Part D: Chemical Safety Procedures for Laboratories

This Part gives general guidance for working safely with chemicals in a laboratory. This document is not a complete safety manual. Additional guidance can be acquired from Safety Data Sheets, equipment operator manuals, and a variety of peer institution web sites or similar legitimate web sites. The UWL Environmental Health and Safety office is also available to provide guidance or acquire qualified assistance.

This Part will help you maintain a safe laboratory. When applied this guidance will aid you in complying with the U.S. Occupational Safety and Health Administration's (OSHA) standard for Occupational Exposure to Hazardous Chemicals in Laboratories. See Appendix B for details of this specific OSHA standard. This Part with Appendix C will help you prepare a Chemical Hygiene Plan for your laboratory, which is required by the OSHA standard.

SAFETY RESPONSIBILITIES

At UWL, faculty, staff, students, and the Environmental Health and Safety office must work together to facilitate safe teaching and research.

Laboratory safety is a joint effort.

Responsibilities of Faculty, Instructors and Managers

If you are responsible for supervising or advising others who use chemicals, you are responsible for their safety. You need to do the following:

- Check to see if necessary and appropriate safety equipment and supplies are present and in working order.
- Review laboratory work practices to see that safety procedures are followed.
- Comply with the OSHA laboratory standard (see Appendix B); including the preparation of a Chemical Hygiene Plan (see Appendix C).
- Submit accident reports for employees to the Worker's Compensation office. Complete this initial reporting within 24 hours of an incident. The UWL Human Resources office has all worker Compensation forms available on their web site.

- Submit accident reports for students. Contact the UWL Risk Management office for a non-employee General Incident/Accident reporting form. This form is also available through the UWL Business Services and Risk Management web site.
- Train new students and staff in chemical safety. Appendix G contains a safety-training outline.
- Inform individuals how to locate Safety Data Sheets (SDS's) for hazardous chemicals in your laboratory. Contact the manufacturer, supplier, or UWL Environmental Health and Safety office to acquire SDS's. The majority of manufacturers and suppliers provide SDS's through their website. A link to common supplier websites and UWL's SDS inventory can be found through a link in the UWL Environmental Health and Safety website.

Safety Responsibilities of Employees and Students

You have the following responsibilities when using chemicals.

- Reading and following your lab's chemical hygiene plan, and the safety procedures of your department and the University.
- Understanding and applying the SDS's prior to initial use of any hazardous chemical. Discuss safety precautions with your principal investigator or supervisor prior to use of any chemical.
- Understanding the proper use of personal protective equipment.
- Understanding the proper use of engineering controls.
- Taking steps to prevent over-exposure to hazardous chemicals. Report symptoms of over-exposure to your supervisor.
- Reporting all spills, accidents, and injuries to your supervisor immediately.
- Disposing of hazardous waste according to UWL procedures.

Before working with any chemical, read the container label and SDS.

Do not perform any procedure unless you are confident of its safety. If you worry about your risks, stop and ask for help. Anyone who uses chemicals or works in a laboratory should ask many questions. Your instructor, principal investigator, or supervisor should discuss safety with you on a regular basis. The Environmental Health and Safety office is also available to provide assistance.

Responsibilities of the Environmental Health and Safety Office

The UWL Environmental Health and Safety office is a resource to campus laboratories. The office can help you with your safety responsibilities and are available to:

- Provide information and advice to laboratories on the safe use of chemicals.
- Assist and inform departments on regulatory and standards compliance.
- Facilitate waste minimization by redistributing unwanted chemicals.
- Provide a central source for SDS's on chemicals used on campus.
- Coordinate campus chemical emergency response with the UWL Police Department, and other emergency responders.
- Safely and properly manage hazardous waste.

How The Environmental Health and Safety Office Can Help...

The Environmental Health and Safety office can help you and your colleagues better understand laboratory hazards and how to control them. There are several ways this is accomplished:

Compliance Training: At your request, the Environmental Health and Safety office can provide compliance-based or specialized/topic specific safety or environmental training to faculty and staff.

This Safety Guide. Appendix G of this Guide gives a suggested outline for a safety-training program for your colleagues and staff. Most parts of this Guide have review questions that can be used as a "Safety Quiz" to get people in your group thinking about safety issues in your laboratory.

SAFE LABORATORY PRACTICES

Step back and look at your laboratory, as if for the first time. This is the view that visitors to your laboratory have. Does it look safe? Is it neat and orderly? Are people taking safety precautions? Is there an odor of volatile chemicals? Are chemicals stored safely? Can you see ways to make your lab a safer place?

Better yet, conduct a more systematic survey of your laboratory's safety practices by using the survey form in Appendix E.

When you plan your laboratory procedures, use these basic principles of chemical safety:

Be informed about the chemicals you are working with. Know their flammability, reactivity, corrosivity, and toxicity.

Don't underestimate risks. Chemical mixtures that contain toxic component(s) shall be assumed to be toxic. Minimize all chemical exposures. Few laboratory chemicals are without hazards. Use precautions when handling *all* laboratory chemicals.

Provide adequate ventilation. The best way to prevent exposure to airborne substances is to vent them away from you. This is best accomplished by the use of chemical exhaust hoods and other ventilation devices.

Housekeeping to Facilitate Safety

Good housekeeping can lower the number of lab accidents and reduce the risk and consequences of a fire. In addition, good housekeeping can increase your working space. For a safe and efficient laboratory:

- Keep passageways to exits clear.
- Do not block areas around safety showers, fire extinguishers, fire blankets, and electrical controls.
- Keep balances, hoods, centrifuges, incubators, refrigerators, ovens, and other common-use items clean and neat for the next user.

Keeping an orderly, well maintained lab can eliminate many lab safety problems.

Laboratory Hygiene

Laboratory hygiene refers to practices to avoid accidental or inadvertent exposure to laboratory chemicals. If there is a small spill of a fine powder, a careless co-worker can quickly spread contamination throughout a laboratory. Even minute exposures can result in harmful

effects for people who work in laboratories every day. Your goal should be no skin contact with laboratory chemicals. Unlike radioactive materials, chemical contamination is difficult to detect. When dyes have been spilled in University buildings, it is shocking to see how widely the contamination is spread. To keep yourself and others safe from accidental contamination:

- Wash your hands after all lab work and before eating or drinking.
- Routinely wash doorknobs, telephones, keyboards and desks.
- Never use mouth suction to fill a pipet. Use a pipet bulb or other mechanical pipet-filling device.
- Do not keep food for consumption in refrigerators that are used to store chemical, radioactive, or biological hazardous materials.
- Never eat or drink in a laboratory.
- Never smoke in any laboratory.
- Never allow a hazardous laboratory chemical to touch your skin; use gloves and wear a lab coat.
- Do not immerse your fingers or hand in liquids; use tongs or a tool.

Your goal should be no skin contact with laboratory chemicals.

Transportation of Chemicals

Chemicals present less of a hazard when left on a shelf in their containers. It is when a chemical is moved there is a risk of a container breaking and uncontrolled releases occurring. Most calls for emergency responders are the result of chemicals spilled while transporting them within a building. Whether you are transporting chemicals across your lab or across campus, take precautions.

Use secondary containment. No matter how careful you are, containers can drop and bottles can break. Use a tray or a bucket to hold your chemicals in transit and contain these possible accidents. Good secondary containment can mean the difference between a small inconvenience and a major building evacuation. Check a laboratory safety catalog to find other secondary containment equipment to suit your needs.

Extra precautions for vehicles. The transportation of chemicals in vehicles on public roads presents additional safety and legal problems. A container of flammable solvent or toxic material ruptured in a road accident drastically increases the risk to your health and makes rescue difficult. Chemicals should never be transported in the passenger compartment of a vehicle.

The Department of Transportation and the Department of Natural Resources regulate the transportation of hazardous materials on public roads. Depending on the type of material transported and the quantity, you may be required by law to have a special driver's license, carry proper shipping papers, and use specified packaging.

If you must transport hazardous chemicals on public roads, call the Environmental Health and Safety office for guidance on how to do it safely. In most cases, transportation may have to be arranged through an external service provider.

Glassware Use

One of most common causes of laboratory injuries is broken glass. To prevent glass injuries, inspect glassware for chips and cracks before use. When you insert tubing into stoppers, lubricate

the glass and use gloves or a towel to protect your hands. When you cut glass, use hand protection and fire-polish all cut surfaces.

Frozen Glass Stoppers

When reagent bottles with ground glass stoppers are not in use it is best to take them apart to prevent sticking. For storage and reuse, put a strip of thin paper between ground surfaces.

If a ground glass stopper sticks, the following procedure will generally free it. Immerse the stopper in a container of carbonated liquid (soda). You will be able to see the liquid penetrate between the ground surfaces. When the surfaces are wet (allow 5 to 10 minutes submersion) remove the bottle and rinse with hot water. Wipe away excess water. If this does not work, gently warm the wall of the bottle neck in hot water or by rotating it for 15 to 20 seconds over a low Bunsen burner flame. (Be sure that 50% of the inner surface is wet before inserting the joint in the flame and that the contents of the bottles can be safely heated.) Remove from the flame and, taking care to protect your hands and fingers, gently twist the two members apart. If they do not come apart, repeat the procedure. Never use force separating ground glass stoppers from bottles. If it is necessary to remove the stopper by tapping, wrap the stopper in a cloth or paper towel. If possible, hold the glass plug with a clamp. Using a wood stick or dowel and hammer, tap lightly but sharply against the outer joint. How hard to tap against the glass joint? Experience will be your guide - just start lightly.

Distillation of Organic Solvents

Take precautions with distillations and reactions, especially when they run overnight. Use these guidelines for safe distillations:

- Prevent overheating by ensuring that all hoses and connections are securely tightened.
- Always leave a phone number where you can be reached. Post it on the door of your lab so that emergency responders can contact you for information in case of a fire or emergency. See the section on emergency posting in Part E of this Guide.
- Use boiling chips or stir bars to prevent bumping during distillations, refluxing, etc.
- Use extreme caution when distilling chemicals that may contain peroxides. Peroxides are most explosive when heated in reduced volumes. For more information on peroxides, see Page 21D.
- Use only round-bottom flasks for vacuum distillations. Erlenmeyer flasks are more likely to implode. Vacuum distillations or evaporations should always be shielded in case of implosion.

Instrument and Equipment Use

Instruments and equipment that operate at high voltage, high pressures, high speeds or high temperatures, are dangerous. Be aware of the hazards and use the following precautions:

- Never attempt to operate a machine or instrument until you have been trained in proper procedures and use.
- Keep the area around instruments and equipment clear of obstructing materials.
- For vacuum pumps, a cold trap should be placed between the apparatus and the pump to prevent volatiles from getting into hot pump oil and vaporizing into the atmosphere.
- All vacuum pumps should have a belt guard to prevent hands, clothing, and other items from being pulled between the belt and pulley.
- If you are working near machinery with belts, pulleys, or moving parts take actions to contain loose clothing and long hair.

- It is a good idea to connect all exit ports from gas chromatographs, atomic absorption spectrometers and other analytical instruments to an exhaust ventilation system to exhaust toxic contaminants from the laboratory.
- Do not leave oil baths unattended. Place your oil bath in a plastic or metal tray to contain any spills.

Never attempt to operate a machine or instrument until you have been trained in proper procedures and use.

CHEMICAL STORAGE AND MANAGEMENT

Do not just store your chemicals; your stocks and inventory of laboratory chemicals need to be actively managed. From the time laboratory chemicals are received in your lab to the time of disposal, you need to inventory them, separate incompatibles, store them safely, and regularly review their status.

Review your chemical inventory. On an annual basis, check the integrity of containers and labels. For peroxide formers, check expiration dates. Add water to keep picric acid moist. Dispose of unwanted, degraded or discolored chemicals. If you find chemicals in good condition that you no longer need, offer them to others who might want them, or give them to the Environmental Health and Safety office for redistribution or to manage in other appropriate manners.

Know your chemicals and their hazards. For each chemical you purchase, the manufacturer is required to provide UWL a Safety Data Sheet (SDS). For a copy of SDS's, contact your supervisor, instructor, manufacturer or the Environmental Health and Safety office. Link to UWL's Environmental Health and Safety Office for more information or acquiring SDS's. If desired, keep a binder of your SDSs for everyone in your lab to use.

Upon receipt, review the SDS's to determine the hazards of the chemical. Part B of this Guide can help you interpret SDS's and other hazard information. Make sure the container is labeled with the chemical's hazard, so that others know too.

Store your chemicals in a safe place. Do not use a fume hood for chemical storage; keep fume hoods clear for work. For storage of extremely odorous chemicals, consider using a ventilated cabinet.

Use sturdy shelving with ample space for every container. Do not store liquids above solids. To avoid the risks of lifting and reaching, keep large and heavy items on lower shelves. Keep containers off the floor, safe from an accidental kick. Use plastic trays for secondary containment to contain liquid spills. Think about ways to keep your chemicals from spilling and contained if they do spill.

Avoid storing chemicals on shelves more than five feet above floor. Do not store liquids above eye level. Nothing may be stored within 18 inches of a fire sprinkler head.

Keep incompatible chemicals separate. Use your knowledge of chemical reactions to separate chemical stocks into compatible categories. Appendix F of this Guide provides information on determining compatible storage of chemicals.

Label all chemical containers. If you make solutions, synthesize products or transfer chemicals to another container, make sure all containers are labeled. Each chemical container in your laboratory should be clearly labeled with:

- The chemical name
- Its principal hazard (e.g., carcinogen, irritant, corrosive, etc.)
- Manufacturer name
- The date prepared, opened or received

Other useful information on labels is the quantity contained and a date when disposal should be considered.

Labeling Small Bottles

All chemical containers must be labeled to enhance safety and assist with disposal. Labeling many small vials with complete chemical names can be a difficult and tedious task. To make this job easier use these tips.

Label the entire group. If you have a rack with vials that hold various fractions from a column, label the entire rack with a description of what is contained in the individual vials.

Refer to your notebook. Give the containers numbers that are referenced in your laboratory notebook.

For larger stocks, devise an inventory system. The benefits of a laboratory chemical inventory system are that it prevents the purchase of duplicates, it helps you monitor chemicals that degrade with age (e.g., peroxide formers), and it helps you keep incompatibles separate.

You can keep information on each chemical container using a box of file cards or a database. A database can be shared with other laboratories to advertise surplus stocks and prevent redundant purchasing for the entire department.

The Tragedy of a Laboratory Fire

Usually a small event starts a laboratory fire. Examples include a hot plate left on or an unattended water bath dries out and overheats. These events ignite a fuel source, and there are plenty of fuel sources in laboratories: paper, bench top covers, plastic lab ware, wooden shelves, and flammable solvents.

It is easy to start a lab fire. It is easy to destroy a laboratory. All it takes is a lapse of memory or judgment (we are always in a hurry) or a careless coworker. Even a careless colleague down the hall threatens your life and work.

If the laboratory door is left open, every room in the area or building can be affected. Even if the fire is quickly extinguished, soot and the extinguishing agent will cover analytical equipment, papers, lab manuals, computers, and all other lab contents. Collateral damage is a reason for the entire department to be concerned about preventing fires.

What is the value of lost research notes, destroyed samples, and lost time? What can you do? Beware of heaters and other fire hazards. Minimize the amount of flammable solvents stored in your room, and store those you must keep in a flammable storage cabinet.

Storage of Flammable and Combustible Chemicals

Chemical labels, SDS's, and Part B of this Guide will help you identify flammable and combustible chemicals. Improperly stored flammable and combustible chemicals provide fuel that can lead to a catastrophic laboratory fire. Use the following rules for storing flammable chemicals:

- Minimize the amount of flammable liquids in your lab. Buy only what you will use in the immediate future and buy the smallest size that you need. Excess flammable solvents increase the risk of a fire or spill, take up more space, and increase the risk of adverse health effects. Unused surpluses have cost UWL thousands of dollars in disposal costs.
- In the laboratory, store flammables in a flammable storage cabinet. Remember, cabinets need to be marked as approved for flammable liquids storage. In general, flammable liquids may not be stored in cabinets below fume hoods or standard wood lab cabinets.
- Store flammables, combustibles, and other fuels away from strong oxidizers, such as perchloric or nitric acids. It is best to store flammable liquids in an approved stock cabinet dedicated solely for that purpose. See Part B of this Guide for a list of oxidizers.
- For laboratory storage of flammable liquids outside of safety cans and flammable storage cabinets, limit the amount to less than ten gallons per laboratory.
- If you include flammables stored in safety cans and flammable storage cabinets, limit the amount of flammable liquids to less than sixty gallons per laboratory.
- On your benchtop, limit the storage of flammable liquids to only those in immediate use.
- It is best to store bottles of liquids in a tray or pan (secondary containment) to catch any spills.
- Use plastic trays for storage of chemicals in freezers. This prevents the bottles from becoming embedded in ice and frost that can form in freezers. This practice also contains spills and drips.
- Always bond metal containers to metal receivers when transferring large volumes of flammable liquids or gases.
- Static electricity can ignite flammable gases or vapors. If static electricity is a problem, minimize static electricity by spraying with an anti-static agent. Use conductive materials (floors, mats, etc.) and using grounding straps on instruments and machines. The greatest hazard from static electricity is in the winter when the air is dry.

It is best to store flammable liquids in an approved storage cabinet dedicated solely for that purpose. For laboratory storage of flammable liquids outside of safety cans and flammable storage cabinets, limit the amount to less than ten gallons per laboratory. On your benchtops, limit the storage of flammable liquids to only those in immediate use.

Storage of Flammable Chemicals in Refrigerators

Take precautions when storing flammable chemicals in a refrigerator. Electrical sparks from a conventional refrigerator can ignite flammable vapors that build up inside. Unless a cold room is ventilated and has a fire suppression sprinkler system, do not store flammable liquids there. Two kinds of refrigerators are approved for storage of flammables:

1. *Flammable liquid storage refrigerators.* These have no spark sources within the refrigerator cabinet. There are, however, spark sources outside the refrigerator cabinet from switches, motors, relays, etc. These spark sources can ignite flammable vapors present outside of the refrigerator. A bottle of flammable liquid dropped and broken near one of these refrigerators can easily be ignited by the sparks.

2. *Explosion-proof refrigerators.* These refrigerators are considerably more expensive because they have all spark sources completely sealed inside and are safe for flammable atmospheres both within and outside of the refrigerator cabinet.

Conventional refrigerators in laboratories and cold rooms (not safe for flammable storage) should be labeled "NO FLAMMABLES". Labels are available from the Environmental Health and Safety office.

PERSONAL PROTECTIVE EQUIPMENT

Will a splash of caustic cause a small mess or a blinding injury? Your use of personal protective equipment (PPE) could determine the answer. Contact Environmental Health and Safety for assistance with PPE selection.

Eye Protection

Eye injuries are horrifying events. OSHA and Wisconsin law requires eye protection for all laboratory workers, so no one should enter a laboratory without proper eye protection.

Safety glasses are the minimum requirement for laboratory eye protection. Wear enclosed goggles and a face shield over your safety glasses if there is a danger of splashed liquids or shattering glass. If you work with ultraviolet or laser light, wear protective lenses specific for the wavelength.

Many safety equipment vendors have a large assortment of non-prescription eye protection. Newer models are nearly fog proof, comfortable to wear, come in a great variety of sizes and styles, and are fashionable. There are also many styles of safety glasses and goggles designed to be worn over prescription glasses; this eyewear is designated as Over-The-Glasses (OTG).

There is no excuse for not wearing eye protection in a laboratory.

Do not step into a lab without wearing safety eyewear!

Respiratory Protection

The Occupational Safety and Health Administration (OSHA) has strict requirements for respirator use (i.e., gas mask or filter mask). Even a simple paper filter mask is subject to OSHA rules. These requirements could include a medical examination and a respirator fit test for all users. A medical exam is necessary because wearing respirators increases the work of breathing, which may cause health problems for some people. In addition, one needs to know the identity and concentration of the air contaminant before selecting the appropriate filter to ensure that it will work.

To avoid these problems, it is best to prevent inhalation exposures, by using engineering controls, (e.g., increased room ventilation, fume hoods, and glove boxes) rather than respirators. If you must wear respirators, contact the Environmental Health and Safety office. We can help you conform to OSHA regulations.

Avoid the problems of using respirators. Use a fume hood, glove box or other isolation device to prevent exposure to airborne contaminants.

Clothing

Wear clothing that protects your skin. Shoes should completely cover your feet; do not wear sandals and other open style footwear into a lab. Wear long pants instead of shorts or skirts. Use a lab coat for further protection. The coat sleeves keep splashes, aerosols and dusts from touching

your forearm and wrist. Have a plastic or rubber apron available for when you work with strong caustics or corrosives. If you are transferring highly flammable material or working with any pyrophoric material, wear a flame retardant lab coat.

Hand Protection

Disposable nitrile gloves should be common in all laboratories. They are inexpensive, comfortable and provide a nominal barrier to common hazards. Check them for holes and change them frequently. Since latex allergies are common, they should be avoided. Be aware that latex gloves offer limited protection from many corrosives and organic solvents. Use a glove selection chart available from glove manufactures, safety equipment vendors, or the Environmental Health and Safety office to choose the appropriate glove for the chemical you are working with.

Be aware that chemicals to some degree can permeate all gloves. They are not meant to provide protection from prolonged immersion in chemicals. Use tongs to retrieve items from the bottom of your acid bath. Do not routinely reach into any liquid with a gloved hand. Some day your hand could go in deeper than the cuff or the glove could fail.

For reusable gloves, do not forget to wash or at least rinse off the gloves after use. This will prolong their useful life and prevent the spread of chemical contamination from the dirty gloves.

Individuals washing glassware, repairing broken/chipped glassware, performing tasks with fragile glass or glass that could be a shatter hazard, should wear cut resistant gloves. Cut-resistant gloves come in various fabrics offering different level of cut resistance. It is important to consider the requirements of a particular application when choosing a glove material.

For laboratory chemicals, your goal should be zero skin contact.

REDUCING YOUR EXPOSURE TO CHEMICALS

The most important tool to reduce exposure to a toxic chemical is a complete knowledge of the chemical's properties. First, read and understand the Safety Data Sheet (SDS) that is available for every purchased chemical. Use Manufacturer on-line SDS resources, UW-L's SDS online links, or contact UWL Environmental Health and Safety office to obtain a copy of any SDS's you need. Consult Part B of this Guide, reference books, web documents, contact the Environmental Health and Safety office for toxicity information, or talk to experienced users of the chemical before working with any unfamiliar chemical.

When you have a thorough knowledge of the chemical, use appropriate controls to ensure its safe use.

Fume Hoods and Other Engineering Controls

The preferred method of reducing or eliminating exposure to airborne substances is the proper use of engineering controls. With engineering controls, safety is designed into the process and there is less reliance upon the skill and vigilance of the worker. Examples of engineering controls include chemical fume hoods, glove boxes, and remote automation that keeps a worker away from a dangerous process. Fume hoods are the most important and common type of engineering control.

How a Fume Hood Works

A fume hood's purpose is to assist in the safe handling of hazardous materials, especially those that produce vapors, gases, or dusts. Fume hoods provide ventilation to carry away airborne contaminants, and exhaust them outside of the building**.** The fume hood's sash will also provide shielding to protect the user, and containment for *small* fires and explosions.

A fume hood must have an adequate face velocity (measured at the work opening) to ensure the proper removal of toxic materials.

During use, the face velocity must be 100 feet per minute +/- 10% (with the sash fully open or at installed sash stop) to be compliant with State safety standards. Fume hoods have a velocity meter that alarms when the face velocity is not within limits. These velocity meters are calibrated annually to ensure accuracy.

Most fume hoods have labels, comparable to examples D-1 and D-2, to describe fume hood operating instructions and to provide fume hood safety instructions. For additional information relating to fume hood use, contact the Environmental Health and Safety office.

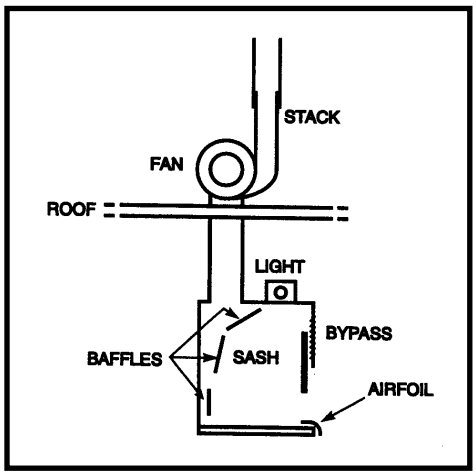
If you doubt the velocity of your hood, contact the Environmental Health and Safety office to request completion of a velocity survey.

Note that ***use of hot, concentrated perchloric acid*** requires a specially constructed hood with washdown facilities to avoid the build up of explosive metal perchlorates in downstream metal ductwork.

A biosafety cabinet is not a chemical fume hood. Their motors are not explosion-proof and a biosafety cabinet should never be used for working with flammable, corrosive, toxic, or other non-particulate chemicals. UWL biosafety cabinets do not eject exhausted air from the building; they merely filter the air to remove airborne microbes and particulates. Chemical vapors and gasses easily pass through the filter and are dispersed back into the room.

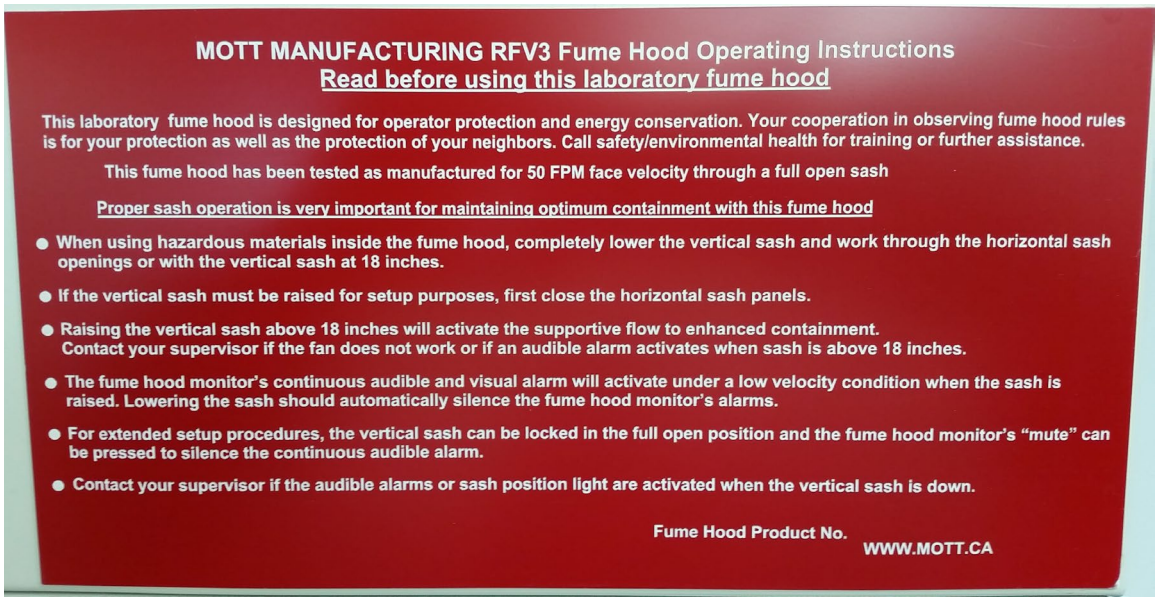
A biosafety cabinet is a stand-alone piece of equipment in the laboratory. Biosafety cabinets can be connected to the building's exhaust ventilation. An annual recertification of the cabinet's performance is required.

Never store flammable liquids in your biosafety cabinet.

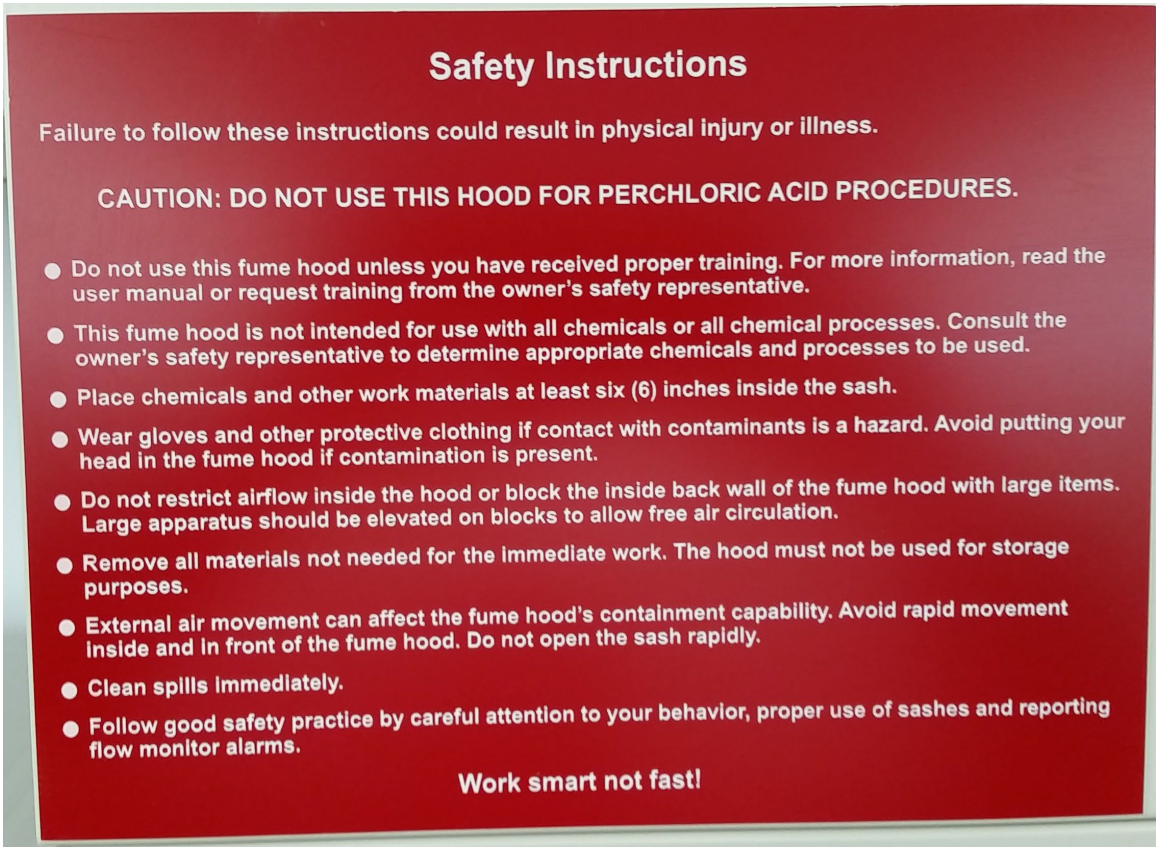


Fume Hood Features and Their Function

Fan and Stack*:* Directs effluent upward at high velocity well above the roof.
Fan outside of building*:* Ensures that ductwork inside building is under negative pressure.
Light*:* Located outside of hood or explosion proof.
Baffles*:* Provides airflow through face.
Sash*:* Provides mechanical protection for user.
Bypass*:* Provides constant face velocity independent of sash position.
Airfoil*:* Prevents dead space at front of hood, helps protect user from small spills.



Label D-1. Fume Hood Operating Instructions.



Label D-2. Fume Hood Safety Instructions

Work Practice and Administrative Controls

In addition to engineering controls, exposure to hazardous substances can be controlled by work practice and administrative controls.

Work practice controls manage the way workers use hazardous substances to reduce exposure. Examples include:

- Using smaller portions of hazardous chemicals by scaling down experiments.
- Making sure containers of volatile chemicals are closed when not being dispensed.
- Any other means that you can think of to reduce the generation of airborne contaminants.
- In essence, work smarter by being aware of the dangers of chemical exposure and constantly searching for ways to reduce them.

Keep your containers closed when they are not being used.

Administrative controls involve standard operating procedures and work rules designed to minimize exposure to hazardous substances. Examples of administrative controls include:

- Limitations on the amount of time that someone is allowed to use a substance.
- A requirement that any new uses of a particularly hazardous substance be reviewed by the supervisor or principal investigator prior to its use.
- Writing and following a chemical hygiene plan. A chemical hygiene plan contains standard laboratory operating procedures that are designed to limit exposure to hazardous laboratory chemicals. (See Appendices B and C of this Guide.*)*

To be effective, administrative controls require commitment and follow-up on the part of supervisors or the principal investigator.

CHEMICALS REQUIRING SPECIAL PRECAUTIONS

This section deals with controlling specific chemical hazards that are common in research laboratories. For more information on the nature of these hazards, see Part B of this Guide.

Special Precautions for Toxic Chemicals

The OSHA laboratory standard (see Appendix B) requires special precautions be taken for work with chemicals with high acute toxicity, select carcinogens, and reproductive toxins. Guidance on acquiring the most recent version of these lists is included in Appendix D. If you use a particularly hazardous substance, be sure to address its storage, use, disposal, and possible spillage in your laboratory's Chemical Hygiene Plan (see Appendix C).

General Precautions

Consult safety data sheets and current references that list the toxic properties of the substances that you work with. Employ all specified safety measures in addition to the following general precautions:

***Establish a Designated Area*.** Use and store these chemicals only in designated, restricted access areas. Post these areas with the appropriate warning signs. See Part E for a sample warning sign. Avoid working alone with these materials.

Chemical Storage and Management. Store breakable containers in chemical resistant trays. Work over trays or plastic-backed absorbent paper. Keep an accurate record of your inventory of these chemicals. This inventory may include amount of chemicals stored, amount used, and the dates and

names of people who work with them. Store all hazardous waste in closed, labeled, impervious containers.

Use a Containment Device. Work in a fume hood when using volatile chemicals.

Personal Protective Equipment. Wear a double pair of impervious gloves and change them frequently. Do not touch doorknobs, telephones or computer keyboards with contaminated gloves. When leaving the area, thoroughly wash your hands, forearms, and any other skin that may have been contaminated. Wear a long sleeved fully buttoned lab coat. If clothing becomes contaminated, decontaminate or dispose of it before leaving the area.

Waste Removal. See Part G of this Guide.

Decontamination Procedures. If surfaces become contaminated, use a wet mop or a HEPA filtered vacuum cleaner to decontaminate surfaces; never dry sweep powders. Decontaminate any equipment or glassware removed from the area. See Procedure Lab ware 1 in Part G for decontamination and reuse of chemically contaminated lab ware.

Emergency Planning and Response. Be prepared for accidents or spills by reading Part E. If a major spill occurs outside of a fume hood, evacuate the area and call University Police at 789-9999 to initiate chemical spill emergency response procedures.

Avoid spreading contamination throughout your laboratory.

Precautions for Reproductive Toxins

Use extreme care with chemicals suspected of being reproductive toxins. For pregnant women, excess exposure can affect the fertilized egg or fetus, cause malformations, or deficits in postnatal function. Remember that pregnancy starts at conception, not after the first missed menstrual period. Questionable exposures should be discussed with your physician and stopped, if advisable, prior to conception. Additional information on reproductive health is available online from the Wisconsin Department of Health Services and a variety of other reputable resources.

CHEMICALS THAT HAVE A SPECIFIC OSHA STANDARD

Because of their hazards, OSHA has specific standards for exposure to:

Asbestos	Respirable Crystalline Silica
Coal tar pitch volatiles	Inorganic Arsenic
4-Nitrobiphenyl	Lead
Alpha-naphthylamine	Benzene
Methyl chloromethyl ether	1,2-dibromo-3-chloropropane
3.3'- Dichlorobenzidine (and its salts)	Acrylonitrile
bis-Chloromethyl ether	Ethylene oxide
Beta-Naphthylamine	Formaldehyde
Benzidine	Cadmium
4-Aminodiphenyl	Coke oven emissions
Ethyleneimine	Methylenedianiline
Beta-Propiolactone	1,3-Butadiene
Vinyl Chloride	Cotton Dust
2-Acetylaminofluorene	Methylene chloride
4-Dimethylaminoazobenzene	Chromium(VI)
N-Nitrosodimethylamine	Beryllium

If you work with any of the above chemicals, you need to be aware of and comply with the specific OSHA standards governing their use. These standards are above those required by the OSHA laboratory standard and, in some cases, may require special signs, medical surveillance, and routine air monitoring of your workplace. If you use these chemicals routinely, even for short periods, you must have your workplace evaluated by the Environmental Health and Safety office to assure that your work practices and engineering controls are sufficient to keep your exposures below the OSHA specified limits. The most common of these in laboratories are formaldehyde (formalin), benzene, ethylene oxide, and methylene chloride.

Formaldehyde is a potent irritant, a skin sensitizer, and a carcinogen. The current time weighted average Permissible Exposure Limit (PEL) for formaldehyde is 0.75 ppm and the odor threshold for most people is 1 ppm. If you can routinely smell formaldehyde in your work area, you may be overexposed.

First, try to find a less toxic substitute material. If you must use formaldehyde, perform all operations in a fume hood. Wear splash proof goggles and neoprene, butyl rubber or polyvinyl gloves.

Air monitoring audits have shown that formaldehyde vapor is very difficult to control. Air monitoring shows that it is often necessary to add ventilation and other engineering controls to protect laboratory workers from dangerous levels of formaldehyde exposure. Contact the Environmental Health and Safety office if you have any questions about the health risks of formaldehyde.

If you can routinely smell formaldehyde in your work area, you may be overexposed.

Benzene is a known human carcinogen, with an 8-hour time weighted average OSHA Permissible Exposure Limit of 1 ppm. Generally accepted safety guidance for carcinogen exposure is to limit exposure to the lowest level feasible. Laboratory use of benzene has diminished markedly in recent years. Substitutions of benzene with less toxic xylene or toluene are usually satisfactory.

Methylene Chloride research has shown suggestive (but not absolute) evidence that the material is a human carcinogen. The current 8-hour time weighted average OSHA permissible exposure limit is 25 ppm. Methylene chloride can also have an adverse effect on the heart, central nervous system, and liver. The odor threshold for methylene chloride ranges from 25 - 30 ppm. If you can routinely smell methylene chloride, you may be overexposed. Use this material in a fume hood and wear appropriate protective equipment.

Precautions for Storing Osmium Tetroxide

Osmium tetroxide and sometimes ruthenium tetroxide are used in electron microscopy. Because they are strong oxidizers, acutely toxic, volatile and difficult to contain, their storage merits special precautions. Poorly stored osmium tetroxide is an unusually difficult disposal problem.

Generally, all of the osmium tetroxide in an ampule is used at one time, but if surplus needs to be stored, it should be contained in the smallest container possible. This minimizes the amount of vapor in the headspace and the release of volatile hazardous material when the container is opened.

Storage of concentrated solutions (1-5%) is a problem for the electron microscope labs because usually only small amounts are used at a time. We recommend sealing spare crystals or solutions in glass ampules, using a flame to melt the glass. To avoid the problems of recontaining surpluses, purchase tetroxide solutions in small, resealable ampules. If you are uncomfortable

with flame sealing ampules, a screw cap or crimp collar and septum container is satisfactory for storage. It is essential that the cap or septum liner not react with osmium tetroxide (use polyethylene or Teflon) and that it firmly contacts the bottle or vial rim. This requires that the liner be cushioned to provide a seal when the cap is in place.

Wrapping a ground glass stopper with Teflon tape may adequately contain osmium tetroxide if done carefully. A Teflon or polyethylene stopper in precision ground glass may also work. Plastic snap-on caps on smooth rim volumetric flasks are suitable if they fit correctly. Polyethylene snap-top tubes work as well, but they can splash upon forcing open the snap-top.

Other attempts to contain osmium tetroxide usually fail; even the best ground glass stoppers allow osmium tetroxide to leak. Silicone grease or Parafilm wrapping only postpones the eventual leaking.

Precautions for Corrosive Chemicals

Corrosives are materials that cause destruction on contact with living tissue. Precautions for corrosives focus mainly on preventing such contact. Acids with a pH< 2 and bases with a pH> 12 are especially dangerous.

Eye protection that forms a complete seal around the eyes (chemical goggles) and gloves should always be used when handling corrosive materials. A face shield, a rubber apron, and rubber boots may also be appropriate. An eyewash and safety shower must be readily accessible in areas where corrosives are used and stored.

When mixing acids with water, slowly add the acid into the water. Acids that generate heat during dilution, such as sulfuric, should be mixed over an ice bath to quench the heat.

Acids and bases should be stored separately. Organic acids should be stored with flammable materials, separate from oxidizers and oxidizing acids.

Precautions for Reactive Chemicals

The hazards of reactive chemicals are specific to each chemical's properties. Before working with reactive chemicals, understand their dangers. Read the label for recommended precautions. Consult references for specific information on their reactivity and compatibilities. Part B provides an overview of reactive chemicals and their identification.

With all reactives, use as small a quantity as possible. When working with reactive chemicals, use a hood sash, a safety shield, or a face shield. Segregate your reactive chemicals and store them away from heat and sunlight.

Oxidizers: Oxidation reactions are a frequent cause of chemical accidents. When stored, segregate oxidizers from flammable and combustible materials, organic material and reducers.

Pyrophoric Chemicals: Pyrophoric materials (e.g., boranes, n-butyllithium, white phosphorus) ignite spontaneously on contact with air. Avoid a flammable spill by storing breakable glass bottles inside a rubber or plastic bottle carrier. Use and store all pyrophorics in an inert atmosphere (e.g., stored under nitrogen or argon).

Shock-Sensitive/Explosive Materials: Shock-sensitive and explosive materials can spontaneously release large amounts of energy when struck, vibrated, dropped or agitated. Some chemicals become increasingly shock sensitive with age, so inspect your stock of reactive chemicals regularly to see if they are degraded and should be disposed.

Many laboratory accidents occur from the inadvertent formation of explosive or shock sensitive materials, such as peroxides, perchlorates, and azides.

PRECAUTIONS FOR PEROXIDE-FORMING CHEMICALS

Certain chemicals can turn into dangerous, shock sensitive, organic peroxides with prolonged storage and/or concentration. Avoid the prolonged storage of all peroxide forming chemicals. Use the table on the following page as a guideline to determine safe storage limits for these chemicals.

The chemicals listed as Peroxide Hazard on Storage in the table can form polyperoxide chains or cyclic oligoperoxides that are difficult to detect and eliminate. These peroxides can come out of solution and form crystals or a gel in the bottom of the container. They are extremely unstable and can violently decompose with the smallest disturbance, sometimes even spontaneously. Do not store these chemicals more than 12 months, unless tests show that they contain less than 80 ppm of peroxides.

The chemicals listed as Hazard Due to Peroxide Initiation of Polymerization can undergo explosive polymerization initiated by dissolved oxygen. Do not store these chemicals more than 18 months, unless tests show that they contain less than 80 ppm of peroxides.

The chemicals listed as Peroxide Hazard on Concentration can form hydroperoxides and ketone peroxides. These peroxides are soluble and can be detected with peroxide test strips or a KI-starch test. It is common to distill these peroxidizable solvents before use and this concentrates the dissolved peroxides and subjects them to heat and mechanical shock.

To safely distill peroxidizable solvents:

- Eliminate the peroxides with a chemical reducing agent or pass the solvent through activated alumina.
- Add mineral oil to the distillation pot. This has the combined effect of "cushioning" any bumping, maintaining dilution and serving as a viscous reaction moderator in case the peroxides begin to decompose.
- Carefully monitor the distillation process to ensure that it does not dry out completely, and then overheat.

Reducing Peroxides During Distillation

Small pieces of sodium metal can be added to the distillation vessel to reduce peroxides. Use benzophenone as an indicator for the presence of sodium metal (benzophenone, in the presence of sodium metal forms a radical with a deep-blue color). When the blue color disappears, add more sodium metal.

If you have any of the peroxidizable solvents listed in the table that are older than the recommended shelf life, test them for peroxides if you can do so safely or call the Environmental Health and Safety office to coordinate proper disposal.

Peroxide-forming Chemicals

The most hazardous compounds are those that form peroxides on storage without being concentrated. These materials can accumulate hazardous levels of peroxides simply on storage after exposure to air. When they are stored as a liquid, the peroxide-forming potential increases and some of the monomers (especially butadiene, chloroprene, and tetrafluoroethylene) should be considered a peroxide hazard on storage.

Peroxide Hazard On Storage

Recommended shelf life: 12 months

Decahydronaphthalene
Diethyl ether
Isopropyl ether
Divinyl acetylene
Vinylidene chloride
Ethylene glycol dimethyl ether
Dicyclopentadiene
Methyl acetylene
Tetrahydronaphthalene
Cyclohexene
1-Pentene
1-Octene

Peroxide Hazard On Concentration

Recommended shelf life: 18 months

Acetal
Dioxane
Tetrahydrofuran
Vinyl ether
Vinyl acetate
Vinyl chloride
Vinyl pyridine
Chlorobutadiene (Chloroprene)
Ethylbenzene
Methylcyclopentane
Benzyl alcohol
2-Butanol
2-Propanol
3-Methyl-l-butanol
2-Pentanone
3-Pentanone

Hazard Due to Peroxide Initiation of Polymerization

Recommended shelf life: 18 months

Styrene
Butadiene
Tetrafluoroethylene
Chlorotrifluoroethylene

Testing Peroxide-forming Agents

Prior to working with a listed compound, test its peroxide level.

1. Carefully examine the container for date of receipt and overall condition. Containers that show signs of oxidation (e.g., rusty container or cap) or are stored longer than the recommended shelf life should be handled with extreme caution. Do not open or move any of these containers. Contact the Environmental Health and Safety office for assistance.
2. If the material is within the recommended shelf life, determine its peroxide content. Quantitative test strips are available from numerous vendors. They are as easy to use as pH paper.
3. Materials with peroxide levels less than 80 ppm may be used as usual.
4. Any compound containing peroxides in excess of 80 ppm should be treated and disposed. Contact the Environmental Health and Safety office to discuss specific treatment and disposal procedures.

OTHER LABORATORY HAZARDS

Use precautions when using gas cylinders, cryogenic liquids, and electricity.

Compressed Gas Cylinders

If compressed gas cylinders are handled incorrectly, they can become a lethal hazard. A broken cylinder valve can cause a cylinder to act like a rocket. Exposure to some gases, such as hydrogen sulfide from a cylinder leak, can be lethal.

Storage of Large (50 inch) Compressed Gas Cylinders

- Prairie Spring Science Center and Cowley Hall have designated areas for storing newly received cylinders and empty cylinders for return. There are cylinder racks and chains or straps to keep cylinders secured.
- Never accept a cylinder if the name of the contents is missing or illegible.
- Transport cylinders on a cylinder cart with a safety chain.
- Always secure gas cylinders to a wall or a stable bench with clamps, straps or chains. Even empty cylinders must be secured.
- Do not remove protective cylinder caps until the cylinder is secured. Replace cylinder caps before returning cylinders to their storage area.
- Flammable gas and oxygen or other oxidizer cylinders shall not be stored in the same storage rooms.
- Try to keep only the cylinders that are necessary for current work in your laboratory.
- Keep cylinders away from all sources of heat and direct sunlight in order to prevent an increase in pressure.
- Unless in a specially designed room no more than three flammable, oxygen, or toxic gas cylinders can be stored per 500 square feet.

Always secure gas cylinders to a wall or a stable bench with clamps, straps or chains.

Use of Gas Cylinders

- Use the correct regulator for a particular gas; never use improvised adapters.
- Before using, check all connections under pressure for leaks. Swab connections with a soap solution and look for bubbles.
- Do not leave regulators and valves on corrosive gas cylinders except when they are in frequent use. Work the valve stem of a corrosive gas cylinder often to keep it from freezing.
- Do not force valve stems; they can easily snap off.
- Turn off both the main valve and regulator when not using the cylinder.
- Clearly mark empty cylinders "empty." Secure empty cylinders in your building's designated cylinder storage area until removed by the vendor.

Rent and Demurrage for Large Gas Cylinders

For larger gas cylinders, there is usually a charge for the time the cylinder is in service. Often this charge is in the form of demurrage, that is, a rental charge that starts after an agreed upon period. These charges are quite small on a monthly basis, but can add up over time. To minimize these rental charges:

- Order only the quantities of the gas that you need.

- Keep track of the location of each cylinder and the date you received it.
- Use your cylinders on a first-in first-out basis.
- If you have no plans to use a cylinder for several months, it may be worthwhile to return a partially full cylinder rather than storing it.

Precautions for Lecture Bottles

Lecture bottles are small gas containers that can become a serious disposal problem for UWL. Analysis and disposal costs for lecture bottles can range from $350.00 to $2,000.00 per cylinder. This high disposal cost reflects the hazards of laboratory gases and the difficulty of disposing of lecture bottles. Exotic and toxic gases (e.g., arsine, phosgene, and nitrogen dioxide) are usually supplied in lecture bottles. The most expensive to dispose of are lecture bottles that are old, have inoperable valves, or have no markings to indicate the contents. Old lecture bottles can leak or spontaneously rupture.

Here are some steps to take to minimize the hazards and cost of lecture bottle disposal.

Annually inspect your lecture bottles. Examine your lecture bottles for the integrity of their markings, tare weight tags, and for corrosion. Use a soap solution (see above) to check for leaks at the valves. Dispose of all lecture bottles that you have no plans to use in the immediate future. Contact the Environmental Health and Safety office for disposal instructions (see **Part G** of this Guide*)*.

Store them safely. Lecture bottles should be stored in a separate ventilated cabinet. Lay them on their sides with their valves pointed toward the ventilation port.

Do not store corrosives with lecture bottles. The corrosive vapors of chemicals such as hydrochloric acid or nitric acid can destroy markings and damage valves.

Track their use. Attach a clipboard to the cabinet or a tag to the cylinder to record dates and the weight of bottles before and after use.

Buy what you need; use what you buy. Buy only the amount of gas necessary for your work and use it all. Consider the efficiency of sharing gases with other labs.

Return unwanted or surplus cylinders or lecture bottles to the vendor. Some vendors will take back surplus gas and empty lecture bottles. When buying gases, talk to the vendor about providing this service. Consider the high cost of disposal if the vendor will not accept surplus gases for return. Contact Environmental Health and Safety for assistance with packaging, labeling, and shipping cylinders to be returned.

Give the Environmental Health and Safety office your empties. If you have empty lecture bottles that will not be returned to the vendor, clearly mark the bottle "empty" and contact the Environmental Health and Safety office for removal. Environmental Health and Safety will dispose of lecture bottles not returned to the vendor.

Buy only the amount of gas necessary for your work and use it all.

Cryogenic Liquids

Cryogenic liquids are hazardous because of the physical and chemical characteristics of their super-cooled state. Cryogenic liquids may cause explosions, fires, asphyxiation, tissue destruction, or embrittlement of structural materials. Follow these guidelines for using cryogenic liquids:

- Always wear chemical goggles and a face shield.
- Keep cryogenic oxygen away from all sources of ignition.
- Do not use gloves that can be frozen to the skin.

- Handle Dewar flasks carefully. Make sure flasks are in a carrier or are otherwise protected to prevent the release of a large number of tiny shards of glass, in the event the flask shatters.
- Select work materials wisely. Cryogenic liquids alter the physical characteristics of some materials.
- Use extreme care in transporting cryogenic containers. Use a cart for large cryogenic containers.

Electrical Safety

The careless handling of electrical equipment starts most laboratory fires. Laboratories have stills, water baths, and other apparatus that can overheat or cause electrical shocks. Minimize electrical safety hazards with the following:

- Before use, check all electrical apparatus for worn or defective insulation and loose or broken connections. Power cords should be checked closely and replaced if found defective.
- Connect all ground wires to clean metal, avoid painted surfaces. Use three-prong grounded plugs whenever possible.
- Keep electrical wires away from hot surfaces.
- Do not allow water to leak on electrical wires, switches and outlets.
- Avoid the use of extension cords. Federal and State regulations only allow extension cords in temporary situations. The cord must be grounded.
- Never touch a switch, outlet or other sources of electrical power with wet hands.
- Avoid using homemade or makeshift wiring. Contact UWL Facilities Planning and Management to have a qualified electrician complete building or equipment wiring tasks.

The careless handling of electrical equipment starts most laboratory fires.

REVIEW QUESTIONS

1. To help ensure a safe laboratory, always make sure that your lab is:
   a) Neat, clean and orderly.
   b) Never stocked with more hazardous chemicals than you could be used within one year.
   c) Well equipped with a nearby eyewash station, safety shower, fire extinguisher, and fire alarm so that you are ready when an emergency occurs.
   d) Staffed by trained workers, who know about the hazardous properties of the chemicals they work with, how to work with them safely, and what to do in an emergency.
   e) All of the above.

2. Horseplay and practical jokes in a laboratory is:
   a) Common practice.
   b) Very dangerous and strictly forbidden.
   c) Okay on April Fools' Day since everybody else is doing it.
   d) Unprofessional and should never be allowed.
   e) b and d.

3. Before you open a container of any hazardous chemical you should:
   a) Find out if there is a less hazardous substitute for the chemical.
   b) Find out all you can about the materials physical, chemical, and toxicological properties.
   c) Have a plan for using the chemical, and know the proper method of disposal.
   d) Write the date that you opened it on the label, so that someone else will be able to determine if the shelf life of the chemical has expired.
   e) All of the above.

4. Today's properly attired lab worker is wearing:
   a) A Tyvek suit.
   b) Closed-toe shoes, safety glasses with side-shields, a lab coat, and gloves that have been selected on the basis of what chemicals are in use.
   c) Natural fibers, such as cotton or wool.
   d) A three-piece suit and necktie. (clip-on, of course)
   e) A self-contained breathing apparatus and a fully encapsulating chemical resistant suit.

5. Flammable liquids should never be stored:
   a) In paper cups.
   b) On your lab bench top.
   c) In a conventional refrigerator.
   d) In your lab in large quantities (greater than ten gallons).
   e) All of the above.

6. Regarding water and concentrated acids, always:
   a) Add acid to water.
   b) Add water to acid, then watch it bubble over.
   c) Have a bucket of water available for emergencies.
   d) Dispose of concentrated and low pH (<6) acid by rinsing it down the drain with lots of water.

7. Corrosives are materials that cause tissue destruction on contact. Corrosives include:
   a) Acids with a pH<2.
   b) Bases with a pH≥12.
   c) Mineral oil.
   d) Saline solution.
   e) a and b.

8. Protective equipment required for using corrosives in a laboratory includes:
   a) A respirator.
   b) Steel-toed shoes.
   c) Goggles that form a seal completely around the eyes.
   d) Heavy-duty rubber gloves.
   e) c and d.

9. According to State fire codes, the maximum number of large four foot tall oxygen, flammable, or health hazard gas cylinders allowed per 500 square foot laboratory area is:
   a) Five.
   b) Twelve.
   c) Three.
   d) As long as they are securely chained, as many as you want.

10. Formaldehyde is:
   a) A potent irritant.
   b) A skin sensitizer.
   c) A carcinogen.
   d) Something you should only use under carefully controlled conditions, in a properly operating fume hood.
   e) All of the above.

11. A chemical fume hood's purpose is:
   a) For storage of chemicals.
   b) A display case for fancy lab equipment.
   c) To assist in the safe handling of hazardous materials that represent an inhalation hazard.
   d) To contain small explosions that may occur in certain laboratory operations.
   e) c and d.

12. Responsibility for laboratory safety at UWL lies with:
   a) Students and employees.
   b) Faculty and staff.
   c) Campus Administration.
   d) All of the above.

13. Employees and students are responsible for:
   a) Making sure that all fire extinguishers are inspected once a year.
   b) Making sure safety glasses are available for everyone in the laboratory.
   c) Reading Safety Data Sheets for every chemical that they work with.
   d) Writing a Chemical Hygiene Plan for their laboratory.

14. When transporting or shipping hazardous chemicals:
    a) Keep them safely stored in the passenger compartment of your vehicle.
    b) Contact Environmental Health and Safety office first.
    c) Keep all containers hidden from view.
    d) Have another person accompany you.

15. When distilling organic solvents:
    a) Use an Erlenmeyer flask.
    b) Stay out of the room.
    c) Make sure every last drop is boiled off.
    d) Use boiling chips or stirbars to prevent bumping.

16. A refrigerator for storing flammable chemicals must be:
    a) Set at a very cold temperature.
    b) Frost free.
    c) Vented.
    d) Have no spark sources inside.
    e) All of the above.

17. Chemicals can be safely stored by:
    a) Putting them up high, out of the way.
    b) Keeping them on the floor.
    c) Putting them as close to a fire suppression sprinkler as possible.
    d) None of the above.

18. Flammable liquids can be safely stored:
    a) In a cabinet under a fume hood.
    b) In a flammable storage cabinet.
    c) In a functioning biosafety cabinet.
    d) All of the above.

19. Wisconsin law requires that:
    a) No contact lenses are worn in a chemical laboratory.
    b) At least one respirator is available in every laboratory.
    c) Eye protection is worn by everyone in a laboratory.
    d) All of the above.

20. A good way to tell if a fume hood is properly running is:
    a) The audible alarm is not activated or muted.
    b) The duct work is connected to the hood.
    c) Look at the velocity sensor to ensure the flow is 100 feet per minute +/- 10 feet per minute with the sash at the sash lock height typically around 18 inches.
    d) All of the above.

21. When working with particularly hazardous chemicals (Appendix D):
    a) Establish a designated area.
    b) Use a containment device.
    c) Wear a double pair of gloves.
    d) Have brush available to sweep up any spilled powders.
    e) All of the above.
    f) a, b and c only

ANSWERS

1. e) All of the above.

2. e) b and d.

3. e) All of the above.

4. b) Closed-toe shoes, safety glasses with side-shields, a lab coat, and gloves that have been selected on the basis of what chemicals are in use.

5. e) All of the above.

6. a) Add acid to water.

7. e) a and b.

8. e) c and d.

9. c) Three.

10. e) All of the above.

11. e) c and d.

12. d) All of the above.

13. c) Reading Safety Data Sheets for every chemical that they work with.

14. b) Contact the Environmental Health and Safety office first.

15. d) Use boiling chips or stirbars to prevent bumping.

16. d) Have no spark sources inside.

17. d) None of the above.

18. b) In a flammable storage cabinet.

19. c) Eye protection is worn by everyone in a laboratory.

20. d) All of the above.

21. f) a, b and c only.