental Health and Safety (EH&S) with assistance from a faculty committee consisting of experts in the areas of toxicology, chemistry, and environmental engineering.

Staff at the Ithaca Area Waste Water Treatment Plant, the destination of Cornell's wastewater, were consulted in developing these guidelines to assure that local government regulations are followed.

2.0 RESPONSIBILITIES

Within individual laboratories, authorization for specific operations, delineation of appropriate safety procedures and instruction about these procedures is a responsibility of the principal investigator.

It is the responsibility of each Cornell laboratory worker to be sure that chemical waste generated from their activities is disposed of properly. Some materials can be safely let into the sanitary sewer and others can cause damage to health, the environment or the functioning of the wastewater plant.

Inappropriate chemicals put down the drain may be incorporated into sludge formed in waste water treatment, contaminating it enough to be classified as a hazardous waste where otherwise it might have been recycled. After treated waste water leaves the plant, it flows to Cayuga Lake, a major recreational and drinking water resource for this area. **The stewardship of this important natural resource is our collective responsibility.**

Laboratory workers should consult this guide before undertaking drain disposal of any lab chemicals.

3.0 GENERAL GUIDELINES

What

Send down the drain **only** those materials found on the safe list. *Compounds not listed are not suitable for drain disposal.*

Where

Drain disposal must only be used when the drain flows to a sanitary sewer system* which eventually goes to the waste water treatment plant. Storm drain systems flow directly into surface water (Fall or Cascadilla Creeks, for example) and should ***NEVER*** be used for chemical disposal. *Floor drains may*

flow to storm sewers and should never be used for disposal. Laboratory sinks should be used for disposal of chemicals on the safe list as discussed below.

How Much

Quantities of chemical waste for drain disposal should be limited generally to a few hundred grams or milliliters or less per day. Larger amounts should have prior approval from EH&S. **Only materials listed as safe for drain disposal in this document are approved for drain disposal in quantities up to 100 grams or 100 milliliter per discharge**. Disposal should be followed by flushing with at least 100-fold excess of water at the sink. (That means for 100 ml of chemical run the water for about two minutes at maximum flow.)

Note: Sulfuric, hydrochloric, acetic and phosphoric acids may be discharged in larger quantities since they ***must*** be neutralized to a pH of between 5.5 and 9.0 before they can be drain disposed to the sanitary sewer.

*Sanitary sewer is the system of sinks, toilets, drains and associated pipes that send waste water to a treatment plant where it is biologically and chemically treated before discharge into the environment.

Safety

Understand the hazards and toxicity of the materials you work with by consulting material safety data sheets (available in every department in large red notebooks, on the Internet, or through EH&S). Work slowly to avoid splashes and wear the proper protective equipment (lab coat, goggles, face shield, gloves) during drain disposal.

Chemicals that are not appropriate for drain disposal are collected by Environmental Health and Safety. See pages 7.7-9 of this section.

4.0 NOT SAFE FOR DRAIN DISPOSAL

THE FOLLOWING MATERIALS ARE ***PROHIBITED*** FROM DRAIN DISPOSAL BY THE CITY OF ITHACA:

- Ashes, cinders, sand, mud, straw, shavings, metal, glass, rags, feathers, tar, plastics, wood, manure, hair and fleshings, entrails, paint residues, solid or viscous substances capable of causing obstruction to the flow of sewers.

- Some chemicals that are ***not appropriate*** for drain disposal include:
  Halogenated hydrocarbons
  Nitro compounds
  Mercaptans
  Flammables (immiscible in water)
  Explosives such as azides and peroxides
  Water soluble polymers that could form gels in the sewer system
  Water reactive materials
  Malodorous chemicals

Toxic chemicals such as carcinogens, mutagens, teratogens

- Substances that boil below 50° C.
- Mixtures that have a component not found on the safe list.
- Any material not found on the safe list.

Check with Environmental Health and Safety at 255-8200 if you are not certain about drain disposal for a particular material. We may also be able to provide you with instructions for laboratory detoxification for some materials.

5.0 SAFE FOR DRAIN DISPOSAL

Inorganics

Dilute solutions of inorganic salts where both caution and anion are listed below are suitable for drain disposal. Materials listed are considered to be relatively low in toxicity. Compounds of any of these ions that are strongly acidic or basic should be neutralized before drain disposal.

Cations	Anions
Al^{+3}	BO_3^{-3}
Ca^{+2}	$B_4O_7^{-2}$
$Fe^{+2}, ^{+3}$	Br^-
H^+	CO_3^{-2}
K^+	Cl^-
Li^+	HSO^{-3}
Mg^{+2}	OCN^-
Na^+	OH^-
NH_4^+	I^-
Sn^{+2}	NO_3^-
$Sr2^+$	PO_4^{-3}
$Ti^{+3}, ^{+4}$	SO_4^{-2}
Zr^{+2}	SCN^-

- Mineral acids and bases should be neutralized to pH 5.5 to 9 range before disposal, following procedures in Appendix A.
- Copper and Zinc have specific discharge limits required by the Sewage Treatment Plant. Contact Environmental Health and Safety at 255-8200 prior to discharging any copper or zinc.

Organics

Materials listed below in quantities up to about 100g or 100 ml at a time are suitable for disposal down the drain while flushing with excess water. These materials are soluble to at least 3 percent, present low toxicity hazards and are readily biodegradable.

Alcohols

Alkanols with 4 or fewer carbon atoms:

methanol
ethanol
propanol and isomers
butanol and isomers

Alkanediols with 7 or fewer carbon atoms

ethylene glycol
propylene glycol
butylene glycol
butanediol + isomers
pentylene glycol
pentanediol + isomers
hexylene glycol
hexanediol + isomers
heptamethylene glycol
heptanediol + isomers

Alkoxyalkanols with 6 or fewer carbon atoms:

methoxyethanol
ethoxyethanol
butoxyethanol
2-methoxyethoxyethanol
n-C4H9OCH2CH2OCH2CH2OH (2(2-butoxyethoxy)ethanol)

Aldehydes

Aliphatic aldehydes with 4 or fewer carbon atoms:

formaldehyde (10% or less aqueous solution)
propanal (propionaldehyde)
butanal (butyraldehyde)
isobutyraldehyde

Amides

RCONH2 and RCONHR with 4 or fewer carbon atoms and RCONR2 with 10 or fewer carbon atoms:

formamide
N-methyl formamide
N,N-diethyl formamide
N,N-dimethyl formamide
N-ethyl formamide
acetamide
N-methyl acetamide
N,N-dimethyl acetamide
N-ethyl acetamide
propionamide
N-methyl propionamide
N, N-dimethyl propionamide
butyramide
isobutyramide

Amines*

Aliphatic amines with 6 or fewer carbon atoms:

methylamine
ethylamine
trimethylamine
N-ethyl methylamine
N-methyl propylamine
dimethyl propylamine
isopropylamine
1-ethyl propylamine
butylamine
methyl butylamine
N-ethyl butylamine
isobutylamine
amylamine
hexylamine

Aliphatic diamines with 6 or fewer carbon atoms:

1,2- or 1,3- propanediamine (1,2- or 1,3- diaminopropane)

*Amines with a disagreeable odor, such as dimethylamine and 1,4-butanediamine should be neutralized, and the resulting salt solutions flushed down the drain, diluted with at least 100 volumes of water. Disposal limit is 100ml of material.

Carboxylic Acids

Alkanoic acids with 5 or fewer carbon atom: *

formic acid
acetic acid
propionic acid
butyric acid
isobutyric acid
valeric acid
isovaleric acid

Alkanedioic acids with 5 or fewer carbon atoms:
oxalic acid (1,2-ethanedioic acid)
malonic acid (1,3-propanedioic acid)
succinic acid (1,4-butanedioic acid)
glutaric acid (1,5-pentanedioic acid)

Hydroxyalkanoic acids with 5 or fewer carbon atoms:

lactic acid (2- hydroxypropanoic acid)
3-hydroxybutyric acid
2-hydroxy isobutyric acid

Aminoalkanoic acids with 6 or fewer carbon atoms and the ammonium, sodium and potassium salts of these acids.

Amino acids and the ammonium, sodium and potassium salts of these acids.

*Organic acids with a disagreeable odor, such as butyric acids and valeric acids should be neutralized and the resulting salt solutions flushed down the drain, diluted with at least 100 volumes of water. Disposal limit is 100 ml. of material.

Esters

Esters with 4 or fewer carbon atoms:

methyl formate
ethyl formate
isopropyl formate
propyl formate
methyl acetate
ethyl acetate
methyl propionate
Isopropyl acetate

Ketones

Ketones with 4 or fewer carbon atoms:

acetone
methyl ethyl ketone (butanone)
methyl isopropyl ketone (3-methyl butanone)

Sulfonic Acids and the Ammonium, Sodium, and Potassium Salts of these Acids:

methane sulfonic acid, sodium or potassium salt
ethane sulfonic acid, sodium or potassium salt
1-propane sulfonic acid, sodium or potassium salt
1-butane sulfonic acid, sodium or potassium salt
1-pentane sulfonic acid, sodium or potassium salt
1-hexane sulfonic acid, sodium or potassium salt
1-heptane sulfonic acid, sodium or potassium salt
1-octane sulfonic acid, sodium or potassium salt
1-decane sulfonic acid, sodium or potassium salt
1-dodecane sulfonic acid, sodium or potassium salt
1-tetradecane sulfonic acid, sodium or potassium salt
1-hexadecane sulfonic acid, sodium or potassium salt

6.0 RADIOACTIVE MATERIALS

Radioactive materials **may not be drain disposed** with the following exceptions:

- Wash and rinse water used for cleaning contaminated glassware that has been double rinsed may be drain disposed. The first two rinses of the glassware must be collected in liquid radioactive waste containers.

- With specific written permission from the Radiation Safety Officer, in accordance with procedures stipulated by Federal, State, and Local regulations, Cornell's license to use radiation, and the University Radiation Safety Committee, certain radioactive materials may be approved for drain disposal. **Call 255-8200 (Environmental Health and Safety) for specific information.**

APPENDIX A

NEUTRALIZATION PROCEDURES

General

- Do neutralizations in a fume hood behind a safety shield, as fumes and heat may be generated. Wear lab coat or apron, gloves and goggles.
- Keep containers cool during process.
- Work slowly.
- After neutralization is complete, flush to sewer with 20 parts water.

Acid Neutralization

1. While stirring, add acids to large amounts of an ice water solution of base such as sodium carbonate, calcium hydroxide, or sodium hydroxide for concentrated acids.
2. When a pH of at least 5.5 is achieved, dispose of the solution into the sewer, followed by 20 parts water.

Base Neutralization

1. Add the base to a large vessel containing water. Slowly add a 1M solution of HCI.
2. When a pH of 9 or less is achieved, dispose of solution into sewer system followed by 20 parts water.

APPENDIX B

WASTE OIL COLLECTION AND DISPOSAL

1.0 WASTE OIL COLLECTION (INCLUDING VACUUM PUMP OILS)

Oil should be collected locally and stored temporarily in approved and properly marked containers (30 or 55 gallons drums) provided by Environmental Health and Safety. The Containers must be stored *inside the building.* The containers must be clearly marked "**Waste Oil Only: No Solvents**."

2.0 DISPOSAL OF WASTE OILS

When the oil drums are full please contact the Cornell Purchasing Department at 255-3804 to obtain information on the disposal of oils. A contract with a recycling company has been made through Purchasing. You must supply a purchase order number or an account number to facilitate the pick up of oils in your department or facility.

References:

National Research Council, *Prudent Practices in the Laboratory, Handling and Disposal of Chemicals,* National Academy Press, 1995.

American Chemical Society, *Safety in Academic Chemistry Laboratories*, 1995.

Safety Manuals from the Universities of Wisconsin and Cincinnati.

Ithaca Area Sewer Ordinance

USER'S GUIDE TO FUME HOODS

Procedures for Increasing the Effectiveness of Laboratory Hoods

Revised December, 1998

A laboratory fume hood system is designed to protect the operator from undesirable substances being used, so its most important function is containment. While users have little control over a system that is already in place, they can greatly increase or decrease its effectiveness by the way the hood is used. The purpose of this document is to make those who use hoods aware of some of the factors that contribute to the effectiveness of a hood system.

Hood Basics

There are a wide variety of fume hoods on campus and some of these suggestions may not be applicable to all systems. The basic structure of a fume hood is not unlike a conventional fireplace and chimney combination. They usually have dampers that permit ventilation of the laboratory when the hood is not in use. In some cases, hoods with vertical sashes are designed to automatically exhaust about the same amount of air from the room even when the sash is closed. In other cases, the hoods have dampers that change the ratio of room air that goes through the hood compared to that which bypasses the system.

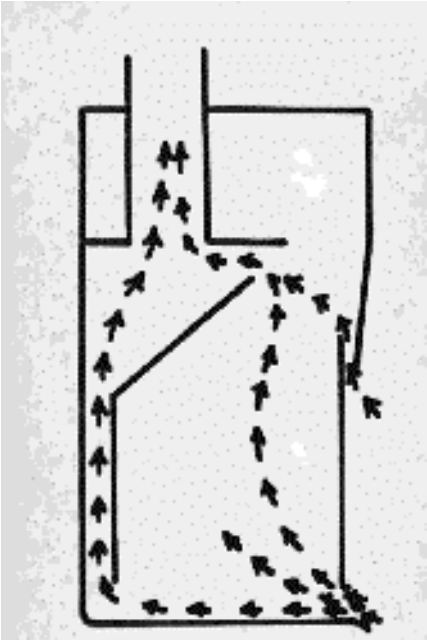


Figure 1. Fume hood system
Side view

As shown in Figure 1, most hoods have an arrangement of movable panels, called baffles, with openings or slots at their edges. Air exhausted from the hood is drawn out through the slots. The slots are always at the top and the bottom, with some systems having a middle adjustable slot or slots on the vertical edges of the baffles. The ratio of air that is drawn into the top and bottom slots can be varied by repositioning the baffles. Hood manufacturers claim that the upper exhaust slot should be opened when working with lighter than air vapors and the lower exhaust slot should be used to collect heavier than air vapors. Experts dispute this claim as a useful concept, noting that, except in unusual circumstances, the amount of material mixing with the air has minimal effect on the density of the mixture. You should check the setting of the upper slot. This should be between one-half and three-quarters of an inch. If this setting is not fully open, efficiency can drop by a large factor due to turbulence in the upper portion of the hood. The bottom slot is usually open one to four inches depending upon the design of the hood.

Good Work Practices and Changes You Can Make

Keep the Sash Down

For hoods that have a movable front sash, keeping the opening as small as reasonably possible usually increases the flow rate through the aperture and enhances effectiveness. The sash also operates as a safety shield. It is strongly recommended that the hood sash be closed to within one or two inches when not in use. In many cases, such a practice not only saves energy, but can increase efficiency of other hoods on the same system.

Have an Airfoil Installed

A source of undesirable turbulence results when air entering the hood impacts on the front edge of the floor of the hood. This effect can be minimized by the installation of an airfoil along the front edge of the hood. Experiments conducted in the Chemistry Department showed a significant decrease in turbulence when such devices were installed. These devices are relatively inexpensive (around $100) and can be purchased for existing hoods through fume hood suppliers. Contact the Purchasing Department for vendors selling these devices. These devices are simple enough to be fabricated on campus; if you are interested, call the Sheet Metal Shop at 255-4752.

Use an Airflow Indicator

It is possible that without the knowledge of the user, the fan motor may not be operating, with the result that the individual does not have the protection expected from the system. Inexpensive (around $100) flow monitors that serve as indicators are available from scientific supply houses. These are listed under airflow monitors, manometers and vaneometers. A simple telltale consisting of an eight-inch narrow length of light material will also serve this purpose.

Keep Laboratory Doors and Windows Closed

In closed buildings, ventilation and fume hood systems are usually designed on the assumption that doors to the laboratory and windows will be in the closed position. If the doors and windows are left open, unplanned airflow patterns may degrade the efficiency of a hood.

Limit Traffic

Pedestrian traffic in front of the hood induces turbulence and can overcome the capture of vapors and pull them back out of the hood and into the operator's breathing zone. A painted line or length of tape placed on the floor of the room two feet away from the hood will discourage traffic this close to the hood.

Reduce Clutter

Achieving even, laminar airflow across the deck or bench surface of the hood increases the effectiveness of a hood system. The presence of objects in the hood tends to increase turbulence, so the more cluttered the working surface, the lower the efficiency and the less protection you have. For this reason, the number of objects in a hood should be kept to a workable minimum. In particular, keep the number of chemicals stored in a hood as low as possible. Not only does such storage decrease hood efficiency, but it also increases the possibility and seriousness of accidental fires. Solvents should be placed in vented cabinets rather than wasting useful and expensive hood space. When circumstances dictate such storage of chemicals, they should not be placed near the exhaust slots or in the front six inches. Shelving constructed of noncombustible materials may be placed in a hood as long as the bottom shelf is several inches off the deck of the hood and as long as it is placed in a way that does not interfere with the flow of air through the hood.

Work Far into the Hood

You can substantially increase your protection by putting experimental materials as far back into the hood as practical. By moving a fume source from the plane of the hood face back six inches into the hood's interior, the capture rate for volatile materials can be greatly improved. Operations should not be carried out within six inches from the plane of the sash and as a useful reminder, paint a line or place a strip of tape at this six-inch limit. However, in attempting to work as far back in the hood as possible, you should realize that the concentration of escaping vapors falls off very rapidly from the plane of the sash outward. Therefore, one's face should not be within the plane of the sash.

Other Considerations

Explosions

The glass sash offers protection from accidents and, when possible, it is safest to keep the sash between your face and the experiment. But the glass face is not designed to protect against explosions. When an explosive hazard is present, rounded safety shields should be placed between the operator and the experiment and as close as possible to the plane of the hood sash. Full-face protection should also be used in such circumstances. Evaporations and digestions involving perchloric acid must not be carried out in hoods that were not designed for that purpose. Perchloric acid can condense in the ductwork and result in an explosion hazard.

Exhaust

Care should be taken with the use of paper products, aluminum foil and other lightweight materials within the hood. For example, a single piece of Kleenex, if sucked into the exhaust ducts, can potentially cause a profound deterioration in the velocity of air flowing into the hood.

Drains

Run water in hood drains at least once a week if the drains are not normally used. This is to prevent the drain traps from drying out and possibly perturbing airflow in the system.

Power Outages

In case of a loss of power, the hood sash should be lowered to within an inch or so of the closed position so the chimney effect will keep some air flowing into the hood. Electric powered devices in the hoods should be disconnected to minimize accidents when the power is restored.

Adjustments to the Hood System

Get Assistance for Mechanical Changes

Venting of laboratory apparatus (e.g., vacuum pumps and storage cabinets) into the face or side of a hood can disrupt the design flow and lower efficiency. When such venting is deemed necessary, the connection should be further along the exhaust ducts of the hood system rather than into the face of the hood. To avoid the possibility of disrupting the efficient operation of the system, such installations should not be undertaken without consultation with Facilities Engineering, EH&S and the appropriate technical shops.

Likewise, installation of a new fume hood cannot be undertaken without the possibility of seriously disrupting the existing ventilation system and at times making other hoods in the building much less efficient. You should never consider doing this work yourself.

Environmental Health and Safety's Role

Environmental Health and Safety performs annual testing of fume hoods on campus. If the existing inspection sticker on your fume hood indicates a year or more has passed since we last inspected that hood, please call us. If your fume hood doesn't have an inspection sticker or if you have questions concerning the hood’s operation, contact Environmental Health and Safety at 255-8200 for air flow measurements or questions.

Please remember that all fume hood purchase requests need prior review and approval through our office. We can also provide information regarding the selection, purchase and inspection requirements for laminar flow clean benches, biosafety cabinets and portable fume hoods.

Mechanical Problems

If your fume hood suddenly seems to stop working and you suspect mechanical problems, ask your building coordinator to call Customer Service. If maintenance workers are going to be working on your hood system, you should remove all chemicals from the hood.

Points to Remember

Many advisory notices of this sort are read but forgotten over time. To emphasize the more important operating factors, remember the following:

1. Make sure the hood is working (telltale indicates airflow).
2. Keep the sash as low as practical--sash is a safety shield.
3. Keep lab equipment elevated at least one inch off work surface.
4. Keep the hood free from clutter--don't block baffle openings.
5. Work at least six inches into hood.
6. Minimize rapid movements in front of hood.

Training programs on the safe use of fume hoods are available from Environmental Health and Safety.

Additional Information

For additional information on fume hoods and laboratory ventilation systems please see the following:

ANSI/AIHA Standard Z9.5-1992, *Laboratory Ventilation*. A paper copy of this document is available at the EH&S office at 125 Humphreys Service Building.
Cornell University Design and Construction Standards, "15010 Laboratories." available by request from EH&S or at: http://cds.pdc.cornell.edu/DesignStandards/Mechanical/15010-Laboratories.htm

ANSI/ASHRAE Standard 110-1995, *Method of Testing Performance of Laboratory Fume Hoods.* A paper copy of this document is available at the EH&S office at 125 Humphreys Service Building.

"Fume Hood Evaluation Procedures," as used by EH&S for testing fume hoods at Cornell.

"The Dry Ice Capture Test as Performed on Fume Hoods at Cornell," as used by EH&S for determining the ability of a hood to capture vapors and fumes.

"Cornell EH&S Fume Hood Shell Selection Guide," developed to help lab staff and designers select the appropriate fume hood.

BASIC TOXICOLOGY

Introduction

As a laboratory worker, you use a variety of chemicals as part of your daily work routine. Many of these substances are potentially hazardous to your health and that of your co-workers. The actual hazards that a chemical may present depend not only on the properties of the chemical, but also on the manner in which it is used, and the resulting exposure to the worker. With the proper handling, even highly toxic or dangerous chemicals can be used safely. On the other hand, chemicals that are not highly toxic can be extremely hazardous if handled improperly.

Whether or not a chemical exposure will result in injury depends on many factors. In addition to the dose, the outcome of exposure is determined by the way in which a chemical enters the body, the properties of the chemical itself, and the susceptibility of the individual receiving the dose. Understanding these factors will help you know what precautions to take to reduce your exposures.

Routes of Entry

Skin:

Symptoms of skin exposure to chemicals include dry, whitened skin, redness and swelling, rashes or blisters, and itching. Protect your hands against abrasions and lacerations that may increase chemical entry. Wear the correct gloves and other protective clothing to prevent or minimize skin contact with hazardous chemicals. Any time contact occurs, you should rinse promptly and thoroughly, for at least ten minutes, with lots of water. Remember that the longer the chemical is in contact with the skin, the more damage it may do. Rinse first, and then seek medical advice when necessary.

Eyes:

You should always be careful to protect your eyes since most chemicals are hazardous to this delicate tissue. Chemical splash goggles provide better protection than safety glasses. If you get a chemical in your eye, immediately flush the eye with large amounts of clean water for at least fifteen minutes.

Respiratory Tract:

Factors that affect the absorption of gases and vapor by your body include the chemical's vapor pressure, its concentration in the inhaled air, and its chemical properties. Symptoms of exposure to gases include headache, eye, nose and throat irritation, and increased mucus production. Narcotic effects may also result from the inhalation of certain chemicals (hydrocarbon solvents, for example), and they include symptoms such as headache, dizziness, confusion, and collapse.

Should you experience these symptoms, immediately reduce your exposure by working under a hood, closing containers, opening windows, or leaving the area. If your symptoms persist, get medical attention. You may wish to consider the use of a respirator, however, good work practices and the use of a properly working fume hood generally obviate the need for respiratory protection in a lab context.

Gastrointestinal Tract

You can greatly limit this route of entry by *never* storing or using foods or beverages in the laboratory. Always wash your hands thoroughly after using chemicals.

Some Terms Used To Describe Toxic Effects

The actual *dose* that a person receives depends on the concentration of the chemical as well as the frequency and duration of exposure.

ACUTE TOXICITY

Single short exposure
Effects usually appear quickly
Effects often reversible

CHRONIC TOXICITY

Repeated exposure
Effects usually delayed
Usually irreversible

SOME KNOWN HUMAN TERATOGENS

Alcohol ingestion
Organic mercury compounds
Lead compounds
Ionizing radiation
Some drugs

SOME SUBSTANCES KNOWN TO CAUSE MALE REPRODUCTIVE EFFECTS

1,2-Dibromo-3-chloropropane
Some pesticides
Ionizing radiation
Some drugs

FACTORS INFLUENCING SUSCEPTIBILITY

Obesity
Nutritional Habits
Physical condition
Medical condition
Drinking and smoking
Sensitization
Pregnancy

Evaluating Toxicity Data

It is conventional to summarize the acute toxicity of a compound by stating the dose at which 50% of the animals are affected. In tests for lethality, this dose is called an LD50. Remember that chronic exposure may have effects that are very different and not at all related to effects from acute exposure.

Estimating Human Lethal Doses

Class	*Animal LD50*	*Probable Lethal Dose for 70 kg Person (150 lbs.)*	*Example*
Super Toxic	Less than 5 mg/kg	A taste (7 drops or less)	Botulinum toxin
Extremely Toxic	5 - 50 mg/kg	< 1 teaspoonful	Arsenic trioxide, Strychnine
Very Toxic	50 - 500 mg/kg	< 1 ounce	Phenol, Caffeine
Moderately Toxic	0.5 - 5 g/kg	< 1 pint	Aspirin, Sodium chloride
Slightly Toxic	5 - 15 g/kg	< 1 quart	Ethyl alcohol, acetone

The safe use of toxic chemicals is a dilemma faced not only by laboratory and chemical workers but by everyone. Estimating the hazard posed by the use of a chemical is controversial and complex. It involves much more than determining its toxicity. The severity of a chemical hazard depends not only on the toxicity but on its chemical and physical properties and the manner and quantity in which it is used. By learning about the potential hazards of the substances you use, and by practicing appropriate procedures for those substances, you can work safely in an informed and intelligent manner.

Respiratory Protection

Respirators are generally not recommended for laboratory workers. Engineering controls, meaning the use of dilution ventilation and fume hoods and other devices which capture vapors, fumes and gases and remove them from the breathing zone of the user, are preferred over the use of respirators in most laboratory environments. There are certain exceptions to this general rule such as the changing out of cylinders of toxic gases and emergency response to chemical spills. The use of respirators is heavily regulated by OSHA. **A laboratory worker at Cornell may not purchase a respirator and bring it to their lab for their personal use.** The use of all types of respiratory protection at Cornell is governed by the Cornell EH&S Respiratory Protection Program.

There are some situations, as alluded to above, where respiratory protection is appropriate for laboratory workers:

- The use of dust masks for weighing powdery or dusty hazardous materials. (Note: The use of dust masks may or may not be regulated by OSHA depending upon the circumstances of use. If you think that you need to use a dust mask when weighing out materials that have an inhalation hazard you must contact EH&S for prior approval for the use of a dust mask.)
- The large volume use of certain hazardous chemicals, such as formaldehyde, in a room where dilution ventilation or capture devices will not be able to offer adequate protection.
- Changing out cylinders of hazardous gases. (Additional training is required.)
- Cleaning up chemical spills. (Additional training is required.)
- To reduce exposure to some chemicals to which certain individuals may become sensitive. (This would be a rare and unusual situation.)

There are some situations in which the use of a respirator would be prohibited:

- When the air in a laboratory is severely contaminated and immediately dangerous to life and health (IDLH).
- When the air in a room does not have enough oxygen to support life (<19.5%).
- When dangerous vapors are present that have inadequate warning properties (such as odor), should the respirator fail.
- When the air contaminants can also penetrate or damage skin and eyes unless other suitable protection is also worn.

Information About Respirators

To get more information concerning the use of respirators at Cornell call EH&S at 255-8200. If you are approved for the use of a respirator after meeting the requirements of the OSHA Standards and the Cornell EH&S Respiratory Protection Program, in most cases, you may purchase a respirator from the Cornell Distribution Center on Palm Rd. If your use of a respirator is required to perform your job duties, your department will pay for the respirator. You will also receive training on the use and maintenance of your respirator.

Hand Protection and Glove Selection

Including Glove Selection for Some Specific Chemicals
Tom Shelley, Cornell EH&S
Revised September, 1999

Introduction

Glove selection is difficult for many lab staff. Different references seem to give conflicting information and the many available styles and types of glove materials add another layer of confusion. The process of glove selection can also be very time consuming. Consequently, many chemical users select a glove that may not be appropriate for the chemicals in use.

Due to the publicity surrounding the death of a prominent Dartmouth researcher, **Federal OSHA** has placed a strong emphasis on hand protection in the workplace, especially in academic and R&D labs. In 1994 OSHA made substantial changes to the PPE Standard, 29 CFR 1910.138 - Hand Protection. The revised requirements are as follows:

Hazard assessment and equipment selection
Employee training
Record keeping requirements
Guidelines for selecting PPE, and
Hazard assessment certification

Cornell EH&S Occupational Health and Safety Section has developed a revised written *Personal Protective Equipment Program* reflecting the changes in the OSHA standard.

Supervisors are responsible for the selection, availability and use of gloves and other personal protective equipment in the workplace. Cornell EH&S can assist supervisors with the requirements of the revised OSHA standard. Please contact us at 255-8200 for additional information.

The various glove manufacturers use different formulations for their polymers. A glove from one firm may not have the same chemical resistance as a glove that appears to be an identical glove made by another firm. Therefore, it is prudent to check the **glove selection charts** provided by the glove manufacturer for the gloves you use to determine their suitability for use with any particular chemical.

However, glove selection based on the manufacturers' glove selection charts is often impossible, as only a limited range of chemicals have been tested for use with a specific manufacturer's glove. Many research grade chemicals are used in such small quantities that the various glove manufacturers will probably never test them. If a chemical is not listed on a glove selection chart it is advisable to have a specialist in **personal protective equipment (PPE)** make the glove selection for you. In this case the PPE specialist would attempt to match the known characteristics of the chemical to be used with the known characteristics of the polymers commonly used to make gloves to select a glove that would be appropriate. This glove selection document includes a compilation of gloves recommended by EH&S for specific chemicals.

In some cases it may be required to hire a **testing laboratory** specializing in PPE to physically test a variety of gloves with the chemical to be used to scientifically select an appropriate glove. We have contacted a local testing firm that is capable of testing gloves for chemical resistance for a modest fee. If you have an especially hazardous chemical for which glove selection is difficult, we can make arrangements to have various gloves tested with the chemical in question.

The glove selection for the materials listed below is offered for anyone using these chemicals at Cornell. If a particular manufacturer's glove charts vary from the glove selections below, *follow the manufacturer's glove charts* for the model of glove recommended or contact EH&S at 255-8200 for a second opinion on glove selection for the chemical in use. The **Cornell Distribution Center** carries an assortment of 4 mil and 8 mil disposable nitrile gloves. They also carry or can order for you a wide variety of other types of gloves.

Latex gloves, especially thin, disposable exam gloves, are widely used in labs, shops and many other work environments. Our concern is two-fold: latex gloves offer little protection from commonly used chemicals and many people, up to 20% of the population by some estimates, have developed the allergen to latex products.

The use of latex gloves is *only* appropriate for:

most biological materials
nonhazardous chemicals
very dilute, aqueous solutions of hazardous chemicals*
clean work area requirements
medical or veterinary applications

*Less than 1% for most hazardous chemicals or less than 0.1% if a known or suspect human carcinogen is in use in aqueous solution.

Latex gloves offer no protection against many common lab and shop chemicals. They will severely degrade, often in a matter of seconds or minutes, when used with some materials.

Staff required to wear latex gloves should receive training on the potential health effects related to latex. Hypoallergenic, non-powdered gloves should be used when possible. If a good substitute glove material is available, use gloves made of a material other than latex. A general-purpose substitute for latex products is lightweight nitrile gloves.

Many of the recommendations below are for "**incidental contact**." This means that, as with many chemical procedures, no or very little actual contact with a chemical in use is anticipated. The gloves specified are basically there to prevent chemical contact with the skin when something goes wrong--a spill or splash to the hand, over spray from a dispensing device, etc. As soon as practical after the chemical makes contact with the gloved hand the gloves are removed and replaced. Often a glove specified for incidental contact is not suitable for **extended contact**, when the gloved hands may come into substantial contact with or actually may become covered with or immersed in the chemical in use.

Generally speaking, a more substantial glove is required for extended contact than for incidental contact, although there are exceptions.

The practice of **double gloving** is recommended for many materials listed below. Two pairs of gloves are worn, one over the other. This affords a double layer of protection. If the outer glove starts to degrade or tears open, the inner glove continues to offer protection until the gloves are removed and replaced. The best practice is to check the outer glove frequently, watching for signs of degradation (change of color, change of texture, etc.). With the first sign of degradation remove the outer glove and reglove.

There are **different approaches to double gloving**. The most common practice is to wear a thin disposable glove (4 mil nitrile) under a heavier glove (8 mil nitrile). The outer glove is the primary protective barrier while the under glove retains dexterity and acts a vapor barrier in the event of mechanical failure or the permeation of the chemical in use through the outer glove. Alternately, you can wear the heavier (and usually more expensive and durable) nitrile glove as the under glove and wear thinner disposable nitrile gloves over those, changing the thinner outer gloves frequently. It is sometimes desirable to double glove with two sets of gloves made from different materials. Here, in the event of the failure of one material, the second, different material will act as a protective barrier until the gloves can be removed. The technique of using gloves of different materials is often advisable when a mixture of hazardous materials is in use. One type of material gives protection against one component or class of chemicals in the mixture and the second glove material gives protection against other components of the mixture. The requirements for double gloving and the materials of the gloves selected are specific to the chemical(s) in use.

For those materials that are rated **"supertoxic"**, which are easily absorbed through the skin, the glove material generally recommended is **Norfoil** (Silver Shield by North Hand Protection, 4H by Safety4, or New Barrier™ brand by Ansell Edmont). Norfoil is a thin, five-layer laminate with each layer made of a different polymer. They are chemically resistant to a wide range of materials that readily attack other glove materials. (Note that one of the common lab chemicals for which they are not recommended is chloroform.) Norfoil gloves look odd, like they were stamped out of a common garbage bag. They tend to be somewhat bulky but dexterity is regained by using a heavier weight (8 mil) disposable nitrile glove over the Norfoil glove. These gloves and others are also available at the Cornell Distribution Center and from lab safety supply houses.

Definitions for terms used in glove selection charts, the materials of which gloves are made and those used to describe different characteristics of gloves are listed towards the end of this document.

References used in preparation of this document are listed at the end.

If there is a chemical for which you have a question concerning glove selection that is not on the following list, please use the ***Glove Selection Request Form*** to be found at the end of this document.

Glove Selection for Some Specific Chemicals in Use at Cornell University

For quick glove selection see the table on pages 11.16-18.

Acetic acid (glacial or concentrated solutions): nitrile gloves (incidental contact); neoprene or butyl rubber gloves are recommended if contact with acetic acid above 10% is probable for an extended period of time.

Acetic anhydride: double glove with heavier weight (8 mil) nitrile gloves (incidental contact). Acetic anhydride is very corrosive to human tissues (skin, eyes, mucus membranes) and a poison by inhalation. For handling larger quantities of pure material *only* heavier weight (.28-.33 mm) butyl rubber or neoprene gloves are recommended.

Acetone: heavier weight (8 mil) natural rubber (incidental contact); for extended contact with acetone the *only* recommended glove type is butyl rubber.

If you are cleaning parts with acetone, or have any other use of acetone where there is more than incidental contact, you *must* use butyl rubber gloves. Natural rubber gloves have about a 10 minute breakthrough time and are for incidental contact only. Nitrile gloves have a less than four minute breakthrough time and are *not recommended* for any use of acetone.

Acetonitrile: nitrile gloves or double glove with nitrile gloves (incidental contact)

For transfer of acetonitrile or for large scale use, *only* heavier weight butyl rubber or poplyvinyl acetate gloves are recommended. Acetonitrile permeates though disposable latex exam gloves in a matter of seconds and latex gloves should *never* be used to handle this material.

Acrylamide: nitrile gloves or double glove with nitrile gloves (incidental contact); butyl rubber gloves are recommended for extended contact (such as repackaging pure acrylamide into smaller containers)

Acrylamide is readily absorbed through unbroken skin. Acrylamide is a carcinogen, mutagen, teratogen and a potent neurotoxin with *no known antidote*, so adequate hand protection is essential when using this chemical. Note that once acrylamide solutions are polymerized the resulting gels are no longer hazardous and, assuming that they are not contaminated with other hazardous materials, they may be disposed of in the ordinary trash.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with acrylamide.

***bis*- Acrylamide:** nitrile gloves

Bis- Acrylamide (N,N'-dihydroxy-ethylene-*bis*- acrylamide) does not share the more extreme toxic characteristics of acrylamide. However, its toxicological properties have not been fully investigated and it should be treated as a hazardous material.

Ammonium hydroxide: nitrile gloves; for extended contact heavier weight neoprene or butyl rubber gloves are superior to nitrile gloves

Benzotriazole, 1,2,3-: nitrile gloves

Carbon disulfide: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to carbon disulfide*

Most nitrile gloves have a breakthrough time of only 8 to 20 minutes and thus offer little protection when exposed to carbon disulfide. For operations involving the use of larger amounts of carbon disulfide, when transferring carbon disulfide from one container to another or for other potentially extended contact, the *only* gloves recommended are viton and polyvinyl acetate (PVA).

Carbon tetrachloride: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to carbon tetrachloride*

Most nitrile gloves have a breakthrough time of only a few minutes and thus offer little protection when exposed to carbon tetrachloride. For operations involving the use of larger amounts of carbon tetrachloride, when transferring carbon tetrachloride from one container to another or for other potentially extended contact, the *only* gloves recommended are viton. Viton gloves are expensive, but they are the standard glove to use with carbon tetrachloride.

Carbon tetrachloride is a poison, carcinogen, mutagen and teratogen. It is readily absorbed through unbroken skin. Alcohol and acetone are known to enhance the toxicity of carbon tetrachloride. The dose required to cause poisoning in humans varies significantly, with the ingestion of as little as 2 ml. having caused death. Carbon tetrachloride is also a substantial ozone depleting chemical and its use has been banned commercially. If you can find a substitute for carbon tetrachloride, it is strongly recommended that you use an alternative material.

Catechol: nitrile gloves

Chloroform: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to chloroform*

Thin (3-4 mil) Nitrile gloves have a 4 minute breakthrough time and thus offer little protection when exposed to chloroform. For operations involving the use of larger amounts of chloroform, such as transferring chloroform from one container to another or for large-scale extractions, etc., the *only* gloves recommended are viton or polyvinyl acetate (PVA). Viton gloves are expensive, but they are the standard glove to use with chloroform.

Cobalt Chloride: See Heavy Metal Salts**.**

Copper (Cupric) Sulfate: nitrile gloves

3,3'-Diaminobenzidine (DAB): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with DBA.

Diazomethane in Ether (a derivatizing reagent): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to diazomethane in ether.*

For possible extended contact, such as when transferring diazomethane in ether or when making reagent solutions containing this material, the *only* recommended glove would be a Norfoil glove, due to the extreme hazards associated with this material. Diazomethane is an extreme poison, a cancer suspect agent, extremely flammable, easily detonated and has an autoignition temperature of 100° C. (an ordinary light bulb would cause a sufficient quantity of the vapor in air to autodetonate). This is easily one of the most dangerous materials in use in labs at Cornell. If there is any way you can substitute another material for diazomethane in ether it is strongly recommended that you do so.

Dichloromethane: See Methylene Chloride.

Diethyl pyrocarbonate: nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Dimethyl sulfoxide (DMSO): heavier weight natural rubber gloves (15-18 mil; *not* 4 mil latex exam gloves) (incidental contact); butyl rubber gloves are recommended for extended contact; if you are allergic to natural latex products you may double glove with heavier weight (8 mil) disposable nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to DMSO.*

Nitrile gloves are *not* recommended for use with DMSO if extended contact with the hands is expected. Some brands of nitrile gloves have degradation times of five minutes when used with DMSO. DMSO freely penetrates the skin and may carry dissolved chemicals with it into the body, so hand protection is especially important if you are working with any hazardous materials dissolved in DMSO.

1,4-Dioxane (dioxane): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to dioxane*

Most nitrile gloves have a breakthrough time of only a few minutes and thus offer little protection when exposed to dioxane. For operations involving the use of larger amounts of dioxane, when transferring dioxane from one container to another or for other potentially extended contact, the *only* gloves recommended are butyl rubber gloves. Dioxane is one of the few commonly used lab chemicals that readily degrades viton gloves.

Dioxane is only moderately toxic, but it is a listed carcinogen, mutagen and teratogen. It is readily absorbed through unbroken skin so hand protection is especially important when working with this material.

Dithiothreitol (Cleland's Reagent): nitrile gloves

Ethanol: nitrile gloves

Ethidium bromide (EtBr): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with EtBr

Ethyl Ether (diethyl ether, ether)**:** double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to ether*

Ether is one of those chemicals that attacks almost all known commonly used glove materials. It permeates through viton, butyl rubber, neoprene, nitrile and natural rubber in a matter of minutes. The ***only*** recommended glove material for extended contact is polyvinyl acetate (PVA), such as the PVA™ brand made by Ansell Edmont.

Formaldehyde: nitrile gloves

Formamide: nitrile gloves (incidental contact); butyl rubber gloves are the *only* gloves recommended for direct contact with the pure material.

Formamide is often used in the pure form. If you use pure formamide in a procedure where there is probable contact with the skin, it is *strongly recommended* that you wear butyl rubber gloves.

Formic acid: double glove with heavier weight (8 mil) nitrile gloves (incidental contact)

Formic acid is very corrosive to human tissues (skin, eyes, mucus membranes). For handling larger quantities of pure material *only* heavier weight (.28-.33 mm) butyl rubber or neoprene gloves are recommended.

Gallic acid: nitrile gloves

Heavy Metal Salts (especially those that are easily soluble in water): nitrile gloves or double glove in some cases*****

For most *inorganic* (ionic) salts of heavy metals the human skin is usually an effective barrier against absorption of the heavy metal ions. If there are cracks in the skin, areas of inflammation, insect bites, cuts or other breaches of the integrity of the skin, heavy metal ions may be passed directly through the skin. The salts of many heavy metals are toxic or highly toxic and rated as poisons: **arsenic, bismuth, cadmium, chromium, cobalt, lead, mercury, nickel, osmium, silver and uranium**. Some of these materials are also listed as corrosives (chromium trioxide), inhalation hazards (osmium tetroxide), known or suspect carcinogens and mutagens (lead and lead salts, mercury and its salts, etc.) or radioactive (uranium). Disposable nitrile gloves are generally acceptable for the use of the pure salts and stock (concentrated) or dilute solutions for the common salts of the above metals (acetates, chlorides, sulfates,

nitrates, anhydrides, oxides, hydroxides, etc.) *where only incidental contact* will be made with these materials or their solutions.

Several heavy metal salts are more easily absorbed by the skin than others. **Osmium tetroxide** is readily absorbed by the skin and is very toxic. **Lead acetate** is absorbed 1-1/2 times more easily than other lead salts. **Mercuric chloride** can be absorbed fairly easily, especially if there are cracks, cuts or other breaks in the skin. It is also very toxic. It is re**c**ommended to *****double glove***** with nitrile gloves when using these materials, especially when handing the pure compounds or their strong solutions.

It is important that used gloves, and other dry materials, contaminated with heavy metals are ***not*** disposed of in the ordinary trash. Place all heavy metal contaminated gloves in a separate waste stream (container). The College of Veterinary Medicine maintains a Medical Waste Program. Gloves (and other dry waste items) contaminated with trace amounts of heavy metals may be sent to the Vet College for disposal. EH&S can furnish the guidelines provided by the Vet College or you may contact Dr. Larry Thompson at 253-3966 or Denver Metzler at 253-3288 for information on this program. It is important that the materials being disposed of are clearly identified on the Medical Waste Tracking Tag you will be required to complete as part of the disposal process, such as "Trace contaminated with lead acetate." (Note that this method of disposal is also acceptable for trace contaminated gloves and other dry waste generated from the use of carcinogens, mutagens and other materials that can not be disposed of in the ordinary trash.) Uncontaminated or decontaminated gloves may be disposed of as ordinary trash.

Heptane: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

For extended contact, as when using heptane for large scale extractions, refilling secondary containers or as a cleaning fluid, a heavier weight nitrile (35 mils or thicker), viton or PVA gloves are recommended. Note that the permeation time for heptane through 4 mil nitrile gloves is about 8 minutes and through latex exam gloves is even less time; subsequently, these gloves are *not recommended* for use with heptane.

Hexamethylenediamine (1,6-diaminohexane): heavier weight (8 mil) nitrile gloves (incidental contact); use a heavier weight neoprene glove when handling the pure material or concentrated stock solutions (extended contact)

Hexane: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

For extended contact, as when using hexane for large scale extractions, refilling secondary containers or as a cleaning fluid, a heavier weight nitrile (35 mils or thicker), viton or PVA gloves are recommended. Note that the permeation time for hexane through 4 mil nitrile gloves is about 12 minutes and through latex exam gloves is only about 5-6 minutes; subsequently, these gloves are *not recommended* for use with hexane.

Hydrochloric Acid (concentrated and strong solutions): nitrile gloves (incidental contact)

A heavier weight neoprene or butyl rubber glove would be superior for long-term use with more concentrated solutions, such as cleaning glassware that has been soaking in an HCl bath or other larger-scale use of HCl.

Hydrofluoric acid (HF): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

Note that additional protective equipment must always be worn when using larger quantities of HF. Nitrile or rubber sleeves, rubber aprons, face shields and splash goggles (*not* safety glasses) should also be worn. All users of HF must maintain an HF first aid kit in their lab. HF users are advised to contact EH&S for an "HF Users Information Packet."

Isopropanol: nitrile gloves

Lead Acetate: See Heavy Metal Salts**.**

Laser dyes: nitrile gloves
Mecuric Chloride: See Heavy Metal Salts**.**

Mercury: nitrile gloves

Methanol (methyl alcohol): nitrile gloves

Methanol should never be allowed to make contact with the skin, as it is fairly easily absorbed by the skin. Methanol is a poison.

Methylene Chloride: double glove with heavier weight (8 mil) nitrile gloves (incidental contact)

Methylene chloride will permeate through thin (3-4 mil) nitrile gloves in four minutes or less. If you are double gloved, as recommended, and you splash or spill methylene chloride on your gloves, stop what you are doing and change the outer glove *immediately*. If you allow methylene chloride to remain on the outer nitrile glove for more than two to four minutes you must discard both sets of gloves and re-double glove. Methylene chloride permeates disposable latex exam gloves in a matter of seconds and latex gloves should *never* be used to handle this material.

For use of methylene chloride where contact with the glove is anticipated, such as stripping paint or gluing plastics, *only* polyvinyl acetate (PVA) or viton gloves are recommended. These gloves come in .28-.33 mm thickness. PVA offers the best protection.

Methyl sulfonic acid, ethyl ester (EMS) (ethyl methanesulfonate): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with EMS.
Monoethanolamine: nitrile gloves

Nickel chloride: See Heavy Metal Salts**.**

N-Methylethanolamine: : double glove with heavier weight (8 mil) nitrile gloves (incidental contact); *remove outer glove at once if exposed to N-methylethanolamine*

Viton, neoprene or butyl rubber gloves are recommended for extensive use of N-methyl-ethanolamine such as working with the pure material or making solutions.

Organophosphorous compounds: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves

Osmium Tetroxide: See Heavy Metal Salts**.**

Paraformaldehyde: nitrile gloves

Petroleum ether: nitrile gloves (incidental contact); or heavy weight nitrile or viton for extended contact.

Phenol: double glove with heavier weight (8 mil) nitrile gloves (incidental contact); neoprene or butyl rubber gloves are recommended for extensive use of phenol such as working with the pure material or making solutions.

Nitrile gloves have a 30-minute breakthrough time with phenol. If working with double gloved nitrile gloves, change the outer glove frequently if exposed to this material.

Phenol-chloroform mixtures: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to mixture.*

Viton gloves are recommended for work with phenol-chloroform mixtures when probable exposure to the mixtures exists, such as when making up the mixtures. See the entries for phenol and chloroform.

Phenylmethylsulfonyl fluoride (PMSF): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions.

Phenylmethylsulfonyl fluoride is corrosive (causes burns) on contact with the skin, eyes and mucus membranes. It is also a highly toxic cholinesterase inhibitor and central nervous system poison. Avoid all contact.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with PMSF.

Polychlorinated biphenyls (PCBs): For weighing out of pure or concentrated materials, wear an 8 mil or heavier nitrile glove over a neoprene glove. For dilute solutions in corn oil (1 p.p.m. or less) neoprene gloves (20 mil) are recommended.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with PCBs.
Polyoxyethylenesorbitan monolaurate (Tween 20): nitrile gloves

Psoralen: nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Psoralen is corrosive (causes burns) on contact with the skin, eyes and mucus membranes. It is anticipated to be a carcinogen, it is a mutagen and a strong photosensitizer. Avoid all contact.

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with psoralen.

Pump oil: butyl rubber gloves

If you are changing pump oil or servicing pumps where contact with the oil may occur, the *only* recommended glove type is butyl rubber.

Silane based silanization or drivatization compounds: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if signs of degradation occur.*

Silver nitrate: See Heavy Metal Salts**.**

Sodium dodecyl sulfate (SDS): nitrile gloves

Sodium azide: nitrile gloves or double glove with nitrile gloves (incidental contact)

Sulfuric acid: heavier weight (8 mil) nitrile gloves (incidental contact); heavier weight (20 mil or greater) neoprene or butyl rubbber gloves (extended contact)

Tetrahydrofuran (THF): double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if THF contacts glove*

For extended contact, such as when using THF for larger scale reactions, refilling secondary containers or as a cleaning fluid, *only* Norfoil gloves are recommended. Polyvinyl acetate (PVA) gives some limited protection (up to 1-1/2 hours for some gloves) but are inferior to the Norfoil gloves. Note that the permeation time for THF through 4 mil nitrile gloves and latex exam gloves is almost instantaneous; subsequently, these gloves are *not recommended* for use with THF.

3,3',5,5'-Tetramethylbenzidine (TMB): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions

Note: See Heavy Metal Salts for proper disposal of gloves and other dry waste contaminated with TMB.

N, N, N', N'-Tetramethylethylenediamine (TEMED): nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions.

TEMED is corrosive (causes burns) on contact with the skin, eyes and mucus membranes.
Toluene: double glove with heavier weight (8 mil) nitrile gloves (incidental contact) or use 15 mil or heavier nitrile gloves; *remove outer glove at once if exposed to toluen.*

For extended contact, such as when using toluene for larger scale reactions, refilling secondary containers or as a cleaning fluid, *only* viton or polyvinyl acetate (PVA) gloves are recommended. Note that the permeation time for toluene through 4 mil nitrile gloves is less than 4 minutes and through latex exam gloves is less than that; subsequently, these gloves are *not recommended* for use with toluene.

Trichloromethyl chloroformate (diphosgene): This chemical, usually supplied in sealed glass ampules, is *very* air/moisture reactive, a corrosive and it is considered to be highly toxic by all routes of exposure. It must be used in a vented glove box or environmental chamber under dry nitrogen or argon. Glove boxes are usually fitted with substantial butyl rubber gloves, however, one manufacturer recommends that "heavy" gloves be worn over the glove box gloves. I would recommend using 8 mil or heavier nitrile gloves over the butyl rubber glove box gloves. *Please contact EH&S if you have any questions concerning the special procedures required for the use of this chemical.*

Triton-X100: nitrile gloves

Xylene: nitrile gloves (incidental contact)

For use of xylene where contact with the glove is anticipated, such as pouring of new or used xylene into containers or other operations, polyvinyl acetate (PVA) or viton gloves are recommended.

Definitions

Breakthrough is the time elapsed between the initial contact with a chemical and its detection inside a glove. Breakthrough time is directly proportional to glove material thickness for most materials.

Butyl rubber is a synthetic rubber (butylene and isoprene copolymer) that provides the highest permeation resistance to gases and water vapor of any protective material used to make gloves. Butyl rubber is an excellent choice for protection against esters and ketones, especially for extended contact with acetone.

Degradation is a change in one or more of the physical properties of a glove due to chemical contact. Some of these changes, such as discoloring, swelling, shrinkage or stiffness, may be visually detected but others are invisible. Degradation almost always results in a loss of performance of a glove and is an indicator of how long a glove will last. Degradation is usually detected by a change in weight of a glove and degradation ratings are often based on % change in weight over time.

Double gloving (see introduction, above) is the use of two layers of gloves to provide improved hand protection when using certain hazardous chemicals. This affords a double layer of protection. If the outer glove starts to degrade or tears open, the inner glove continues to offer protection until the gloves are removed and replaced.

Gauge or thickness of gloves is generally measured in mils. Higher gauge (thicker) gloves generally offer more protection. Generally speaking, doubling the thickness halves the permeation rate.

Finish refers to the surface texture of a glove material. Most laboratory gloves have a smooth finish. Textured surfaces are added to glove materials to provide a better grip on objects being handled.

Flock lining is a natural or synthetic shredded fiber that covers the inside of a glove to provide comfort by absorbing perspiration and providing ease in putting on and removing the glove.

Hypalon is a synthetic polymer that offers superior resistance to oxidizing agents and ozone. It is frequently used for glove box gloves.

Lower detection limit (LDL) is the minimum level detected with analytical test equipment, measured in parts per million (ppm) detected at breakthrough time.

Mil is the standard unit for measuring the gauge or thickness of glove materials. A mil is one-thousandth of an inch or 0.001". A millimeter is 39.37 mils; a mil is .00254 mm.

Natural rubber (or latex), produced from the sap of certain species of tropical trees, is used to make gloves that are suitable for the handling of biological materials, human blood and other body fluids, electronics assembly, food service and other applications where the *work* needs to be kept clean. Latex gloves are generally not suitable for use with most laboratory chemicals (see introduction, above). Latex products are also a health concern because of their protein component, to which many people are allergic. Natural rubber is often blended with other polymers to achieve various characteristics of those materials.

Neoprene is a synthetic rubber that is especially resistant to oils and petroleum products. It is also good for corrosives, alcohols, and many solvents. Neoprene is probably the best substitute material for the replacement of latex gloves for janitorial services, shop workers,
mechanics and other trades.

Nitrile, also referred to as NBR or acrylonitrile-butadiene, offers superior chemical resistance as well as puncture and abrasion resistance. 4 and 8 mil nitrile gloves are most often specified for general lab use for handling a wide variety of chemicals.

Norfoil (see introduction, above) is a lightweight, flexible laminate of several layers of polymers which offers superior resistance to permeation by a wide range of hazardous materials which often quickly degrade other glove materials. They are often used as an underglove with a tighter fitting glove of another material as an overglove to restore dexterity. Brand names of Norfoil gloves are Silver Shield by North Hand Protection, 4H by Safety4, and New Barrier™ brand by Ansell Edmont.

Overglove is a glove worn over another glove (underglove) when double gloving to provide multiple layers of resistance to hazardous chemicals. The overglove protects the underglove from chemical degradation and permeation. It is changed out when it begins to be chemically attacked to protect the underglove.

Penetration is the nonchemical transport of a chemical through a glove, usually by pinholes or microscopic tears or cracks resulting from degradation.

Permeation is the process by which a chemical passes through a glove's protective film. Permeation occurs at the molecular level and often leaves the appearance of the glove unchanged. The *rate of permeation* of a chemical through a glove is one of the determining factors in the effectiveness of a glove for use with a particular chemical. Generally speaking, the permeation rate is inversely proportional to thickness (gauge), although the length of time of exposure and temperature can be important factors for some glove materials. Permeation is an indicator of how long gloves are safe to wear.

Permeation rate at steady state is the maximum rate at which a chemical passes through a glove material, usually expressed in milligrams per square meter per second (mg./m.^{2}/sec.).

Permeation breakthrough is the time in minutes it takes for a chemical to permeate through a glove. Generally speaking, doubling the thickness of a glove quadruples breakthrough time.

Polyvinyl alcohol, or PVA, gloves give superior service for handling solvents, such as chloroform, that attack most other glove materials. PVA is water soluble and may not be used with *any* water-based materials.

Powdered gloves have an interior coating of cornstarch or other absorbent material. Powdered gloves are usually easier to take on and off and are often more comfortable for the wearer, but the powder may contribute to allergic responses in some individuals.

Supported means that the polymer of the glove is a coating over a fabric liner. This two- component glove style offers more durable hand protection. Very few gloves for laboratory use are supported.

Underglove is a glove worn under another glove (overglove) when double gloving to provide multiple layers of resistance to hazardous chemicals.

Unsupported means that a glove is made only of a pure polymer or mix of polymers. Unsupported gloves tend to offer greater dexterity and tactile sensitivity but less protection from physical damage.

Vinyl or polyvinyl chloride (PVC) gloves are economical substitutes for latex gloves for food service or assembly work but they are not resistant to many common laboratory chemicals and are not recommended for general laboratory work.

Viton is a very chemically resistant fluoroelastomer synthetic rubber. It protects against PCBs, benzene, aniline and most chlorinated and aromatic solvents. For some chemicals, such as chloroform, it is the only resistant material commonly available. Viton gloves are expensive, but they have a very long lifespan.

References Used

Ansell Edmont, *Chemical Resistance Guide,* 1990. For gloves made by this firm.

Best, *Guide to Chemical-Resistant Best Gloves,* 1997. For gloves made by this firm.

Cole-Parmer, '97-'98 *Catalog,* pp.1366-1372. This is a very generic, but useful, materials compatibility chart.

Fisher Safety, Sept., 1996, *Safety Products Reference Manual,* p. 223, 225 and 227. These charts are specific to gloves sold by Fisher. There is also a good overview of glove selection on pp. 220-222 of this catalog.

Lab Safety Supply, Aug., 1997 *General Catalog,* pp.99. This chart is specific to gloves sold by Lab Safety Supply.

Material Safety Data Sheets, from both manufacturers' and MDL-OHS data base at EH&S.
Merk Index, 10th Edition, 1983.

National Toxicology Program (NTP) chemical information sheets (available at EH&S). These information sheets are very well written and give information on specific gloves selected by NTP.

NIOSH, *Registry of Toxic Effects of Chemical Substances,* 1981-2.

Pioneer Industrial Products, *Chemical Resistance Guide,* no date. For gloves made by this firm.

Safety 4 A/S, *4H Chemical Protection Guide,* Sept. 1995. A chart for 4H brand gloves.

VWR Scientific Products, '97-'98 *Catalog,* p. 788-9. This chart is applicable only to Best gloves sold by VWR.

Electronic Resources

For those of you with Windows-based computers, Best has an electronic version of their glove selection chart available on their Web site at:

http://www.bestglove.com

You can download the software and install it on your PC. It does not have a Mac version.

---------- Cut Here ----------

Glove Selection Request Form

Name of chemical(s) _____
Please give the full name. Abbreviations may be difficult to find in the literature.

How is this chemical(s) being used? _____

How much is being used during a procedure? _____

Do you anticipate that the chemical may/will be in contact with the gloves? _____

Explain if possible. _____

Your name _____

Building _____ Room No. _____ Dept. _____

E-mail address _____ Phone No. _____

---------- Cut Here ----------

Copy and paste this form into an e-mail addressed to tjs1@cornell.edu. Please give your e-mail a subject, such as "Glove Selection Request."

Cornell University Chemical Hygiene Plan

Glove Selection Guide

Chemical	Incidental Contact	Extended Contact
Acetic Acid	nitrile	neoprene, butyl rubber
Acetic Anhydride	nitrile (8 mil), double glove	butyl rubber, neoprene
Acetone	natural rubber (latex) (8 mil)	butyl rubber
Acetonitrile	nitrile	butyl rubber, polyvinyl acetate (PVA)
Acrylamide	nitrile	butyl rubber
bis-Acrylamide	nitrile	
Ammonium Hydroxide	nitrile	neoprene, butyl rubber
Arsenic Salts	nitrile	
Benzotriazole, 1,2,3-	nitrile	
Bismuth Salts	nitrile	
Cadmium Salts	nitrile	
Carbon Disulfide	nitrile (8 mil), double glove	viton, polyvinyl acetate (PVA)
Carbon Tetrachloride	nitrile (8 mil), double glove	viton
Catechol	nitrile	
Chloroform	nitrile (8 mil), double glove	viton, polyvinyl acetate (PVA)
Chromium Salts	nitrile	
Cobalt Chloride	nitrile	
Cobalt Salts	nitrile	
Copper (Cupric) Sulfate	nitrile	
3,3'-Diaminobenzidine (DAB)	nitrile	nitrile, double glove
Diazomethane in Ether	nitrile (8 mil), double glove	Norfoil
Dichloromethane	nitrile (8 mil), double glove	polyvinyl acetate (PVA) or viton
Diethyl Pyrocarbonate	nitrile	nitrile, double glove
Dimethyl Sulfoxide (DMSO)	[1]natural rubber (latex)(15-18 mil)	butyl rubber
1,4-Dioxane	nitrile (8 mil), double glove	butyl rubber
Dithiothreitol	nitrile	
Ethanol	nitrile	
Ethidium Bromide (EtBr)	nitrile	nitrile, double glove
Ethyl Ether	nitrile (8 mil), double glove	polyvinyl acetate (PVA)
Formaldehyde	nitrile	
Formamide	nitrile	butyl rubber
Formic Acid	nitrile (8 mil), double glove	butyl rubber, neoprene (30 mils)
Gallic Acid	nitrile	
Heptane	nitrile (8 mil), double glove	nitrile (35 mil or thicker), viton, PVA
Hexamethylenediamine (1,6-Diaminohexane)	nitrile (8mil)	neoprene
Hexane	nitrile (8 mil), double glove	nitrile (35 mil or thicker), viton, PVA

Hydrochloric Acid	nitrile	neoprene, butyl rubber
Hydrofluoric Acid (HF)	nitrile (8 mil), double glove	
Isopropanol	nitrile	
Laser Dyes	nitrile	
Lead Acetate	nitrile, double glove	
Lead Salts	nitrile	
Mercuric Chloride	nitrile, double glove	
Mercury	nitrile	
Mercury Salts	nitrile	
Methanol	nitrile	
Methylene Chloride	nitrile (8 mil), double glove	polyvinyl acetate, viton
Methyl Sulfonic Acid, Ethyl Ester (EMS) (Ethyl Methanesulfonate)	nitrile	nitrile, double glove
Monoethanolamine	nitrile	
Nickel Chloride	nitrile	
Nickel Salts	nitrile	
N-Methylethanolamine	nitrile (8 mil), double glove	viton, neoprene, butyl rubber
Organophosphorous compounds	nitrile (8 mil), double glove	
Osmium Salts	nitrile	
Osmium Tetroxide	nitrile, double glove	
Paraformaldehyde	nitrile	
Phenol	nitrile (8 mil), double glove	neoprene, butyl rubber
Phenol-Chloroform mixtures	nitrile (8 mil), double glove	viton
Phenylmethylsulfonyl Fluoride (PMSF)	nitrile	nitrile, double glove
Polychlorinated Biphenyls (PCB's)	nitrile (8 mil) glove over a neoprene glove	neoprene (20 mil)
Polyoxyethylenesorbitan Monolaurate (Tween 20)	nitrile	
Psoralen	nitrile	nitrile, double glove
Pump Oil	butyl rubber	
Silane based silanization or derivatization compounds	nitrile (8 mil), double glove	
Silver Nitrate	nitrile	
Silver Salts	nitrile	
Sodium Dodecyl Sulfate (SDS)	nitrile	
Sodium Azide	nitrile	
Sulfuric Acid	nitrile (8 mil)	neoprene, butyl rubber (20 mil or greater)
Tetrahydrofuran (THF)	nitrile (8 mil), double glove	Norfoil
3,3',5,5'-Tetramethyl-Benzidine (TMB)	nitrile	nitrile, double glove

N,N,N',N'-Tetramethyl-ethylenediamine (TEMED)	nitrile	nitrile, double glove
Toluene	nitrile (8 mil), double glove	viton, polyvinyl acetate (PVA)
Trichloromethyl Chloroformate (diphosgene)	nitrile (8 mil) over butyl rubber glove box gloves	Material must be used in a glove box.
Triton-X 100	nitrile (8 mil), double glove	
Uranium Salts	nitrile	
Xylene	nitrile	polyvinyl acetate (PVA), viton

[1] If you are allergic to natural rubber products, you may double glove with 8 mil nitrile gloves.

Created 10/22/99 Tom Shelley

The SOP Form

The OSHA Lab Standard mandates that those responsible for laboratory operations develop Standard Operating Procedures (SOPs) "relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals." (29 CFR 1910.1459(e)(3) (i)) This is especially the case if your lab operations include the routine use of " 'select carcinogens,' reproductive toxins and substances which have a high degree of acute toxicity." (29 CFR 1910.1459(e)(3) (viii))

A revised version of the SOP Form has been created for your use. Please use the new version provided when completing new SOPs. The "How to Prepare an SOP" describes in detail how to complete the SOP Form. If you have questions concerning the creation of an SOP please contact the Cornell University Chemical Hygiene Officer at 255-4288.

Table of Contents

12.34 The Safe Use of Perchloric Acid

Revised 11/13/98 by Tom Shelley

STANDARD OPERATING PROCEDURE

for

CARCINOGENS AND HIGHLY TOXIC MATERIALS

Location(s): _____

Chemical(s): _____

Specific Hazards: _____

1. Purchasing: All purchases of this material must have written approval from the Principal Investigator or _____ before ordering. The user is responsible to ensure that a current Material Safety Data Sheet (MSDS) is obtained unless a current one is already available within the laboratory. Quantities of this material will be limited to _____, or the smallest amount necessary to complete the experiment.

2. Storage: Materials will be stored according to compatibility and label recommendations in a designated area: _____. Storage areas will be regularly inspected by _____ to ensure safety. Periodic inventory reductions will be scheduled.

3. Authorized personnel: Use of this material requires prior written approval from the PI or _____, Title: _____. Use will be limited to the following personnel (check all that apply):

Principal Investigator ____ Graduate students____

Technical staff ____ Post doctoral employees____ Undergraduates ____

Other (describe) _____

4. Training requirements: The user must demonstrate competency and familiarity regarding the safe handling and use of this material prior to purchase. Training should include the following:

Review of current MSDS	Special training provided by the department/supervisor
Review of the OSHA Lab Standard	Review of the departmental safety manual
Review of the Chemical Hygiene Plan	Safety meetings and seminars
Laboratory safety training (EH&S)	

5. Use location: Materials shall be used only in the following designated areas in room _____.

Check all that apply:

demarcated area in lab (describe)_____

fume hood _____ glove box _____ other (describe) _____

6. Personal protective equipment: All personnel are required to wear the following personal protective equipment whenever handling this material (check all that apply):

Safety goggles _____ Chemical safety goggles _____ Face shield _____

Gloves (type/use):

Incidental Contact: _____

Extended Contact: _____

Lab coat _____ Rubber apron _____ Tyvek clothing _____

Respirator (type) _____ Other (describe) _____

7. Waste disposal: The authorized person using this material is responsible for the safe collection, preparation and proper disposal of waste unless otherwise stated below. Waste shall be disposed of as soon as possible and in accordance with all laboratory and University procedures.

Specific instructions:

8. Decontamination: Specific instructions:

9. Exposures: Emergency procedures to be followed (from MSDS):

Skin/eye contact--symptoms:

First aid:

Ingestion-- symptoms:

First aid:

Inhalation--symptoms:

First aid:

10. Spills: Spill cleanup materials to be used, location of materials, PPE to be used, disposal of cleanup materials, etc. Please be as complete as possible:

11. Phone numbers:

Cornell Campus Police: **911** (accidents, spills)

Environmental Health and Safety: 5-8200

Gannett Health Center: 5-5155

12. Other: Special precautions, incompatible/reactive materials, usable shelf life, etc. Please be as specific as possible:

Prepared by: _____

Date: _____

Reviewed/Revised: _____

A copy of the completed SOP must be filed with the Cornell Chemical Hygiene Officer at EH&S, 125 Humphreys Service Building.

Revised 11/13/98 by Tom Shelley

How to Prepare an SOP

Using the Cornell University "Standard Operating Procedure for Carcinogens and Highly Toxic Materials" Form

Prepared by Tom Shelley

11/17/97

Part A: Some Frequently Asked Questions

When is an SOP required? The OSHA Lab Standard mandates that those responsible for laboratory operations develop Standard Operating Procedures (SOPs) "relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals." (29 CFR 1910.1459(e)(3) (i)) This is especially the case if your lab operations include the routine use of " 'select carcinogens,' reproductive toxins [or] substances which have a high degree of acute toxicity." (29 CFR 1910.1459(e)(3) (viii))

How do I know if a chemical I am using is a select carcinogen or acutely toxic? If any of the following questions are answered with "yes."

Is the chemical on the list "Cornell University Select Carcinogens?"

Is the chemical on the list "Cornell University Acutely Toxic Chemicals?"

Does the chemical have an NFPA/HMIS health hazard rating[1] of 4?

Is the chemical rated HIGHLY TOXIC? (LD_{50} of 50 mg./kg. or less.)[2]

Is the chemical rated SUPER TOXIC? (LD_{50} of 5 mg./kg. or less.)[2]

Is the chemical a poison inhalation hazard?

Note: Not all carcinogens and acutely toxic chemicals are listed in the above references. If you can't locate a chemical in these lists and you have reason to believe that it is a carcinogen or acutely toxic, you must refer to the MSDS for the chemical (or other sources of chemical safety information) to determine the hazardous characteristics of the chemical.

[See the document "How to Obtain an MSDS" if you do not have one available for the chemical.]

In addition, SOPs may need to be prepared for very flammable chemicals (NFPA/HMIS flammability rating[1] of 4) and very reactive chemicals (NFPA/HMIS reactivity rating[1] of 3 or 4) such as strong corrosives, oxidizers and reducing agents, depending upon the extent and duration of use.

Do I need to prepare an SOP for all of the carcinogens and acutely toxic chemicals I use in my lab? An SOP may not be required if a chemical meets the following criteria:

1) It is *not* a *known* human carcinogen,
2) It is *not* a poison inhalation hazard,
3) It does *not* require an antidote for ordinary lab usage (certain cyanide compounds, for example, require an antidote to be on hand in the lab for first aid treatment in the event of the exposure of an employee to the chemical),
4) It is used very infrequently (not as a component of an on-going or frequently performed experiment or process), and
5) It is used in very small quantities, meaning less than one-half of the LD_{50} for an "average" person calculated as:

$$\frac{LD_{50} \text{ in mg./kg. x 74 / 1000}}{2} \quad \text{(in grams)}$$

Do I need to prepare a separate SOP for each chemical in use in my lab? An SOP may be prepared for an experiment or *process* using more than one carcinogen or acutely toxic chemical. Or, an SOP may be prepared for a *class* of chemicals having similar hazardous characteristics. Examples of the above conditions are:

a) Chlorine, phosgene and carbon monoxide are combined in varying proportions in an evacuated reaction vessel and the by-products are studied using various analytical procedures. The starting materials are all poison inhalation hazards and an SOP may be written for the ***process*** in which they are used.
b) Copper and zinc cyanides are used in a plating bath with the evolution of small amounts of hydrogen cyanide. The starting materials and one by-product are highly toxic and an SOP may be written for the ***process*** in which they are used.
c) Benzene, carbon tetrachloride, chloroform and methylene chloride are frequently used as components of solvent systems in an organic chemistry lab. They are all select carcinogens. An SOP may be written for the ***class*** of solvents used in the lab that are known or suspect carcinogens.
d) Dichlorobenzidine, benzo[a]pyrene and N-nitrosomethyethyl-amine are used as mutagens in a microbiology laboratory. An SOP may be written for the ***class*** of carcinogens used as mutagens in this microbiology laboratory.
e) Inorganic arsenic, chromium, lead and nickel compounds are used to prepare standards used in an environmental analytical laboratory. The compounds, all select carcinogens, may have an SOP prepared for the ***class*** of compounds which are carcinogenic metal compounds.

Can Dr. Smith's lab use the SOP for formaldehyde that our lab wrote? If the *process* for the use of formaldehyde is the same in both labs, then the same SOP may be used with appropriate changes under location, storage, authorized personnel and other information that is specific to each lab. We strongly encourage departments and colleges to develop "generic" SOPs for

commonly used chemicals and processes which can then be customized for each individual lab in the department or College.

Part B: How to Complete the SOP Form

A Step-By-Step Guide

Location(s) means the building and room number(s) where a chemical or process is used.

Chemical(s) means the full name of the chemical(s) used in a process. The chemical(s) name may be abbreviated in subsequent sections of the SOP form. Also include the CAS number of each compound, if known, and an approximate quantity of the material that would need to be kept on hand, if known.

Specific Hazards means the known hazard statements concerning the chemical(s) listed above. This information is usually available from the MSDS and consists of short statements or phrases identifying specific hazards, such as “very toxic,” “highly flammable,” “carcinogen,” “peroxide former,” “irritant,” etc.

Purchasing identifies the person giving written approval to purchase the chemical(s) and the limit on the amount of the chemical(s) that may be purchased at any one time. This person is usually the principal investigator or a designated responsible person, such as a lab supervisor, technician, post doc or a senior graduate student.

Storage identifies the area(s) designated for the storage of the chemical(s). This must be as specific as possible, such as, "the flammable materials storage cabinet to the north of the fume hood in room 312" or "the cabinet on the south wall of room 312."

[Please see the documents "Brief Guide to the Proper Storage of Chemicals" and "Safe Storage of Chemicals" for information on the storage of chemicals.]

Authorized personnel identifies the person who gives approval for the use of the chemical(s), usually the principal investigator or lab supervisor. Check the appropriate entries on the list of possible users provided. If "Other" is checked, please explain.

Training requirements may vary greatly depending upon the chemical(s) in use. The user must demonstrate knowledge of a) the hazards of the chemical(s) and b) procedures for the safe handling of the chemical(s). The list of written programs and other training materials provided is not inclusive. Additional written materials may be added at the discretion of the person responsible for training.

Note: There is a requirement that *written records* verifying the training given to all chemical users must be maintained by each department. A *"Chemical(s) User Authorization Form,"* which can be used to verify the training for users of hazardous chemicals, is provided for your convenience. A copy of the completed *Authorization Form* must be kept in or near the lab where the chemical(s) is used.

Use location designates the room and specific areas where the chemical(s) is used in the room. If "Other" is checked, please explain. Be as specific as possible.

Personal protective equipment requirements may vary greatly depending upon the chemical(s) in use. Please check all items that apply. If additional safety equipment or conditions are required, please record these items in Section 12 below. Please note the following:

1) There is a requirement to use chemical splash goggles when corrosive liquids or other materials with a potential to splash the eyes or face are in use.
2) Glove selection is particularly critical for carcinogens and acutely toxic materials. Many glove selection charts are available and the MSDSs for many chemicals make recommendations for the type of hand protection required. EH&S can facilitate the selection of hand protection. Call 255-8200 for assistance in glove selection if necessary.
   Incidental contact means the type and use of the glove to be worn when no contact with the chemical(s) is anticipated under normal conditions of use.
   Extended contact means the type and use of the glove to be worn when contact with the chemical(s) is anticipated, such as the immersion of the hands in a chemical when it is used as a cleaning agent, etc.
3) Respirators are rarely needed in a lab setting. Generally speaking, all use of chemicals which pose an inhalation hazard must be conducted in a functional fume hood in a lab setting. *All use of respirators at Cornell must be approved by EH&S.* Call 255-8200 for assistance with respiratory protection if this is required for the chemical(s) in use.

   [Please see the document "Cornell University Respiratory Protection Program."]

4) Shorts, sandals, open toed shoes and other apparel which allow the legs and feet to be exposed are prohibited when corrosives and other chemicals which pose a skin exposure hazard are in use.
5) Note that long hair, jewelry and other items may present a hazard when hazardous chemicals and energized systems are in use and appropriate precautions should be taken as required.

Waste disposal must follow the procedures outlined in Section 7 of the Cornell *Chemical Hygiene Plan.* Please be as specific as possible in describing the waste disposal procedures for the chemical(s) in use.

Decontamination procedures must be developed when possible. For example, if an acid or base can be neutralized with sodium bicarbonate describe how this is done. If special conditions exist, such as the chemical(s) is only easily soluble in acetone, please make a note of these conditions. If a method is available that can be used to detoxify the chemical(s) or the byproducts of an experiment or process using the chemical(s) as the last step in an experiment or process used in your lab, please attach a copy of a detailed procedure for this process. It may not be possible to develop decontamination or detoxification methods for all chemicals.

Exposures lists symptoms, first aid and other emergency procedures to be followed in the event that a person is exposed to the chemical(s) in use. The required information may be obtained from an MSDS for the chemical(s).

[See the document "How to Obtain an MSDS" if you do not have one available for the chemical.]

Spills describes procedures to be used in the event of a spill or other uncontrolled release of the chemical(s). *There is a requirement that lab staff using the chemical(s) be trained on the procedures used to clean up a spill.* It is also important that users of the chemical(s) are trained to recognize when they are able to clean up the spill without the help of others (an incidental spill) and when the assistance of others is required (an emergency response). EH&S can facilitate the development of procedures for spill cleanup. The principle investigator, supervisor or responsible person is required to meet the above training requirements.

Phone numbers are those to be used in the event of an emergency. Call ***911*** for all spills that are not incidental spills, accidents damaging property (explosions, fires) and substantial personal injuries. *All lab injuries must be reported to the supervisor of the lab and a "Cornell University Accident Report" must be completed.*

Other specifies any special precaution that must be taken for the handling, use and storage of the chemical(s). Please be as specific as possible.

A copy of the completed SOP must be filed with EH&S electronically or by campus mail to 125 Humphreys Service Building.

Please use extra pages as required.

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[1] NFPA is the National Fire Protection Association which has developed a system of rating the hazards of chemicals on a scale of 0-4 for health, flammability and reactivity. HMIS is a similar but proprietary system used by some chemical companies. The rating scales range from 0 for "no hazard" to 4 for "extremely hazardous" for each of the hazardous characteristics listed above. Many chemical company catalogs contain an explanation of the NFPA/HMIS rating system.

[2] The LD50, or Lethal Dose 50, is the amount of a chemical which will cause 50% of a population of test animals to die when the chemical is administered via a particular route of exposure for a specified length of time.

Revised 11/16/98 Tom Shelley

Chemical User Authorization Form

I hereby certify that I have read the Standard Operating Procedure, the MSDS and associated materials concerning the use of

_____

_____
in this lab.

I also certify that I understand and agree to the following:

- I must follow the written Standard Operating Procedure for the chemical(s) listed above.
- I understand the requirements for the use of personal protective equipment and other safety devices required for the use of the chemical(s) listed above.
- I am aware of the location of and procedures for the use of first aid supplies for exposure to the chemical(s) listed above.

	Supervisor's Name (Please Print)	Signature	Date	Signature
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____
5.	_____	_____	_____	_____
6.	_____	_____	_____	_____
7.	_____	_____	_____	_____
8.	_____	_____	_____	_____

Cornell University Select Carcinogens

Chemical	CAS Number
A-alpha-C (2-Amino-9H-pyrido[2,3-b]indole)	26148-68-5
Acetaldehyde	75-07-0
Acetamide	60-35-5
Acetochlor	34256-82-1
2-Acetylaminofluorene	53-96-3
Acifluorfen	62476-59-9
Acrylamide	79-06-1
Acrylonitrile	107-13-1
Actinomycin D	50-7-60
Adriamycin (Doxorubicin hydrochloride)	23214-92-8
AF-2;[2-(2-furyl)-3-(5-nitro-2-furyl)]acrylamide	3688-53-7
Aflatoxins	1402-68-2
Alachlor	15972-60-8
Alcoholic beverages, when associated with alcohol abuse	n/a
Aldrin	309-00-2
Allyl chloride	107-05-1
Aluminum products	n/a
2-Aminoanthraquinone	117-79-3
p-Aminoazobenzene	60-09-3
ortho-Aminoazotoluene	97-56-3
4-Aminobiphenyl (4-aminodiphenyl)	92-67-1
3-Amino-9-ethylcarbazole hydrochloride	6109-97-3
1-Amino-2-methylanthraquinone	82-28-0
2-Amino-5-(5-nitro-2-furyl)-1,3,4-thiadiazole	712-68-5
Amitrole	61-82-5
Analgesic mixtures containing phenacetin	n/a
Androgenic (anabolic) steroids	n/a
Aniline	62-53-3
ortho-Anisidine	90-04-0
ortho-Anisidine hydrochloride	134-29-2
Antimony oxide (antimony trioxide)	1309-64-4
Aramite	140-57-8
Arsenic (inorganic arsenic compounds)	various
Asbestos	1332-21-4
Auramine	492-80-8
Azaserine	115-02-6
Azathioprine	446-86-6

Azacitidine	320-67-2
Azobenzene	103-33-3
Benz[a]anthracene	56-55-3
Benzene	71-43-2
Benzidine [and its salts]	92-87-5
Benzidine-based dyes	various
Benzo[b]fluoranthene	205-99-2
Benzo[j]fluoranthene	205-82-3
Benzo[k]fluoranthene	207-08-9
Benzofuran	271-89-6
Benzo[a]pyrene	50-32-8
Benzotrichloride	98-07-7
Benzyl chloride	100-44-7
Benzyl violet 4B	1694-09-3
Beryllium and beryllium compounds	various
Betel quid with tobacco	n/a
Bis(2-chloroethyl)ether	111-44-4
N,N-Bis(2-chloroethyl)-2- naphthylamine (Chlornapazine)	494-03-1
Bischloroethyl nitrosourea (BCNU) (Carmustine)	154-93-8
Bis(chloromethyl)ether	542-88-1
Bitumens, extracts of steam-refined and air refined	various
Bleomycins	various
Bracken fern	n/a
Bromodichloromethane	75-27-4
Bromoform	75-25-2
1,3-Butadiene	106-99-0
1,4-Butanediol dimethanesulfonate (Busulfan)	55-98-1
Butylated hydroxyanisole (BHA)	25013-16-5
beta-Butyrolactone	3068-88-0
Cadmium and cadmium compounds	various
Caffeic acid	331-39-5
Captafol	2425-06-1
Captan	133-06-2
Carbon tetrachloride	56-23-5
Carbon-black extracts	n/a
Carrageenan, degraded	n/a
Ceramic fibers (airborne particles of respirable size)	n/a
Certain combined chemotherapy drugs for lymphomas	n/a
Chlorambucil	305-03-3
Chloramphenicol	56-75-7
Chlordane	57-74-9
Chlordecone (Kepone)	143-50-0
Chlordimeform	6164-98-3

Chlorendic acid (approximately 60 percent chlorine by weight)	115-28-6
Chlorinated Parrafins (C12, 60% chlorine)	108171-26-2
alpha-Chlorinated toluenes	various
p-Chloroaniline	106-47-8
Chlorodibromomethane	124-48-1
Chloroethane (ethyl chloride)	75-00-3
1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU) (Lomustine)	13010-47-4
1-(2-Chloroethyl)-3-(4-methylcyclohexyl)-1-nitrosourea (Methyl-CCNU)	13909-09-6
Chloroform	67-66-3
Chloromethyl methyl ether (technical grade)	107-30-2
3-Chloro-2-methylpropene	563-47-3
4-Chloro-ortho-phenylenediamine	95-83-0
p-Chloro-o-toluidine	95-69-2
Chlorophenols	various
Chlorophenoxy herbicides	various
Chlorothalonil	1897-45-6
Chlorozotocin	54749-90-5
Chromium (hexavalent compounds)	various
Chrysene	218-01-9
C. I. Acid Red 114	6459-94-5
C. I. Basic Red 9 monohydrochloride	569-61-9
Ciclosporin (Cyclosporin A; Cyclosporine)	59865-13-3
Cinnamyl anthranilate	87-29-6
Cisplatin	15663-27-1
Citrus Red No. 2	6358-53-8
Coal gasification	n/a
Coal-tar pitches	n/a
Coal-tars	n/a
Cobalt metal powder	7440-48-4
Cobalt [II] oxide	1307-96-6
Coke Production oven emissions	n/a
Conjugated estrogens	n/a
Creosotes	n/a
para-Cresidine	120-71-8
Cupferron	135-20-6
Cycasin	14901-08-7
Cyclophosphamide (anhydrous)	50-18-0
Cyclophosphamide (hydrated)	6055-19-2
D&C Orange No. 17	3468-63-1
D&C Red No. 8	2092-56-0
D&C Red No. 9	5160-02-1
D&C Red No. 19	81-88-9
Dacarbazine	4342-03-4
Daminozide	1596-84-5

Dantron (Chrysazin; 1,8-Dihydroxyanthraquinone)	117-10-2
Daunomycin	20830-8-13
DDD (Dichlorodiphenyldichloroethane)	72-5-48
DDE (Dichlorodiphenyldichloroethylene)	72-55-9
DDT (Dichlorodiphenyltrichloroethane)	50-29-3
DDVP (Dichlorvos)	62-73-7
N,N'-Diacetylbenzidine	613-35-4
2,4-Diaminoanisole	615-05-4
2,4-Diaminoanisole sulfate	39156-41-7
4,4'-Diaminodiphenyl ether (4,4'-Oxydianiline)	101-80-4
2,4-Diaminotoluene	95-80-7
Diaminotoluene (mixed)	n/a
Dibenz[a,h]acridine	226-36-8
Dibenz[a,j]acridine	224-42-0
Dibenz[a,h]anthracene	53-70-3
7H-Dibenzo[c,g]carbazole	194-59-2
Dibenzo[a,e]pyrene	192-65-4
Dibenzo[a,h]pyrene	189-64-0
Dibenzo[a,i]pyrene	189-55-9
Dibenzo[a,l]pyrene	191-30-0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8
1,2-Dibromoethane	106-93-4
2,3-Dibromo-1-propanol	96-13-9
p-Dichlorobenzene	106-46-7
3,3'-Dichlorobenzidine	91-9-41
3,3'-Dichlorobenzidine 2HCl	612-83-9
1,4-Dichloro-2-butene	764-41-0
3,3'-Dichloro-4,4'-diaminodiphenyl ether	28434-86-8
1,1-Dichloroethane	75-34-3
1,2-Dichloroethane	107-06-2
Dichloromethane (Methylene chloride)	75-09-2
1,2-Dichloropropane	78-87-5
1,3-Dichloropropene (technical grade)	542-75-6
Dieldrin	60-57-1
Dienestrol	84-17-3
Diepoxybutane	1464-53-5
Diesel engine exhaust	n/a
Di(2-ethylhexyl)phthalate	117-81-7
1,2-Diethylhydrazine	1615-80-1
Diethyl sulfate	64-67-5
Diethylstilbestrol	56-53-1
Diglycidyl resorcinol ether (DGRE)	101-90-6
Dihydrosafrole	94-58-6
Diisopropyl sulfate	2973-10-6
3,3'-Dimethoxybenzidine (ortho-Dianisidine)	119-90-4

3,3'-Dimethoxybenzidine dihydrochloride (ortho-dianisidine dihydrochloride)	20325-40-0
para-Dimethylaminoazobenzene	60-11-7
4-Dimethylaminoazobenzene	60-11-7
trans-2-[(Dimethylamino)methylimino]-5-[2-(5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole	55738-54-0
7,12-Dimethylbenz(a)anthracene	57-97-6
3,3'-Dimethylbenzidine (ortho-Tolidine)	119-93-7
3,3'-Dimethylbenzidine dihydrochloride	612-82-8
Dimethylcarbamoyl chloride	79-44-7
1,1-Dimethylhydrazine (UDMH)	57-14-7
1,2-Dimethylhydrazine	540-73-8
Dimethyl sulfate	77-78-1
Dimethylvinyl Chloride	513-37-1
1,6-Dinitropyrene	42397-64-8
1,8-Dinitropyrene	42397-65-9
2,4-Dinitrotoluene	121-14-2
2,6-Dinitrotoluene	606-20-2
1,4-Dioxane	123-91-1
Diphenylhydantoin (Phenytoin)	57-41-0
Diphenylhydantoin (Phenytoin), sodium salt	630-93-3
Direct Black 38 (technical grade)	1937-37-7
Direct Blue 6 (technical grade)	2602-46-2
Direct Brown 95 (technical grade)	16071-86-6
Disperse Blue 1	2475-45-8
Epichlorohydrin	106-89-8
Erionite	12510-42-8
Estradiol 17B	50-28-2
Estrone	53-16-7
Ethinylestradiol	57-63-6
Ethyl acrylate	140-88-5
Ethyl methanesulfonate	62-50-0
Ethyl-4,4'-dichlorobenzilate	510-15-6
Ethylene dibromide	106-93-4
Ethylene dichloride (1,2-Dichloroethane)	107-06-2
N-Ethyl-N-nitrosourea	759-73-9
Ethylene oxide	75-21-8
Ethylene thiourea	96-45-7
Ethyleneimine	151-56-4
Folpet	133-07-3
Formaldehyde (gas or aqueous solution)	50-00-0
2-(2-Formylhydrazino)-4-(5-nitro-2-furyl) thiazole	3570-75-0
Furan	110-00-9
Furazolidone	67-45-8
Furmecyclox	60568-05-0

Fusarin C	79748815
Gasoline engine exhaust (condensates/extracts)	n/a
Glasswool fibers (airborne particles of respirable size)	n/a
Glu-P-1 (2-Amino-6-methyldipyrido[1,2- a:3', 2'-d]imidazole)	67730-11-4
Glu-P-2 (2-Aminodipyrido[1,2-a:3',2'-d]imidazole)	67730-10-3
Glycidaldehyde	765-34-4
Glycidol	556-52-5
Griseofulvin	126-07-8
Gyromitrin (Acetaldehyde methylformylhydrazone)	16568-02-8
HC Blue 1	2784-94-3
Heptachlor	76-44-8
Heptachlor epoxide	1024-57-3
Hexachlorobenzene	118-74-1
Hexachlorocyclohexanes (technical grade)	various
Hexachlorodibenzodioxin	34465-46-8
Hexachloroethane	67-72-1
Hexamethylphosphoramide	680-31-9
Hydrazine	302-01-2
Hydrazine sulfate	10034-93-2
Hydrazobenzene (1,2-Diphenylhydrazine)	122-66-7
Indeno [1,2,3-cd]pyrene	193-39-5
IQ (2-Amino-3-methylimidazo[4,5-f]quinoline)	76180-96-6
Iron dextran complex	9004-66-4
Isosafrole	120-58-1
Kepone (Chlordecone)	143-50-0
Lactofen	77501-63-4
Lasiocarpine	303-34-4
Lead acetate	301-04-2
Lead and lead compounds	various
Lead phosphate	7446-27-7
Lindane and other hexachlorocyclohexane isomers	various
Mancozeb	8018-01-7
Maneb	12427-38-2
Me-A-alpha-C (2-Amino-3-methyl-9H-pyrido[2, 3-b]indole)	68006-83-7
Medroxyprogesterone acetate	71-58-9
MeIQ(2-Amino-3,4-dimethylimidazo[4,5-f]quinoline)	7094112
MeIQx(2-Amino-3,8-dimethylimidazo[4,5-f]quinoxaline)	7500-04-0
Melphalan	148-82-3
Merphalan	531-76-0

Mestranol	72-33-3
Methoxsalen with ultraviolet A therapy	n/a
8-Methoxypsoralen with ultraviolet A therapy	298-81-7
5-Methoxypsoralen with ultraviolet A therapy	484-20-8
2-Methylaziridine (Propyleneimine)	75-55-8
Methylazoxymethanol	590-96-5
Methylazoxymethanol acetate	592-62-1
3-Methylcholanthrene	56-49-5
5-Methylchrysene	3697-24-3
4,4'-Methylene bis(2-chloroaniline) (MOCA)	101-14-4
4,4'-Methylene bis(N,N-dimethyl)benzenamine	101-61-1
4,4'-Methylene bis(2-methylaniline)	838-88-0
4,4'-Methylenedianiline	101-77-9
4,4'-Methylenedianiline dihydrochloride	13552-44-8
Methylhydrazine and its salts	13552-44-8
Methyl chloromethyl ether	107-30-2
Methyl-CCNU	13909-09-6
Methyl iodide	74-88-4
Methyl methanesulfonate	66-27-3
2-Methyl-1-nitroanthraquinone (of uncertain purity)	129-15-7
N-Methyl-N'-nitro-N-nitrosoguanidine (MNNG)	70-25-7
N-Methyl-N-nitrosourea	
N-Methylolacrylamide	924-42-5
Methylthiouracil	56-04-2
Metiram	9006-4222
Metronidazole	443-48-1
Michler's ketone	90-94-8
Mineral Oils, untreated and mildly treated	n/a
Mirex	2385-85-5
Mitomycin C	50-07-7
MOPP	
Monocrotaline	135-22-0
5-(Morpholinomethyl)-3-[(5-nitro-fufurylidene)-amino]-2-oxazolidinone	139-91-3
Mustard gas	505-60-2
Nafenopin	3771-19-5
1-Naphthylamine	134-32-7
2-Naphthylamine	91-59-8
3-Naphthylamine	
Nickel and certain nickel compounds	various
Nickel carbonyl	13463-3933
Nickel refinery dust, from the pyrometallurgical process	7440-02-0
Nickel subsulfide	12035-72-2
Niridazole	61-57-4
Nitrilotriacetic acid	139-13-9

Nitrilotriacetic acid, trisodium salt monohydrate	18662-53-8
5-Nitroacenaphthene	602-87-9
5-Nitro-o-anisidine	99-59-2
o-Nitroanisole	91-23-6
4-Nitrobiphenyl	92-93-3
6-Nitrochrysene	7496-02-8
Nitrofen (technical grade)	1836-755
2-Nitrofluorene	607-57-8
Nitrofurazone	59-87-0
1-[(5-Nitrofurfurylidene)amino]-2-imidazollidinone	555-84-0
1-[(5-Nitrofurfurylidene)-N-[4-(5-Nitro-2-furyl)-2 thiazolyl]acetamide	531-82-8
Nitrogen mustard (Mechlorethamine)	51-75-2
Nitrogen mustard hydrochloride (Mechlorethamine hydrochloride)	55-86-7
Nitrogen mustard N-oxide	126-85-2
Nitrogen mustard N-oxide hydrochloride	302-70-5
2-Nitropropane	79-46-9
4-Nitropyrene	57835-92-4
N-Nitrosodi-n-butylamine	924-16-3
N-Nitrosodiethanolamine	1116-54-7
N-Nitrosodiethylamine	55-18-5
N-Nitrosodimethylamine	62-75-9
p-Nitrosodiphenylamine	156-10-5
N-Nitrosodiphenylamine	86-30-6
N-Nitrosodi-n-propylamine	621647
N-Nitroso-N-ethylurea	759-73-9
3-(N-Nitrosomethylamino)propionitrile	60153-49-3
4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK)	64091-91-4
N-Nitrosomethylethylamine	10595-95-6
N-Nitroso-N-methylurea	684-93-5
N-Nitroso-N-methylurethane	615--532
N-Nitrosomethylvinylamine	4549-40-0
N-Nitrosomorpholine	59-89-2
N-Nitrosonornicotine	16543-55-8
N-Nitrosopiperidine	100-75-4
N-Nitrosopyrrolidine	930-55-2
N-Nitrososarcosine	13256-22-9
Norethisterone (Norethindrone)	68-22-4
Ochratoxin A	303-47-9
Oestrogen replacement therapy	n/a
Oestrogen, nonstreoidal	
Oestrogen, steroidal	
Oil Orange SS	2646-17-5
Oral contraceptives, combined	n/a
Oral contraceptives, sequential	n/a

4,4'-Oxydianiline	101-80-4
Oxadiazon	19666-30-9
Oxymetholone	434-07-1
Oxazepam	604-75-1
Panfuran S	794-93-4
Pentachlorophenol	87-86-5
Phenacetin	62-44-2
Phenazopyridine hydrochloride	136-40-3
Phenesterin	3546-10-9
Phenobarbital	50-06-6
Phenoxybenzamine	59961
Phenoxybenzamine hydrochloride	63-92-3
Phenyl glycidyl ether	122-60-1
Phenylhydrazine and its salts	various
o-Phenylphenate, sodium	132-27-4
Phenytoin	57-41-0
PhiP(2-Amino-1-methyl-6-phenylimidazol[4,5-b]pyridine)	105650-23-5
Polybrominated biphenyls	various
Polychlorinated biphenyls	various
Polychlorinated biphenyls (containing 60 or more percent chlorine by molecular weight)	various
Polychlorinated dibenzo-p-dioxins	various
Polychlorinated dibenzofurans	various
Polycyclic aromatic hydrocarbons	various
Polygeenan	53973-98-1
Ponceau MX	3761-53-3
Ponceau 3R	3564-09-8
Potassium bromate	7758-01-2
Procarbazine	671-16-9
Procarbazine hydrochloride	366-70-1
Procymidone	32809-16-8
Progesterone	57-83-0
Progestins	various
1,3-Propane sultone	1120-71-4
Progargite	2312-35-8
beta-Propiolactone	57-57-8
Propylene oxide	75-56-9
Propylthiouracil	51-52-5
Radionuclides	various
Radon	10043-92-2
Reserpine	50-55-5
Residual (heavy) fuel oils	n/a

Saccharin	81-07-2
Saccharin, sodium	128-44-9
Safrole	94-59-7
Selenium sulfide	7446-34-6
Shale-oils	68308-34-9
Silica, crystalline (airborne particles of respirable size)	n/a
Sodium ortho-phenylphenate	
Soots, tars, and mineral oils (untreated and mildly treated oils and used engine oils)	n/a
Sterigmatocystin	10048-13-2
Streptozotocin	18883-66-4
Styrene	100-42-5
Styrene oxide	96-09-3
Sulfallate	95-06-7
Talc containing asbestiform fibers	n/a
Terrazole	2593-15-9
Testosterone and its esters	58-22-0
2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)	1746-01-6
1,1,2,2-Tetrachloroethane	79-34-5
Tetrachloroethylene (Perchloroethylene)	127-18-4
p-a,a,a-Tetrachlorotoluene	5216-25-1
Tetranitromethane	509-14-8
Thioacetamide	62-55-5
4,4'-Thiodianiline	139-65-1
Thiourea	62-56-6
Thorium dioxide	1314-20-1
Tobacco, oral use of smokeless products	n/a
Tobacco smoke	n/a
Toluene diisocyanate	26471-62-5
ortho-Toluidine	95-53-4
ortho-Toluidine hydrochloride	636-21-5
para-Toluidine	106-49-0
Toxaphene (Polychorinated camphenes)	8001-35-2
Treosulfan (Tresoluphan)	299-75-2
Trichlormethine (Trimustine hydrochloride)	817-09-4
2,4,6-Trichlorophenol	88-06-2
1,2,3-Trichloropropane	96-18-4
Triphenyltin hydroxide	76-87-9
Trichloroethylene	79-01-6
Tris(aziridinyl)-para-benzoquinone (Triaziquone)	68-76-8
Tris(1-aziridinyl)phosphine sulfide (Thiotepa)	52-24-4
Tris(2-chloroethyl) phosphate	115-96-8
Tris(2,3-dibromopropyl)phosphate	126-72-7
Trp-P-1 (Tryptophan-P-1) (3-Amino-1,4-dimethyl-5H-pyrido[4,3-b]indole)	62450-06-0
Trp-P-2 (Tryptophan-P-2) (3-Amino-1-methyl-5H-pyrido[4,3-b]indole)	62450-07-1

Trypan blue (commercial grade)	72-57-1
Unleaded gasoline (wholly vaporized)	n/a
Uracil mustard	66-75-1
Urethane (Ethyl carbamate)	51-79-6
Vinyl bromide	593-60-2
Vinyl chloride	75-01-4
4-Vinyl-1-cyclohexene diepoxide (Vinyl cyclohexene dioxide)	106-87-6
Vinyl trichloride (1,1,2-Trichloroethane)	79-00-5
2,6-Xylidine (2,6-Dimethylaniline)	87-62-7
Zineb	12122-67-7

Chemicals Known To Cause Reproductive Toxicity

Developmental Toxicity

Chemical	**CAS Number**
Acetohydroxamic acid	546-88-3
Actinomycin D	50-76-0
All-trans retinoic acid	302-79-4
Alprazolam	28981-97-7
Amikacin sulfate	39831-55-5
Aminoglutethimide	125-84-8
Aminoglycosides	various
Aminopterin	54-62-6
Angiotensin converting enzyme (ACE) inhibitors	various
Anisindione	117-37-3
Aspirin (NOTE: It is especially important not to use aspirin during the last three months of pregnancy, unless specifically directed to do so by a because it may cause problems in the unborn child or complications during delivery.)	50-78-2
Barbiturates	various
Benomyl	17804-35-2
Benzphetamine hydrochloride	5411-22-3
Benzodiazepines	various
Bischloroethyl nitrosourea (BCNU) (Carmustine)	1540-93-8
Bromoxynil	1689-84-5
Butabarbital sodium	143-81-7
1,4-Butanediol dimethylsulfonate (Busulfan)	55-98-1
Carbon disulfide	75-15-0
Carbon monoxide	630-08-0
Carboplatin	41575-94-4
Chenodiol	474-25-9
Chlorcyclizine hydrochloride	1620-21-9
Chlorambucil	305-03-3
Chlordecone (Kepone)	143-50-0
Chlordiazepoxide	58-25-3
Chlordiazepoxide hydrochloride	438-41-5
1-(2-Chloroethyl)-3-cyclohexyl-l-nitrosourea (CCNU) (Lomustine)	13010-47-4
Clomiphene citrate	50-41-9
Clorazepate dipotassium	57109-90-7
Cocaine	50-36-2
Colchicine	64-86-8

Conjugated estrogens	n/a
Cyanazine	21725-46-2
Cycloheximide	66-81-9
Cyclophosphamide (anhydrous)	50-18-0
Cyclophosphamide (hydrated)	6055-19-2
Cyhexatin	13121-70-5
Cytarabine	147-94-4
Danazol	17230-88-5
Daunorubicin hydrochloride	23541-50-6
Demeclocycline hydrochloride (internal use)	64-73-3
Diazepam	439-14-5
Dicumarol	66-76-2
Diethylstilbestrol (DES)	56-53-1
Dinocap	39300-45-3
Dinoseb	88-85-7
Diphenylhydantoin (Phenytoin)	57-41-0
Doxycycline (internal use)	564-25-0
Doxycycline calcium (internal use)	94088-85-4
Doxycycline hyclate (internal use)	24390-14-5
Doxycycline monohydrate (internal use)	17086-28-1
Ergotamine tartrate	379-79-3
Ethyl alcohol in alcoholic beverages	n/a
Ethylene glycol monoethyl ether	110-80-5
Ethylene glycol monomethyl ether	109-86-4
Ethylene glycol monoethyl ether acetate	111-15-9
Ethylene glycol monomethyl ether acetate	110-49-6
Ethylene thiourea	96-45-7
Etoposide	33419-42-0
Etretinate	54350-48-0
Fluorouracil	51-21-8
Fluoxymesterone	76-43-7
Flurazepam hydrochloride	1172-18-5
Flutamide	13311-84-7
Halazepam	23092-17-3
Hexachlorobenzene	118-74-1
Ifosfamide	3778-73-2
Iodine-131	10043-66-0
Isotretinoin	4759-48-2
Lead	7439-92-1

Lithium carbonate	554-13-2
Lithium citrate	919-16-4
Lorazepam	846-49-1
Lovastatin	75330-75-5
Medroxyprogesterone acetate	71-58-9
Megestrol acetate	595-33-5
Melphalan	148-82-3
Menotropins	9002-68-0
Meprobamate	57-53-4
Mercaptopurine	6112-76-1
Mercury and mercury compounds	various
Methacycline hydrochloride	3963-95-9
Methimazole	60-56-0
Methotrexate	59-05-2
Methotrexate sodium	15475-56-6
Methyl bromide as a structural fumigant	74-83-9
Methyl mercury (dimethyl mercury)	593-74-8
Methyltestosterone	58-18-4
Midazolam hydrochloride	59467-96-8
Minocycline hydrochloride (internal use)	13614-98-7
Misoprostol	59122-46-2
Mitoxantrone hydrochloride	70476-82-3
Nafarelin acetate	86220-42-0
Neomycin sulfate (internal use)	1405-10-3
Netilmicin sulfate	56391-57-2
Nicotine	54-11-5
Nitrogen mustard (Mechlorethamine)	51-75-2
Nitrogen mustard hydrochloride (Mechlorethamine hydrochloride)	55-86-7
Norethisterone (Norethindrone)	68-22-4
Norethisterone acetate (Norethindrone acetate)	51-98-9
Norethisterone (Norethindrone)/Ethinyl estradiol	68-22-4/57-63-6
Norethisterone (Norethindrone)/Mestranol	68-22-4/72-33-3
Norgestrel	6533-00-2
Oxazepam	604-75-1
Oxytetracycline (internal use)	79-57-2
Oxytetracycline hydrochloride(internal use)	2058-46-0
Paramethadione	115-67-3
Penicillamine	52-67-5
Pentobarbital sodium	63-98-9
Phenprocoumon	435-97-2
Pipobroman	54-91-1

Plicamycin	18378-89-7
Polybrominated biphenyls	922-66-0
Polychlorinated biphenyls	various
Procarbazine hydrochloride	366-70-1
Propylthiouracil	51-52-5
Retinol/retinyl esters, when in daily dosages in excess of 10,000 IU, or 3,000 retinol equivalents. (NOTE: Retinol/retinyl esters are required and essential for maintenance of normal reproductive function. The recommended daily level during pregnancy is 8,000 IU.)	
Ribavirin	36791045
Secobarbital sodium	309-43-3
Streptomycin sulfate	3810-74-0
Tamoxifen citrate	54965-24-1
Temazepam	846-50-4
Testosterone cypionate	58-20-8
Testosterone enanthate	315-37-7
2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)	1746-01-6
Tetracyclines (internal use)	various
Tetracycline (internal use)	60-54-8
Tetracycline hydrochloride (internal use)	64-75-5
Thalidomide	50-35-1
Thioguanine	154-42-7
Tobacco smoke (primary)	n/a
Tobramycin sulfate	108-88-3
Triazolam	28911-01-5
Trilostane	13647-35-3
Trimethadione	127-48-0
Uracil mustard	66-75-1
Urethane	51-79-6
Urofollitropin	26995-91-5
Valproate (Valproic acid)	99-66-1
Vinblastine sulfate	143-67-9
Vincristine sulfate	2068-78-2
Warfarin	81-81-2

Female Reproductive Toxicity

Aminopterin	54-62-6

Anabolic steroids	n/a
Aspirin(NOTE: It is especially important not to use aspirin during the last three months of pregnancy, unless specifically directed to do so by a physician because it may cause problems in the unborn child or complications during delivery.)	50-78-2
Carbon disulfide	75-15-0
Cocaine	50-36-2
Cyclophosphamide (anhydrous)	50-18-0
Cyclophosphamide (hydrated)	6055-19-2
Ethylene oxide	75-21-8
Lead	
Tobacco smoke (primary)	n/a
Uracil mustard	66-75-1

Male Reproductive Toxicity

Anabolic steroids	n/a
Benomyl	17804-35-2
Carbon disulfide	75-15-0
Colchicine	64-86-8
Cyclophosphamide (anhydrous)	50-18-0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8
m-Dinitrobenzene	99-65-0
o-Dinitrobenzene	528-29-0
p-Dinitrobenzene	100-25-4
Dinoseb	88-85-7
Ethylene glycol monoethyl ether	110-80-5
Ethylene glycol monomethyl ether	109-86-4
Ethylene glycol monoethyl ether acetate	111-15-9
Ethylene glycol monomethyl ether acetate	110-49-6
Hexamethylphosphoramide	680-31-9
Lead	7439-92-1
Nitrofurantoin	67-20-9
Tobacco smoke (primary)	n/a
Uracil mustard	66-75-1

Last Update: 8/20/97 Tom Shelley

Cornell Acutely Toxic Chemicals

Based on OSHA Standard 29 CFR 1910.119 App A

CHEMICAL NAME	CAS NUMBER
Acetaldehyde	75-07-0
Acrolein (2-Propenal)	107-02-8
Acrylyl Chloride	814-68-6
Allyl Chloride	107-05-1
Allylamine	107-11-9
Alkylaluminums	Varies
Ammonia, Anhydrous	7664-41-7
Ammonia solutions (greater than 44% ammonia by weight)	7664-41-7
Ammonium Perchlorate	7790-98-9
Ammonium Permanganate	7787-36-2
Arsine (also called Arsenic Hydride)	7784-42-1
Bis(Chloromethyl) Ether	542-88-1
Boron Trichloride	10294-34-5
Boron Trifluoride	7637-07-2
Bromine	7726-95-6
Bromine Chloride	13863-41-7
Bromine Pentafluoride	7789-30-2
Bromine Trifluoride	7787-71-5
3-Bromopropyne (also called Propargyl Bromide)	106-96-7
Butyl Hydroperoxide (Tertiary)	75-91-2
Butyl Perbenzoate (Tertiary)	614-45-9
Carbonyl Chloride (see Phosgene)	75-44-5
Carbonyl Fluoride	353-50-4
Cellulose Nitrate (concentration greater than 12.6% nitrogen)	9004-70-0
Chlorine	7782-50-5
Chlorine Dioxide	10049-04-4
Chlorine Pentafluoride	13637-63-3
Chlorine Trifluoride	7790-91-2
Chlorodiethylaluminum (also called Diethylaluminum Choride)	91-10-6
1-Chloro-2, 4-Dinitrobenzene	97-00-7
Chloromethyl Methyl Ether	107-30-2
Chloropicrin	76-06-2
Chloropicrin and Methyl Bromide mixture	None
Chloropicrin and Methyl Chloride mixture	None
Commune Hydroperoxide	80-15-9
Cyanogen	460-19-5

Cyanogen Chloride	506-77-4
Cyanuric Fluoride	675-14-9
Diacetyl Peroxide (concentration greater than 70%)	110-22-5
Diazomethane	334-88-3
Dibenzoyl Peroxide	94-36-0
Diborane	19287-45-7
Dibutyl Peroxide (Tertiary)	110-05-4
Dichloro Acetylene	7572-29-4
Dichlorosilane	4109-96-0
Diethylzinc	557-20-0
Diisopropyl Peroxydicarbonate	105-64-6
Dilauroyl Peroxide	105-74-8
Dimethyldichlorosilane	75-78-5
Dimethylhydrazine, 1,1-	57-14-7
Dimethylamine, Anhydrous	124-40-3
2, 4-Dinitroaniline	97-02-9
Ethyl Methyl Ketone Peroxide (also Methyl Ethyl Ketone Peroxide; concentration greater than 60%)	1338-23-4
Ethyl Nitrite	109-95-5
Ethylamine	75-04-7
Ethylene Fluorohydrin	371-62-0
Ethylene Oxide	75-21-8
Ethyleneimine	151-56-4
Fluorine	7782-41-4
Formaldehyde (Formalin)	50-00-0
Furan	110-00-9
Hexafluoroacetone	684-16-2
Hydrochloric Acid, Anhydrous	7647-01-0
Hydrofluoric Acid, Anhydrous	7664-39-3
Hydrogen Bromide	10035-10-6
Hydrogen Chloride	7647-01-0
Hydrogen Cyanide, Anhydrous	74-90-8
Hydrogen Fluoride	7664-39-3
Hydrogen Peroxide (52% by weight or greater)	7722-84-1
Hydrogen Selenide	7783-07-5
Hydrogen Sulfide	7783-06-4
Hydroxylamine	7803-49-8
Iron, Pentacarbonyl	13463-40-6
Isopropylamine	75-31-0
Ketene	463-51-4
Methacrylaldehyde	78-85-3
Methacryloyl Chloride	920-46-7
Methacryloyloxyethyl Isocyanate	30674-80-7
Methyl Acrylonitrile	126-98-7
Methylamine, Anhydrous	74-89-5

Methyl Bromide	74-83-9
Methyl Chloride	74-87-3
Methyl Chloroformate	79-22-1
Methyl Ethyl Ketone Peroxide (concentration greater than 60%)	1338-23-4
Methyl Fluoroacetate	453-18-9
Methyl Fluorosulfate	421-20-5
Methyl Hydrazine	60-34-4
Methyl Iodide	74-88-4
Methyl Isocyanate	624-83-9
Methyl Mercaptan	74-93-1
Methyl Vinyl Ketone	79-84-4
Methyltrichlorosilane	75-79-6
Nickel Carbonyl (Nickel Tetracarbonyl)	13463-39-3
Nitric Acid (94.5% or greater by weight)	7697-37-2
Nitric Oxide	10102-44-0
Nitroaniline (para-Nitroaniline)	100-01-6
Nitromethane	75-52-5
Nitrogen Dioxide	10102-44-0
Nitrogen Oxides (NO; NO(2); N2O4; N2O3)	10102-44-0
Nitrogen Tetroxide (also called Nitrogen Peroxide)	10544-72-6
Nitrogen Trifluoride	7783-54-2
Nitrogen Trioxide	10544-73-7
Oleum (65% to 80% by weight; also called Fuming Sulfuric Acid)	8014-94-7
Osmium Tetroxide	20816-12-0
Oxygen Difluoride (Fluorine Monoxide)	7783-41-7
Ozone	10028-15-6
Pentaborane	19624-22-7
Peracetic Acid (concentration greater than 60% Acetic Acid; also called Peroxyacetic Acid)	79-21-0
Perchloric Acid (concentration greater than 60% by weight)	7601-90-3
Perchloromethyl Mercaptan	594-42-3
Perchloryl Fluoride	7616-94-6
Peroxyacetic Acid (concentration greater than 60% Acetic Acid; also called Peracetic Acid)	79-21-0
Phosgene (also called Carbonyl Chloride)	75-44-5
Phosphine (Hydrogen Phosphide)	7803-51-2
Sulfur Dioxide (liquid)	7446-09-5
Sulfur Pentafluoride	5714-22-7
Sulfur Tetrafluoride	7783-60-0
Sulfur Trioxide (also called Sulfuric Anhydride)	7446-11-9
Sulfuric Anhydride (also called Sulfur Trioxide)	7446-11-9
Tellurium Hexafluoride	7783-80-4

Tetrafluoroethylene	116-14-3
Tetrafluorohydrazine	10036-47-2
Tetramethyl Lead	75-74-1
Thionyl Chloride	7719-09-7
Trichloro (chloromethyl) Silane	1558-25-4
Trichloro (dichlorophenyl) Silane	27137-85-5
Trichlorosilane	10025-78-2
Trifluorochloroethylene	79-38-9
Trimethyoxysilane	2487-90-3

Poison Inhalation List (Revised 5/23/95)

arsenic pentafluoride
arsine
boron trichloride
boron trifluoride
bromine pentafluoride
bromine trifluoride
bromotrifluoroethylene
carbonyl fluoride
carbonyl sulfide
chlorine
chlorine pentachloride
chlorine trifluoride
chloropicrin (in mixes)
cyanogen chloride
diborane
dichlorosilane
digermane
dimethylamine
dinitrogen tetroxide
disilane
ethylene oxide
fluorine
germane
hexamethyltetraphosphate
hydrogen bromide
hydrogen chloride
hydrogen cyanide
hydrogen fluoride
hydrogen iodide
hydrogen selenide
hydrogen sulfide
methyl chloride
methyl mercaptan
methyl silane
nitric oxide
nitrogen dioxide
nitrogen trifluoride
nitrogen trioxide
oxygen difluoride
phosgene
phosphine
phosphorous pentafluoride
selenium hexafluoride
silane
silicon tetrachloride
silicon tetrafluoride
stibine
sulfur dioxide
sulfur tetrafluoride
tellurium hexafluoride
tetraethyldithiopyrophosphate
tetraethylpyrophosphate
triethylaluminum
triethylborane
triethylgallium
trimethylaluminum
trimethylamine
trimethylgallium
vinyl bromide
vinyl chloride
vinyl fluoride

Peroxide Forming Compounds

Many liquid organic compounds, a few solid and gaseous organic compounds and a few inorganic solids form peroxides upon storage. Most organic peroxides are sensitive to shock, heat or friction to varying degrees. These compounds form by the reaction of the chemical with oxygen allowed in the head space of chemical containers once the container is opened for the first time. Peroxides form at varying rates depending upon the compound. Some peroxides quickly build up to an explosive level and some are only explosive on concentration, such as when a solvent is distilled. Although there is no agreement upon what level of peroxides present a significant hazard, several sources suggest that the "safe" range of peroxide formation is 100 ppm or less. We recommend that all peroxide forming chemicals be tested at the end of the appropriate storage period (see below). If peroxides are detected at a level above 100 ppm, the material must be decontaminated with standard procedures for removing peroxides or discarded as hazardous waste if the material can not be drain disposed. Test strips for the detection of peroxides may be purchased from the Chemistry Department stock room in S. T. Olin Research Wing or from VWR, Fisher Scientific or other lab supply houses. Several chemical methods for the detection of peroxides are also available.

Control and Safe Use of Peroxide Formers

Peroxide formation may be controlled by the following methods:

- Date all incoming containers of peroxide formers when received and again when opened.
- Many chemical companies now routinely print an expiration date on containers of the worst peroxide formers.
- Purchase the smallest possible container size for your needs.
- Store peroxide formers in sealed, air-impermeable containers such as dark amber glass with a tight-fitting cap.
- Iron inhibits the formation of peroxides in some materials, which is why diethyl ether and some other materials are purchased in metal cans. Ground glass stoppered bottles and plastic containers are not advisable, however, plastic squeeze bottles may be used for small quantities of some materials, such as 2-propanol, for immediate use.
- Store peroxide formers in the dark.
- Inhibitors are added to some chemicals and the purchase of peroxide formers with added inhibitors is encouraged.
- Store peroxide formers, especially those in Table A below, under nitrogen or other inert gas or keep and use them in an inert atmosphere chamber. Note: Some inhibitors actually need small amounts of oxygen to prevent peroxide formation and it is recommended that inhibited chemicals are not stored under an inert atmosphere.

Avoid the distillation of peroxide formers without first testing for the existence of peroxides in the material. Most explosions with the use of peroxide formers occur when a material is distilled to dryness. Leave at least 10-20% bottoms. Stir such distillations with a mechanical stirrer or a bubbling inert gas. Air or an oxygen containing mixture should never be used for bubbling or stirring.

Safe Storage Periods for Peroxide Formers

Unopened chemicals from manufacturer	18 months (or expiration date)
Opened containers:	
Chemicals in Table A.	3 months
Chemicals in Tables B. and D.	12 months
Uninhibited chemicals in Table C.	24 hours
Inhibited chemicals in Table C.	12 months

(Do not store under an inert atmosphere)

A. Chemicals that form explosive levels of peroxides without concentration.

Butadiene[a]	Isopropyl ether	Sodium amide (sodamide)
Chloroprene[a]	Potassium metal	Tetrafluoroethylene[a]
Divinylacetylene	Potassium amide	Vinylidene chloride

B. Chemicals that form explosive levels of peroxides on concentration

Acetal	Diethyl ether	2-Pentanol
Acetaldehyde	Diethylene glycol dimethyl ether (diglyme)	4-Penten-1-ol
Benzyl alcohol	Dioxanes	1-Phenylethanol
2-Butanol	Ethylene glycol dimethyl ether (glyme)	2-Phenylethanol
Cumene	4-Heptanol	2-Propanol
Cyclohexanol	2-Hexanol	Tetrahydrofuran
2-Cyclohexen-1-ol	Methylacetylene	Tetrahydronaphthalene
Cyclohexene	3-Methyl-1-butanol	Vinyl ethers
Decahydronaphthalene	Methylcyclopentane	Other secondary alcohols
Diacetylene	Methyl isobutyl ketone	
Dicyclopentadiene	4-Methyl-2-pentanol	

C. Chemicals that may autopolymerize as a result of peroxide accumulation

Acrylic acid[b]	Methyl methacrylate[b]	Vinyl chloride
Acrylonitrile[b]	Styrene	Vinylpyridine
Butadiene[c]	Tetrafluoroethylene[c]	Vinyladiene chloride
Chloroprene[c]	Vinyl acetate	
Chlorotrifluoroethylene	Vinylacetylene	

D. Chemicals that may form peroxides but cannot clearly be placed in sections A - C.

Acrolein
Allyl ether[d]
Allyl ethyl ether
Allyl phenyl ether
p-(*n*-Amyloxy)benzoyl chloride
n-Amyl ether
Benzyl *n*-butyl ether[d]
Benxyl ether[d]
Benzyl ethyl ether[d]
Benzyl methyl ether
Benzyl 1-napthyl ether[d]
1,2-Bis(2-chloroethoxy)ethane
Bis(2 ethoxyethyl)ether
Bis(2-(methoxyethoxy)ethyl) ether
Bis(2-chloroethyl)ether
Bis(2-ethoxyethyl)adipate
Bis(2-ethoxyethyl) phthalate
Bis(2-methoxyethyl) carbonate
Bis(2-methoxyethyl) ether
Bis(2-methoxyethyl) phthalate
Bis(2-methoxymethyl) adipate
Bis(2-n-butoxyethyl) phthalate
Bis(2-phenoxyethyl) ether
Bis(4-chlorobutyl) ether
Bis(chloromethyl) ether[e]
2-Bromomethyl ethyl ether
B-Bromophenetole
o-Bromophenetole
p-Bromophenetole
3-Bromopropyl phenyl ether
1,3-Butadiyne
Buten-3-yne
tert-Butyl ethyl ether
tert-Butyl methyl ether
n-Butyl phenyl ether
n-Butyl vinyl ether
Chloroacetaldehyde diethylacetal[d]
2-Chlorobutadiene
1-(2-Chloroethoxy)-2-phenoxyethane -
Chloroethylene
Chloromethyl methyl ether[e]
B-Chlorophenetole
o-Chlorophenetole
p-Chlorophenetole
Cyclooctene[d]
Cyclopropyl methyl ether
Diallyl ether[d]
p-Di-n-butoxybenzene
1,2-Dibenzyloxyethane[d]
p-Dibenzyloxybenzene[d]
1,2-Dichloroethyl ethyl ether
2,4-Dichlorophenetole
Diethoxymethane[d]
2,2-Diethoxypropane
Diethyl ethoxymethylenemalonate
Diethyl fumarate[d]
Diethyl acetal[d]
Diethyketene[f]
m,o,p-diethoxybenzene
1,2-Diethoxyethane
Dimethoxymethane[d]
1,1-Dimethoxyethane[d]
Dimethylketene[f]
3,3-Dimethoxypropene
2,4-Dinitrophenetole
1,3-Dioxepane[d]
Di(1-propynyl)ether[f]
Di(2-propynyl)ether
Di-*n*-propoxymethane[d]
1,2-Epoxy-3-isopropoxypropane[d]
1,2-Epoxy-3-phenoxypropane
p-Ethoxyacethophenone
1-(2-Ethoxyethoxy)ethyl acetate
2-Ethoxyethyl acetate
(2-Ethoxyethyl)-o-benzoyl benzoate
1-Ethoxynaphthalene
o,p-Ethoxyphenyl isocyanate
1-Ethoxy-2-propyne
3-Ethoxyopropionitrile
2-Ethylacrylaldehyde oxime
2-Ethylbutanol
Ethyl *B*-ethoxypropionate
2-Ethylhexanal
Ethyl vinyl ether

Furan
2,5-Hexadiyn-1-ol
4,5-Hexadien-2-yn-1-ol
n-Hexyl ether
o,p-Iodophenetole
Isoamyl benzyl ether[d]
Isoamyl ether[d]
Isobutyl vinyl ether
Isophorone[d]
B-Isopropoxypropionitrile[d]
Isopropyl 2,4,5-trichlorophenoxyacetate
Limonene
1,5-*p*-Methadiene
Methyl *p*-(*n*-amyloxy)benzoate
4-Methyl-2-pentanone
n-Methylphenetole
2-Methyltetrahydrofuran
3-Methoxy-1-butyl acetate
2-Methoxyethanol
3-Methoxyethyl acetate
2-Methoxyethyl vinyl ether
Methonxy-1,3,5,7-cyclooctatetraene
B-Methoxypropionitrile
m-Nitrophenetole
1-Octene
Oxybis(2-ethyl acetate)
Oxybis(2-ethyl benzoate)
B,B-oxydipropionitrile
1-Pentene
Phenoxyacetyl chloride
a-Phenoxypropionyl chloride
Phenyl *o*-propyl ether
p-Phenylphenetone
n-Propyl ether
n-Propyl isopropyl ether
Sodium 8,11,14-eicosatetraenoate
Sodium ethoxyacetylide[f]
Tetrahydropyran
Triethylene glycol diacetate
Triethylene glycol dipropionate
1,3,3-Trimethoxypropene[d]
1,1,2,3-Tetrachloro 1,3-butadiene
4-Vinyl cyclohexene
Vinylene carbonate
Vinylidene chloride[d]

NOTES:

[a] When stored as a liquid monomer**.**

[b] Although these chemicals form peroxides, no explosions involving these monomers have been reported**.**

[c] When stored in liquid form, these chemicals form explosive levels of peroxides without concentration. They may also be stored as a gas in gas cylinders. When stored as a gas, these chemicals may autopolymerize as a result of peroxide accumulation**.**

[d] These chemicals easily form peroxides and should probably be considered under Part B.

[e] OSHA - regulated carcinogen**.**

[f] Extremely reactive and unstable compound**.**

References:

Prudent Practices in the Laboratory, National Research Council, 1995.
"Review of Safety Guidelines for Peroxidizable Organic Chemicals," *Chemical Health and Safety*, September/October 1996.

The Safe Use of Perchloric Acid

Perchloric acid is a very strong oxidizing agent, often used for the hot digestion of a variety of materials. Perchloric acid as used in the cold, dilute form in certain biochemical protocols is relatively safe. It can cause violent explosions if misused or when concentrated above the normal commercial strength of 72%. Anhydrous perchloric acid should never be prepared as it is unstable at room temperature and will decompose with a violent explosion. The following rules for the hot use of perchloric acid must be followed at all times:

- Hot perchloric acid work may only be conducted in a rated perchloric acid hood or, under special, well-controlled circumstances, with a high efficiency scrubber.
- A perchloric acid hood must be washed down after every use or once per week, which-ever comes first.
- Do not store or use organic materials, such as solvents, in a perchloric acid use hood.
- If a vacuum is needed for perchloric acid work use a water aspirator rather than a mechanical pump. Perchloric acid contact with hydrocarbon based oils or greases in a conventional mechanical vacuum pump may result in an explosion.
- Use the minimum amount of material possible.
- Purchase the smallest quantity available for your needs.
- Store perchloric acid away from all oxidizable materials, using secondary containment.
- All containers of perchloric acid in storage must be inspected frequently. Discolored perchloric acid is dangerous and must be disposed of at once.
- Do not use or store perchloric acid on wooden lab furniture or cracked or porous benchtop materials.
- When possible, use alternative techniques not requiring perchloric acid.
- Do not attempt to clean up spills of concentrated perchloric acid yourself as contact with oxidizable materials can cause an immediate explosion. If you spill perchloric acid call 911 and EH&S will respond to clean up the spill.

References:

Prudent Practices in the Laboratory, National Research Council, 1995.
CRC Handbook of Laboratory Safety, 3rd Ed., CRC Press, 1990.

INCOMPATIBLE CHEMICAL COMBINATIONS

Substances in the left-hand column should be stored and handled so they cannot contact corresponding substances in the right-hand column. The following list contains some of the chemicals commonly found in laboratories, but it should not be considered exhaustive. Information for the specific chemical you are using, can usually be found in the "REACTIVITY" or "INCOMPATIBILITIES" section of the Material Safety Data Sheet. EH&S has a copy of *Rapid Guide to Chemical Incompatibilities*, by Pohanish and Greene, which lists the incompatibilities of hundreds of chemicals. You may come to our office at 125 Humphreys Service Building and use this valuable reference at any time.

Alkaline and alkaline earth metals, such as sodium, potassium, cesium, lithium, magnesium, calcium	Carbon dioxide, carbon tetrachloride and other chlorinated hydrocarbons, any free acid or halogen . Do not use water, foam or dry chemical on fires involving these metals.
Acetic anhydride	Chromic acid, nitric acid, hydroxyl-containing compounds, ethylene glycol, perchloric acid, peroxides and permanganates.
Acetone	Concentrated nitric and sulfuric acid mixtures.
Acetylene	Copper, silver, mercury and halogens.
Aluminum alkyls	Halogenated hydrocarbons, water.
Ammonia (anhydrous)	Silver, mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride, chlorine dioxide.
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organics or combustibles.
Aniline	Nitric acid, hydrogen peroxide.
Benzoyl peroxide	Chloroform, organic materials.
Bromine	Ammonia, acetylene, butadiene, butane and other petroleum gases, sodium carbide, turpentine, benzene and finely divided metals.
Calcium carbide	Water (see also acetylene).
Calcium hypochlorite	Methyl carbitol, phenol, glycerol, nitromethane, iron oxide, ammonia, activated carbon.
Calcium Oxide	Water.
Carbon, activated	Calcium hypochlorite.
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organics or combustibles.
Chlorine	Ammonia, acetylene, butadiene, butane and other

	petroleum gases, hydrogen, sodium carbide, turpentine, benzene and finely divided metals.
Chlorine dioxide	Ammonia, methane, phosphine and hydrogen sulfide.
Chlorosulfonic acid	Organic materials, water, powdered metals.
Chromic acid	Acetic acid, naphthalene, camphor, glycerine, turpentine, alcohol and other flammable liquids, paper or cellulose.
Copper	Acetylene, hydrogen peroxide, ethylene oxide.
Cumene hydroperoxide	Acids, organic or mineral.
Ethylene oxide	Acids, bases, copper, magnesium perchlorate.
Fluorine	Almost all oxidizable substances.
Hydrocyanic acid	Nitric acid, alkalis.
Hydrogen peroxide	Copper, chromium, iron, most metals or their salts, any flammable liquid, combustible materials, aniline, nitromethane.
Hydrides	Water, air, carbon dioxide, chlorinated hydrocarbons.
Hydrofluoric acid, anhydrous (hydrogen fluoride)	Ammonia (anhydrous or aqueous), organic peroxides.
Hydrogen sulfide	Fuming nitric acid, oxidizing gases.
Hydrocarbons (benzene, butane, propane, gasoline, turpentine, etc.)	Fluorine, chlorine, bromine, chromic acid, sodium peroxide, fuming nitric acid.
Hydroxylamine	Barium oxide, lead dioxide, phosphorus pentachloride and trichloride, zinc, potassium dichromate.
Iodine	Acetylene, ammonia (anhydrous or aqueous).
Maleic anhydride	Sodium hydroxide, pyridine and other tertiary amines.
Mercury	Acetylene, fulminic acid, ammonia, oxalic acid.
Nitrates	Acids, metal powders, flammable liquids, chlorates, sulfur, finely divided organics or combustibles.
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic, acid, hydrogen sulfide, flammable liquids, flammable gases, nitratable substances, organic peroxides, chlorates.
Nitroparaffins	Inorganic bases.

Oxygen	Oil, grease, hydrogen, flammable liquids, solids, or gases.
Oxalic acid	Silver, mercury, organic peroxides.
Perchlorates	Acids.
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oil, organic amines or antioxidants.
Peroxides, organic	Acids (organic or mineral); avoid friction.
Phosphorus (white)	Air, oxygen.
Phosphorus pentoxide	Propargyl alcohol.
Potassium chlorate	Acids (see also chlorates).
Potassium perchlorate	Acids (see also perchloric acid).
Potassium permanganate	Glycerine, ethylene glycol, benzaldehyde, any free acid.
Silver	Acetylene, oxalic acid, tartaric acid, fulminic acid, ammonium compouunds.
Sodium	See alkaline metals (above).
Sodium amide	Air, water.
Sodium nitrate	Ammonium nitrate and other ammonium salts.
Sodium oxide	Water, any free acid.
Sodium peroxide	Any oxidizable substance, such as ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerine, ethylene glycol, ethyl acetate, methyl acetate and furfural.
Sulfuric acid	Chlorates, perchlorates, permanganates, organic peroxides.
UDMH (1,1-Dimethylhydrazine)	Oxidizing agents such as hydrogen peroxide and fuming nitric acid.
Zirconium	Prohibit water, carbon tetrachloride, foam and dry chemical on zirconium fires.

Reference Materials on Chemical Safety

All of the following references are available for your use at the Environmental Health and Safety office at 125 Humphreys Service Building.

ACS Task Force on Laboratory Waste Management, *Laboratory Waste Management: A Guidebook*, American Chemical Society, 1994.

The best available reference on lab waste management.

American Chemical Society, *Safety in Academic Chemistry Laboratories*, Sixth Edition, American Chemical Society , 1995.

A concise, highly readable, basic safety manual.

Armour, M. A., *Hazardous Laboratory Chemicals Disposal Guide*, Second Edition, CRC Press, 1991.

Very useful reference on the detoxification of hazardous laboratory chemicals.

Ash, M. and Ash, I., *Gardner's Chemical Synonyms and Trade Names*, Gower, 1994.

This is a very useful reference for identifying the components of commercial products.

Barlow, S. M. and Sullivan, F. M., *Reproductive Hazards of Industrial Chemicals*, Academic Press, 1982.

A detailed reproductive hazard analysis is given for a wide variety of chemicals, many of which are commonly used in laboratories.

Benedetti, B. P., Ed., *Flammable and Combustible Liquids Code Handbook*, Third Edition, National Fire Protection Association, 1987.

Industry standard handbook for the use of flammable liquids.

Budavari, S., Ed., *The Merk Index*, Merk & Co., Inc., 1996

"An encyclopedia of chemicals, drugs and biologicals."

Clayton, G. D. and Clayton, F. C., *Patty's Industrial Hygiene and Toxicology*, Fourth Edition, John Wiley and Sons, Inc., 1993

An encyclopedic ten volume work covering all aspects of industrial hygiene, hazardous chemicals and toxicology.

Compressed Gas Association, *Handbook of Compressed Gases*, Third Edition, Chapman and Hall, 1990.

Industry standard handbook for the use of compressed gases.

Forsberg, K. and Mansdorf, S. Z., *Quick Selection Guide to Chemical Protective Clothing*, Third Edition, Van Nostrand Reinhold, 1997.

A very useful pocket guide for the selection of gloves and chemically resistant clothing.

Furr, A. Keith, ed., *CRC Handbook of Laboratory Safety*, Fourth Edition, CRC Press, Inc., 1995.

Comprehensive laboratory safety resource that provides specific procedures for many laboratory operations.

Klaassen, C. D., Amdur, M. O. and Doull, J., *Casarett and Doull's Toxicology*, Third Edition, Macmillan Publishing Co., 1986.

The classic, standard treatise on toxicology.

Lewis, Richard J., Sr., Ed., *Hawley's Condensed Chemical Dictionary*, 13th Edition, Van Nostrand Reinhold, 1997.

Very useful general reference in a dictionary format.

Lewis, Richard J., Sr., Ed., *Rapid Guide to Hazardous Chemicals in the Workplace*, Van Nostrand Reinhold, 1994.

A useful paperback quick-reference to the properties of hazardous chemicals.

Lunn, G. and Sansone, E. B., *Destruction of Hazardous Chemicals in the Laboratory*, Second Edition, John Wiley and Sons, Inc., 1994.

Very useful reference on the detoxification of hazardous laboratory chemicals.

Meyer, E., *Chemistry of Hazardous Materials*, Third Edition, Prentice-Hall, 1998.

A thorough treatment of the chemistry of various hazardous materials. Good background material.

National Research Council Committee on Prudent Practices for Handling, Storage and Disposal of Chemicals in Laboratories, *Prudent Practices in the Laboratory*, National Academy Press, Washington, D. C., 1995.

Designed as a reference tool for laboratory personnel. Recommends procedures for the safe handling and disposal of hazardous substances, and for the development of comprehensive safety programs.

NIOSH, *Registry of Toxic Effects of Chemical Substances (RTECS)*, 1988 Edition, NTIS Order Number: PB90-131582INZ.*

Cross-indexed information on over 133,000 different chemicals. RTECS is a compendium of data extracted from the open scientific literature. The data are arranged in alphabetical order by prime chemical name. Six types of toxicity data are included in the file: (1) primary irritation; (2) mutagenic effects; (3) reproductive effects; (4) tumorgenic effects; (5) acute toxicity; and (6) other multiple dose toxicity. Specific numeric toxicity values such as LD50, LC50, TDLo, and TCLo are noted as well as species studied and route of administration used. For each citation, the bibliographic source is listed thereby enabling the user to access the actual studies cited. A standard reference for toxicologists.

NIOSH/OSHA, *Pocket Guide to Chemical Hazards*, 1997, DHHS (NIOSH) Publication No. 97-140, GPO Stock No. 017-033-00483-8. *

Quick reference for hundreds of hazardous chemicals for which there are specific Federal regulations. Contains key data on exposure levels, properties, incompatibilities, personal protection, and health hazards. Also available on the Web at: http://www.cdc.gov/niosh/npg/npg.html

Patnaik, P., *A Comprehensive Guide to the Hazardous Properties of Chemical Substances*, Van Nostrand Reinhold, 1992.

An authoritative guide to the properties, hazards, toxicology and disposal of hundreds of hazardous chemicals. These concise entries would be very useful for those planning a wide variety of experiments.

Pipitone, D. A., *Safe Storage of Laboratory Chemicals*, John Wiley and Sons, 1984.

A classic text on the storage of chemicals.

Reinhardt, P., A., Leonard, K. L., and Ashbrook, P. C., *Pollution Prevention and Waste Minimization in Laboratories*, CRC Press, Inc., 1996.

A useful collection of in-depth essays on lab waste minimization.

Richardson, J. H., and Barkley, W. E., Ed., *Biosafety in Microbiological and Biomedical Laboratories*, Centers for Disease Control and National Institutes of Health, Second Edition, 1988, HHS Publication No. (CDC) 88-8395.*

Comprehensive, “official” guidelines for the use of biohazardous materials.

Sax, N. I., *Cancer Causing Chemicals*, Van Nostrand Co., Inc., 1981.

A comprehensive, although slightly dated, list of all classes of carcinogens and their properties and effects.

Sax, N. I., *Dangerous Properties of Industrial Materials*, Sixth Edition, Van Nostrand Reinhold Co., 1984.

Contains very brief "hazard analysis" information for over 10,000 industrial laboratory substances. Emphasis is on flammability, explosivity, and reactivity data. Gives a limited amount of toxicity information. Lists some references.

Sax, N. I. and Lewis, R. J., Sr., *Rapid Guide to Hazardous Chemicals in the Workplace*, Van Nostrand Co., Inc., 1986.

A compact book with basic information on about 700 common hazardous chemicals.

Shepard, T. H., *Catalog of Teratogenic Agents*, Fifth Edition, John Hopkins University Press, 1986.

A comprehensive, although slightly dated, list of all classes of teratogens and their properties and effects.

Stopford, W. and Bunn, W. B., Ed., *Effects of Exposure to Toxic Gases--First Aid and Medical Treatment*, Third Edition, Matheson Gas Products, 1988.

This is considered the standard reference for the topic.

Urben, P. G., *Bretherick's Handbook of Reactive Chemical Hazards*, Fifth Edition, Butterwoirth-Heinemann, 1995.

A very comprehensive compilation of the incompatibilities of thousands of hazardous chemicals. Extremely useful for planning experiments.

Walters, D. B., *Safe Handling of Chemical Carcinogens, Mutagens, Teratogens and Highly Toxic Substances*, Ann Arbor Science, 1980.

Detailed essays on the handling of highly hazardous chemicals.

* For sale by Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

FEDERAL HAZARD COMMUNICATION STANDARD

Basic Purpose

The Federal Hazard Communication Standard was designed to require employers to furnish their employees with information concerning the hazards of chemicals used in the workplace and protective measures employees can take to reduce their exposure to those chemicals.

Requirements of the Standard

Employers are required to provide information to employees about the hazardous chemicals to which they are exposed. For employees routinely exposed to hazardous chemicals, employers are required to take the following steps:

1. Develop an inventory of hazardous chemicals known to be present in the work place, make this list available to employees.
2. Material Safety Data Sheets (MSDSs) are to be obtained from chemical manufacturers and distributors, and maintained in a file that must be accessible to employees. Ask your supervisor for the location of the red Toxic Substances Notebook, which contains the MSDSs, or call Environmental Health and Safety (255-8200).
3. Employers are required to ensure that the labels on incoming containers list the identity of the contents as well as appropriate hazard warnings. The labels are not to be defaced or removed. When chemicals are transferred from an incoming container to a portable container, the portable container must be labeled with the identity and hazards of that chemical.
4. Employers are required to establish an information and training program for employees. The information and training on hazardous chemicals is to be provided prior to the assignment of an employee to a department, and whenever a new hazard is introduced into the work area.
5. Employers are required to prepare a written hazard communication program. This program must describe how the employer will convey labeling, MSDS, and various other information and training to employees. The written program must also include a list of hazardous chemicals used in the work place, as well as the method employers will use to inform employees of the hazards of non-routine tasks. The written Hazard Communication program for Cornell University, which is available for employees' review, is located at Environmental Health and Safety, 125 Humphreys Service Building (255-8200), and is also available at Campus Police, G-2 Barton Hall, where it is accessible on a 24-hour basis.

Of Special Interest to Laboratory Workers:

For laboratory operations, the following aspects of the Hazard Communication Program will apply:

1. Labels on incoming containers will not be removed or defaced.
2. Material safety data sheets that are received with the products must be maintained and will be available to laboratory personnel.
3. Employees will be informed of the potential hazards of chemicals through an appropriate information and training program.

The MSDS

This section provides information for researchers who may need to prepare an MSDS. An MSDS must be prepared for a newly created *hazardous* chemical or an intermediate product produced in a chemical reaction if:

1) The newly created chemical or intermediate is going to be shipped by the originator off the Cornell Campus or,

2) The newly created chemical or intermediate is going to be kept in the lab on an on-going basis for use by researchers, current or future, in the lab where it was originally made or at other research facilities at Cornell.

Note: If a newly created *hazardous* chemical is going to be used by a number of persons over time it may be required that a Right-to-Know chemical container label be prepared for the new chemical.

Section 16 is broken down into two parts. The first part (16.1-16.4) is a blank MSDS form (OSHA Form 174) which you may print out and use to create an MSDS for a chemical you have produced. The second part (16.5-16.8) is an annotated Form 174 with instructions on completing the Form. It is important to consider that all sections must be completed when writing an MSDS. If a particular characteristic is unknown, you must state "unknown" or "not available" or "N/A." Under Section V, Health Hazard Data, you may be able to say, "The toxicological effects of this chemical have not (or not fully) been investigated."

If you need help completing an MSDS, please contact EH&S at 255-8200.

Prepared by Tom Shelley, 11/13/98

Material Safety Data Sheet

May be used to comply with
OSHA's Hazard Communication Standard,
29 CFR 1910.1200. This Standard must be
consulted for specific requirements.

U.S. Department of Labor

Occupational Safety and Health Administration
(Non-Mandatory Form)
Form Approved
OMB No. 1218-0072

IDENTITY *(As Used on Label and List)*	Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I

Manufacturer's Name	Emergency Telephone Number
Address *(Number, Street, City, State, and ZIP Code)*	Telephone Number for Information
	Date Prepared
	Signature of Preparer *(optional)*

Section II - Hazard Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% *(optional*

Section III - Physical/Chemical Characteristics

Boiling Point		Specific Gravity (H_2O = 1)	
Vapor Pressure (mm Hg.)		Melting Point	
Vapor Density (AIR = 1)		Evaporation Rate (Butyl Acetate = 1)	
Solubility in Water			
Appearance and Odor			

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
Extinguishing Media			
Special Fire Fighting Procedures			
Unusual Fire and Explosion Hazards			

Section V - Reactivity Data

Stability	Unstable		Conditions to Avoid
	Stable		
Incompatibility *(Materials to Avoid)*			
Hazardous Decomposition or Byproducts			
Hazardous Polymerization	May Occur		Conditions to Avoid
	Will Not Occur		

Section VI - Health Hazard Data

Route(s) of Entry:	Inhalation?	Skin?	Ingestion?
Health Hazards *(Acute and Chronic)*			
Carcinogenicity:	NTP?	IARC Monographs?	OSHA Regulated?
Signs and Symptoms of Exposure			
Medical Conditions Generally Aggravated by Exposure			
Emergency and First Aid Procedures			

Section VII - Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled
Waste Disposal Method
Precautions to Be taken in Handling and Storing
Other Precautions

Section VIII - Control Measures

Respiratory Protection *(Specify Type)*		
Ventilation	Local Exhaust	Special
	Mechanical *(General)*	Other

Protective Gloves	Eye Protection
Other Protective Clothing or Equipment	
Work/Hygienic Practices	

Section IX - Special Precautions

Precautions to be taken in Handling and Storing
Other Precautions

Each MSDS must be reviewed for correctness and completeness every three years.

Reviewed by _____ Reviewed by _____

Revision date _____ Revision date _____

HOW TO UNDERSTAND MATERIAL SAFETY DATA SHEETS

Chemical manufacturers are required by law to supply "Material Safety Data Sheets" (OSHA Form 174 or its equivalent) upon request by their customers. These sheets have nine sections giving a variety of information about the chemical. Following is a section-by-section reproduction and explanation of a Material Safety Data Sheet (MSDS).

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

MATERIAL SAFETY DATA SHEET

Required For compliance with OSHA Act of 1970
Public Law 91-596 (CFR 1910)

SECTION I	
Product Name	Size
Chemical Name	
Formula	
Manufacturer	
Address	
For Information on Health Hazards Call	
For Other Information Call	
Signature and date	

This section gives the name and address of the manufacturer and an emergency phone number where questions about toxicity and chemical hazards can be directed. Large chemical manufacturers have 24-hour hotlines manned by chemical safety professionals who can answer questions regarding spills, leaks, chemical exposure, fire hazard, etc. Other information that may be contained in Section I:

Trade Name: This is the manufacturer's name for the product.

Chemical Name and Synonyms: This refers to the generic or standard names for the chemical.

Chemical Family: This classification allows one to group the substance along with a class of similar substances, such as mineral dusts, acids, caustics, etc. The potential hazards of a substance can sometimes be gauged by experience with other chemicals of that class.

SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES		
Principal Hazardous component(s)	%	TVL (Units)

This section describes the percent composition of the substance, listing chemicals present in the mixture. It lists Threshold Limit Values for the different chemicals that are present.

Threshold Limit values (TLV's) are values for airborne toxic materials that are to be used as guides in the control of health hazards. They represent concentrations to which nearly all workers (workers without special sensitivities) can be exposed to for long periods of time without harmful effect. TLV's are usually expressed as parts per million (ppm), the parts of gas or vapor in each million parts of air. TLV's are also expressed as mg/m^3, the milligrams of dust or vapor per cubic meter of air.

SECTION III - PHYSICAL DATA			
Boiling Point (^oF)		Specific Gravity (H_2O=1)	
Vapor Pressure (mm Hg)		Percent Volatile By Volume (%)	
Vapor Density (Air=1)		Evaporation Rate (Butyl Acetate=1)	
Solubility in Water			
Appearance and Odor			

Vapor Pressure: Vapor pressure (VP) can be used as a measure of how volatile a substance is. That is, how quickly it evaporates. VP is measured in units of millimeters of mercury (mm Hg). For comparison, the VP of water (at 20^o Centigrade) is 17.5 mm Hg. The VP of Vaseline (a nonvolatile substance) would be close to zero mm Hg, while the VP of diethyl ether (a very volatile substance) is 440 mm Hg.

Vapor Density: This figure tells whether the vapor is lighter or heavier than air. The density of air is 1.0. A density greater than 1.0 indicates a heavier vapor, a density less than 1.0 indicates a lighter vapor. Vapors heavier than air (gasoline vapor for instance) can flow along just above the ground and can collect in depressions where they may pose a fire and explosion hazard.

Specific Gravity: This figure tells whether the liquid is lighter or heavier than water. Water has a density of 1.0.

Percent Volatile by Volume: Tells how much of the substance will evaporate away.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA			
Flash Point (^oF)	Flammable Limits in Air (% by Vol.)	Lower	Upper
Extinguisher Media		Autoignition Temperature (^oF)	
Special Fire Fighting Procedures			
Explosion Hazards			

This section gives information, which is important for preventing and extinguishing fires and explosions. If a fire does occur, this information should be made available to fire fighters.

Flash Point: This is the lowest temperature at which a liquid gives off enough vapor to ignite when a source of ignition is present. At or above this temperature, a fire or explosion hazard may exist if the substance is used in the presence of spark or flame.

Flammable Limits: In order to be flammable, a substance must be mixed with a certain amount of air (as in an automobile carburetor). A mixture that is too "lean" (not enough chemical) or too "rich" (not enough air) will not ignite. The Lower Explosive Limit (LEL) and the Upper Explosive Limit (UEL) define the range of concentration in which combustion can occur.

SECTION V - HEALTH HAZARD DATA
Threshold Limit Value
Effects of Overexposure
Acute Overexposure
Chronic Overexposure
Emergency and First Aid Procedures
Inhalation
Eyes
Skin
Ingestion

This section describes the potential health effects resulting from overexposure to the chemical, and gives emergency and first aid procedures. The symptoms and effects listed are the effects of exposure at hazardous levels: most chemicals are safe in normal use and the vast majority of workers never suffer toxic harm. However, any chemical can be toxic in high concentrations, and the precautions outlined in the MSDS must be followed.

The Health Hazards section often contains information on the toxicity of the substance. The data most often presented are the results of animal experiments. For example, "LD50 (mouse) = 250 mg/kg." The usual measure of toxicity is dose level expressed as weight of chemical per unit body weight of the animal-usually milligrams of chemical per kilogram of body weight (mg/kg). The LD50 or "Lethal Dose Fifty," is the dose of substance that will cause the death of half the experimental animals. The LC50 is the concentration of the substance in air that will cause the death of half the experimental animals.

A rough and somewhat arbitrary classification: when evaluating rodent LD50's, materials with an oral LD50 less than 50 mg/kg are considered highly toxic, and those with an oral LD50 of 50-500 mg/kg are considered moderately toxic.

Health hazard information may also distinguish the effects of acute and chronic exposure. An acute exposure is a single, massive exposure, while chronic exposure is regular exposure to small amounts of a substance over a long period of time.

SECTION VI - REACTIVITY DATA			
Stability		Unstable	Conditions to avoid
		Stable	
Incompatibility (Materials to Avoid)			
Hazardous Decomposition Products			
Hazardous Polymerization		Conditions to Avoid	
May Occur	Will Not Occur		

Chemical substances may be hazardous not just in them, but may be hazardous when they decompose (break down into other substances) or when they react with other chemicals.

Stability: Unstable indicates that a chemical can decompose spontaneously under normal temperatures, pressures, and mechanical shocks. Rapid decomposition may be hazardous because it produces heat and may cause fire or explosion. **Stable** compounds do not decompose under normal conditions.

Incompatibility: Certain chemicals should never be mixed because the mixture creates hazardous conditions. Incompatible chemicals should not be stored together where an accident could cause them to mix.

Hazardous Decomposition Products: Other chemical substances may be created when a chemical burns or decomposes.

Hazardous Polymerization: Some chemicals can undergo a type of chemical reaction (rapid polymerization) which may produce enough heat to cause containers to explode. Conditions to avoid are listed in this section.

SECTION VII - SPILL OR LEAK PROCEDURES
Steps to be Taken in Case Material is Released or Spilled
Waste Disposal Method

SECTION VIII - SPECIAL PROTECTION INFORMATION		
Respiratory Protection (Specify type)		
Ventilation	Local Exhaust	Special
	Mechanical (general)	Other
Protective Gloves	Eye protection	
Other Protective clothing or Equipment		

SECTION IX - SPECIAL PRECAUTIONS
Precautions to be Taken in Handling and Storing
Other Precautions

These sections describe other precautionary and protection information. Some of the precautions presented are intended for large-scale users and may not be necessary for use of small quantities of chemical. Any questions about precautions or health effects should be referred to Environmental Health and Safety.

Labeling Requirements for Secondary Chemical Containers

All chemical containers come with a label. The original label of most containers purchased in recent years provides detailed information on the properties and health hazards of the chemical and should never be defaced or removed unless the container is empty and well rinsed. All containers should be dated and inventoried upon arrival and dated again when first opened. As a general rule, if a material is transferred from an original container to other containers, such as making a solution of a chemical or repackaging into smaller bottles for redistribution within a research or teaching lab, all such *secondary containers* need to be properly labeled with the full name of the materials in the container, the concentration if a solution or mixture, the date and the name or initials of the person making the solution or repackaging the chemical.

The OSHA Lab Standard and the OSHA Hazard Communication Standard have specific requirements for the labeling of chemicals. The Lab Standard states that "Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced." The Standard, as written, has no specific requirements for chemicals that are repackaged in secondary containers. However, various letters of interpretation from OSHA and enforcement actions have pointed to the use of hazard warnings on secondary containers of laboratory chemicals as a prime means of hazard identification, which *is* mandated by the Standard. Because this is considered "best practice", Cornell EH&S has instituted a labeling program for secondary containers based upon contemporary, widely used and accepted labeling procedures:

> If a chemical is designated as a hazardous material, that is having the characteristics of corrosivity, ignitability, toxicity (generally meaning a highly toxic material with an LD_{50} of 50 mg./kg. or less), reactivity, etc., and if it is made into a solution or repackaged as a solid or liquid in a concentration greater than 1% (0.1% for a carcinogen) it should have a so called Right-To-Know (RTK) label which duplicates the hazard warnings and target organs, precautions and first aid steps found on the original label.

In a non-lab setting, such as a shop, greenhouse or hospital, the Hazcom Standard dictates that *all* repackaged chemicals, including commercial products that are a mixture of chemicals, need a RTK label. Without the proper labeling of chemicals a work place is not in compliance with Federal regulations.

Right-To-Know labels are available for many common materials from various labeling companies. However, they are quite expensive. To facilitate the proper and compliant labeling of secondary chemical containers EH&S offers **free** RTK labels for solutions or repackaged chemicals to the campus community. We now have several hundred labels available on the EH&S Web site. These chemical labels include:

- many commonly used hazardous lab chemicals
- some rarely used specialty chemical labels made for specific labs
- some commercial products used by Buildings Care, shops, the Vet College clinics, and other units at Cornell

All of the available labels are on the EH&S Web site in html and pdf formats at:

http://www.ehs.cornell.edu/labels/index.html

In addition to the listed chemical labels, our office can make a RTK label for any material for which we can obtain an MSDS. If you need a label made for a material not listed on our Web site, please contact us at 255-8200.

Revised 10/99 by Tom Shelley.

CORNELL UNIVERSITY
Environmental Health and Safety
125 Humphreys Service Building

Date_____

"Right-to-Know"
Chemical Information Request Form

Information requests may be submitted by phone or in writing at any time. This form is provided to assist employees in requesting information concerning the health and safety hazards of hazardous materials found in the workplace. Use this form or, for your convenience, the version found on our Web site. If you have questions, call Environmental Health and Safety at 255-8200. Send your written requests to Environmental Health and Safety, 125 Humphreys Service Building, Ithaca, NY, 14853.

Name _____ Department _____

Campus Phone _____ Campus Address _____

List chemicals for which you would like us to send Material Safety Data Sheets. If a trade product, or if the substance is uncommon, please provide manufacturer's name.

_____

_____

_____

_____

_____

List chemicals for which you would like more detailed information or list specific questions you have. Include pertinent details such as physical form of substance, amount used, and conditions of use.

_____

_____

_____