Physical Hazards in a Lab

A guide to physical hazards found in a lab and guidelines for control.

TrentEmployee

4/2/2013

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Preamble

This guide, "Physical Hazards in a Laboratory", is to be used by those persons who work in a lab as part of the course of studies, research related activities or as part of their job. The rules, recommendations and guidelines stated in this guide are provided to assist the user in identifying, understanding and mitigating the risks associated with physical hazards in a Lab. Any deviations from the recommendations in this guide should always be towards a safer protocol.

This document forms an integral part of the Science Health and Safety Program as outlined in the Science Health and Safety Program core document and should be reviewed by all personnel who work in laboratory setting, and shall be reviewed by all personnel who's supervisor has indicated that they are required to have training in the physical hazards in a lab as part of the individual Health and Safety Training record. Supervisors shall determine what additional training is required by the personnel working in their labs.

Introduction:

There are many types of physical hazards which may exist in a lab. They vary from slip, trip and fall hazards to the use of lasers and high voltage electrical equipment. This document will highlight some of the more common physical hazards in a lab and provide some guidance and direction on mitigating these risks. The information in this document is provided as guidance only. It is the responsibility of the Supervisor to ensure that specific hazards are identified and controlled within their area of responsibility and that operating and emergency procedures are communicated to their employees and supervisees.

1.0 Lab Caretaking

Lab caretaking and cleanliness is often overlooked as a safety issue especially in a lab where it is perceived as more of an organizational issue. The classic view of the "mad scientist" where everything appears to be a mess, but is claimed to be stored in some warped logic system, is pervasive in the media and in the minds of many. In reality, the most productive and safest labs are often those where there is a "place for everything and everything is in its place".
Cluttered and unorganized lab spaces represent a safety risk due to material on floors, material stored in awkward locations or in unsafe fashions, and blocked or partially blocked pathways (i.e., between benches). While labs do not need to be "spic and span" overly cluttered labs are an entirely preventable safety risk.

Some Do and Don'ts for Lab Caretaking

Don't Store Material in aisles between benches.
Don't Store Heavy Material above your shoulders, or in an unstable manner.
Do clean up spills immediately.
Do wipe the working surfaces down regularly.
Don't run cords across the floor if possible and if not, cover the cords with anti trip mats or bridges.
Don't fill the garbage to overflowing, contact Caretaking (fixit@trentu.ca) if you require more frequent removal of garbage then is currently occuring
Do wear the appropriate footwear for working in the lab (no open toes or high heels)

2.0 Electrical Safety

Problems with electrical equipment and cords account for many of the unplanned incidents which occur in labs. Problems with electrical cords and equipment have been identified as the cause of several lab fires and injuries in universities and colleges.

2.1 Certification of Equipment:

In Ontario, it is illegal to use electrical equipment unless it has been certified by at least one of several approved safety organizations. Certification by CSA, UL Canada, Intertek (ETLc) and Entela c. are just a few of the marks acceptable to the Ontario Electrical Safety Authority which is the government agency responsible for Electrical Safety in Ontario.

It is important, then, when purchasing scientific equipment that the equipment be certified for use in Canada/Ontario. Unfortunately that is often not the case. In the event that you purchase equipment not currently approved it is possible to get ESA certification through a site inspection by an ESA field inspector. This will usually require a site visit to visually inspect the equipment and a review of the electrical specifications and drawings. The costs associated with field inspections and certification will be borne by the purchaser.

It is normally best that you purchase equipment previously approved by an accepted certification company (the list of acceptable testing services is available on the ESA website), ,however sometimes it is not practicable. This is particularly the case when purchasing equipment from American and European manufacturers where often the equipment has not been certified for use in Canada (or Ontario) ahead of time. Be wary of claims that a company already sold them in Canada, unfortunately that doesn't necessarily mean they have been certified. All certified equipment will have tags or marks on visible parts of the instrument or equipment (often at the back) indicating that the device has been certified. If the mark or tag is not physically present on the device then it is not certified for use in Canada or Ontario.

2.2 General electrical safety practices

Inspect electrical cords regularly and have any frayed or damaged cords replaced.

Extension cords are permitted for temporary set-ups only.

“Piggy-backing” or “Daisy Chaining “ of extension cords is prohibited.

Ensure that electrical equipment is located to minimize the possibility of it being affected by spills, floods, condensation etc.

Ensure laboratory personnel are aware of power shut-offs.

Protect against accidental contact with exposed electrical circuits.

Use of ground fault interrupter circuits is preferable in receptacles located near sinks.

Electrical plugs are never to be modified in any way, except by a certified electrician.

Adapters to allow 3-prong plugs to be used with 2-prong outlets are not permitted.

2.3 Electrical Safety Checklist

Electrical safety, like all other types of safety, is important to your laboratory. It prevents personal injury as well as fire hazards. In 2009, the University of Manitoba had an electrical fire due to an electrical short in a refrigerator cord– this cost them 50 million dollars in damage. Use this checklist to assess equipment and electrical safety in your lab.

1. Outlets, Plates and Covers

   - ✓ Are outlet and switch covers in good condition?
   - ✓ Are the outlets and switches in good condition?

   Not scorched, not warped,not discoloured?

   If yes, no action is required
   If no, the damaged items need to be replaced. **Contact Physical Resources at fixit@trentu.ca or ex 1366**

2. Grounding pins are the round, third prong on plugs. Their purpose is to prevent shocks in case an internal wire comes loose.

   - ✓

   Are the grounding pins present and in good condition?

   - ✓ If yes, no action is required
   - ✓ If no, they need to be fixed or replaced. **Contact Science Shop Electronics Technician at rfox@trentu.ca or ex 7178**

3. Cheater plugs are devices that convert outlets with two slots to outlets with three slots, so that a three pronged plug – one with a grounding pin, for safety – can be plugged in. This is actually dangerous unless the cheater plug is properly grounded. Cheater Plugs are not allowed at Trent University.

   Is the area free of cheater plugs?

   - ✓ If yes, no action is required

- ✓ If no, this will need to be replaced with a permanent outlet with three slots. **Contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**

4. Cords have two layers of insulation – a protective coating that wraps around each wire, and then a larger coating that wraps around all the wrapped wires. If the insulation is damaged in any way, with tears, inner insulation exposed from the outer later peeling back, signs of fraying, or cracks it could cause fire or shock.
    - ✓ Are all cords in good condition?
    - ✓ If yes, no action is required
    - ✓ If no, replace the cords. **For permanent connections, Contact Physical Resources at fixit@trentu.ca or ex 1366. The Electronics Shop can replace cords on equipment Contact RFox@trentu.ca. For questions, contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**

5. Are walking areas free of cords that could pose trip hazards?
    - ✓ If yes, no action is required
      If no, this needs to be resolved. You should reroute the cords so they are not across footpaths or obtain a cord cover mat. These solutions will protect people from tripping as well as protect the cords from wear

    - ✓ Are there cords travelling through windows, doorways, or similar openings?
    - ✓ If no, no action is required
    - ✓ If yes, this needs to be resolved. Reroute the cords so that they do not pass through these openings.

6. Cords need to be properly taken care of to reduce safety hazards. They should be kept in safe places.
    - ✓ If cords are suspended, do they have strain relief?
    - ✓ If yes, no action is required
    - ✓ If no, the suspended cords will need strain relief. **Contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**

    - ✓ Are cords and connections within 1 metre of a water source?
    - ✓ If no, no action is required
    - ✓ If yes, the offending cords and outlets will need to have functioning Ground Fault Circuit Interrupters. **Contact Physical Resources at fixit@trentu.ca or ex 1366 if you think you need a GFCI.**

6. At Trent, you are only allowed to use extension cords temporarily, otherwise you need to have an outlet installed. For Trent, temporarily means that the extension cord is only in use when somebody is present in the lab, and that the extension cord is unplugged overnight and when not in use.
    - ✓ Are extension cords being used only temporarily?
      If yes, no action is required

- ✓ If no, this needs to be resolved. Use the extension cords temporarily. Arrangefor a permanent outlet to be installed if necessary or use a power bar. **Contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**

7. Extension cords are rated for certain maximum amperage to pass through them based on the length of the cord. It is a potential fire hazard if you are not using a cord that is rated appropriately for the device.
   This can be checked by looking at the extension cord and the device. The extension cord should indicate its maximum amperage. The device should state the amperage it uses, and if the extension cord is rated for more amperage than the device, this is good.
   - ✓ Are your extension cords rated appropriately?
   - ✓ If yes, no action is required
   - ✓ If no, obtain extension cords that are rated appropriately for your devices, or obtain power bars. **For questions, contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**
   - ✓ **Be aware that plugging two extension cords together (other wise known as a daisy chain) must be avoided as this can create a fire hazard. If length is an issue, purchase the appropriate length extension cord, rated for the power you require.**

8. If you need more outlets, power bars with circuit breakers (overload protection) could be used. Outlet expanders should be avoided – these are often made of hard plastic and turn either one outlet into three, or two outlets into six. These are unsafe because they usually do not come with circuit breakers (overload protection).

   - ✓ Are approved power bars with circuit breakers being used?
   - ✓ If yes, no action is required
   - ✓ If no, this needs to be addressed. Obtain power bars with circuit breakers to replace power bars without circuit breakers and outlet expanders. Or consider installing a permanent outlet. **Contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**

9. Do circuits blow on a regular basis?
   - ✓ This means that too much electricity is being drawn through the circuit.
   - ✓ If no, no action is required
   - ✓ If yes, this needs to be fixed. **Contact Physical Resources at fixit@trentu.ca or ex 1366 for advice on how to resolve the issue.**

10. Are all machines/equipment CSA, ULc or Ontario ESA approved with a sticker or plate?
    - ✓ These companies ensure that the machines and equipment are in working order and are safe to operate. The stickers or plates are most often found on a motor, or the back of the machine. The stickers or plates will contain

information regarding the voltage, amperage and wattage and will also have safety symbols on it.

- ✓ If yes, no action is required
- ✓ If no, the equipment needs to be approved. **Contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**



11. Has all electrical work greater than 120 volts of alternating current (a/c) been done by aqualified person?
    - ✓ If yes, no action is required
    - ✓ If no, the electrical work will needs to be evaluated. **Contact Science Facilities Manager at cwilliams@trentu.ca or ex 7061**

3.0 Lasers

A laser is a device that emits light (electromagnetic radiation) through a process of optical amplification based on the stimulated emission of photons. The term laser originated as an acronym for Light Amplification by the Stimulated Emission of Radiation. Lasers are found not just in Physics labs but in a wide range of analytical devices.
Lasers can now be classified into 7 classes, 1, 1M, 2, 2M, 3R, 3M and 4.
Lasers are classified as a Physical Hazard under the Occupational Health and Safety Act in Ontario and while little guidance has been given as to the "acceptable minimums" for a laser safety program, most consider the acceptance and implementation of the ANSI Standard Z 136. as the minimum. ANSI (The American National Standards Institute) recommends that those personnel who use lasers of class 3b and above be required to take formal laser safety training. (see Science Services Science Safety Program webpages for details on the Laser Safety Program).

4.0 High Pressure and Vacuum

Working with pressures other than atmospheric, creates additional stress on the apparatus involved, of which glassware is of particular concern. Risk of explosions and implosions needs to be minimized and precautions are to be taken in the event that they occur.
Use glassware suited for high pressure or vacuum (e.g. thick walled).

Ensure that precautions are taken to minimize flying glass in the event of an implosion/explosion, e.g.:
o Wrap glassware in a criss-cross pattern with strong adhesive tape.

o Use safety coated glassware.

o Use wire screening or suitable mesh to cover flasks.
Conduct work behind a safety shield.

Ensure that glassware is not strained and is appropriately secured.

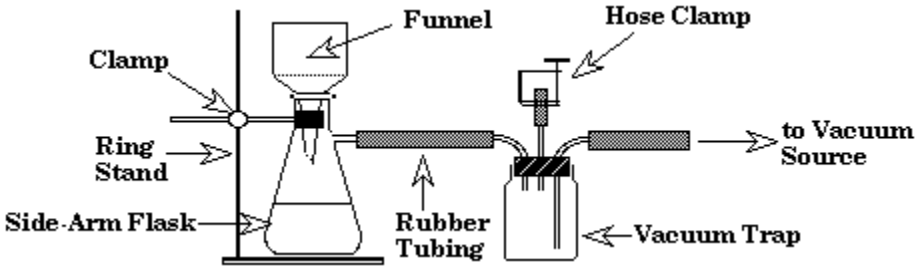
Include pressure relief valves in apparatus set-up for high pressure work.

Before opening a desiccator under vacuum, ensure that the interior pressure has returned to atmospheric pressure.

4.1 Vaccuum systems for filtering

Several of the buildings are now outfitted with central vacuum systems (CSB, LHS Blocks C and D, Science Complex and DNA Block A) When using these central systems there should always be a trap between the filtering apparatus and the point of use fixture for the central system. There are three reasons for this. 1. If the material you are filtering is corrosive or aggressive you may damage the infrastructure piping or pumps in the system; 2. If hazardous material enters the central system there is an increased risk of injury to the people who have to work on and maintain the system and; 3. If incompatible chemicals enter the system, there may be interactions which result in damage to the central system, its components or buildings.

An example of a simple trap system is displayed below.



5.0 Machine Guarding

Injuries can occur from contact with rotating or moving parts as well as pinch points found in various mechanical equipment and instrumentation found throughout laboratories.
Laboratory personnel should be aware of emergency shut-offs for all equipment.

Manufacturer installed guards and safety interlocks are not to be removed or modified without written approval from the laboratory supervisor. This documentation is to be maintained and include the reason the modification is required.

Other equipment containing moving or rotating parts or pinch points not equipped with manufacturer installed guards is to be appropriately guarded so as to protect the operator.

6.0 Glassware

Proper use of glassware can prevent many injuries in the laboratory.
Use only the right size and type of glassware for any given operation.

Ensure that glassware is in good condition prior to use (i.e. no cracks, chips, significant scratches).

Discard broken glassware in appropriate containers.

Cut glass tubes/tubing by scoring using a file or equivalent. Cover the glass with a piece of cloth and break at the score over a piece of cloth/paper to catch any pieces.

Wear leather or other cut-resistant gloves when inserting glass tubing into a stopper or flexible tubing. Fire polish tubing ends and lubricate glass to make connection easier. Ensure that stopper holes are appropriately sized and carefully insert tubing by gently twisting back and forth.

Wear leather gloves when removing glass tubing from flexible tubing or a stopper. If difficult, carefully cut with a scalpel blade or other appropriate glass cutter. Ensure that cuts are made away from the body.

Ensure glassware is stored away from the edges of benches such that it cannot be easily knocked down.

7.0 Ultraviolet lamps

Exposure to ultraviolet light (UV) may result in serious and painful injury to the eyes or skin depending on the specific wavelength of the light to which the individual is exposed, the intensity of the light and the duration of exposure.
Conspicuously label all UV lights sources with the following warning (or equivalent) "Warning – this device produces potentially harmful UV light. Protect eyes and skin from exposure."

Ensure that the UV light source is shielded.

Ensure that appropriate PPE is worn and is sufficient to protect the eyes and skin. PPE should at least include a UV resistant face shield, gloves and a lab coat.

Depending on the situation, shielding of the equipment itself or work area may be warranted.

8.0 Ergonomics

Awkward postures, excessive forces, high repetition and contact stresses can all lead to ergonomic related injuries. Laboratory personnel should be aware of their body positioning and take precautions to ensure proper design and set-up of work to minimize the risk of injury. Contact the Risk Management Office for ergonomic assessments.

9.0 Noise

Noise is one of the most common occupational health hazards. In heavy industrial and manufacturing environments, and laboratory settings with analytical equipment permanent hearing loss is the main concern.

To prevent adverse outcomes of noise exposure, noise levels should be reduced to acceptable levels. The best method of noise reduction is to use engineering modifications to the noise source itself, or to the workplace environment. Where technology cannot adequately control the problem, personal hearing protection (such as ear muffs or plugs) can be used. Personal protection, however, should be considered as an interim measure while other means of reducing workplace noise are being explored and implemented.

As a first step in dealing with noise, workplaces need to identify areas or operations where excessive exposure to noise occurs.

How can I tell if my workplace is too loud?

If you answer yes to any of the following questions, the workplace may have a noise problem.

- Do people have to raise their voices to be heard?
- Do people who work in noisy environments have ringing in their ears at the end of a shift?
- Do they find when they return home from work that they have to increase the volume on their car radio higher than they did when they went to work?
- Does a person who has worked in a noisy workplace for years have problems understanding conversations at parties or restaurants, or in crowds where there are many voices and "competing" noises?

If there is a noise problem in a workplace, then a noise assessment or survey should be undertaken to determine the sources of noise, the amount of noise, who is exposed and for how long. Contact the Risk Management Office for more information or to request a noise assessment.

10.0 Cryogenic Material

Because of the inherent danger, only knowledgeable personnel should handle cryogenic materials, fluid-piping systems, and related equipment. A variety of physical hazards are associated with this class of material:

- Serious burns to the skin can result from direct contact with a cryogen or related equipment.
- Permanent damage to the eyes can result from contact with liquid cryogen.
- Liquid cryogens warmed above their critical temperature will generate high pressures that can cause a confining vessel to rupture or even explode. Fully

containing a cryogenic fluid as a liquid at room temperature is usually not feasible. For example, the pressure required to maintain liquid nitrogen at room temperature is 43,000 psi.

- Cryogens have significant potential for creating oxygen deficiency because they have large liquid-to-gas expansion ratios, generally greater than 700 to 1. A small spill produces a large volume of gas that can displace air in a confined space, creating a serious oxygen deficiency.

In addition to being a physical hazard and an asphyxiant, cryogenic material may also be corrosive, flammable, or reactive. Storage dewars and process vessels must be labeled with the common name of the contents written in English. Material Safety Data Sheets (or comparable safety information) and emergency leak or spill procedures for each cryogen must be available in the immediate area where these materials are stored or used.

Safe handling practices must be observed whenever working with or around cryogens. Do not use cryogens in unventilated spaces such as closets or transport in vehicles without adequate ventilation. When transferring cryogen from pressurized dewars with hoses or tubing, be sure to verify that there are pressure relief devices between all valves. Cryogens can be trapped in the transfer hose or in the tube between two valves, which may cause the hose to rupture and whip around out of control.

Cryogenic liquids present special fire and explosion hazards. A flammable mixture cooled in the presence of air with liquid nitrogen or liquid oxygen can cause oxygen to condense and thereby create an explosive mixture. Keep these mixtures away from ignition sources. Transport fragile cryogenic containers with caution-use a hand truck. Cushion glassware in a protective covering to prevent injury caused by flying glass in the event of implosion/explosion.

Personal Protective Equipment

Eye, hand, and body protection must be worn to prevent contact of liquid cryogens with the eyes or exposed skin. A hazard evaluation performed on each cryogenic operation will determine the specific personal protective equipment (PPE) required. The following are the minimum PPE requirements for cryogenic operations:

Eyes When pouring liquid nitrogen from a dewar, use non-vented chemical goggles or safety glasses with side shields. When working with liquid nitrogen in an open container or when transferring liquid nitrogen from a pressurized device, use safety glasses and a full-face shield.

Hands When working on piping systems with exposed components at cryogenic temperatures, wear loose-fitting gloves made for cryogenic work (or leather welding type without gauntlets) to assure that skin will not freeze to cold pipes or metal parts. Loose-fitting gloves can be thrown off readily if cryogen is spilled into them. Small spills of liquid nitrogen, if not trapped against the skin, will usually evaporate without causing damage.

Feet Wear closed-toe shoes that cover the top of the foot or boots with trouser legs extended over the top of the boot.

Body Wear long-sleeved clothing made of non-absorbent material, cuff-less long trousers worn outside boots or over shoes, and an apron made of leather (or other appropriate material) when handling large quantities of cryogens.

Ears Ear plugs or earmuffs may be required where excessive noise levels occur near filling and venting operations.

Emergency Procedures for Frostbite Injuries

The most likely cause of frostbite to the hands and body is contact with cold metal surfaces. Frostbite can be instantaneous if the skin is moist. Immediate treatment is vital. Report promptly to a medical care facility or call 911 and follow these suggestions:

- Warm the affected area rapidly by immersion in water (not to exceed 105° F), body heat, or exposure to warm air.
- Calm the victim and avoid aggravating the injury. People with frostbitten feet should not walk on them. Do not rub or massage the affected parts of the body.
- If the eyes are affected, flush them with water for least 15 minutes.
- **Always seek medical attention for frostbite injuries.**

(from University of Kentucky Cryogen Information Fact Sheet)

11.0 High Magnetic Fields

At the present time, a review of the scientific and medical research literature do not suggest that there is any direct negative or positive biological effect of high magnetic fields on human or animal organisms. Indeed, high static magnetic fields are used in medical diagnostics (MRI's) on an increasingly regular basis. Many of the hazards associated with High Magnetic Fields (fields which measure greater than 0.2 T) are as a result of the ferromagnetic forces associated with magnetic material and ferrous containing material. Care should be taken when using ferromagnetic instruments around strong magnetic fields as damage to the electromagnet may result and could result in a dangerous situation (such as quenching of an NMR which would result in in the cryogenic liquids explosively converting to gas). In addition those personnel with medical implants (pacemakers or metal rods for exampled) should always take care to remain away from large electromagnetic fields. Owners manuals and user guides will underscore the safe distances that magnetic and ferrous containing materials should be kept away from the magnetic fields.

12.0 Specific Physical Hazards

12.1 Microtomes

Microtomes are an important tool used in the preparation of sample sections for microscopy and must be handled with care to ensure protection against lacerations.
Take particular care when installing or removing blades

Ensure that blade guards remain in place when leaving the microtome for short periods of time.

Remove blades when finished for the day

Carry and store blades within a covered container that holds them in place

Never attempt to catch a dropped blade

Clamp samples securely prior to sectioning

Never leave blades on the bench (including blades used for rough trimming)

Ensure that when the brake is required that it is applied tightly

Turn off microtome when not in use

12.2 Ovens, Hot Plates and Heating Mantles

Ovens are commonly used in the lab to evaporate water from samples, provide a stable elevated temperature environment and dry glassware. Heating mantles are used to heat reaction or sample solutions in round bottom flasks or reaction vessels, and hot plates are used to heat various general laboratory solutions. Bunsen burners are not to be used to heat reaction, sample or general laboratory solutions. The following precautions should be followed to ensure their safe use:
Ensure that laboratory ovens and hot plates are designed such that they prevent contact between flammable vapours and heating elements/spark-producing components.

Avoid heating toxic, even mildly volatile materials in an oven unless it is continuously vented outdoors.

Glassware that has been rinsed with an organic solvent is to be rinsed with distilled water or equivalent before being placed in an oven for drying..
Hot plates or ovens whose thermostat fails are to be removed from service until repaired. (Contact the Electronics Workshop for assistance) Heating devices whose temperature unknowingly rises above that required could create significant fire hazards.

Heating mantles are to be used in conjunction with a variable autotransformer and care is to be taken not to surpass the maximum voltage of the mantle as recommended by the manufacturer.

Discontinue use of any heating mantle whose heating elements have become exposed.

12.3 Heating Baths

Heating baths are designed to heat materials to a constant temperature. They may be filled with a variety of materials including water, mineral oil, sand, glycerin, paraffin or silicone oils, depending on the bath temperature required. Bath temperatures may be as high as 300oC. The following are precautions for heating baths:

Locate on a stable surface, away from flammable and combustible materials including wood and paper.

Ensure bath has cooled before relocation.

Ensure baths are equipped with controls that will turn off the power if the temperature exceeds a preset limit.

Ensure that the thermostat is set well below the flash point of the heating liquid in use.

Equip with a non-mercury thermometer to allow a visual check of the bath temperature.

Do not fill over ⅔ full.

Take care to not allow water to get into oil baths as violent splattering may result.

Steams baths are often safe alternatives for heating because they provide a consistent temperature that will not exceed 100°C. However care must be taken to prevent scalding due to dermal exposure to the steam or steam lines.
Water baths are the most common bath found in the laboratory. When using a water bath:
Clean regularly; a disinfectant, such as a phenolic detergent, can be added to the water.

Avoid using sodium azide to prevent growth of microorganisms; sodium azide forms explosive compounds with some metals.

Decontamination can be performed by raising the temperature to 90oC or higher for 30 minutes once a week.

Unplug the unit before filling or emptying.

12.4 Electrophoresis

The use of voltages of approximately 2000 V and currents of more than 80 mA in electrophoresis procedures create the potential for a lethal electrical shock if the equipment is not operated properly.
Use physical barriers to prevent inadvertent contact with the equipment.

Ensure that electrophoresis equipment is properly grounded.

Ensure electrical interlocks are used.

Inspect electrophoresis equipment regularly for damage and potential buffer tank leaks.

Locate equipment away from high traffic areas and away from wet areas such as sinks or washing apparatus.

Use of ground fault circuit interrupters is recommended.

Display warning signs to identify the electrical hazards (i.e. “Danger – High Voltage”).

Turn off power before connecting leads, opening the lid or reaching into the chamber.

Ensure that lead connectors are insulated

12.5 Distillation Equipment

Hazards involved with distillation procedures include those corresponding to the use of flammable liquids, heat and pressures other than atmospheric pressure.
Ensure that joints are secured. Vapour leaks can lead to fire, unnecessary exposure and contamination of the workspace.

Never distill or evaporate organic compounds to dryness unless they are known to be free of peroxides. See the Chemical Use, Storage, Spills and Waste Guide for information on the hazards of peroxides.

Continuously stir the distillation mixture to prevent bumping of the solution which can result in the apparatus blowing apart. The use of boiling chips may also prevent bumping if the distillation is being performed at atmospheric pressure.

Ensure that the heating source used provides even heating of the solution, e.g. heating mantle, ceramic cavity heater. The addition of a thermometer near the centre bottom of the
distilling flask may provide an early indication of unexpected exothermic decomposition reactions.

If the distillation is being performed at reduced pressure, evacuate the apparatus gradually to reduce the possibility of bumping.

After completing a distillation at reduced pressure, cool the system before slowly introducing air. Introduction of air into a hot system may create an explosive environment.

Solvent stills are to be set-up in the fume hood.

Reduced pressure distillation set-ups or those involving the use of particularly hazardous materials are to include appropriate shielding.

Consider using systems designed to shut down if cooling water fails.

12.6 Centrifuges

Safe use of centrifuges requires proper maintenance and operation. Failed mechanical parts or improper operation can result in release of projectiles, hazardous chemicals and biohazardous aerosols. Maintenance and repairs are only to be performed by trained, qualified personnel. All maintenance is to be documented. To preserve your safety, sample integrity and equipment:
Ensure that centrifuges have an interlocking device that will prevent both the lid from being opened when the rotor is in motion and the centrifuge from starting when the lid is open.

Ensure that centrifuge tubes, heads, rotors and cups are free of hairline cracks, stress lines and chipped rims prior to use.

Ensure that tube materials are chosen such that they provide the necessary chemical resistance and speed rating.

Avoid over-filling tubes.

Cap or stopper centrifuge tubes.

Use sealed centrifuge buckets (safety cups) or rotors that can be loaded and unloaded in a biosafety cabinet or chemical fume hood as appropriate.

Decontaminate the outside of the cups/buckets and rotors before and after centrifugation.

Inspect the o-rings on rotor lids regularly and replace if cracked or dry. Never operate a centrifuge if the rotor lid is missing its o-ring.

Ensure that the centrifuge is properly balanced. Load the rotor with samples arranged symmetrically. Opposing tubes must be of equal weight. If necessary, use "water blank" tubes to balance sample tubes of unequal weight. Do not use sight or volume to conclude that tubes are balanced. Use an electronic balance to balance tubes before using in an ultracentrifuge.

Ensure that the prescribed speed limitations of the rotor or centrifuge are never exceeded.

Unless fitted with a suitable exhaust system, do not centrifuge materials capable of creating flammable or explosive vapours.

Remain with the centrifuge until it has reached its programmed speed.

Abort the run immediately if you hear abnormal vibration, whining or grinding noises. Check the rotor lid and ensure that samples are balanced.

At the end of the run, ensure that the rotor and centrifuge are cleaned according to manufacturer's instructions. Never use abrasive cleaners.

Rotors are easily damaged. Never use metal tools to remove tubes or clean.

For each rotor, record speed and run time for each run in a logbook such that rotors can be downgraded and discarded as appropriate.

If centrifuge is connected to a vacuum pump ensure that the pump exhaust is connected to a trap.

If biohazardous materials are being centrifuged and the centrifuge is connected to a vacuum pump, ensure that a HEPA filter is installed between the centrifuge and the vacuum pump.

12.7 Blenders, Grinders and Sonicators

When used with infectious agents, mixing equipment such as shakers, blenders, grinders, sonicators and homogenizers can release significant amounts of hazardous aerosols, and should be operated inside a biosafety cabinet whenever possible. Equipment such as blenders and stirrers can also produce large amounts of flammable vapours or fine powders depending on the material being used, and therefore should be used within a chemical fume hood.

Ensure equipment is equipped with safety features that minimize leaking and prevent operation if blades are exposed.

Ensure equipment is selected appropriately for the task being performed, e.g. non-sparking (intrinsically safe) motors are used when dealing with flammable solvents.

Ensure that any equipment that could move during use is secured to the bench or floor as applicable.

Ensure equipment is in good condition prior to use.

Allow aerosols to settle for at least one minute before opening containers.

Hearing protection may be required when using sonicators or grinders due to the high frequency or high amplitude sound waves produced.

12.8 Autoclaves

Autoclaves present potential burn and explosion hazards and need to be used with the utmost care.
Autoclaves must have a certificate of inspection prior to use and are inspected annually thereafter. Inspections are coordinated by Science Facilities.

The inspection certificate is to be posted in a conspicuous location near the autoclave itself.

Autoclaves are to be serviced on at least a quarterly basis on a preventative maintenance contract. Service visits are to be documented (e.g. on a tag or in an equipment logbook.)

Inspections and tests are to be performed by trained, qualified personnel.

Autoclaves are to be equipped with a safety/pressure release valve set at or below the maximum pressure of the autoclave.

PPE to be worn when loading or unloading an autoclave:
o heat insulating gloves;

o goggles and a face shield if a splash hazard exists;

o splash apron; and

o closed toed shoes.
Oils, waxes, certain plastics, flammable materials, radioactive materials and samples containing substances that may emit toxic fumes are not to be autoclaved.

Glassware is to be of borosilicate composition and checked for inspected for cracks prior to autoclaving. Ensure that any plastic containers to be put into the autoclave are suitable for high temperature, high pressure conditions, e.g. polycarbonate, PTFE and most polypropylene items. Metal trays are also acceptable.

Ensure that lids to all containers are loosened to prevent pressure build-up during heating and a vacuum upon cooling.

Ensure that containers of liquid are no more than ⅔ full.

Use secondary containment to prevent spillage i.e. put items in trays that will sufficiently catch spills should they occur.

When unloading the autoclave:
o Ensure that the autoclave has depressurized prior to opening door.

o Stand to the side of the autoclave, away from the door and crack open the door approximately 1” to allow steam to escape and pressure within liquids and containers to normalize

o Let autoclaved items stand for at least 10 minutes.

o Open the door and carefully remove the items from the autoclave, transferring them to a safe location where they can cool completely. Superheated liquids can 'bump" when they are removed from the autoclave causing a spray of boiling liquid if proper containers aren't used.
If the autoclave becomes non-functional, label it as such and initiate maintenance/repairs as appropriate and in accordance with department policies.

12.9 Open Flames

The use of open flame devices (alcohol burners, Bunsen burners) represent a higher fire risk then the use of hotplates and other non flame heating devices. The use of open flame devices should only occur when the flame is intrinsically needed for the procedure.

Ensure that the burner is used away from flammable and combustible material as much as is practicable.

Never light a burner with another burner.

Never refill a lit burner.

Take care not to come in contact with the invisible flame.

Ensure that long hair, loose clothing and jewellery are secured.
Never double dip/flame an instrument.

12.10 Acid/Base Baths

Acid and base baths, often used to clean glassware are very corrosive, with the potential to cause significant injury to the personnel using them. Consideration should be given to substituting an acid/base bath with a bath prepared with a laboratory grade detergent. When preparing or handling acid or base baths, ensure that personal protective equipment includes a synthetic rubber apron, safety goggles, a face shield and long synthetic rubber gloves.

Prepare the bath in a fume hood by first adding cold water, to which a measured amount of acid or base is slowly added.

Take particular care to prevent splashing during the loading or unloading of the bath.

When removing items from the bath, empty any residual liquid back into the bath and rinse thoroughly with water.

Dispose of the spent bath in accordance with hazardous waste disposal procedures.

13.0 Compressed Gases

13.1 Hazards of compressed gases

Compressed gases are inherently hazardous due to the high pressure inside the cylinders. Knocking over an unsecured, uncapped cylinder of compressed gas can damage the cylinder valve resulting in a rapid release of gas that can transform a cylinder into an

uncontrollable rocket or pinwheel and cause serious injury or damage. Poorly controlled release of compressed gas in the laboratory can burst reaction vessels, cause leaks in equipment and hoses or result in runaway chemical reactions. Compressed gases may also have flammable, oxidizing, dangerously reactive, corrosive or toxic properties. Inert gases such as nitrogen, argon, helium and neon can displace air, reducing oxygen levels in poorly ventilated or restricted areas and cause asphyxiation.

13.2 Handling and Transport of Gas Cylinders

The following points describe safe handling and transport guidelines for gas cylinders.

Return unlabelled cylinders unopened to the supplier. Colour coding does not provide sufficient identification.

Remove regulators and replace protective cap when cylinders are not in use or are being transported. Use a cylinder cart for transporting cylinders. Chain or strap cylinders to the cart.

Ensure that propane tanks designed for outdoor use are not stored or used indoors.

Label empty cylinders clearly with either “EMPTY” or “MT”.

Never bleed a cylinder completely empty; leave a residual pressure of at least 25 psi to prevent contamination or “suck back”.

Do not lubricate regulators. The mixture of lubricant and oxidizing gases could be explosive.

Do not expose cylinders to high temperature extremes.

Do not force, lubricate or modify cylinder valves in any way.

Ground cylinders containing flammable gases to prevent accumulation of electrostatic charge.

Never expose skin or clothing to compressed gas flow as high velocity gas could penetrate the skin leading to serious injury.

To use a cylinder:

o Ensure the pressure regulating valve (adjusting screw) is closed.

o Open the cylinder valve slowly.

o Open the pressure regulating valve to the desired pressure.

To shut off the gas:

o Close the cylinder valve.

o Open the pressure regulating valve to relieve the pressure.

13.3 Regulators

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Verify that the regulator is appropriate for the gas being used and the pressure being delivered. Regulators are not universal and have to be chosen based on the gas and cylinder being used. Compressed Gas Association (CGA) connector numbers are to be the same on the regulator and cylinder valve.

Label all regulators appropriately and do not use interchangeably with different gases

Do not rely upon the pressure gauge to indicate the maximum pressure ratings; check the regulator's specifications.

Do not use adaptors or Teflon tape to attach regulators to gas cylinders. Regulator inlet connections are designed to fit the outlet connection of the cylinder valve for a particular gas. Gas tight connections are made using metal to metal seals which can be weakened or plugged through the use of Teflon tape.

Use a properly sized wrench to attach a regulator to a cylinder. Adjustable wrenches are not to be used as they can damage the fittings.

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13.4 Storage of Gas Cylinders

Storage of gas cylinders is regulated through the Ontario Fire Code Section 5.6. Proper storage room/locations for compressed gas cylinders are available throughout the University that meet the requirements of the Fire Code. Only cylinders that are in use are to be located in research or teaching labs.

Storage areas are to be conspicuously labelled as such.

All gas cylinders are to be securely supported in an upright position using suitable racks, straps, chains or stands. Cylinders should be secured at ~⅔ of their height. Cylinders with a height of less than 46 cm can be secured in specialized racks.

All cylinders are to be protected from mechanical damage.

Cylinders of flammable gases are to be segregated from oxidizing gases (e.g. oxygen stored separately from hydrogen).

Cylinders are to be located in a dry location away from direct sunlight and heat sources.

Cylinders are to be well removed from doors, aisles, stairs and elevators.

Segregation of Gas Cylinders

As with other chemicals, certain compressed gases are incompatible with each other. The following system describes the segregation required for compressed gases.

Figure E – Compressed gas segregation system COMPRESSED GAS CYLINDER SEGREGATION AND STORAGE PLAN

	Flammable compressed gases	Oxidizing compressed gases	Non-flammable Toxic compressed gases	Non-flammable, Non-Toxic compressed gases
Flammable compressed gases	□	□	□	□

Oxidizing compressed gases	□	□	□	□
Non-flammable Toxic compressed gases	□	□	□	□
Non-flammable, Non-Toxic compressed gases	□	□	□	□

□ may be stored together □ – may not be stored together

Examples:	
Flammable compressed gases	methane, propane, acetylene, hydrogen
Oxidizing compressed gases	oxygen, bromine, chlorine
Non-flammable Toxic compressed gases	carbon monoxide, hydrogen sulphide
Non-flammable, Non-Toxic compressed gases	helium, nitrogen, air, carbon dioxide, argon

14.0 Use of Tools

14.1 Hand and Powered Hand tools:

Personnel using hand tools and small power tools should review the manufacturers safety information which accompanied the tool when purchased. In addition the link below provides information on the hazards and proper use of a variety of hand and hand power tools. Users must be familiar with this information prior to using the tool. Supervisors shall ensure that their personnel are aware of the hazards, follow safe work procedures and use safety features of all hand and powered tools with the appropriate personal protective equipment.

http://www.ccohs.ca/oshanswers/safety_haz/Power_tools/

14.2 Large Powered tools:

In some instances the use of larger powered tools such as lathes, table saws, milling machines too name a few maybe required to manufacture items made of plastic, wood or steel. This work should only be performed by competent personnel. Supervisors should be competent to work with the equipment or they should appoint personnel who have been adequately trained and are themselves competent. Some equipment deemed as potentially very hazardous by a supervisor may be restricted for use to only certain personnel who possess professional designations or training (eg. Milling machines, lathes).