

# **Washington Adventist University**

## **Chemical Hygiene Plan**

A Guide to Chemical Safety for Students, Staff, and Faculty

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Revised November 26, 2018

## WAU's Chemical Hygiene Plan

### Revision History

September 2002	Release of Current Document
June 2012	Document updated to Reflect Institution's Change in Name and Status
November 2018	Update layout and content of document

## Employee Health and Safety Resources at WAU

In an EMERGENCY call 9-911

### Reporting Emergencies

If you believe that 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 9-911. After contacting and finishing the original emergency call, contact the campus security office at ext. 4911.

### Follow-up Report After an Actual Emergency.

Within 24 hours of an accident or emergency, a Accident Report Form must be completed. These forms can be obtained from the departmental administrators or the Human Resources Office.

### Contact Information

Concern	Contact Person
Environmental & Safety Training	Melvin Roberts 301-891-4228
Chemical Information & Material Safety Data Sheets (MSDSs)	Melvin Roberts 301-891-4228
OSHA Laboratory Standard, Chemical Hygiene Plan, Lab Safety	Melvin Roberts 301-891-4228
Radiation Safety	
Occupational Health & Safety	Human Resources 301-891-4542
Biological Safety	Glen Bennett 301-891-4465
Asbestos	Campus Services 301-891-4161
Personal Protective Equipment	Melvin Roberts 301-891-4228
Chemical Waste Disposal	Melvin Roberts 301-891-4228
Security	Public Safety 301-891-4019
Medical Problems	Sharon Wilson 301-891-4009
Health Education Programs	Sharon Wilson 301-891-4009

## **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 Lab Standard became effective May 1, 1990 requiring that a Chemical Hygiene Plan (CHP) be developed for each laboratory workplace. In 1995, a Chemical Hygiene Officer (CHO) was assigned the responsibility of developing and implementing an institutional CHP by Washington Adventist University administration. Each department may adopt or modify this plan, or develop their own.

The purpose of the Laboratory Standard is to protect all employees and students from harm due to chemicals while they are working in a laboratory. Most laboratories and several other areas (darkrooms, art and set design facilities, etc.) of the university are subject to the requirements of the Lab Standard. For the purposes of the Lab Standard, “laboratory employee” may include employees such as office, custodial, maintenance and repair personnel, and others who, as a part of their duties, regularly spend a significant amount of their time within a laboratory environment. Students working as teaching assistants are also subject to the requirements of the Lab 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. Rather than requiring specific detailed actions that would result in obtaining desired results, the Lab Standard simply states the goal it wishes institutions to provide. Therefore, there is flexibility in how various institutions to obtain those results. The primary emphasis is on administrative controls necessary to protect workers from overexposure to hazardous substances in laboratories.

The Washington Adventist University’s Chemical Hygiene Plan is developed and coordinated by the Chemical Hygiene Officer and approved by the Health and Safety Committee. All personnel covered by the Lab Standard share the responsibility for the university’s compliance.

Questions about the university’s CHP should be directed to Dr. Melvin Roberts, Chemistry Department, Washington Adventist University, 7600 Flower Avenue, Takoma Park, MD 20912

## **The Chemical Hygiene Plan**

It will be the responsibility of the supervisors of the areas covered by the Lab Standard to ensure that adequate measure are in place to prevent overexposure to hazardous chemicals. If requested, the CHO of the university will assist supervisors in developing methods specific for their area. In general, the exposure to hazardous chemicals in the laboratory shall be controlled through the use of good laboratory practices, standard operating procedures, engineering controls, and personal protective equipment.

General Laboratory Practices: Information about good general laboratory practices and rules can be found in *Prudent Practices in the Laboratory*. These general procedures include guidelines on the use of chemicals, accidents and spills, personal protection, use of fume hoods, and other laboratory practice information.

Specific Laboratory Practices: Individual supervisors must develop additional written safety procedures whenever necessary to prevent the possibility of overexposure. Written “standard operating procedures”, (SOPs), must be made when workers will be handling select carcinogens or acutely toxic chemicals. Workers should be familiar with the SOPs *before* handling the chemicals. The CHO of the university can assist individuals develop SOPs necessary for their work place (see section 12.0 of the CHP).

Engineering Controls: Common engineering controls at Washington Adventist University include fume hoods, HEPA hoods, and storage cabinets.

Personal Protective Equipment (PPE): Personal protective equipment will be available to laboratory workers for use to reduce exposures to hazardous chemicals in the laboratory. Common PPE such as goggles, gloves, and aprons are recommended for use with hazardous chemicals.

Other: Other control methods that will be used to reduce exposure limits are proper container selection, substitution of less toxic chemicals whenever possible, developing emergency procedures, and periodic testing of the laboratories safety equipment.

### Fume Hoods and Safety Equipment

The fume hood inspection program at WAU consists of an initial comprehensive inspection followed by annual standardized inspections for all campus fume hoods. This initial fume hood assessment will provide extensive information including but not limited to hood usage, type of hood, room and building information, as well as average face velocity measurements. Hoods will be labeled to encourage proper use by employees. Annual inspections will consist of measuring face velocity, a dry-ice capture test, and verifying proper labeling. After each inspection, hoods will be labeled with inspection stickers indicating the result of the tests. All inspection information will be recorded on a standard form and will be kept on file with the Chemical Hygiene Officer. Requests to have hoods inspected before the annual inspection rounds may be made by contacting the CHO.

Hoods will be classified as acceptable or unacceptable based on the face velocity measurement. An average face velocity with a fully opened sash measuring 80 feet per minute (fpm) or greater is acceptable. The hood will be considered unacceptable if it can not achieve an 80 fpm average with the sash opened at two feet or greater. Warning signs will be posted on hoods that are unacceptable. Fume hood repairs will be coordinated with the Campus Services Department of WAU. Following repairs, fume hoods must pass an inspection before any warning sign is removed and the hood is allowed to be used.

The proper functioning and maintenance of other protective equipment used in the lab is the responsibility of the CHO and the Campus Services Department. These include all extinguishers, eyewash/shower facilities, spill response equipment, and mechanical ventilation systems. Periodic inspections and maintenance ensure proper functioning and adequate performance of the equipment.

### Information and Training

Washington Adventist University will provide information and training to ensure that employees are appraised of the hazards of chemicals present in their work area. This training and information will come from a variety of sources. An annual training session conducted by the CHO of the university will inform directors whose area is covered by the Lab Standard. Ideally, the training session will be held in August prior to the Fall semester. Directors will then provide specific training to their employees in their area. Training for custodial staff, physical plant personnel, and other university employees who do not routinely work with chemicals in a laboratory will be informed of safety protocols to ensure their safety.

Notebooks of Material Safety Data Sheets (MSDS) for chemicals commonly used in laboratories are located within each necessary department. Departments who purchase new chemicals have the responsibility to keep their MSDS sheets current. On-line MSDS sheets may also be used as an information source, but paper copies must also be available for times when internet access is not possible. Employees are encouraged to consult these MSDS notebooks prior to working with chemicals. Additional information may be requested from the Chemical Hygiene Officer whenever an employee has questions.

### 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 examination 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 university's contracted physician. 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 by the Health Services Department in accordance with 29 CFR 1910.20. Exposure monitoring, records of contaminate levels in laboratories will be maintained by the Chemical Hygiene Officer.

#### Personnel Responsible for the Chemical Hygiene Plan

The Chemical Hygiene Officer will provide technical information and program support to assist in compliance with the OSHA Laboratory Standard. This officer will be assigned by the university administration and will maintain the Chemical Hygiene Plan. However, it will be the responsibility of the individual supervisor, department head, and the institution itself 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. Work 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. The Chemical Hygiene Officer will assist with the review and make recommendations for additional employee protection such as the following:

- 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 the Chemical Hygiene Officer, Campus Services Department, technical committees, and outside contractors. 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 Washington Adventist University 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 and research laboratories.
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 PELs and TLVs can be obtained by contacting the Chemical Hygiene Officer.

## 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 9-911 or contact Dr. Ho at 9-891-6100.

For large spills call 9-911. For smaller spills requiring assistance, contact Dr. Roberts at x4288.

In the event of a fire call 9-911. If you extinguish a small fire with a portable fire extinguisher, it must be reported to the Chemical Hygiene Officer at x 4228 and the Safety & Security Department.

### Avoidance of “routine” exposure.

- Develop and encourage safe habits. Avoid unnecessary exposure to chemicals by any route (inhalation, absorption through the 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 since these generally have contained, recirculated atmospheres.
- 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.

### 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 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 and buildings at Washington Adventist University.
- 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".
- Practical jokes or other behavior that might confuse, startle, or distract another worker is prohibited.

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.

Personal Apparel:

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. See Section 11 for assistance in the selection of the proper glove type.

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 supervisors or the Health and 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 electricity or cooling water). Whenever possible, use automatic shutoff devices on long term or unattended operations.

### Use of the fume hood

Use the fume hood for operations that might result in the release of toxic chemical vapors, fumes or dust. Bench top 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 recommended height. Keep materials stored in hoods to a minimum and do not allow them to block vents or airflow.

### Vigilance

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

### Working Alone

Avoid working alone when using hazardous chemicals or processes. Use a buddy system or a notification protocol with Security or other individuals in the institution if you must work alone.

**Section 6.0 OSHA Lab Standard.**

## 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.**

*This document deals solely with the disposal of waste that is not radioactive. For assistance of information on disposal of radioactive material, including the licensed material (material authorized under a WAU Radioactive Permit) and non-regulated radioactive material such as uranium and thorium salts, contact the radiation officer for the university at 301-891-4173. Please note the following: 1) A detailed description of the chemical composition must be provided for all liquid radioactive waste; and 2) procedures that produce mixed waste including both radioactive and hazardous chemical material must be approved in advance by the university's Health and 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 Washington Adventist 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 laboratory personnel.

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 which generate a large quantity of waste should be discussed with the Chemical Hygiene Officer in advance. Companies which pick up chemical waste come to WAU upon request. 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.

#### 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. Often times the cost of disposal is higher than the original cost of the chemical. Communication across the campus can help reduce the amount of chemicals needed to be ordered by individuals by finding out if there are unused amounts of in another department. In addition, experiments in teaching and research labs should be done on as small a scale as 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 or not the drum is completely filled with solvents or contains (as in most cases) partially filled bottles packed according to Department of Transportation 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. 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 solvent 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, a commercial disposal company must be brought onto campus to determine the identity of unknown substances at considerable expense. The ideal solution to this problem is to avoid generating this waste by proper labeling of containers and regular disposal of waste materials.

A recurring problem is “orphan” waste. Orphan waste material is waste (with no information) left behind by previous student, faculty, and staff. 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.

Trade names or initials are not sufficient identification unless MSDS sheets are readily available whereby more detailed information can be obtained.

### 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. If this occurs, please contact the Chemical Hygiene Officer. *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 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, the Chemical Hygiene Officer 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 peroxide in solvents are commercially available and should be ordered along with the original purchase of these chemicals. If the amount of peroxide is over 80 ppm, the material should be discarded. If a peroxide bearing solvent is not discarded after six months the peroxide must be destroyed using the appropriate procedures. Recently, chemical companies 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.

Another class of materials which cannot be disposed of without pre-treatment is those which evolve gases. Any waste which requires vent-caps must be treated before any disposal procedures.

### 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 the EPA. At the moment limited disposal methods are available for mercury and other heavy metals compounds.

#### Non-Chemical Paraphernalia

Plastic ware, disposable gloves, glassware, paper towels, tools, pumps, and the like which are contaminated with chemical waste must be decontaminated before disposing in normal trash bins. The resulting rinsate solution for the decontamination process can be disposed using typical methods for hazardous materials. 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. Departments generating this type of waste are responsible for its disposal.

#### 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.

#### Organic Chemicals

- Enzymes
- Sugars and sugar alcohols
- Starch
- Naturally occurring amino acids and salts
- Citric acid and its' Na, K, Mg, Ca, and NH<sub>4</sub> salts
- Lactic acid and its' Na, K, Mg, Ca, and NH<sub>4</sub> salts

#### Inorganic Chemicals

- Silica
- Sulfates: Na, K, Mg, Ca, Sr, and NH<sub>4</sub>
- Phosphates: Na, K, Mg, Ca, Sr, and NH<sub>4</sub>
- Carbonates: Na, K, Mg, Ca, Sr, and NH<sub>4</sub>
- Oxides: Na, K, Mg, Ca, Sr, and NH<sub>4</sub>
- Chlorides: Na, K, Mg, Ca, Sr, and NH<sub>4</sub>
- Borates: Na, K, Mg, Ca, Sr, and NH<sub>4</sub>

## 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.

### Packing Instructions for Dumpster Disposal:

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 personally, since custodians do not handle even nonhazardous laboratory chemicals.

### Disposal of Laboratory Wastes to Sanitary Sewer

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 WAU 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 wastewater facilities. Inappropriate chemicals put down the drain may be incorporated into sludge formed in the waste water treatment thereby contaminating it enough to be classified as a hazardous waste.

### General Guidelines

Send down the drain only those materials found on the safe list found in the following section. Under no circumstances should radioactive chemicals found in section 7.8c be disposed of in the drain. Use only laboratory sinks for drain disposal. Floor drains or storm drains are unacceptable. Quantities of chemical waste for drain disposal should be limited generally to a few hundred grams or milliliters or less per day. Disposal should be followed by flushing with at least 100-fold excess of water at the sink (i.e. 100 ml of chemical should be flushed with water for about two minutes at maximum flow).

Note: Sulfuric, hydrochloric, and phosphoric acids must be neutralized to a pH between 5.5-9.0 before drain disposal. Larger amounts of these materials than the above limits is permissible.

## Chemicals Safe for Drain Disposal

### Inorganics

Cations:  $\text{Al}^{+3}$ ,  $\text{Ca}^{+2}$ ,  $\text{Fe}^{+2}$ ,  $\text{Fe}^{+3}$ ,  $\text{H}^+$ ,  $\text{K}^+$ ,  $\text{Li}^+$ ,  $\text{Mg}^{+2}$ ,  $\text{Na}^+$ ,  $\text{NH}_4^+$ ,  $\text{Sn}^{+2}$ ,  $\text{Sr}^{+2}$ ,  $\text{Ti}^{+3}$ ,  
 $\text{Ti}^{+4}$ , and  $\text{Zr}^{+2}$ .

Anions:  $\text{BO}_3^{-3}$ ,  $\text{B}_4\text{O}_7^{-2}$ ,  $\text{Br}^-$ ,  $\text{CO}_3^{-2}$ ,  $\text{Cl}^-$ ,  $\text{HSO}_3^-$ ,  $\text{OCN}^-$ ,  $\text{OH}^-$ ,  $\text{I}^-$ ,  $\text{NO}_3^-$ ,  $\text{PO}_4^{-3}$ ,  
 $\text{SO}_v^{-2}$ ,  $\text{SCN}^-$ .

Mineral acids and bases should be neutralized to pH 5.5 to 9 before disposal. Copper and zinc have specific discharge limits. Check with the Chemical Hygiene Officer before disposal to ensure those limits are not exceeded.

### Organics

Chemicals listed here can be discarded in quantities up to 100g or 100 ml at a time followed by flushing with a large excess of water. These materials are soluble to at least 3%, present low toxicity hazards, and are readily biodegradable.

Alcohols: methanol, ethanol, propanol, isopropanol, and butanol (and its' isomers)

Alkanediols: ethylene glycol, propylene glycol, butylene glycol, butanediol and its' isomers, pentylene glycol, pentanediol and its' isomers, heylene glycol, hexanediol and its' isomers, heptamethylene glycol, heptanediol and its' isomers.

Alkoxyalkanols with 6 or fewer carbon atoms: methoxyethanol, ethoxyethanol, butoxyethanol, 2-methoxyethoxyethanol, 2(2-butoxyethoxy)ethanol.

Aldehydes: formaldehyde (10% or less aqueous solution), propanal, butanal, and isobutyraldehyde.

Organic acids: 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 with 4 or fewer carbon atoms: methyl formate, ethyl formate, isopropyl formate, propyl formate methyl acetate ethyl acetate, methyl propionate, isopropyl acetate

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, its' sodium or potassium salt; ethane sulfonic acid, sodium or potassium salt; I-propane sulfonic acid, sodium or potassium salt; 1 -butane sulfonic acid, sodium or potassium salt; I -pentane sulfonic acid, sodium or potassium salt; 1-hexane sulfonic acid, sodium or potassium salt; 1-heptane sulfonic acid, sodium or potassium salt; I -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.

## 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.

## APPENDIXA: NEUTRALIZATION PROCEDURES

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. Once 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 HCl.
2. When a pH of 9 or less is achieved, dispose of solution into sewer system followed by 20 parts water.

## APPENDIXB: WASTE OIL COLLECTION AND DISPOSAL

Oil (including vacuum pump oil) should be collected locally and stored temporarily in approved and properly marked containers 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."

When the oil drums are full please contact the Chemical Hygiene Officer at x4228 to obtain information on the disposal of oils.

### References:

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

American Chemical Society, Safety in 4 Academic Chemistry Laboratories, 1995. Safety Manuals from the Universities of Wisconsin and Cincinnati. Ithaca Area Sewer Ordinance

## Fume Hoods

A laboratory fume hood system is designed to protect the operator from undesirable substances being used, so its' most important function is containment. Fume hood users have little control over a system that is already in place, yet 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.

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 \$1 00) and can be purchased for existing hoods through fume hood suppliers.

- 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 \$ 1 00) 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.
- 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 the CHO and the manufactories. 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.

### Health and Safety Committee's Role

The university's CHO 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 the CHO at 301-891-(x4228) for air flow measurements or questions.

### Mechanical Problems

If your fume hood suddenly seems to stop working and you suspect mechanical problems, call Campus Services. 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.

#### Additional Information

For additional information on fume hoods and laboratory ventilation systems please see the following: ANSI/AIHA Standard Z9.5-1992, Laboratory Ventilation; ANSIASHRAE Standard 110-1995, Methods of Testing Performance of Laboratory Fume Hoods.

## 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.

Astrointestinal 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.

## 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	SOME KNOWN HUMAN	FACTORS
INFLUENCING I	TERATOGENS	SUSCEPTIBILITY
exposure	Alcohol ingestion	Single short
Effects usually appear quickly	Organic mercury compounds	Nutritional
Habits Effects often reversible	Lead compounds	Physical
condition	Ionizing radiation	Medical condition
Some drugs	Drinking and smoking	Sensitization Pregnancy
SUBSTANCES KNOWN TO CAUSE MALE	CHRONIC TOXICITY	REPRODUCTIVE EFFECTS
Repeated exposure	1,2-Dibromo-3-chloropropane	Effects usually delayed
Some pesticides		
Usually irreversible	Ionizing radiation	Some drugs

## 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	Lethal Dose for 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 WAU may not purchase a respirator and bring it to their lab for their personal use.

## Hand Protection and Glove Selection (Including Glove Selection for Some Specific Chemicals Tom Shelley, Cornell EH&S Revised February, 2001).

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

Supervisors are responsible for the selection, availability and use of gloves and other personal protective equipment in the workplace. WAU's CHO can assist supervisors with the requirements of the revised OSHA standard.

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 the Health and Safety Committee for specific chemicals.

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.

All of the major vendors of laboratory and safety supplies carry a wide variety of gloves made of many different materials. The local vendor reps are often very good sources of information concerning the gloves their firms supply.

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, and 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. 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 where 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 as 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 available 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 contact the CHO at x 4228.

For quick glove selection see the attached table.

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 polyvinyl 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.

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.

Alkali metals (lithium, sodium, potassium, rubidium, cesium): nitrile gloves  
Note: It is very important that all work with alkali metals be conducted in the absence of water. Water forms hydrogen gas on contact with alkali metals. As this is a very exothermic reaction, working with alkali metals presents a severe fire hazard. All labs working with alkali metals must have a Class D fire extinguisher available.

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

Butanol (and isomers): nitrile gloves (incidental contact); for extended contact, heavier weight butyl rubber or nitrile gloves are recommended

Butyric acid: nitrile gloves (incidental contact); butyl rubber or neoprene gloves are recommended if contact with butyric acid is probable for an extended period of time.

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.

Chlorosulfuron: nitrile gloves

Cobalt chloride: See Heavy Metal Salts. Copper (cupric) sulfate: nitrile gloves

Cryogenic liquids (liquid nitrogen, argon, helium, etc.): Cryogenic materials handling-rated 0 gloves. Cryo-Gloves, made by Tempshield, Inc., are highly recommended. Note that these gloves are made for handling very cold objects, but that they are not for immersion in liquid nitrogen or other extended contact with cryogenic liquids.

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.

2,4-Dichlorophenoxy acetic acid (2,4-D): nitrite gloves

Diethyl pyrocarbonate: nitrite gloves (incidental contact); double glove with nitrite 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 nitrite gloves (incidental contact) or use 15 mil or heavier nitrite gloves; remove outer glove at once if exposed to DMSO. Nitrite gloves are not recommended for use with DMSO if extended contact with the hands is expected. Some brands of nitrite 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) nitrite gloves (incidental contact) or use 15 mil or heavier nitrite gloves; remove outer glove at once if exposed to dioxane. Most nitrite 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): nitrite gloves Ethanol: nitrite gloves

Ethidium bromide (EtBr): nitrite gloves (incidental contact); double glove with nitrite 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 acetate: double glove with heavier weight (8 mil) nitrile gloves (incidental contact). Nitrile gloves are not serviceable for extended contact as even heavy weight nitrile gloves (36 mil) have a breakthrough time of only 8 minutes and thus offer little protection when exposed to ethyl acetate. For operations involving the use of larger amounts of ethyl acetate, when transferring ethyl acetate from one container to another or for other potentially extended contact, the only gloves recommended are butyl rubber and polyvinyl acetate (PVA).

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 PVATM 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 Geneticin: nitrile gloves

Glutaraldehyde: 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 recommended to \*double glove\* with nitrile gloves when using these materials, especially when handling 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). 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.

Rexamethylenediamine (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 (M): 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. In general, use of hydrofluoric acid on the WAU campus is strongly discouraged.

Hypophosphorous acid: double glove with nitrile gloves (4 mil) (incidental contact) or use 8 mil or heavier nitrile gloves

Kanamycin: nitrile gloves

Isoamyl alcohol: nitrile gloves

isooctane: nitrile gloves (incidental contact); for extended contact heavier weight nitrile-gloves are recommended.

isopropanol: nitrile gloves

Lactic Acid: nitrile gloves (incidental contact); double glove with nitrile gloves or use neoprene or butyl rubber gloves if contact with lactic acid is probable for an extended period  
Laser dyes: nitrile gloves

Lead acetate: See Heavy Metal Salts. 2-Mercaptoethanol:

Mercuric 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.

Methylphosphonic acid: double glove with nitrile gloves (4 mil) (incidental contact) or use 8 mil or heavier nitrile gloves.

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.

Nitric acid: double glove with heavier weight (8 mil) nitrile gloves (incidental contact); remove outer glove at once if exposed to nitric acid. Light weight nitrile gloves are not recommended for any use with nitric acid as they are degraded very quickly. Even heavier weight nitrile gloves last only five minutes or less in contact with nitric acid. For handling larger quantities of concentrated nitric acid, or for extended contact, only heavier weight (.28-.33 mm) butyl rubber or neoprene gloves are recommended.

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-methylethanolamine such as working with the pure material or making solutions.

Octane: nitrile gloves (incidental contact); for extended contact heavier weight nitrile gloves or viton gloves are recommended.

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

Pentane: double glove with heavier weight (8 mil) nitrile gloves (incidental contact). Thin nitrile gloves are quickly degraded by pentane. For extended contact with pentane only heavier weight neoprene gloves or viton gloves are recommended.

Pesticides: heavier weight unlined nitrile gloves (8-20 mils) or a glove specified by the pesticide label.\*Each EPA registered pesticide should be provided with an MSDS-like label. The pesticide label may have a glove selection category listed on it which is based on the "EPA Chemical Resistance Category Selection Chart." The glove selection category is listed as A through H, with each category representing a group or class of pesticides. The EPA glove selection chart is available on the Web at: <http://oeh.cals.comell.edu/EPACChemRes.html>. If the label specifies a glove type, the applicator must wear the specified glove.

Perchloroethylene (tetrachloroethylene): Double glove with heavier weight (8 mil) nitrile gloves (incidental contact); remove outer glove at once if exposed to perchloroethylene. For extended contact, such as parts washing, heavier weight nitrile gloves (22 mil or heavier, such as Ansell Edmont Sol-Vex brand, #37-165) may last up to five hours. Viton gloves are recommended for repeated extended contact with perchloroethylene. Thin (4 mil) nitrile gloves have a breakthrough time of 4 minutes or less.; neoprene and vinyl glove have a breakthrough time of less than 10 minutes; none of these materials are suitable for use with perchloroethylene.

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. Nitrite 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 (extended contact), such as when making up the mixtures.

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.

Phosphonic acid: double glove with nitrile gloves (4 mil) (incidental contact) or use 8 mil or heavier nitrile gloves.

Phosphoric acid: double glove with nitrile gloves (4 mil) (incidental contact) or use 8 mil or heavier nitrile gloves

Picloram (4-amino-3,5,6-trichloropicolinic acid): nitrile glove

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 com 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

Potassium ferricyanide: nitrile gloves Potassium ferrocyanide: nitrile gloves

Potassium permanganate: nitrile gloves

Propanol: nitrile gloves

Propionic acid: nitrile gloves (incidental contact); neoprene or butyl rubber gloves are recommended if contact with propionic acid is probable for an extended period of time.

Propylene oxide: heavier weight (17 mil or greater) butyl rubber or neoprene gloves (incidental contact); norfoil gloves are the only glove recommended for extended contact.

Propylene oxide attacks almost all common glove materials. It passes directly through latex gloves and the breakthrough time for nitrile gloves ranges from seconds to a few minutes. Ordinary 4 mil latex and nitrile lab gloves should never be used with this material. Propylene oxide has a breakthrough time of only 10 minutes with viton gloves which are completely resistant to most common lab chemicals. The breakthrough time for neoprene and butyl rubber gloves is on the order of 45-50 minutes. Use heavier weight gloves (17 mil or greater), check the gloves often and discard after 40 minutes or so or of continuous use when there is contact of propylene oxide with the glove. When possible, use a norfoil glove with a heavier weight (8 mil) nitrile.

Psoralen: nitrile gloves (incidental contact); double glove with nitrile gloves when handling the pure material or concentrated stock solutions. Psoralen is corrosive (causes blisters) on contact with the skin, eyes and mucous 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 derivatization 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)

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

Sulfuric acid: heavier weight (8 mil) nitrile gloves (incidental contact); heavier weight (20 mil or greater) neoprene or butyl rubber 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 (TNM): 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', NI-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 mucous membranes.

Timetin: nitrile gloves

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 toluene. 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.

Trichloroethylene: double glove with heavier weight (8 mil) nitrile gloves (incidental contact); remove outer glove at once if exposed to trichloroethylene. For extended contact, such as when using trichloroethylene 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 trichloroethylene through even heavy weight nitrile gloves (3 6 mil) is 4 minutes, and only 10 minutes for even heavier butyl rubber gloves (64 mil). The permeation time for thin nitrile or latex exam gloves (3-4 mil) is on the order of a minute or two; subsequently, these gloves are not recommended for use with toluene.

Trichloromethyl chloroformate (diphosgene): This chemical, usually supplied in sealed glass ampoules, 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. It is recommended to use 8 mil or heavier nitrile gloves over the butyl rubber glove box gloves.

Triton-X100: nitrile gloves

Valeric acid: nitrile gloves (incidental contact); double glove with nitrile gloves or use neoprene or butyl rubber gloves if contact with valeric acid is probable for an extended period.

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 0.0254 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 penetration. 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.<sup>2</sup>/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 Rest Gloves, 1997. For gloves made by this firm.  
Cole-Parmer, '97-'98 Catalog, pp. 13 66-13 72. 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 of Cornell University. Merk Index, 10th Edition, 1983.

National Toxicology Program (NTP) chemical information sheets. 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 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.

## The Standard Operating Procedures for Hazardous Chemicals

### Introduction

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))

All SOPs are to be filed with the Chemical Hygiene Officer. They should include the necessary information listed in the following section. 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 WAU Chemical Hygiene Officer at 301-891-x4228.

### Chemicals needing an SOP

Any carcinogen or acute toxin that fulfills any of the following require an SOP to be prepared and filed:

- Substances having an NFPA/HMIS health hazard of 4
- Substances rated as HIGHLY TOXIC (LD50 of 50 mg./kg. or less.) or SUPER TOXIC (LD50 of 5 mg./kg. or less).
- Substances that are a poison inhalation hazard.

In addition, the following may need SOPs depending upon the extent and duration of use:

- Very flammable chemicals having a NFPA/HMIS flammability rating of 4.
- Very reactive chemicals having a NFPA/HMIS reactivity rating of 3 or 4 including such substances as strong corrosives, oxidizers, and reducing agents.

However, SOP for all of the carcinogens and acutely toxic chemicals may not be necessary. Exemptions may be allowed for a chemical meeting 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 LDSO for an "average" person.

## Necessary Information for an SOP

### STANDARD OPERATING PROCEDURE for CARCINOGENS AND HIGHLY TOXIC MATERIALS

1. Chemical(s): Chemical(s) means the full name of the chemical(s) used in a process. The chemical(s) names 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.
2. Specific Hazards: 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," etc.
3. Purchasing Considerations: 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 faculty member.
4. Storage: Report how the materials will be stored according to compatibility and label recommendations in a designated area. 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. Storage areas should be regularly inspected to ensure safety. Periodic inventory reductions will be scheduled. The SOP should include the person to conduct these inspections as well as the frequency of the inspections.
5. Authorized personnel: State the individuals who will be using the hazardous substance. Authorized personnel identifies the person who gives approval for the use of the chemical(s), usually the principal investigator.
6. Training requirements: Report the training a user must have for safely working with the hazardous material. Training should include the following:
  - i. Review of current MSDS
  - ii. Special training provided by the department/supervisor
  - iii. Review of the OSHA Lab Standard
  - iv. Review of the Chemical Hygiene Plan

b. 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 in the next section. A copy of the completed Authorization Form must be kept in or near the lab where the chemical(s) is used.

7. Use location: Designate the areas (building and room numbers) where the hazardous substance will be used.
8. Personal protective equipment: State the personal protective equipment whenever handling this material. Please note the following:
  - a. 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.
  - b. Glove selection is particularly critical for carcinogens and acutely toxic materials. Contact WAU Chemical Hygiene Officer at 301-891-x4228 for assistance if necessary.
  - c. 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.
  - d. 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.
  - e. 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.
9. Waste disposal: Waste shall be disposed of as soon as possible and in accordance with all laboratory and University procedures. The SOP should state how this will be accomplished.
10. Decontamination: 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
11. Exposures: 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).
12. Spills: 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). 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 9-911 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 "WAU Accident Report" must be completed.

State the spill cleanup materials to be used, location of materials, PPE to be used, disposal of cleanup materials, etc. Please be as complete as possible.

13. Miscellaneous: List any special precautions, incompatible/reactive materials, usable shelf life, etc. Please be as specific as possible.

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.

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.

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.

\_\_\_\_\_  
User's Name (Please Print)

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

\_\_\_\_\_  
Supervisor's Name (Please Print)

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

## WAU's Select Carcinogens

SOPs for the following chemicals are required by the WAU Chemical Hygiene Plan whenever they are used on campus. This is not exclusive. Additional chemicals may also need SOPs if they meet the conditions specified earlier.

<u>Chemical</u>	<u>CAS Number</u>
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
Adriarnycin (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	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-methylantraquinone	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
<u>Chemical</u>	<u>CAS Number</u>
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 metabolized to benzidine	various
Benzo[b]fluoranthene	205-99-2

Benzoo]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 stearn-refined and air refined	various	
Bleomycins	various	
Bracken fem	n/a	
Bromodichloromethane	75-27-4	
Bromofornn	75-25-2	
1,3-Butadiene	106-99-0	
1,4-Butanediol dimethanesulfonate (Busuffan)	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	
Chlordimefonn	6164-98-3	
Chlorendic acid (approximately 60 percent chlorine by weight)	115-28-6	
Chlorinated Parrafins (C 12, 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-methylecyclohexyl)- I -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	
Chloroprene	126-99-8	
Chlorothalonil	1897-45-6	
Chlorozotocin	54749-90-5	
Chromium (hexavalent compounds)	various	
Chrysene	218-01-9	

C. 1. Acid Red 114	6459-94-5
C. 1. Basic Red 9 monohydrochloride	569-61-9
Cielosporin (Cyclosporin A; Cyclosporine)	59865-13-3
U'innainyl 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 [11] 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
jacarbazine	4342-03-4
Dwninozide	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-Diarninoanisole	615-05-4
2,4-Diaminoanisole sulfate	39156-41-7
4,4'-Diarninodiphenyl ether (4,4'-Oxydianiline)	101-80-4
2,4-Diaminotoluene	95-80-7
Diarninotoluene (mixed)	n/a
Dibenz[a,h]acridine	226-36-8
Dibenz[aj]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- I -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
I,I-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 exhaust particles	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 (DGR.E)	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-Dimethylarninoazobenzene	60-11-7	
trans-2-[(Dimethylamino)methylimino]-S-[2-(5-nitro-2-furyl)vinyl]-1,3,4-oxadiazole	55738-54-0	
7,12-Dimethylbenz(a)anthracen,e	57-97-6	
3,3'-Dimethylbenzidine (ortho-Tolidine)	119-93-7	
3,3'-Dimethylbenzidine dihydrochloride	612-82-8	
Dimethylearbamoyl chloride	79-44-7	
I,I-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	
Environmental tobacco smoke	n/a	
Estradiol 17B	50-28-2	
Estrone	53-16-7	
Ethinylestradiol	57-63-6	
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	
<u>Chemical</u>	<u>CAS Number</u>	
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-Fonnylhydrazino)-4-(5-nitro-2-furyl) thiazole	3570-75-0	

Furan	110-00-9
Furazolidone	67-45-8
Furmecyclo	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 methylfonnylhydrazone)	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
Inorganic mists containing sulfuric acid	n/a
IQ (2-Amino-3-methylimidazo[4,5-flquinoline)	76180-96-6
Iron dextran complex	9004-66-4
Isoprene	78-79-5
Isosafrole	120-58-1
143-50-0 Kepone (Chlordecone)	77501-63-4
Lactofen	303-34-4
Lasiocarpine	301-04-2
Lead acetate	various
Lead and lead compounds	7446-27-7
Lead phosphate	various
Lindane and other hexachlorocyclohexane isomers	8018-01-7
Mancozeb	12427-38-2
Maneb	68006-83-7
Me-A-alpha-C (2-Amino-3-methyl-9H-pyrido[2, 3-b]indole)	71-58-9
Medroxyprogesterone acetate	7094112
MeIQ(2-Amino-3,4-dimethylimidazo[4,5-flquinoline)	7500-04-0
MelQx(2-Amino-3,8-dimethylimidazo[4,5-flquinoxaline)	148-82-3
Melphalan	531-76-0
Merphalan	72-33-3
Mestranol	n/a
Methoxsalen with ultraviolet A therapy	298-81-7
8-Methoxypsoralen with ultraviolet A therapy	484-20-8
5-Methoxypsoralen with ultraviolet A therapy	75-55-8
<u>Chemical</u>	<u>CAS Number</u>
2-Methylaziridine (Propyleneimine)	590-96-5
Methylazoxymethanol	592-62-1
Methylazoxymethanol acetate	56-49-5
3-Methylcholanthrene	3697-24-3
5-Methylehrysene	101-14-4
4,4'-Methylene bis(2-chloroaniline) (MOCA)	101-61-1
4,4'-Methylene bis(NN-dimethyl)benzenamine	838-88-0

4,4'-Methylene bis(2-methylaniline)	101-77-9	
4,4'-Methylenedianiline	13552-44-8	
4,4'-Methylenedianiline dihydrochloride	13552-44-8	
Methylhydrazine and its salts	107-30-2	
Methyl chloromethyl ether	13909-09-6	
Methyl-CCNU	74-88-4	
Methyl iodide	66-27-3	
Methyl methanesulfonate	129-15-7	
2-Methyl- 1 -nitroanthraquinone (of uncertain purity)	70-25-7	
N-Methyl-N'-nitro-N-nitrosoguanidine (N4NNG)		
N-Methyl-N-nitrosourea	924-42-5	
N-Methylolacrylamide	56-04-2	
Methylthiouracil	9006-4222	
Metiram	443-48-1	
Metronidazole	90-94-8	
Michler's ketone	n/a	
Mineral Oils, untreated and mildly treated	2385-85-5	
Mirex	50-07-7	
Mitomycin C		
MOPP	135-22-0	
Monocrotaline	139-91-3	
5-(Morpholinomethyl)-3-[(5-nitro-fuirtyridene)-amino]-2-oxazolidinone		505-60-2
Mustard gas	3771-19-5	
Nafenopin	134-32-7	
1-Naphthylamine	91-59-8	
2-Naphthylamine		
3-Naphthylamine	various	
Nickel and certain nickel compounds	13463-3933	
Nickel carbonyl	7440-02-0	
Nickel refinery dust, from the pyrometallurgical process	12035-72-2	
Nickel subsulfide	61-57-4	
Niridazole	139-13-9	
Nitrioltriacetic acid	18662-53-8	
Nitrioltriacetic acid, trisodium salt monohydrate	602-87-9	
5-Nitroacenaphthene	99-59-2	
5-Nitro-o-anisidine	91-23-6	
o-Nitroanisole	92-93-3	
4-Nitrobiphenyl	7496-02-8	
6-Nitrochrysene	1836-755	
Nitrofen (technical grade)	607-57-8	
2-Nitrofluorene	59-87-0	
Nitrofurazone	555-84-0	
1-[(5-Nitrofurfurylidene)amino]-2-imidazollidinone	531-82-8	
1-[(5-Nitrofurfurylidene)-N-[4-(5-Nitro-2-furyl)-2 thiazolyl]acetainide		51-75-2
Nitrogen mustard (Mechlorethamine)		55-86-7
Nitrogen mustard hydrochloride (Mechlorethamine hydrochloride)		126-85-2
Nitrogen mustard N-oxide	302-70-5	
Nitrogen mustard N-oxide hydrochloride	79-46-9	
<u>Chemical</u>	<u>CAS Number</u>	
2-Nitropropane	57835-92-4	
4-Nitropyrene	924-16-3	
N-Nitrosodi-n-butylamine	1116-54-7	
N-Nitrosodiethanolamine	55-18-5	
N-Nitrosodiethylamine	62-75-9	
N-Nitrosodimethylamine	156-10-5	
p-Nitrosodiphenylamine	86-30-6	

N-Nitrosodiphenylamine	621647	
N-Nitrosodi-n-propylamine	759-73-9	
N-Nitroso-N-ethylurea	60153-49-3	
3-(N-Nitrosomethylamino)propionitrile	64091-91-4	
4-(N-Nitrosomethylamino)-1-(3-pyridyl)-1-butanone (NNK)	10595-95-6	
N-Nitrosomethylethylamine	684-93-5	
N-Nitroso-N-methylurea	615--532	
N-Nitroso-N-methylurethane	4549-40-0	
N-Nitrosomethylvinylamine	59-89-2	
N-Nitrosomorpholine	16543-55-8	
N-Nitrosonomicotine	100-75-4	
N-Nitrosopiperidine	930-55-2	
N-Nitrosopyrrolidine	13256-22-9	
N-Nitrososarcosine	68-22-4	
Norethisterone (Norethindrone)	03-47-9	
Ochratoxin A	n/a	
Oestrogen replacement therapy Oestrogen, nonstreoidal		
Oestrogen, steroidal	2646-17-5	
Oil Orange SS	n/a	
Oral contraceptives, combined	n/a	
Oral contraceptives, sequential	101-80-4	
4,4'-Oxydianiline	19666-30-9	
Oxadiazon	434-07-1	
Oxymetholone	604-75-1	
Oxazepam	794-93-4	
Panfuran S	87-86-5	
Pentachlorophenot	62-44-2	
Phenacetin	136-40-3	
Phenazopyridine hydrochloride	3546-10-9	
Phenesterin	50-06-6	
Phenobarbital	59961	
Phenolphthalein	77-09-8	
Phenoxybenzamine	63-92-3	
Phenoxybenzamine hydrochloride	122-60-1	
Phenyl glycidyl ether	various	
Phenylhydrazine and its salts	132-27-4	
o-Phenylphenate, sodium	57-41-0	
Phenytoin	105650-23-5	
PhiP(2-Amino-1-methyl-6-phenylimidazol[4,5-b]pyridine)	various	
Polybrominated biphenyls	various	
Polychlorinated biphenyls	various	
Polychlorinated biphenyls (containing 60 or more percent chlorine by molecular weight)	various	various
Polychlorinated dibenzo-p-dioxins	various	
Polychlorinated dibenzofurans	various	
Polycyclic aromatic hydrocarbons	53973-98-1	
Polygeenan	3761-53-3	
Ponceau Na	3564-09-8	
Ponceau 3R	7758-01-2	
<u>Chemical</u>	<u>CAS Number</u>	
Potassium bromate	671-16-9	
Procarbazine	366-70-1	
Procarbazine hydrochloride	32809-16-8	
Proeimidone	57-83-0	
Progesterone	various	
Progestins	1120-71-4	
1,3-Propane sultone	2312-35-8	

Progargite	57-57-8	
beta-Propiolactone	75-56-9	
Propylene oxide	51-52-5	
Propylthiouracil	various	
Radionuclides	10043-92-2	
Radon	50-55-5	
Reserpine	n/a	
Residual (heavy) fuel oils	94-59-7	
Safrole	7446-34-6	
Selenium sulfide	68308-34-9	
Shale-oils	n/a	
Silica, crystalline (airborne particles of respirable size)	n/a	
Smokeless tobacco	132-27-4	
Sodium ortho-phenylphenate	n/a	
Soots, tars, and mineral oils (untreated and mildly treated oils and used engine oils)		10048-13-2
Sterigmatocystin	18883-66-4	
Streptozotocin	100-42-5	
Styrene	96-09-3	
Styrene oxide	95-06-7	
Sulfallate	n/a	
Talc containing asbestiform fibers	10540-29-1	
Tamoxifen	2593-15-9	
Terrazole	58-22-0	
Testosterone and its esters	1746-01-6	
2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)	79-34-5	
1, 1,2,2-Tetrachloroethane	127-18-4	
Tetrachloroethylene (Perchloroethylene)	5216-25-1	
p-a,a,a-Tetrachlorotoluene	509-14-8	
Tetrafluoroethylene	116-14-3	
Tetranitromethane	62-55-5	
Thioacetamide	139-65-1	
4,4'-Thiodianiline	62-56-6	
Thiourea	1314-20-1	
Thorium dioxide	n/a	
Tobacco, oral use of smokeless products	n/a	
Tobacco smoke	26471-62-5	
Toluene diisocyanate	95-53-4	
ortho-Toluidine	636-21-5	
ortho-Toluidine hydrochloride	106-49-0	
para-Toluidine	8001-35-2	
Toxaphene (Polychlorinated camphenes)	299-75-2	
Treosulfan (Tresoluphan)	817-09-4	
Trichlortnethine (Trimustine hydrochloride)	88-06-2	
2,4,6-Trichlorophenol	96-18-4	
1,2,3-Trichloropropane	76-87-9	
Triphenyltin hydroxide	79-01-6	
Trichloroethylene	68-76-8	
Tris(aziridinyl)-para-benzoquinone (Triaziquone)	52-24-4	
Tris(I-aziridinyl)phosphine sulfide (Thiotepa)	115-96-8	
Tris(2-chloroethyl) phosphate	126-72-7	
Tris(2,3-dibromopropyl)phosphate	62450-06-0	
Trp-P-1 (Tryptophan-P-1) (3-Amino-1,4-dimethyl-5H-pyrido[4,3-b]indole)		62450-07-1
Trp-P-2 (Tryptophan-P-2) (3-Amino-i-methyl-5H-pyrido[4,3-b]indole)		72-57-1
Trypan blue (commercial grade)	n/a	
Unleaded gasoline (wholly vaporized)	66-75-1	
Uracil mustard	51-79-6	

Urethane (Ethyl carbamate)	n/a	
UV radiation (solar, sunlamps, sunbeds)	593-60-2	
Vinyl bromide	75-01-4	
Vinyl chloride	106-87-6	
4-Vinyl-1-cyclohexene diepoxide (Vinyl cyclohexene dioxide)		79-00-5
Vinyl trichloride (1,1,2-Trichloroethane)	87-62-7	
2,6-Xylidine (2,6-Dimethylaniline)	12122-67-7	
Zineb		

## CHEMICALS KNOWN TO CAUSE REPRODUCTIVE TOXICITY

<u>CAS Number</u>	<u>Developmental Toxicity</u>
546-88-3	Acetohydroxamic acid
50-76-0	Actinomycin D
302-79-4	All-trans retinoic acid
28981-97-7	Alprazolam
39831-55-5	Amikacin sulfate
125-84-8	Aminoglutethimide
various	Aminoglycosides
54-62-6	Aminopterin
various	Angiotensin converting enzyme (ACE) inhibitors
117-37-3	Anisindione
50-78-2	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.)
various	Barbiturates
17804-35-2	Benomyl
5411-22-3	Benzphetamine hydrochloride
various	Benzodiazepines
1540-93-8	Bischloroethyl nitrosourea (BCNU) (Cannustine)
1689-84-5	Bromoxynil
143-81-7	Butabarbital sodium
55-98-1	1,4-Butanediol dimethylsulfonate (Busulfan)
75-15-0	Carbon disulfide
630-08-0	Carbon monoxide
41575-94-4	Carboplatin
474-25-9	Chenodiol
1620-21-9	Chlorcyclizine hydrochloride
305-03-3	Chlorambucil
143-50-0	Chlordecone (Kepone)
58-25-3	Chlordiazepoxide
438-41-5	Chlordiazepoxide hydrochloride
13010-47-4	1-(2-Chloroethyl)-3-cyclohexyl-1-nitrosourea (CCNU) (Lomustine)
50-41-9	Clomiphene citrate .
57109-90-7	Clorazepate dipotassium
50-36-2	Cocaine
64-86-8	Coichicine
n/a	Conjugated estrogens
21725-46-2	Cyanazine
66-81-9	Cycloheximide
50-18-0	Cyclophosphamide (anhydrous)
6055-19-2	Cyclophosphamide (hydrated)
13121-70-5	Cyhexatin
147-94-4	Cytarabine
17230-88-5	Danazol

23541-50-6	Daunorubicin hydrochloride
64-73-3	Demeclocycline hydrochloride (internal use)
439-14-5	Diazepam
66-76-2	Dicumarol
56-53-1	Diethylstilbestrol (DES)
39300-45-3	Dinocap
88-85-7	Dinoseb
57-41-0	Diphenylhydantoin (Phenytoin)
564-25-0	Doxycycline (internal use)
94088-85-4	Doxycycline calcium (internal use)
24390-14-5	Doxycycline hyclate (internal use)
17086-28-1	Doxycycline monohydrate (internal use)
379-79-3	Ergotamine tarixate
n/a	Ethyl alcohol in alcoholic beverages
110-80-5	Ethylene glycol monoethyl ether
109-86-4	Ethylene glycol monomethyl ether
111-15-9	Ethylene glycol monoethyl ether acetate
110-49-6	Ethylene glycol monomethyl ether acetate
96-45-7	Ethylene thiourea
33419-42-0	Etoposide
54350-48-0	Etretinate
51-21-8	Fluorouracil
76-43-7	Fluoxymesterone
1172-18-5	Flurazepam hydrochloride
13311-84-7	Flutamide
23092-17-3	Halazepam
118-74-1	Hexachlorobenzene
3778-73-2	Ifosfamide
10043-66-0	Iodine-131
4759-48-2	Isotretinoin
7439-92-1	Lead
554-13-2	Lithium carbonate
919-16-4	Lithium citrate
846-49-1	Lorazepam
75330-75-5	Lovastatin
71-58-9	Medroxyprogesterone acetate
595-33-5	Megestrol acetate
148-82-3	Melphalan
9002-68-0	Menotropins
57-53-4	Meprobamate
6112-76-1	Mercaptopurine
various	Mercury and mercury compounds
3963-95-9	Methacycline hydrochloride
60-56-0	Methimazole
59-05-2	Methotrexate
15475-56-6	Methotrexate sodium
74-83-9	Methyl bromide as a structural fumigant
593-74-8	Methyl mercury (dimethyl mercury)
58-18-4	Methyltestosterone
59467-96-8	Midazolam hydrochloride
13614-98-7	Minocycline hydrochloride (internal use)
59122-46-2	Misoprostol
70476-82-3	Mitoxantrone hydrochloride
86220-42-0	lafarelin acetate
1405-10-3	Neomycin sulfate (internal use)
56301-57-2	Netilmicin sulfate

54-11-5	Nicotine
51-75-2	Nitrogen mustard (Mechlorethamine)
55-86-7	Nitrogen mustard hydrochloride (Mechlorethamine hydrochloride)
68-22-4	Norethisterone (Norethindrone)
51-98-9	Norethisterone acetate (Norethindrone acetate)
68-22-4/57-63-6	Norethisterone (Norethindrone)/Ethinyl estradiol
68-22-4/72-33-3	Norethisterone (Norethindrone)/Mestranol
6533-00-2	Norgestrel
604-75-1	Oxazepam
79-57-2	Oxytetracycline (internal use)
2058-46-0	Oxytetracycline hydrochloride (internal use)
115-67-3	Paramethadione
52-67-5	Penicillamine
63-98-9	Pentobarbital sodium
435-97-2	Phenprocoumon
54-91-1	Pipobroman
18378-89-7	Plicamycin
922-66-0	Polybrominated biphenyls
various	Polychlorinated biphenyls
366-70-1	Procarbazine hydrochloride
51-52-5	Propylthiouracil
36791045	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
309-43-3	Secobarbital sodium
3810-74-0	Streptomycin sulfate
54965-24-1	Tamoxifen citrate
846-50-4	Temazepam
58-20-8	Testosterone cypionate
315-37-7	Testosterone enanthate
1746-01-6	2,3,7,8-Tetrachlorodibenzo-para-dioxin (TCDD)
various	Tetracyclines (internal use)
60-54-8	Tetracycline (internal use)
64-75-5	Tetracycline hydrochloride (internal use)
50-35-1	Thalidomide
154-42-7	Thioguanine
n/a	Tobacco smoke (primary)
108-88-3	Tobramycin sulfate
28911-01-5	Triazolam
13647-35-3	Trilostane
127-48-0	Trimethadione
66-75-1	Uracil mustard
51-79-6	Urethane
26995-91-5	Urofollitropin
99-66-1	Valproate (Valproic acid)
143-67-9	Vinblastine sulfate
2068-78-2	Vineristine sulfate
81-81-2	Warfarin

## Female Reproductive Toxicity

54-62-6	Aminopterin
n/a	Anabolic steroids

50-78-2	Aspirin(NOTE: It is especially important not to use aspirin during the last
50-78-2.1.1	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.)
75-15-0	Carbon disulfide
50-36-2	Cocaine
50-18-0	Cyclophosphamide (anhydrous)
6055-19-2	Cyclophospharnide (hydrated)
75-21-8	Ethylene oxide
	Lead
n/a	Tobacco smoke (primary)
66-75-1	Uracil mustard

### Male Reproductive Toxicity

n/a	Anabolic steroids
17804-35-2	Benomyl
75-15-0	Carbon disulfide
64-86-8	Colchicine
50-18-0	Cyclophosphamide (anhydrous)
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)
99-65-0	m-Dinitrobenzene
528-29-0	o-Dinitrobenzene
100-25-4	p-Dinitrobenzene
88-85-7	Dinoseb
110-80-5	Ethylene glycol monoethyl ether
109-86-4	Ethylene glycol monomethyl ether
111-15-9	Ethylene glycol monoethyl ether acetate
110-49-6	Ethylene glycol monomethyl ether acetate
680-31-9	Hexamethylphosphoramide
7439-92-1	Lead
67-20-9	Nitrofurantoin
n/a	Tobacco smoke (primary)
66-75-1	Uracil mustard

### WAU's Acutely Toxic Chemicals

Based on OSHA Standard 29 CFR 1910-119 App A

CHEMICAL NAME	CASNUMBER
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
3oron 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 PentOxide	13637-63-3	
Chlorine Trifluoride	7790-91-2	
Chlorodiethylaluminum (also called Diethylaluminum Chloride)		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	7697-37-2	(94.5% or greater by weight)
Nitric Oxide	10102-44-0	
Nitroaniline (para-Nitroaniline)	100-01-6	
Nitromethane	75-52-5	
Nitrogen Dioxide	10102-44-0	
Nitrogen Oxides	10102-44-0	(NO; NO <sub>2</sub> ; N <sub>2</sub> O <sub>4</sub> ; N <sub>2</sub> O <sub>5</sub> )
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)	79-21-0 (also called Peroxyacetic Acid)	
Perchloric Acid (concentration greater than 60% by weight)	7601-90-3	
Perchloromethyl Mercaptan	594-42-3	
Perchloryl Fluoride	7616-94-6	
Peroxyacetic Acid	79-21-0	
(concentration greater than 60% Acetic Acid; also called Peracetic Acid)		
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  
Trimethoxysilane

79-38-9  
2487-90-3

### Poison Inhalation List

arsenic pentafluoride	methyl chloride
arsine	methyl mercaptan
boron trichloride	methyl silane
boron trifluoride	nitric oxide
bromine pentafluoride	nitrogen dioxide
bromine trifluoride	nitrogen trifluoride
bromotrifluoroethylene	nitrogen trioxide
carbonyl fluoride	oxygen difluoride
carbonyl sulfide	phosgene
chlorine	phosphine
chlorine pentachloride	phosphorous pentafluoride
chlorine trifluoride	selenium hexafluoride
chloropierin (in mixes)	silane
cyanogen chloride	silicon tetrachloride
diborane	silicon tetrafluoride
dichlorosilane	stibine
digennane	sulfur dioxide
dimethylarnine	sulfur tetrafluoride
dinitrogen tetroxide	tellurium hexafluoride
disilane	tetraethyldithiopyrophosphate
ethylene oxide	tetraethylpyrophosphate fluorine
triethylaluminum germane	triethylborane
hexarnethyltetraphosphate	triethylgallium
hydrogen bromide	trimethylaluminum
hydrogen chloride	trimethylamine
hydrogen cyanide	trimethylgallium hydrogen fluoride
vinyl bromide hydrogen iodide	vinyl chloride hydrogen selenide
vinyl fluoride hydrogen sulfide	

### 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 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

For unopened chemicals from manufacturer: 18 months (or expiration date).

For 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)

Chemicals that form explosive levels of peroxides without concentration:

Butadiene <sup>a</sup>	Isopropyl ether	Sodium amide (sodamide)	Chloroprene <sup>a</sup>
Potassium metal	Tetrafluoroethylene <sup>a</sup>	Divinylacetylene	Potassium amide
Vinylidene chloride			

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		

Chemicals that may autopolymerize as a result of peroxide accumulation:

Acrylic acid <sup>b</sup>	Methyl methacrylate <sup>b</sup>	Vinyl chloride
Acrylonitrile <sup>b</sup>	Styrene	Vinylpyridine
Butadiene <sup>c</sup>	Tetrafluoroethylene <sup>c</sup>	Vinyladiene chloride
Chloroprene <sup>c</sup>	Vinyl acetate	
Chlorotrifluoroethylene		Vinylacetylene

Chemicals that may form peroxides but cannot clearly be placed in sections A – C:

Acrolein	o-Chlorophenetole
Allyl ether'	p-Chlorophenetole
Allyl ethyl ether	Cyclooctene'
Allyl phenyl ether	Cyclopropyl methyl ether
p-(n-Amyloxy)benzoyl chloride	Diallyl ether'
n-Amyl ether	p-Di-n-butoxybenzene
Benzyl n-butyl ether <sup>d</sup>	1,2-Dibenzoyloxyethane <sup>d</sup>
Benzyl ether <sup>d</sup>	p-Dibenzoyloxybenzene <sup>d</sup>
Benzyl ethyl ether <sup>d</sup>	1,2-Dichloroethyl ethyl ether
Benzyl methyl ether	2,4-Dichlorophenetole
Benzyl 1-naphthyl ether'	Diethoxymethane <sup>d</sup>
1,2-Bis(2-chloroethoxy)ethane	2,2-Diethoxypropane
Bis(2 ethoxyethyl)ether	Diethyl ethoxymethylenemalonate
Bis(2-(methoxyethoxy)ethyl) ether	Diethyl fumarate'
Bis(2-chloroethyl)ether	Diethyl acetal'
Bis(2-ethoxyethyl)adipate	Diethyketene'
Bis(2-ethoxyethyl) phthalate	m, o,p-diethoxybenzene
Bis(2-methoxyethyl) carbonate	1,2-Diethoxyethane
Bis(2-methoxyethyl) ether	Dimethoxymethane'
Bis(2-methoxyethyl) phthalate	1,1-Dimethoxyethane'
Bis(2-methoxymethyl) adipate	Dimethylketene'
Bis(2-n-butoxyethyl) phthalate	3,3-Dimethoxypropene
Bis(2-phenoxyethyl) ether	2,4-Dinitrophenetole
Bis(4-chlorobutyl) ether	1,3-Dioxepane <sup>d</sup>
Bis(chloromethyl) ethers	Di(1 -propynyl)ether'

2-Bromomethyl ethyl ether  
 B-Bromophenetole  
 o-Bromophenetole  
 p-Bromophenetole  
 3-Bromopropyl phenyl ether  
 1,3-Butadiyne  
 Buten-3-yne  
 tert-Butyl ethyl ether  
 Butyl methyl ether  
 n-Butyl phenyl ether  
 n-Butyl vinyl ether  
 Chloroacetaldehyde diethylacetal'  
 2-Chlorobutadiene  
 1-(2-Chloroethoxy)-2-phenoxyethane  
 Chloroethylene  
 Chloromethyl methyl ether'  
 B-Chlorophenetole  
 Furan  
 2,5-Hexadiyn-1-ol  
 4,5-Hexadien-2-yn-1-ol  
 n-Hexyl ether  
 o,p-Iodophenetole  
 isoarnyl benzyl ether<sup>d</sup>  
 Isoamyl ether'  
 Isobutyl vinyl ether  
 Isophoroned  
 B-Isopropoxypropionitrile<sup>d</sup>  
 Isopropyl 2,4,5-trichlorophenoxyacetate  
 Limonene  
 1,5-p-Methadiene  
 Methyl p-(n-ainyloxy)benzoate  
 4-Methyl-2-pentanone  
 n-Methylphenetole  
 2-Methyltetrahydrofaran  
 1-butyl acetate  
 2-Methoxyethanol  
 Methoxyethyl acetate  
 2-Methoxyethyl vinyl ether  
 Methoxy- 1,3,5,7-cyclooctatetraene  
 B-Methoxypropionitrile  
 Di(2-propynyl)ether  
 Di-n-propoxymethane<sup>d</sup>  
 1,2-Epoxy-3-isopropoxypropaned  
 1,2-Epoxy-3-phenoxypropane  
 p-Ethoxyacethophenone  
 1-(2-Ethoxyethoxy)ethyl acetate  
 2-Ethoxyethyl acetate  
 (2-Ethoxyethyl)-o-benzoyl benzoate tert-  
 1-Ethoxynaphthalene  
 o,p-Ethoxyphenyl isocyanate  
 1-Ethoxy-2-propyne  
 3-Ethoxypropionitrile  
 2-Ethylacrylaldehyde oxime  
 2-Ethylbutanol  
 Ethyl B-ethoxypropionate  
 2-Ethylhexanal  
 Ethyl vinyl ether  
 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 ethoxyacetylde'  
 Tetrahydropyran  
 Triethylene glycol diacetate  
 Triethylene glycol dipropionate 3-Methoxy-  
 1,3,3-Trimethoxypropene<sup>d</sup>  
 1,1,2,3-Tetrachloro 1,3-butadiene 3-  
 4-Vinyl cyclohexene  
 Vinylene carbonate  
 Vinylidene chloride<sup>d</sup>

#### 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.

12.33

#### **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, whichever 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.

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## 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.

<u>Left Column</u>	<u>Right Column</u>
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 Acid	Chromic acid, nitric acid, hydroxyl compounds, ethylene glycol, perchloric acid, peroxides, permanganates.
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, fluorine, chlorine, bromine.
Alkali & alkaline earth metals (such as powdered aluminum or magnesium, calcium, lithium, sodium, potassium)	Water, carbon tetrachloride or other chlorinated hydrocarbons, carbon dioxide, and halogens.
Aluminum alkyls	Halogenated hydrocarbons, water.
Ammonia (anhydrous)	Silver, mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride, chlorine dioxide, hydrofluoric acid (anhydrous).
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulfur, finely divided organics or combustibles.
Aniline	Nitric acid, hydrogen peroxide.
Arsenical materials	? reducing agent.
Azides	Acids
Benzoyl peroxide	Chloroform, organic materials.
Bromine	Ammonia, acetylene, butadiene, butane and other petroleum gases, sodium carbide, turpentine, benzene and finely divided metals, methane, propane, hydrogen.

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, all oxidizing agents.
Carbon tetrachloride	Sodium
Chlorates	Ammonium salts, acids, metal powders, sulfur, finely divided organics or combustibles.
Chlorine	Ammonia, acetylene, butadiene, butane, propane, and other petroleum gases, hydrogen, sodium carbide, turpentine, benzene and finely divided metals, methane.
Chlorine dioxide	Ammonia, methane, phosphine and hydrogen sulfide.
Chlorosulfonic acid	Organic materials, water, powdered etals.
Chromic acid & Chromium trioxide	Acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol and other flammable liquids, paper or cellulose.
Copper	Acetylene, hydrogen peroxide, ethylene oxide.
Cumene hydroperoxide	Acids, organic or mineral.
Cyanides	Acids
Ethylene oxide	Acids, bases, copper, magnesium perchlorate.
Flammable Liquids	Ammonium Nitrate, chromic acid, hydrogen peroxide, nitric acid, sodium peroxide, halogens.
Fluorin	Almost all oxidizable substances.
Hydrocarbons (e.g. butane)	Fluorine, chlorine, chromic acid, sodium peroxide.
Hydrocyanic acid	Nitric acid, alkalis.
Hydrofluoric acid (anhydrous)	Ammonia (aqueous or anhydrous) Hydrogen Peroxide
Copper, chromium, iron, most metals or their salts, any flammable liquid, combustible materials, aniline, nitromethane, alcohols, acetone, organic materials, aniline.	
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, 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.
Hypochlorites	Acids, activated carbon
Iodine	Acetylene, ammonia (anhydrous or aqueous), hydrogen.

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, sulfuric acid.
Nitric acid (concentrated)	Acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulfide, flammable liquids, flammable gases, nitratable substances, organic peroxides, chlorates, copper, brass, any heavy metals.
Nitroparaffins	Inorganic bases, amines.
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, store cold.
Phosphorus (white)	Air, oxygen, alkalis, reducing agents.
Phosphorus pentoxide	Propargyl alcohol.
Potassium	Carbon tetrachloride, carbon dioxide
Potassium chlorate	Acids, sulfuric acid (see also chlorates).
Potassium Perchlorate	Sulfuric & other acids (see also perchloric acid, & chlorates).
Potassium permanganate	Glycerin, ethylene glycol, benzaldehyde, any free acid, sulfuric acid.
Selenides	Reducing agents.
Silver	Acetylene, oxalic acid, tartaric acid, fulminic acid, ammonium compounds.
Sodium	Carbon tetrachloride, carbon dioxide, water. 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.

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NIOSWOSHA, *Pocket Guide to Chemical Hazards*, 1997, DHHS (NIOSH) Publication No. 97-140, GPO Stock No. 0 1 7-033-00483-8. 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>

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## **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.

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.

### 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.

## How to Prepare a Material Safety Data Sheet

### Introduction

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 WAU 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 area at WAU.

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 (16.2) is a blank MSDS form (OSHA Form 174) which may be printed out and used to create an MSDS for a chemical produced at WAU. The second part (16.3) 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, it may be stated, "The toxicological effects of this chemical have not (or not fully) been investigated."

If you need help completing an MSDS, please contact the Chemical Hygiene Officer at 301-891-4228.

Material Safety Data Sheet Form

May be used to comply with Occupational Safety and Health Administration (OSHA's) Hazard Communication Standard, (Non-Mandatory Form) 29 CFR 1910.1200. This Standard must be consulted for specific requirements. 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  
Address (Number, Street, City, State, and ZIP Code)  
Telephone Number for Information  
Date Prepared  
Signature of Preparer (optional)  
Emergency Telephone Number

Section II - Hazard Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity;  
Other Limits %  
Common Name(s)  
(optional)  
OSHA PEL  
ACGIH  
TLV  
Recommended

Section III - Physical/Chemical Characteristics

Boiling Point  
Melting Point  
Vapor Density (AIR = 1)  
(Butyl Acetate 1) Solubility in Water  
Appearance and Odor  
Specific Gravity (H<sub>2</sub>O = 1) Vapor Pressure (mm Hg.)  
Evaporation Rate

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used) flammable LEL UEL  
Extinguishing Media  
Special Fire Fighting Procedures  
Unusual Fire and Explosion Hazards

Section V - Reactivity Data

Stability Unstable  
Incompatibility (Materials to Avoid)  
Hazardous Decomposition or Byproducts  
Hazardous May Occur  
Polymerization  
Will Not Occur  
Conditions to Avoid Stable  
Conditions to Avoid



## 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).

### SECTION I

Product Name	Chemical Name Formula
Manufacturer Address	

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 1 including: trade names (the manufacturer's name for the product), chemical name and synonyms (refers to the generic or standard names for the chemical), and chemical family (allows one to group the substance along with a class of similar substances),

### SECTION II - HAZARDOUS INGREDIENTS OF MIXTURES

Principal Hazardous component(s)	%	TVL (Units)
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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, the milligrams of dust or vapor per cubic meter of air.

### SECTION III - PHYSICAL DATA

Boiling Point (F)	Specific Gravity (H <sub>2</sub> O=1.0)
Vapor Pressure (mm Hg)	Percent Volatile By Volume
Vapor Density (Air--1)	Evaporation Rate (Butyl Acetate)
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° 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 (F)      Flammable Limits in Air (% by Lower Upper I Vol.)

Extinguisher Media                  Autoignition Temperature (°F)

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 (LJEL) 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 (Materials to Avoid)	Unstable	Conditions to avoid Stable Incompatibility
Hazardous Decomposition Products		
Hazardous Polymerization		Conditions to Avoid May 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

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.

## 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", WAU has instituted a labeling program for secondary containers based upon contemporary, widely used and accepted labeling procedures:

- a) 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 LD50 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.
- b) 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. Examples for labels can be found at the Environmental, Health, and Safety web site of Cornell University at:

<http://www.ehs.comelf.edu/labels/index.html>.

## **"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 a photocopy of this form for your convenience. If you have questions, call the Chemical Hygiene Officer at 301-891-x4228. Written requests may be sent to Melvin Roberts, Chemistry Department, Washington Adventist University, 7600 Flower Avenue, Takoma Park, MD 20912.

Name Department

Campus Phone Campus Address

List chemicals for which you would like us to send Material Safety Data Sheets. If a trade it is 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.: