CHEMICAL SAFETY GUIDELINE

Guidelines for the Use, Storage and Handling of Chemicals or WHMIS Hazardous Products in Laboratories

March 2019

Prepared by Environmental Health and Safety

Table of Contents

UNIVERSITY OF MANITOBA

CHEMICAL SAFETY GUIDELINE

STANDARD PRACTICES FOR USING HAZARDOUS PRODUCTS IN A LAB

Draft 2017

APPLICABILITY

Chemicals

For the purpose of this document shall mean any materials used in labs or that are regulated by the Transportation of Dangerous Goods Act, Nuclear Safety and Control Act, Explosives Act, Pest Control Products Act, Human Pathogens and Toxins Act and Workplace Hazardous Materials Information System such as:

-Explosive Materials
-Pesticides
-Compressed Gases
-Oxidizing Materials
-Corrosive Materials

and

-Unsealed Radioactive Materials
-Dangerously Reactive Materials
-Flammable and Combustible Materials
-Poisonous and Infectious Materials
-Biohazardous Materials

WHMIS Hazardous Products:
The purchase, possession and the use of WHMIS Hazardous Products (which include chemicals) as per Part 35 of the Workplace Safety and Health regulations, requires:

- proper facilities and equipment as outlined in the *Summary of Needs* and Designer's Checklist
- WHMIS training given by the department/unit; also for academic departments this training shall be integrated into the curriculum.
- Supplier or Workplace labels (affixed to chemicals or WHMIS Hazardous Products)
- Safety Data Sheets (SDS) are maintained

Radiological Material Usage:
The purchase, possession and the use of radioactive materials requires:
-a permit issued by the University Radiation Protection Committee;
-design approval for a laboratory using radioactive material;
-specific training and:
-may require a dosimetry program and/or design approval for the laboratory
Contact Radiation Safety at radsafe@umanitoba.ca or call Environmental Health and Safety.

Biological Material Usage:
The purchase, possession and the use of biological materials requires:
-a permit issued by the University Biological Safety Advisory Committee;

-design approval for a laboratory using biological material, and;
-specific training.

Advice should be obtained through Environmental Health and Safety.

All labs at the University using, storing or handling chemical hazardous products should have a copy of the Chemical Safety Guideline. Copies of this guideline, WHMIS HANDBOOK, Radiation Safety Manual and Biological Safety Guide are available at: http://umanitoba.ca/admin/vp_admin/risk_management/ehso/ or Environmental Health and Safety , 191 Extended Education Complex, University of Manitoba, Winnipeg, MB, R3T 2N2 Tel:(204) 474-6633.

PURPOSE

University facilities operate under applicable legislation/regulations – Part 35 -Workplace Hazardous Materials Information System, Part 18- Radiation and Part 36 – Chemical and Biological Substances of the Manitoba Workplace Safety and Health regulations, National Fire Code, National Building Code, Nuclear Safety and Control Act, Human Pathogens and Toxins Act and Health Canada Guidelines.

The Chemical Safety Guideline is the minimum standard which must be practiced in labs and other areas where Chemicals or WHMIS hazardous products are stored, handled or used. As an accepted practice, the Chemical Safety Guideline will provide chemical users a clear and concise document to ensure that chemicals or (WHMIS) hazardous products are being handled, stored and disposed in a consistent and safe manner. Individual areas or administrative units may require additional and specific practices according to the type of application and processes involved. The site-specific procedures have to be developed by the Administrative Unit Head or area supervisor who ensures that personnel working in those units follow those safe practices.

1.0 Responsibility/Authority

Responsibility for implementation of this standard rests at all levels including:

1.1 The University

It is the responsibility of the University acting through deans, directors, heads of departments and other administrative unit to provide:

1.1a A safe and healthy working environment.

1.1b Support for implementation of this Guideline.

1.2 The Department Chairperson or Director or Head of an Administrative Unit is responsible for:

1.2a Establishing and maintaining EHS safety programs which comply with the regulations in providing a safe and healthy work environment in their labs or work areas.

1.2b Appointing a senior staff member as WHMIS Coordinator for the department who will receive WHMIS orientation training from EHS and will provide guidance to the department in implementing WHMIS and other safety programs in the department.

1.2c Ensuring that a University Chemical Inventory Database is supported for the Department and kept current.

1.3 Principal Investigators, Laboratory Supervisors and Managers are responsible for ensuring that:

1.3a A University of Manitoba Chemical Safety Permit Application is filled out for labs using chemical or WHMIS hazardous products and submitted to EHS for the purpose of obtaining a Chemical Permit number.

1.3b Safe Work Procedures are created, periodically reviewed, followed and in compliance with the current WSH regulations.

1.3c Staff and all students receive the required safety training on WHMIS, Radiation Safety, Biosafety, Fire Safety Training and on lab/unit specific hazards and their control with specific safety rules and safe work procedures. Training is documented and records maintained.

1.3d Regular lab safety inspections are performed by lab/unit personnel. All written or electronic records of these inspections should be readily available for inspection.

1.3e Any unsafe work procedures and unsafe conditions are promptly recorded and corrected.

1.3f Chemical inventory is current and up-to-date and readily available to worker and emergency personnel.

1.3g All reasonable steps are taken to ensure that necessary personal protective equipment (PPE) are worn by lab/unit personnel.

1.4 The Departmental WHMIS Coordinator is responsible for:

1.4a Providing technical guidance to the department/unit in the implementation of WHMIS for that particular area.

1.4b Ensuring that departmental Chemical or WHMIS Hazardous Products inventory using the University chemical inventory database and SDS are maintained current and accessible.

1.4c Attending WHMIS/safety training.

1.4d Providing WHMIS training to staff and students of the department/unit and maintaining records of the training.

1.5 Laboratory/Unit Personnel (including students and employees) are responsible for:

1.5a Not participating in any activity that may endanger the health and safety of anyone or damage University property.

1.5b Following established safe work procedures (training) and safety practices set for their labs as well as the standard procedures for chemicals or WHMIS hazardous products.

1.5c Wearing personal protective equipment to protect them from the identified hazard in the manner prescribed to yield maximum protection.

1.5d Notifying the Principal Investigator, Laboratory Supervisor, Manager, or EHS of any unsafe or potentially unsafe condition.

1.6 Environmental Health and Safety (EHS) is responsible for:

1.6a Ensuring adequate programs are provided, for compliance with safety and health regulations and for the protection of the health and safety of students, faculty, staff and the surrounding community.

1.6b Facilitate WHMIS program training to Departmental WHMIS Coordinators and other safety training.

1.6c Providing information resource base and assist departments/units in providing training sessions to laboratory/unit personnel, maintaining records, through guidance and consultancy to departmental WHMIS Coordinators.

1.6d Providing advice, guidance and technical support to departments and labs/units in safety matters which includes general/fire safety, personal safety, laboratory safety (Chemical, Biological and Radiation), Hazardous waste disposal.

1.6e Ensuring fume hoods, biological safety cabinets and eye wash and safety shower equipment are inspected on a regular schedule by qualified personnel

1.6f Ensuring that periodic audits and inspections of the labs or work spaces are conducted by qualified personnel to identify hazards and recommendations for abatement to ensure compliance with this guideline and relevant regulations and guidelines such as WHMIS, CNSC, Health Canada, Fire and Building Codes, Provincial and Federal Environment laws and City Bylaws.

1.7 Chemical Safety Committee (CSC)

1.7.1 Membership

1.7.1a The CSC will be comprised of representatives from both the Fort Garry and Bannatyne campus of the University of Manitoba knowledgeable in the safe use and handling of chemicals. The total number of voting committee members shall be not less than six and not more than twelve. Voting members appointed to the CSC may include:

- Principal Investigators
- Laboratory Researchers
- Laboratory Technical Staff
- Faculty or Departmental Safety Managers/Coordinators
- EHS Technical/Support staff (Non-voting member)

1.7.1b Once appointed to the CSC, membership will be for two year terms. Members may continue to sit on the committee until reappointed or re-elected, or until a replacement is appointed or elected.

1.7.2 Responsibilities

1.7.2a The purpose of the CSC is to review current programs and procedures that are related to chemical safety at the University.

The CSC will:

- Work in cooperation with EHS, who is responsible for the administration of occupational health and safety matters at the University of Manitoba.
- Meet regularly to discuss specific chemical safety issues.
- Assist EHS in prioritizing issues related to chemical safety.
- Form smaller working groups to provide advice and feedback regarding elements of the University's chemical safety program.
- Allow for a forum where special committee projects can be presented and voted for implementation or revision.
- Assist in carrying out Laboratory inspections/audits.
- Assist in conducting incident/accident investigations related to chemical or WHMIS hazardous product usage (including near misses).
- Provide assistance to Local Area Safety and Health committees in the identification, recording, examination, evaluation and resolution of chemical safety concerns arising within the University.
- Receive, consider and recommend action to be taken to address or respond to concerns and complaints with respect to chemical safety. CSC will set up a specific email address where non-emergency concerns can be sent. This account will be monitored by EHS.
- Forward recommendations to the Director (Safety & Insurance) and Chief Risk Officer and act on their response.
- Perform other duties as may be specified by the committee

2.0 Procedures

2.1 Chemical Safety Permit Application Process (for Labs and Work Areas)

To provide a better account of chemical or WHMIS hazardous products in your lab or work area, the Principal Investigator or Laboratory Designate will fill out and submit a Chemical Safety Permit Application.

A completed questionnaire will provide the following:

- Emergency contact information for the lab
- Personnel working in the lab
- Labs/rooms/workshops
- A listing of specialty equipment to be used in the lab (i.e. fume hoods)
- A scope of the experimental work to be conducted in the lab
- A list of Chemicals or WHMIS hazardous products to be used in the lab
- Any special waste disposal procedures
- Assurances that:
    - A thorough risk assessment in the lab has been carried out
    - All workers have received training on prescribed safe work procedures
    - All hazardous waste disposal is conducted in accordance with the Hazardous Waste Management Program guidelines
    - Any incidents that may occur in the lab are investigated and a report is submitted
    - An understanding that their lab may be audited or inspected for compliance in accordance with the U of M Chemical Safety Standard.

Environmental Health and Safety (EHS) will review applications and generate a new sign to indicate the hazards from all risk programs, such as radiological, biologicals and chemicals. The hazards within the lab spaces or work areas have not typically changed.

The new signs will include specific headings to identify the work space.

- Research Laboratory
- Instructional Laboratory
- Hazardous Material Storage
- Hazardous Material Work Area
- Clinical Space

2.2 Procurement of Chemicals or WHMIS Hazardous Products

2.2.1 Ordering

2.2.1a Prior to ordering a chemicals or WHMIS hazardous product, users shall make an evaluation of the potential hazards and ensure that proper control measures to minimize risk to all persons are in place.

2.2.1b Any chemical or WHMIS hazardous products which pose a special hazard or risk shall be limited to the minimum quantities required to meet the short-term needs of the program.

2.2.1c Some chemicals such as diethyl ether, isopropyl ether form potentially unstable compounds on storage and need to be disposed within a recommended time. For example, this could be six months from the opening of the new container (see appendix E). Proper planning of experiments should be followed to ensure that Chemicals or WHMIS Hazardous Products are not stored past expiration dates.

2.2.2 Receiving

2.2.2a Before a substance is received, information on proper handling, storage and disposal (from the Safety Data Sheet or other appropriate references) must be known to those who will be involved. No container should be accepted without proper supplier or workplace label as required under Part 35 WSH regulation.

2.2.2b Individual receiving packages containing chemicals or WHMIS hazardous products shall inspect them for integrity. Leaking packages shall be refused. If this is not possible, spill containment procedures are to be initiated at once. Immediately inform the supplier. If the label is no longer legible a workplace label is to be attached. Contents of packages are to be verified with the packing slip.

2.2.2c Consult the inventory and see that the amount of the particular chemical or WHMIS hazardous product does not exceed the maximum quantity and adjust if necessary.

2.2.2d Ethers and other materials which degrade to unstable compounds shall be shelf dated for disposal six months after being opened and not more than twelve months after purchase even if unopened unless processed to remove any unstable peroxides that may have formed.

2.3 Chemical Safety

2.3.1 Workplace Hazardous Material Information System (WHMIS)

2.3.1a A Canada-wide system created to provide information about hazardous products used in the workplace.

2.3.1b WHMIS addresses workers' "right to know" about safety and health hazards posed by hazardous products used in the workplace**.**

2.3.1c The purpose of WHMIS is to protect a worker's health and safety; by providing important information and by identifying potential hazards which workers may be exposed to in the workplace**.**

2.3.1d **As per part 35 of the WSH regulations,** staff and students using, handling and storing chemicals or WHMIS hazardous products must be trained in WHMIS.

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/chemical_safety/WHMIS Program.html

2.3.2 Inventory of Chemicals or WHMIS Hazardous Products

2.3.2a The Principal Investigator or Lab Supervisor of the chemicals or WHMIS hazardous products in the use area (a laboratory, store room, workshop) shall maintain an up-to-date and continuous chemical inventory. The chemical inventory should be accessible (electronically) and maintained for the department by the WHMIS departmental coordinator using a University chemical inventory database.

2.4 Storage

2.4.1 Stockrooms/storerooms

2.4.1a A dedicated storage area for chemicals or WHMIS hazardous products should be provided for large amounts of flammable or potentially explosive products and in accordance with the National Fire Code. Such a storage facility should be located away from offices and exits. Where possible stockrooms/storerooms should be accessible to the usage areas such that transportation of chemicals or WHMIS hazardous products through public areas is minimized.

2.4.1b Stockrooms/storerooms should be adequately and continuously ventilated at the ceiling and at the floor, and be air conditioned. Electrical connections shall be intrinsically safe or explosion proof.

2.4.1c Incompatible substances should never be stored together or near one another. (Generally an SDS provides compatibility information for a chemical. Refer to the Appendix - D "Guidelines for Storage of Laboratory Chemicals).

2.4.1d Stockrooms/storerooms should not be used as a preparation, decanting and repackaging area.

2.4.1e Stockrooms/storerooms should be secured and controlled by one person, so designated by the department/unit (shall not be left unsecured or unlocked).

2.4.1d Stored chemicals or WHMIS Hazardous Products should be examined during regularly scheduled inspections for deterioration and container integrity.

2.4.1e Large or heavy containers should be stored on low shelves.

2.4.1f Toxic substances should be segregated in a well-identified area with local exhaust ventilation.

2.4.1g Highly toxic liquids and mercury in particular should be in unbreakable secondary containers.

2.4.1h An up-to-date inventory of chemicals in the stockroom/storeroom shall be maintained and posted in a conspicuous location.

2.4.2 Work-site Storage

2.4.2a The amount of WHMIS hazardous products at a work-site shall never exceed the amount required for normal daily operation. Any excess amount of WHMIS hazardous products should be stored in an appropriate storage container.

2.4.2b Supplier/ Workplace labels and the integrity of containers to be inspected at each use. Illegible and/or fading/missing labels shall be promptly replaced.

2.4.3 Laboratory Storage

2.4.3a Amounts of chemicals or WHMIS Hazardous Products permitted for laboratory use should be as small as practical.

2.4.3b Storage Chemicals or WHMIS Hazardous Products on bench tops and in fume hoods is not recommended.

2.4.3c Avoid storing chemicals (WHMIS hazardous products) and equipment on top of cabinets in order to maintain clearance of at least 18 inches from the sprinkler heads or if unsprinklered, 24 inches from the ceiling.

2.4.3d Be sure that the weight of the chemicals (WHMIS Hazardous products) does not

exceed the load capacity of the shelf or cabinet.

2.4.3e Cabinets for chemical or WHMIS Hazardous products storage must be of solid, sturdy construction and corrosion resistant.

2.4.3f Regular weekly/monthly inspection of stored chemicals or WHMIS hazardous products will be done by the laboratory supervisor or designate. Outdated and unwanted chemicals shall be disposed through the EHS Hazardous Waste Management Program. All illegible labels should be replaced.

2.4.3g A flammable material storage cabinet shall be used exclusively for the storage of flammable materials. (For more information on maximum quantities for flammable liquids, (please see Appendix B – "The University of Manitoba Flammable Liquid Storage Procedure")

2.4.3h Flammable liquids requiring refrigeration shall only be stored in explosion proof or approved flammable storage refrigerators.

2.4.3i Keep flammable hazardous products away from ignition sources.

2.4.3j Chemicals should be stored in accordance with their compatibility (See Compatibility Chart in Appendix D).
This applies also to spent or unused chemicals slated for disposal as laboratory waste chemicals

Segregate flammable and combustibles from oxidizing acids and oxidizers;
Store reducing materials away from oxidizers;
Segregate acids from bases and from active metals;
Segregate acids from chemicals that could generate toxic gases on contact such as sodium cyanide, iron sulphide;
Segregate oxidizing mineral acids from organic acids, flammable and combustible materials**.**

2.4.3k Perchloric acid and Picric acid Special Handling Requirements

Operations involving heating and digestion with Perchloric acid must be conducted in a special wash down fume hood (Perchloric Acid Fume hood) made of non-combustible material usually stainless steel. Stored perchloric acid must be inspected monthly, and if any discoloration noticed, it must be disposed of immediately. Perchloric acid is also potentially explosive and shall be stored separately.

Picric acid must be kept wet because it is reactive with metals or metal salts and explosive when dry.

2.5 Labelling

2.5a All containers of chemicals or WHMIS hazardous products shall be properly labelled. Supplier or workplace labels are required on the original containers. Once decanted

into other containers workplace labelling is required to comply with WHMIS, or other applicable regulations (Refer to the University of Manitoba WHMIS program.

2.5b Read the label carefully before using the chemical or WHMIS hazardous product. If you are unable to clearly read the label, then confirm the contents prior to use.

2.5c Any food products used for experimental purposes in labs must be labeled with a Workplace label. The workplace label should clearly indicate "not for human consumption"

2.5d Damaged or illegible labels shall be replaced

2.5e ***Cabinet or storage lockers containing chemicals or WHMIS hazardous products in labs or worksites should be labeled with the appropriate WHMIS pictogram label***.

2.6 Safety Data Sheets (SDS)

2.6a A Safety Data Sheets binder/file shall be maintained for all chemicals in the facility. The SDS shall be arranged alphabetically and the binder/file shall be easily accessible to all personnel. WHMIS Regulation requires that SDS shall be kept for 30 years which means that after the expiry date SDS shall be archived for 30 years.

2.6b Where a complete set of SDS in hard copy is not available, personnel shall have access to networked computer to obtain SDS on the Web.

2.7 Workplace Hazard Information Placard (WHIP) and other signage

2.7a Information provided on the chemical safety permit application will be used to populate a Workplace Hazardous Information Placard (WHIP). This WHIP will be posted at the entrance of your laboratory or work area and will provide a descriptive account to first responders in regards to the volumes and types of chemicals or hazardous products in your area.

2.7b To receive a new placard or an amended placard, fill out the Chemical Safety Permit Application Questionnaire - in Adobe PDF or Word Document.
http://umanitoba.ca/admin/vp_admin/risk_management/ehso/geninfo/WHIP.html

2.7c Signs identifying the location of emergency safety showers, eyewash stations, other safety and first aid equipment and exits shall be posted in the lab or facility such that they are visible from both sides of travel.

2.7d Color coded signage used to identify a potential hazard in a lab or facility shall be prominently posted at the entrance door.

2.8 Access

2.8a Access to laboratories/facilities where chemicals or WHMIS hazardous products are used or stored should be restricted to authorized persons. Principal Investigators or any other persons with supervisory role should be responsible to insure that authorized persons under their care should receive the required training. This includes site specific training in the nature of the hazards and in appropriate safe handling precautions including procedures in the event of emergencies such as spillage and fire (WHMIS).

2.8b All visitors including; outside contractors or U of M personnel (i.e. Physical Plant Trades, Security Services) who are required to enter laboratories/facilities where chemicals or WHMIS hazardous products are used or stored should be escorted by an authorized person. The authorized person will inform the visitor of potential hazards in the area and provide any PPE required and direction on appropriate safe behavior in the area.

2.8c Persons under the age of 16 years should not be permitted in labs or work areas where chemicals or WHMIS hazardous products are used or stored. However, on occasions where such persons are permitted in laboratories as part of educational or class room activity, they must be under direct supervision of authorized personnel who will be responsible to ensure that they are protected at all times from potential hazards.

2.8d The following parental consent form should be filed out prior to minors being allowed into the lab.

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/media/MinorsLabsConsentForm.pdf

2.9 Distribution/transporting within facility

Use care and caution before and during transport. In doing so, you minimize danger to yourself, others and the environment. Individuals transporting chemicals or WHMIS hazardous products must be familiar with the hazards of the products and know what to do in the event of a spill or release. Prescribed spill procedures and PPE shall be on hand while transporting. Safety Data Sheets (SDS) should be consulted. Do not wear PPE in public areas.

2.9a While preparing chemicals for distribution/transportation, wear appropriate Personal Protective Equipment (PPE) - safety glasses/splash goggles, lab coats, and appropriately rated gloves.

2.9b Chemicals or WHMIS hazardous products must be attended at all times while being transported. Do not attempt to carry more bottles than you can handle. Larger quantities should be transported on carts.

2.9c Use safety containers for flammable solvents. If these solvents must be kept in

glass bottles for reasons of purity, keep the volumes in the bottles to a minimum. Secondary containment should be used for transporting other liquids.

2.9d Breakable containers of chemicals or WHMIS hazardous products should be placed in an outside shatter-proof and leak-proof container such as rubber bucket or plastic pail (i.e. secondary containment). Other secondary containers include plastic bottle carriers with closed tops and handles and liquid-tight carts with lips on all four sides. The volume of the secondary containment shall be able to hold the maximum volume transported. Never transport non-compatible chemicals in the same secondary containment or in any way that might allow the chemicals to mix or react. The same consideration shall apply to transportation of chemicals in public hallways on a cart.

2.9e Choose routes to minimize transportation through public areas. Consider transporting during low traffic time periods. Use freight elevators when available, in transporting chemicals between floors. If freight elevator is not available, use uncrowded passenger elevator. Stairs should be used only if elevators are not available. Use a dumb waiter if available, making sure all other safety precautions taken. The dumb waiter should be intrinsically safe for transporting flammable materials.

2.9f Use sturdy carts with railings/guards on the sides (to prevent sliding off the cart during transport) for transporting multiple, large or heavy containers. The cart wheels must be large and wide, e.g., pneumatic wheels (5 inches wide), so that they don't get caught in groove/slider of an elevator during transport. Consideration must be given to the weight and balance of the load.

2.9g Compressed gas cylinders shall be moved only with the valve covers screwed on and when securely attached/restrained to a dolly/compressed gas cart.

2.9h Transport cryogens only in approved storage vessels e.g., Dewar flasks with pressure relief mechanisms. Safe Work Procedures should be established.

3.0 Dispensing Procedures

Dispensing should be done in a well ventilated area. A fume hood can be used for this purpose.

3.1 Dispensing of Flammable and Combustible liquids

3.1a There is a danger of fire due to static build up and discharge during dispensing of flammable/combustible liquids from metal storage containers having a capacity of 25 litres or more to smaller ones. The danger can be avoided by bonding and grounding.

3.1b In dispensing flammable and combustible liquids from container having a capacity of

25 L or more to smaller containers, one has to consider the hazard of static electricity. Static charges are produced by the flow of liquid from one container to another. The primary hazard involves liquids of high electrical resistance - mostly those liquids immiscible in water and having low flash points. While transferring an ignitable vapor/air mixture static sparks can develop. Sparks can be prevented by following the procedures:

3.1b.1 Dispensing should be done only in well ventilated area, preferably in a chemical fume hood using a pump.

3.1b.2 GROUNDING - Electrically ground the storage container (i.e. the 25 L drum). Grounding is done by providing a path for static charge to drain off to the earth. Grounding straps or wires must be connected to known grounds such as metal water pipes, grounded metal building framework, and metallic underground gas piping systems.

3.1b.3 BONDING - Electrically connect together the metal containers. This can be done with a flexible bonding conductor - a bonding strap or wire. Check bonding and grounding connections to ensure that they are in good condition.

3.1b.4. Allow flammable liquids to flow slowly to minimize the generation of static electricity. Do not splash-fill containers since the turbulence of the liquid can generate static charge. Pour the liquid through a funnel having a long delivery stem immersed deeply in the receiving container to avoid splashing and turbulence. Build-up of static electric charges near the surface of liquids being poured into non-conducting containers can be controlled by limiting the flow-rate to less than 1 m/s, using a grounded lance or nozzle extension to the bottom of the container.

4.0 Basic Lab Safety expectations where Chemicals or WHMIS Hazardous Products are used

4.1 The preparation, consumption, or storage of food and drink and smoking are not permitted in laboratories/worksites.

4.2 Individuals should:

4.2a Act in a manner to minimize risk, injury to themselves or co-workers or damage to University property;

4.2b Know the location of emergency exits, alarms, available telephones and safety equipment such as extinguishers, emergency eyewash and showers;

4.2c Learn how to use the safety equipment and have good understanding of the safety rules and emergency procedures;

4.2d Identify potential hazards associated with any experiment before beginning it;

4.2e Wear appropriate personnel protective equipment;

4.2f Remove gloves and wash hands prior to touching phones, pens and light switches;

4.2g Use equipment only for its designated purpose;

4.2h Ensure guards are in place for movable parts of equipment, e.g. belt-guard for a vacuum pump, workshop machinery (drills, lathes, saw etc.)

4.3 Individuals should:

4.3a Be aware of other people's movements/activities and the surrounding;

4.3b Be aware of the potential hazards of the work done by co-workers;

4.3c Be alert to unsafe conditions and see that they are reported to the Principal Investigator or person responsible. Warn co-workers who are carrying out work in an incorrect or dangerous way;

4.3d Communicate your movements to co-workers to avoid distracting or startling them. Keep your co-workers informed of your activities so that they can respond appropriately in the event of an emergency;

4.3e Confine long hair and loose clothing;

4.3f Avoid wearing jewelry;

4.3g Wear appropriate laboratories/worksites clothes that cover legs, feet and arms;

4.3h Wear shoes that have no perforations and cover the entire foot;

4.3i Keep cabinet and bench drawers closed;

4.3j Keep passages and aisles clear.

4.3k Keep the work area clean and uncluttered with chemicals and equipment properly labelled and stored; clean the work area on completion of an operation or at the end of each day;

4.3l Extension cords **shall not be used** on a permanent basis but if required for a short time, must be approved by the Physical Plant Electrical Department;

4.3m Be aware modification of utilities (e.g. plumbing, electrical lines, ventilation/fume hood ducts etc.) would require appropriate consent/approval from Physical Plant/EHS.

5.0 Personal Protective Equipment (PPE)

Personal Protective Equipment (PPE) is to be used when substitution or engineering controls are not feasible. PPE does not reduce or eliminate the hazard and protects only the wearer. Wherever possible, engineering controls (e.g., ventilation, local exhausts, fume hood, Glove box etc.) should be installed to make the lab or worksite safe. There are some situations where engineering controls are not practical or available

A job hazard analysis shall be conducted by the Principal Investigator and laboratory personnel to determine if PPE is required.

General Concept

Personal protective equipment is an individual's means of protecting themselves from specific hazards in the laboratory or worksite**.** Personal protective equipment must be provided if it is required to perform the operation safely. The need for and type of PPE required will depend on the particular hazards of the materials, equipment and procedures used. PPE includes (but not limited); gloves, protective clothing, eye protection, footwear and respiratory protection. The workers who rely on PPE must understand the functioning, proper use, and limitation of the PPE used. **Contact EHS for more information (476-6633)**.

5.1 Workplace Hazard Information Placards (WHIP) will identify what the minimum personal protective equipment requirements are for entry into labs or areas where chemicals or WHMIS hazardous products are used. Additional PPE may be required for work.

5.2 Personal protective equipment (safety glasses with side shields, safety goggles,

gloves, apron, lab coats, overalls etc.) is to be used in the laboratory/facility only. PPE should be removed before leaving the laboratory or worksite. Remove laboratory coats immediately on significant contamination. Wash areas of exposed skin well before leaving the laboratory/worksite

5. 3 Eye protection

5.3.1 Safety Glasses, Goggles and Face shields

5.3.1a At minimum, safety glasses with side shields must be worn in the laboratory or in an area where eye hazards are a possibility (particles, glass or metal shards striking the eye), **Prescription eye glasses (with safety lenses), do not provide adequate eye protection especially from the sides.**

5.3.1b For optical light hazards, different kinds of eye protections are necessary. For UV protection, plastic safety glasses are preferred. For Lasers, specially designed goggles which absorb at specific wavelength regions appropriate for the particular laser are to be worn.

5.3.1c Chemical safety goggles are designed for additional eye protection against splashing from hazardous materials. They should have indirect ventilation so that hazardous substances cannot drain into the eye area. Some goggles can be worn over prescription glasses.

5.3.1d Face shields should be worn when working with large volumes of hazardous materials, to protect face from splash or flying particles. Face shields must be used in conjunction with safety glasses or goggles.

5.3.1e If wearing contact lenses in a laboratory or an area where eye exposure is anticipated, safety glasses with side shields or tight fitting safety goggles must be worn.

5.4 Skin protection

5.4.1 Protective Clothing (Lab coats, Aprons, Overalls)

5.4.1a When there is a risk of chemical contamination to the skin, protective clothing that resists the physical and chemical hazard should be worn over street clothes.

5.4.1b Lab clothes are appropriate for minor chemical splashes and spills, while plastic or rubber aprons are best for protection against corrosive or irritating liquids.

5.4.1c Disposable outer garments e.g., Tyvek suits may be useful when cleaning of

reusable protective clothing is difficult.

5.4.1d Loose clothing such as oversized lab coats or ties could more easily become caught in machinery, come in contact with chemicals and/or catch on fire, therefore should not be worn in the laboratory or worksite.

5.5 Footwear

5.5.1a Close toed shoes should be worn at all times in laboratories or worksites where chemicals or WHMIS hazardous products are stored or used. **Perforated shoes, open toed shoes, sandals or cloth sneakers should not be worn in laboratories or where mechanical work is done**.

5.5.1b Chemical resistant overshoes or boots may be used to avoid possible exposure to corrosive chemicals or large quantities of solvents or water that may penetrate normal foot wear in situations such as, during spill cleanup.

5.5.1c Steel-toed safety shoes may be necessary when there is a risk of heavy objects falling or rolling onto the feet, such as in bottle-washing operations or in animal care facilities.

5.6 Gloves

Most glove manufacturers have chemical compatibility charts for their gloves; these charts can be found in laboratory safety supply catalogues. Many SDS also provide information about most protective glove material. Manufacturers test data refer to laboratory conditions, which can vary significantly under actual work place conditions.

5.6.1a Wear appropriate gloves when there is potential of contact with toxic or corrosive materials, chemicals of unknown toxicity, rough or sharp objects, and very hot or cold materials.

5.6.1b Inspect the glove for puncture or signs of degradation before each use. Test for puncture by blowing or trapping air.

5.6.1c Wash them before removal, and replace them periodically. To avoid accidental skin exposure, remove the first glove by grasping the cuff and peeling the glove off the hand so that the glove is inside out. Repeat the process with the second hand, touching the inside of the glove cuff. Wash hands immediately with soap and water.

5.6.1d Check resistance to chemicals of common glove materials available from manufacturer/distributor of gloves. Gloves should be selected based on chemical compatibility. Choose gloves appropriate for the chemical you would use or the work

you would do; Nitrile gloves provide the best all around chemical protection while latex surgical gloves provide little or no protection from most chemicals. Make sure when wearing gloves not to contaminate water taps/utility/door handles or other surfaces likely to be touched with bare hands. Be aware of touching the face, hair and clothing as well. Change disposable gloves frequently.

5.6.2 ***Selecting the appropriate Glove Material***

5.6.2a The following characteristics need to be considered in selecting the appropriate glove: degradation rating, breakthrough time, permeation rate

Degradation is the change in one or more of the physical properties of a glove caused by contact with a chemical. This typically occurs as hardening, stiffening, swelling, shrinking or cracking of the glove. Degradation rating indicates how well a glove will hold up when exposed to a chemical and is reported as E (excellent), G (good), F (fair), P (poor), NR (not recommended), NT (not tested).

Breakthrough time is the elapsed time between the initial contact of the test chemical on the surface of the glove and the analytical detection of the chemical on the inside of the glove.

Permeation rate is the rate at which the test chemical passes through the glove material once the breakthrough has occurred and equilibrium is reached. Permeation involves absorption of the chemical on the surface of the surface of the glove, diffusion through the glove, and desorption of the chemical on the inside of the glove. Resistance to permeation rate is reported as E (excellent), G (good), F (fair), P (poor), NR (not recommended). If chemical breakthrough does not occur, permeation rate is not measured and is reported as ND (not detected).

Manufacturers test data refer to laboratory conditions, which can vary significantly under actual work place conditions.

Most glove manufacturers have chemical compatibility charts for their gloves; these charts can be found in laboratory safety supply catalogues. Many SDS also provide information about most protective glove material.

5.6.3 Other considerations - other factors to consider in selecting gloves are:

Dexterity - the amount of dexterity needed to perform a particular manipulation must be weighed against the glove material recommended for maximum chemical resistance. When working with very delicate objects where fine dexterity is very important, a bulky glove may actually be more of a hazard.

Where fine dexterity is needed, consider double gloving with a less compatible material, immediately removing and

replacing the outer glove if there are any signs of contamination. In some cases, as for example, when wearing a Silver Shield gloves, it may be possible to wear a tight fitting glove over the loose glove to increase dexterity.

Thickness - is usually measured in mils or gauge. A 10-gauge glove is equivalent to 10 mils or 0.01 inches. Thinner, lighter gloves offer better touch sensitivity and flexibility but may provide shorter break through times. Doubling the thickness of the glove usually quadruples the breakthrough time.

Glove length - should be chosen based on the depth to which the arm would be immersed or where chemical splash is likely. Gloves longer than 14 inches provide extra protection against splash or immersion.

Size - this is important because one size does not fit all. Gloves which are too tight tend to cause fatigue, while gloves that are too loose will have loose finger ends that make work more difficult. The circumference of the hand measured in inches is roughly equivalent to the reported glove size.

5.7 Respiratory Protection

5.7a The purpose of a respirator is to prevent the user from inhaling harmful particles/fumes harmful chemicals or WHMIS hazardous products in the lab or facility. **Most labs should be equipped with a fume hood to capture particles and fumes that may present when working with such hazardous products (chemicals)**

5.7b A respirator is to be used as personal protective equipment (PPE), therefore, prior to requesting a respirator fit test, a hazard assessment should be conducted to determine: workplace conditions, chemicals or WHMIS hazardous products used and potential exposure.

5.7c The hazard assessment should be jointly carried out between the Principal Investigator/supervisor and laboratory personnel.

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/emanagement/rpd.htm

6.0 Working Alone or in Isolation

6.1a The person assigned to work alone and the supervisor or employer assigning the working alone work activity must work together to identify the hazards and risks that may arise from the specific activities to be performed, the lab space where the work is to be completed, and the variety of conditions or circumstances that may occur while working alone.

6.1b Following the identification of risks and hazards associated with performing work alone, the development of procedures to address these identified hazards and risks is required in order to prevent, eliminate, or reduce these hazards and to enable the individual working alone to perform his/her work safely.

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/general_safety/WorkingAlone.html

6.2 Safe Work Procedures

6.2a Safe work procedures act to ensure that a task or work activity is carried out in a safe and consistent manner. In formulating a safe work procedure, all hazards associated with the procedure should be taken into account.

6.2b Safe work procedures will also act as a training document that should be signed by the student or staff when reviewed with Principal Investigator or person responsible for the lab or worksite.

6.2c Steps involved in putting together a Safe Work Procedure include:

- A critical job inventory
- Job hazard analysis

6.2d For more information on Safe Work Procedures, visit the following link:

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/general_safety/SafeWork.html

7.0 Emergency Preparedness

A written emergency plan should be established and communicated to all personnel. The plan should include procedures for ventilation failure, fire, chemical spill, evacuation, medical care, reporting and drills.

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

7.2 Be prepared for accidents - before beginning an experiment. Must be aware of emergency protocols - the location of emergency exits, alarms and available

telephones and emergency telephone numbers to call for assistance the location of spill kits and emergency equipment and how to use them. Permanent signs showing the evacuation routes, emergency procedures and exits must be in place

7.3 Know specific actions to take in the event of an accidental release of any controlled products before beginning any experiment or operation.

7.4 Before handling or storing any chemical or WHMIS hazardous products, read the label and the MSDS for safety, hazard and precautionary and emergency information.

7.5 Treat all unknown compounds as toxic substances. Do not underestimate risks - assume that any mixture of chemicals will be more toxic than its most toxic component.

7.6 Use laboratory hoods or other ventilation devices to prevent exposure to airborne substances. Do not smell, taste or make direct skin contact with chemicals or WHMIS hazardous products.

For emergency medical attention resulting from such accidents/spill, the nearest medical facilities should be accessed. As for example: Fort Garry Campus – University Health Services at the University Centre (Mon-Fri 8:30 AM - 4:30 PM) / Emergency Department, Victoria General Hospital, 2340 Pembina Hwy.); Bannatyne Campus – Emergency Department, Health Sciences Centre).

When seeking medical attention, it is recommended to provide a copy of the SDS of the appropriate chemical to the attending medical personnel.

8.0 Accident and Incidents (spills or releases or medical care?)

8.1a There should be a system to alert people in all parts of the facility including isolation areas such as cold rooms.

8.1b A spill control policy should be developed and should include consideration of prevention, containment, clean-up and reporting.

For more information on reporting an accident or incident, please see the following link:

8.1c The following should be used for personal contamination from chemicals

a. Eye contact: Promptly flush eyes with water with eye lids open for 15 minutes and seek medical attention.

b. Ingestion: Rinse mouth with water and seek medical attention.

c. Skin contact: Promptly flush the affected area with water and remove any contaminated clothing. If any symptoms persist after washing, seek medical attention.

d. Inhalation: Remove to fresh air and seek medical attention.

e. Puncture:

Complete a notice of injury form at the following link:

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/media/Notice_of_Injury_Form_New.pdf

8.2 Reporting

8.2a All accidents or near-misses should be analyzed (causes and consequences) with results (corrective measures to prevent recurrence) distributed to all who may benefit.

8.2b Report all accidents and near-misses to your supervisor, Local Area Safety and Health (LASH) committee, Chemical Safety Committee (CSC) and EHS.

8.2c Keep records of all accidents and incidents. A joint investigation by the Principal Investigator, EHS, CSC and LASH committee may be required.

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/occ_health_comp/aiwcb.html

8.3 Spill Clean-up Procedures

8.3a Spill clean-up material/kit (absorbents, neutralizers or decontaminants) shall be readily available together with instructions for their use and appropriate personal protective equipment for the user. Spills shall be cleaned up promptly and affected area decontaminated and rendered safe by qualified laboratory personnel. All personnel who work with chemicals, biohazardous and radioactive materials should be familiar with appropriate procedures for dealing with any substances handled in their laboratory.

8.3b Promptly clean up spills, using appropriate personal protective equipment and follow proper disposal procedures.

For more information about spill clean-up procedures, please visit the following link:

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/emanagement/4622.html

9.0 Basic Rules and Procedures for Working with Chemicals or WHMIS Hazardous Products

9.1 General Rules

9.1a It shall be mandatory to wear any personal protective equipment prescribed or deemed necessary to conduct work in a safe manner.

9.1b The Principal Investigator will ensure that all safe work procedures are reviewed before the work is to commence. Review the relevant SDS before starting any procedures. Whenever possible, substitution with non-hazardous or less hazardous alternative chemicals should be practiced.

9.1c Chemicals or WHMIS Hazardous Products should only be used when the quality of ventilation is deemed appropriate given the possible exposure hazards of the chemical.

9.1d Apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns etc.) should be vented into local exhaust devices.

9.1e Do not allow release of toxic substances in cold rooms or similar environmental rooms which recirculate the air.

9.1f Mechanical pipetting devices shall be available. Mouth pipetting and using mouth suction to start a siphon are **prohibited.**

9.1g The facility should be maintained in an orderly fashion.

9.1h Prior approval from the Principal Investigator or Lab Supervisor should be necessary for any new laboratory procedure.

9.1i Unattended experiments and equipment should be left operating during night or off hours, only with the permission of the Principal Investigator. The risks involved should be assessed and details of the procedures explained by the Principal Investigator.

9.1j The telephone number of the Principal Investigator should be displayed on the WHIP placard.

9.1k Protective laboratory practices and equipment shall be available and in common use to minimize the potential employee exposure to chemicals (WHMIS hazardous products) and devices.

9.1l Glove boxes should be tested and inspected before use (contact Environmental Health and Safety for more information).

9.1m Appropriate respiratory protective equipment shall be used when air contaminant is not sufficiently restricted by engineering controls. Inspecting and properly fit testing the respirator before use is required. Consult EHS on selection of respirators and their use before ordering or using them. Proper maintenance and care of respirators is necessary.

9.1n Any special equipment needed to maintain the required isolation for materials in the laboratory shall be provided e.g. specially labelled waste containers, autoclaves, disposable clothing

9.2 Compressed Gas

9.2a Compressed gas cylinders must be restrained with a rack, straps, chain or appropriate brackets to prevent from falling. Do not use rope, strings or plastic tubing for restraint.

9.2b Use appropriate wrench (tool) to remove protective cap (housing) when connecting to regulator for use. If a compressed gas cylinder is not being used, the regulator must be removed and the protective cap replaced.

9.2c Do not expose compressed gas cylinders to temperatures above 50C in order to prevent the safety valve from opening. Small cylinders which do not have this safety valve can explode when exposed to high temperatures.

9.2d After using a cylinder, turn off the cylinder valve.

9.2e Never use a cylinder in which contents are not clearly identified.

9.2f Never lubricate, modify or force the valve of a cylinder.

9.2g Store and use of cylinders containing toxic, flammable, and very reactive gases should be stored in a fume hood or other continuously mechanically ventilated areas away from heat or ignition sources.

9.2h Never direct a stream of gas under pressure towards another person.

9.2i Avoid any rapid release of gas under pressure which could cause the apparatus to break or the supply line could detach and whip.

9.2j Connect the cylinder to a ground to avoid static discharge.

9.2k Before extinguishing a fire fed by a flammable gas, turn off the cylinder valve.

9.2l Do not empty a gas cylinder completely. Always leave a slight pressure (preferably not less than 25 psi residual pressure) to prevent entry of contaminants. When a cylinder is empty, close the valve, remove the regulator, replace the protective cylinder cap, and label the cylinder “EMPTY”.

9.2m Use only the pressure regulator appropriate to each type of gas and cylinder.
Never use a pressure regulator or tube made of copper or brass with a cylinder of acetylene.

9.2n Avoid oil or grease coming into contact with the valves on cylinders of compressed oxygen, Chlorine, or other oxidizing agent, because of the risk of fire or explosion.

9.2o Use a check valve to prevent chemicals from entering the cylinder when an experiment is carried out at cylinder pressure.

9.2p Store empty cylinders and full cylinders in different areas.

9.2q Store gas cylinders according to compatibility. Interactive gases shall be stored separately.

9.3 Electrical

9.3a Plugs, cords, outlets and receptacles should be in good condition and not have any splices or exposed conductors. Frayed cords shall be replaced.

9.3b All electrical equipment must be properly grounded. Do not alter original wiring by removing grounding wire or using ungrounded adapters.

9.3c Avoid using extension cords. They should be used for temporary use only. Place equipment where it can access an electrical outlet directly or have an electrician extend the outlets with approved conduit and wiring to reach the equipment.

9.3d All electrical components including switches, electrical panels, outlets etc. must have covers in place and intact.

9.3e Do not overload outlets. Install additional outlets if needed.

9.4 Hazardous Waste Management

9.4a Follow the University of Manitoba's **Waste Disposal Chart for Laboratories**. http://umanitoba.ca/admin/vp_admin/risk_management/ehso/media/WasteDisposalChart_-_updated.pdf
This chart should be prominently displayed in the laboratory or facility. No laboratory chemicals or WHMIS hazardous products should be disposed through regular non-hazardous waste stream that is handled by caretaking staff.

9.4b Chemicals or WHMIS Hazardous products **should not** be released to the environment. Disposal by recycling or chemical decontamination should be used when possible. **Do not** dump hazardous products down the drain in the sink or fume hood or in the trash.

9.4c Labels on empty reagent bottles re-used for laboratory waste disposal should be defaced and labelled with hazardous waste labels

9.4d The Waste tag label will clearly display the chemical name of the material contained within the container. The container must be sealed with a properly fitted cap or lid (to avoid spillage or release during transport

9.4e. Waste tag labels consisting of non-specific names such as "organic waste" or "waste solvents" **will not** be accepted by the Hazardous Waste Program.

9.4f Always check compatibility of chemicals before adding to the waste container (appendix D). Only compatible chemicals shall be mixed/added.

9.4g To avoid a large inventory, dispose of laboratory waste regularly. This will be dependent upon the amount of waste generated and the space allotted for storage. **Do not store hazardous waste on the floor.**

9.4h Create a system to date and monitor chemical or WHMIS hazardous product inventory that may be time sensitive (deteriorate) and dispose of prior to expiration.

9.4i Removal of most hazardous wastes is available to University departments at no charge. Individual departments may however be charged for the cost of identification and disposal of "unknowns".

9.4j Pick up of hazardous waste at the Fort Garry campus is initiated by filling out a **Hazardous Waste Removal Form** and sending it to EHS.
http://umanitoba.ca/admin/vp_admin/risk_management/ehso/media/HazWastepickup_Extended_Features.pdf

Pick up is normally within two weeks for smaller quantities, whereas larger laboratory clean outs require more notice.

9.4k At the Bannatyne campus, lab personnel will drop off hazardous waste to room 071 Brodie Centre at a schedule time. All hazardous waste containers must be properly labelled, sealed and accompanied with a **Hazardous Waste Removal Form.**

9.5 Housekeeping and Maintenance

9.5a In view of limited supervision of general and shared facilities, responsibility for the condition of the room and its equipment must be designated. With the exception floor care that can be done periodically by custodians, the laboratory personnel should keep the rooms well organized and clean. Custodian personnel should not clean floors without checking with the laboratory supervisor to arrange times that is convenient for the laboratory staff and not hazardous to the custodians.

9.5b Floors should be kept clean and uncluttered. Do not order more supplies, e.g., cell culture ware, than there is capacity for. Do not store chemicals and supplies on the floor.

9.5c Step-stools and or ladder should be available and special attention should be given to ensure that they are in good condition. Never climb on drums, carton or boxes to reach for objects on high shelves.

9.5d Housekeeping and chemical hygiene inspections should be done on a continual basis.

9.5e Eye wash fountains should be flushed weekly and inspected annually.

9.5g Emergency eyewash fountains and safety shower and other safety equipment (fume hood, biological safety cabinet etc.) shall be tested regularly and shall have test sticker/certificate attached to them. **Contact Environmental Health and Safety for more information.**

9.5h Stairways, hall ways and crawl space shall not be used as storage areas.

9.5i Access to exits, emergency equipment and utility controls shall never be blocked.

9.6 Lab Inspections

9.6a To ensure that labs are in compliance with respect to the safe handling, storage and use of chemicals or WHMIS hazardous products, Principal Investigators (PIs) or Lab designates will conduct a monthly lab inspection

9.6b The monthly lab inspections shall be conducted by internal lab personnel assigned by the Principal Investigator or external departmental lab staff

9.6c An itemized checklist will be used by lab staff when conducting the monthly self-inspection (please see appendix for compliance inspection)

9.6d Self-inspections will be submitted and filed within the Department office. Filed inspections will be reviewed by external Departmental entities; such as the Chemical Safety Committee (CSC) and/or Environmental Health and Safety (EHS)

9.6e A more comprehensive lab inspection will be carried out more or less frequently, dependent upon the hazard or risk rating given to the lab following the submission of a chemical permit questionnaire. The rating will be based on the information provided the Principal Investigator or Laboratory Supervisor when applying for a chemical permit number.

- High Hazard labs should be inspected once every 3 months
- Medium Hazard labs should be inspected once every 6 months
- Low Hazard labs should be inspected once a year

9.7 Laboratory Fume Hood

9.7a All work with chemicals or WHMIS hazardous products or any operations which might result in release of toxic vapours, aerosols or dust shall be performed in a laboratory fume hood or in totally enclosed systems.

9.7b Before each use, ensure that the hood is working properly (fume hood face velocity should be 80-120 linear feet per minute (lfpm) at a sash height of 11 inches). In accordance with **CSA Z316.5-15**-**Fume hoods and associated exhaust systems**

9.7c Follow the recommended work practices for laboratory hoods.

9.7d A fume hood should not be used as a storage space, only chemicals or WHMIS hazardous products being used in an ongoing experiment should be kept in a fume hood.

9.7e The hood fan should be kept on when a hazardous product (e.g. toxic and flammable chemicals) is inside the hood, whether or not any work is being done in the hood.

9.7f Leave the sash lowered (closed) when the hood is unattended.

9.7g Keep the sash glass clean. Never obstruct your view with paper, decals, notices or other items.

9.7h Fume hoods should not be used as a means of disposal of volatile chemicals.

9.7i Flammable liquids should be handled only in areas free of ignition sources. Heating should be limited to water and oil baths and heating mantles. Oil baths should be used with care and should not be left operating unattended; use another heating process where possible.

9.7j When transferring flammable liquids in metal containers/equipment, care should be taken that metal lines and vessels are bonded together with flexible conducting material of sufficient strength and grounded to a common ground.

9.7k Highly exothermic or potentially explosive reactions must never be left unattended.

9.7l Other workers should be notified when an explosive hazard is present through direct announcement and conspicuous warning signs.

9.8 Vacuum Systems

9.8a Vacuum systems (e.g. Dewar flasks, large vacuum bottles, vacuum desiccators) capable of imploding, resulting in large quantities of glass shrapnel or flying debris, should be protected with cages or barriers or, for smaller systems, shall be wrapped in adhesive tape.

9.8b When using a vacuum pump, place a condensation trap with coolant between the pump and the apparatus in order to prevent any volatile substances from getting into the pump. Vacuum traps should be wrapped with adhesive tape.

10.0 Cooling and use of Cryogenic substances

10.1 Exothermic (heat releasing)) reactions can become extremely violent when temperatures cannot be quickly controlled. For such reactions, plan to use cooling baths (water and ice) and do not add reagents too quickly.

10.1a Other cooling baths can be made with a mixture of dry ice (solid carbon dioxide) and an organic liquid. The organic liquid must be nontoxic, non flammable and nonvolatile. Liquids such as ethylene glycol diethers and Isopar L are recommended. Isopar L is a mixture of long chain isoparaffins having a boiling point in the range of 188 – 207 C and a flash point of 60 C. When mixed with dry ice, a temperature as low as -75 C can be achieved. Other toxic organic liquids for the purpose must be used only in fume hoods.

10.1b Add dry ice to the cooling liquid only in small amounts. Always wait for the release of gas to stop before adding more dry ice. Dry ice can be added more quickly as the liquid cools.

10.1c Never put your head inside a dry ice chest. The absence of oxygen and presence of carbon dioxide could cause suffocation.

10.1d Never handle dry ice with bare hands; use insulated or leather gloves.

10.1e Cryogenic substances are materials with boiling points of less than -73 C e.g., liquid nitrogen, oxygen, helium, argon and slush mixtures of dry ice and isopropanol. in Keep cryogenic materials in containers which are not tightly closed to prevent explosive build-up of pressure. Do not use domestic thermos bottle; use special industrial thermos bottles (Dewar).

10.1f Be aware of the hazards associated with the use of cryogens - asphyxiation due to displacement of oxygen (does not apply to liquid air and oxygen), cracking of material from cold, frost bite, explosion due to pressure build-up, condensation of oxygen and fuel (e.g. hydrocarbons) resulting in explosive mixtures. Cryogenic liquids must be handled by personnel who are familiar with potential hazards.

10.1g Precautions for handling cryogens:

- Avoid skin contact with cryogenic liquids. Even for brief contact can result in severe frost bite and/or torn flesh.
- Always wear a full face shield, insulated/impervious loose fitting gloves and apron or lab coat preferably without pockets.

- Use cryogens only in approved containers (Dewars) that can withstand extreme cold without becoming brittle.
- Use and store cryogens in well ventilated areas.
- Properly label cryogenic material.
- Keep cryogens away from sparks and flames.
- Do not keep liquid oxygen near flammables and combustibles.

10.1h Never use liquid nitrogen or liquid air to cool substances combustible in air because of the risk of explosion from condensation of the oxygen in air.

10.2 Transportation of Dangerous Goods

10.2a The Transportation of Dangerous Goods Act and Regulations state that "**no person shall handle, offer for transport, or transport dangerous goods unless he or she is trained or under the direct supervision of a trained person".**

10.2b **For the purpose of this guideline, dangerous goods will include any chemicals or WHMIS hazardous products being shipped by ground or air transport.**

10.2c Any University staff or student shipping dangerous goods must be certified for the applicable means of transport. EHS offers Transport of dangerous goods courses for ground and air.

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/emanagement/tdg.html

11.0 Decommissioning and Lab Hazard Clearance

Activities involving Decommissioning (a laboratory or equipment) or a Lab Hazard Clearance may only be undertaken by technically qualified persons. Under no circumstances may administrative staff be tasked with these duties. The signatory on the forms must be someone with technical knowledge and a significant level of responsibility in the lab.

Follow the instructions on the appropriate forms found at the following link:
http://umanitoba.ca/admin/vp_admin/risk_management/ehso/bio_safety/Decomm.html

11.1 Decommissioning of Laboratory Equipment

11.1a Equipment involving the use of WHMIS hazardous products (chemical, biological or radiological) must be decontaminated prior to disposal.

11.1b Decontamination of equipment leaving the lab is the responsibility of the Principal Investigator (PI) or a qualified lab designate.

11.1c Laboratory Equipment should not be disposed without following the Final Disposal of Laboratory Equipment process, including completing an Asset Disposal Form. http://umanitoba.ca/admin/financial_services/cams/

11.1d Follow the instructions on the "**Decommissioning of Laboratory Equipment"** form

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/media/DecomEquipForm20160915.pdf

11.2 Whole Room Decommissioning

11.2a Prior to a major renovation, abandonment or change of use in an area where chemicals or WHMIS hazardous products were used or stored, the process of decommissioning should be carried.

11.2b Decommissioning is the responsibility of the Principal Investigator (PI) or a lab designate.

11.2c **Under no circumstances** should administrative staff be tasked with any duties related to decommissioning.

11.2d **Prior to decommissioning, contact EHS for an onsite consultation at hazwaste@umanitoba.ca**

11.2e Chemicals or WHMIS hazardous products within the lab (space) must be inventoried and disposed of through the EHS Hazardous Waste Management.

11.2f Follow the instructions on the "**Whole Room Decommissioning**" form

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/media/DecomLabForm20160414.pdf

11.3 Lab Hazard Clearance

11.3a Laboratories, work areas or storage areas where WHMIS hazardous products (chemical, biological or radiological) are being used should be cleared of hazards prior to maintenance or service activities.

11.3b Decontamination of equipment and clearance must take place prior to servicing in the lab by non-lab staff.

11.3c **Lab Hazard Clearance is not intended for decommissioning (final disposal) of a lab or equipment**

11.3d Follow the instructions on the "**Laboratory Hazard Clearance Declaration"** form

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/media/New_Laboratory_Hazard_Clearance_Declaration_Form_fillable.pdf

Bibliography

1. The following books, manual, regulations, guidelines etc. were consulted in developing this Standard. The invaluable help from these is gratefully acknowledged.

2. *American National Standard for Laboratory Ventilation, ANSI/AIHA Z9.5*, American Industrial Hygiene Association, Fairfax, Virginia.

3. Bretherick, L., *Handbook of Reactive Chemical Hazards*, 2nd Ed., Butterworths, London, 1979.

4. Centres for Disease Control and Prevention and National Institutes of Health, Biosafety *in Microbiological and Biomedical Laboratories*, 4th ed., U.S. Department of Health and Human Services - Public Health Service, 1999.

5. Communications and Coordination Directorate, Treasury Board of Canada, *Handbook of Occupational Safety and Health,* 5th Ed., 1994.

6. Design Guide for Basic & Intermediate Level Radioisotope Laboratories, Atomic Energy Control Board, R-52 (revision 1) June 7, 1991.

7. Diberardinis, L. J., Baum, J. S., First, M. W., Gatwood, G. T., Seth, A. K., *Guidelines for Laboratory Design: Health and Safety Considerations*, 3rd ed., John Wiley and Sons Inc., New York, U.S.A., 2001.

8. Furr, A. K., Ed., *CRC Handbook of Laboratory Safety,* 4th ed., CRC Press Inc., Boca Raton, FL, 1995.

9. Health Canada, *Laboratory Biosafety Guidelines,* 3rd ed., 2004.

10. *Laboratory Safety Handbook*, The Chemical Institute of Canada, 1987.

11. National Research Council, *Prudent Practices in the Laboratory: handling and disposal of chemicals,* National Academy Press, Washington, D.C., 1995.

12. Rosenlund, S. J., *The Chemical Laboratory: Its Design and Operation: A Practical Guide for Planners of Industrial, Medical, or Educational Facilities*, Noyes Publications, Park Ridge, New Jersey, U.S.A. 1987.

13. *Safety in Academic Chemistry Laboratories*, *Vols. 1 and 2* American Chemical Society, Washington, D.C.,2003

14. Saunders, G. T., *Laboratory Fume hoods: A User's Manual*, John Wiley and Sons Inc., New York, U.S.A., 1993.

15. Wood, W. D. and Shematek, G. M., *Laboratory Safety - CSLT Guidelines*, 4th Ed., Canadian Society of Laboratory Technologists, 1996.

16. U.S. Department of Labour, Occupational Safety and Health Administration, *OSHA Laboratory Standard,* 1990.

17. Young, J. A., Kingsley, W. R., and Wahl, G. H., *Developing a Chemical Hygiene Plan*, American Chemical Society, Washington, D.C., 1995.

18. Princeton University Laboratory Safety Manual, 2003

APPENDIX - A

Glossary

LABORATORY
A laboratory is a room where scientific experimentation using controlled products occurs such as sample preparation and reactions. Compared to the instrument labs, relatively large volumes or high concentrations of controlled products are used.

INSTRUMENT LABORATORY
A laboratory where instruments are segregated from wet laboratory processes to avoid contamination. Controlled products may be present but only in small volumes or concentrations.

STORAGE ROOM FOR CONTROLLED PRODUCTS
A room used only to store controlled products. A storage room shall have adequate ventilation without recirculation of exhaust air.

HAZARDOUS PRODUCTS WORK AREAS
Rooms where Chemicals or WHMIS hazardous products are used for support services.

BASEMENT
A basement is defined as a storey or stories of a building located below the first storey.

FIRST STOREY
First storey is defined as the uppermost storey having its floor level not more than 2 metres above grade.

APPENDIX - B

Flammable Liquid Storage Procedure

University of Manitoba
November 2016

This document represents the manner in which flammable liquids must be stored at the University of Manitoba. These requirements are specifically designed to conform to the Manitoba Fire Code as it pertains to the storage of flammable and combustible liquids.

I. **Laboratories**

A. Flammable and combustible liquids shall be kept in closed containers of not more than 4 L in size.

B. Where larger quantities of Flammable and combustible liquids are required in the open laboratory; they shall be kept in approved Safety Containers of not more than 25 L in size. The containers must conform to ULC/ORD-C30 “Safety Containers”.

C. The storage of dangerous goods shall be minimized and shall not exceed the lesser of:
   a) the supply necessary for normal operation or,
   b) 300L of flammable and combustible liquids which not more than 50L shall be Class I liquids.

D. Flammable and combustible liquids in excess of the above statement shall be kept in Flammable Storage Cabinets. Flammable and combustible liquids may be stored in more than one Flammable Storage Cabinet; however, the total stored amount may not exceed the maximum capacity for one cabinet (500L) per lab.

E. The storage of flammable and combustible liquids stored outside of a cabinet shall be permitted, provided that such storage is minimized to the extent possible.

F. Not more than 5 L of flammable liquids shall be permitted in basement locations and shall be kept in a Safety Container.

G. Flammable Storage Cabinets shall be U.L.C. approved and shall be closed at all times with the door latched. The cabinets shall not be placed near an exit door or block access to an exit.

H. Spill cleanup kits must be available and suitable for the material being used.

I. Flammable and combustible liquids shall not be stored with other controlled products (as defined by WHMIS & TDG).

J. Flammable and combustible liquids that require refrigeration shall be stored only in approved explosion proof refrigerators.

K. Flammable and combustible liquids shall be dispensed in accordance with University of Manitoba dispensing guidelines.

II. **Storage Rooms for Flammable Liquids (Class I)**

A. Storage room may be located on any floor above basement level, provided it is not in or adjacent to exits, elevators, stairways or principal routes that provide access to exits.

B. Must have 2-hour fire rating.

C. Must be able to contain liquid spills and any water used for firefighting purposes. To accomplish this, the walls must be liquid tight with the floor, the door entrance must have a ledge, and there shall be no drain to sewer systems or waterways.

D. Must have a ventilation system that does not return air back to other building areas.

E. Must have appropriate fire protection devices (smoke and/or heat detector, etc.).

F. A sprinkler or self-contained fire extinguishing system should be considered.

G. Where dispensing will occur, a proper ground rod, cable and grounding clips must be supplied.

H. Emergency lighting should be considered.

I. Ensure that no one can be accidentally locked in the room.

III. **Non- Laboratory Areas**

The following procedures apply to any area that can be classified as a Fire Compartment as defined by the Fire Code.

A. Flammable and combustible liquids shall be kept in closed containers of not more than 4 L in size.

B. Where larger quantities of Flammable and combustible liquids are required in a room; they shall be kept in approved Safety Containers of not more than 25 L in size.

C. The storage of flammable and combustible liquids stored outside of a cabinet shall be permitted, provided that such storage does not exceed 10L, including not more than 5L of Class I liquids, in a single room.

D. Flammable and combustible liquids in excess of the above statement shall be kept in Flammable Storage Cabinets.

E. Flammable Storage Cabinets shall be U.L.C. approved and shall be closed at all times with operable door latches. The Cabinets shall not be placed near an exit door or block access to an exit.

F. Spill cleanup kits must be available and suitable for the material being used.

G. Flammable and combustible liquids shall not be stored with other controlled products (as defined by WHMIS & TDG).

H. Flammable and combustible liquids that require refrigeration shall be stored only in approved explosion proof refrigerators.

I. Flammable and combustible liquids shall be dispensed in accordance with University of Manitoba dispensing guidelines. (See Appendix C)

APPENDIX - C

STORAGE OF FLAMMABLE AND COMBUSTIBLE LIQUIDS IN LABORATORIES

Definitions:

Flammable Liquid - A liquid having a **flash point (f.p.) below 37.8^{0}C**.

Class I Liquids -

a) Class IA: f.p. below 22.8^{0}C and boiling point (b.p.) below 37.8^{0}C

b) Class IB: f.p. below 22.8^{0}C and b.p. at or above 37.8^{0}C

c) Class IC: f.p. at or above 22.8^{0}C and below 37.8^{0}C.

Combustible Liquid - A liquid having a **f.p. at or above 37.8^{0}C**.

Class II Liquids - f.p. at or above 37.8^{0}C and below 60^{0}C.

Class III Liquids -

a) Class IIIA: f.p. at or above 60^{0}C and below 93^{0}C

b) Class IIIB: f.p. at or above 93^{0}C.

Note: 22.8^{0}C = 73^{0}F, 37.8^{0}C = 100^{0}F, 60^{0}C = 140^{0}F, 93^{0}C = 200^{0}F

COMMON FLAMMABLE AND COMBUSTIBLE LIQUIDS

Flammable Class IA Liquids flash point (f.p.) below 22.8^{0}C and boiling point below 37.8^{0}C			**Flammable Class IB Liquids f.p. below 22.8^{0}C and b.p. at or above 37.8^{0}C**		
Liquid	**f.p. (^{0}C)**	**b.p. (^{0}C)**	**Liquid**	**f.p. (^{0}C)**	**b.p. (^{0}C)**
2-Methylbutane	-56	30	Gasoline	-42	
Isoprene	-53	34	Methyl sulphide	-36	38
Ethyl chloride	-50	12.3	Allyl chloride	-32	44
Pentane	-49	35	Carbon disulfide	-30	46
2-Pentene	-45	37	Isopropyl ether	-28	68
Diethyl ether	-45	34.6	Acrolein	-26	53
Ethyl vinyl ether	-45	33	Hexane	-22	69
Acetaldehyde	-37	21	Cyclohexane	-20	80.7
Isopropylamine	-37	33	Ethyl bromide	-23	38
Propylene oxide	-37	34	Nickel carbonyl	-20	43
Furan	-35	32	Acetone	-17.8	56
1-Pentene	-28	30	1,1 Dimethyl hydrazine	-15	64
Tetramethylsilane	-27	26-28	Tetrahydrofuran	-14	65
Methylformate	-26	34	Butylamine	-12	63
2-chloropropane	-35	34-36	Benzene	-11	80
Ethylformate	-19	52-54	Ethyleneimine	-11	
Ethanethiol	-17	35	Methyl acetate	-10	57.5
Ethylamine	-16	16.6	Methyl ethyl Ketone	-5.5	80
Trichlorosilane	-13	32	Ethyl acetate-4.4	-4.4	77
Trimethylamine	-6	2.9	Heptane	-3.9.	98
			Acrylonitrile	-1.1	77
			Butyl mercaptan	1.7	98
			Toluene	4.4	110.6
			Acetonitrile	5	81
			2-Pentanone	7.2	100
			Ethanol	8	78

Cont'd

Class IB Liquids = f.p. below 22.8^{0}C and b.p. at or above 37.8^{0}C			**Class IC Liquids – f.p. at or above 22.8^{0}C and below 37.8^{0}C**		
Liquid	**f.p. (^{0}C)**	**b.p. (^{0}C)**	**Liquid**	**f.p. (^{0}C)**	**b.p. (^{0}C)**
VM & P Naphtha	9	113-144	Methyl isobutyl ketone	22.8	117
Methyl methacrylate	10	100	2-Butanol	23.9	98
Methanol	11	64.7	*n*-amyl acetate	25	149
Isopropanol	11.6	82.4	2-Hexanone	25	127
1,4 Dioxane	12.2	100	Isoamyl acetate	25	142
Ethylene dichloride	12.8	83	*p*-Xylene	27	138
Petroleum spirits	13	79-89	Butyl alcohol	28.9	117.7
Octane	13.3	125	Chlorobenzene	28.9	132
sec-Butyl acetate	16.6	111	*sec*-Amyl acetate	31.7	
Pyridine	20	115	Styrene	32.2	145
Allyl alcohol	21.1	96	Nitropropane	33	131-132
Butyl acetate	22.2	124	Ethylene diamine	33.9	118
			Morpholine	35	129
			Turpentine	35	156-170

Combustible Liquids **Class II Liquids – f.p. at or above 37.8^{0}C and below 60^{0}C**			**Combustible Liquids** **Class IIIA Liquids – f.p. at or above 60^{0}C and below 93^{0}C**		
Liquid	**f.p. (^{0}C)**	**b.p. (^{0}C)**	**Liquid**	**f.p. (^{0}C)**	**b.p. (^{0}C)**
Acetic acid	40	116	Bunker C	66	Wide range
Varsol	43	156-197	Cyclohexanol	67	160-161
2-Ethoxy ethanol	44	135	Aniline	70	184
Diesel oil	45	160-370	Furfural	73	162
Ethylene glycol monomethyl ether	46	124-125	Acetophenone	82	202
Cyclohexanone	46	155	Ethyl acetoacetate	84	181
Kerosene	48		Isophorone	84	213-214
Hydrazine	52	113.5	Nirobenzene	87	210-211
Acetic anhydride	54	138-140			
N,N-Dimethyl formamide	57	153			

Combustible Liquids **Class IIIB Liquids – f.p. at or above 93^{0}C**		
Liquid	**f.p. (^{0}C)**	**b.p. (^{0}C)**
Dimethyl sulphoxide	95	189
Mineral Oil (360^0)	104	
Fusel oil	109	

APPENDIX - D

Guidelines for Storage of Laboratory Chemicals

General Considerations:

Location

Chemicals should be stored only in operating laboratories or supervised and secured storage rooms accessible only to authorized laboratory personnel. One chemical storage room under the supervision of a qualified person is essential for each department or building.

Chemicals should not be stored in teaching labs, closets or unoccupied rooms.

Areas around exits, under the tables and benches, in front of fire extinguishers, eye washes or safety showers and passageways or hallways are not acceptable for chemical storage.

Minimize quantities of chemicals kept in the laboratory - store reserves in chemical storeroom.

Store chemicals away from direct sunlight and heat sources.

Storage Facilities/Equipment

Storage rooms must have proper ventilation including an air supply and exhaust (at least six air changes per hour).

Storage facilities should have:

- Fire extinguishers of the approved type positioned near an escape route.
- Smoke detector.
- Spill control and clean-up materials.
- Approved eye wash/emergency shower.
- Safety cabinets for specific groups of compatible chemicals.

Storage facilities and equipment must be sturdy, stable and secure against sliding and collapse, and not subject to flooding.

Use cabinets with doors for chemical storage. Shelves with edge lips/guards that prevent chemicals from sliding off are also acceptable. Ensure that shelf units are stable and in no danger of tilting. The shelves must have a load capacity well above the weight of the chemicals placed on them.

Do not store materials and equipment on top of cabinets.

Exits, passageways, area under tables and benches should be free of stored materials and equipment.

Avoid storing chemicals on bench tops, except for those being used currently; return each chemical to the designated storage place after each use.

Maintain a minimum of 18 inches of clearance from sprinklers.

Up-to-date and Continuous Chemical Inventory

Order and store chemicals in the smallest practical amount.

All containers must be labelled with the chemical name and identity of hazardous components, appropriate hazard warnings, name, address and telephone number of the responsible user (supervisor/researcher), and date of receipt, date of opening and where applicable an expiry date.

Dispose of chemicals which do not have an identified use through Environmental Health and Safety (474-6633) within a reasonable period, usually 1 year.

Dispose of, or remove to storage, all chemicals at the end of a laboratory supervisor's association with that lab. The Department must enforce this cleanout policy for departing researchers to avoid accumulation of orphaned chemicals.

Store chemicals below eye level.

This limits chemicals from getting lost out of sight or put out of reach. It protects chemicals from getting dropped. Eyes and faces are protected from chemicals being spilled from above. This avoids strain and injuries that can result from lifting materials too high.

Store off the floor.

Keep glass containers protected from collisions with people and equipment.

Store larger containers on lower shelves to minimize the extent of splash or spill in case a container falls or breaks.

Store hazardous liquids in compartments or devices capable of containing spills i.e., secondary containment (trays, diked storage vaults).

Do not store chemicals in the fume hood.

Stored chemicals clutter up the work space in the hood and impede the air flow which results in the hood not working properly.

Inspection/Monitoring

Examine chemical storage areas weekly - replace any faded or loose labels on containers; arrange for disposal of used, surplus or unwanted chemicals through Environmental Health and Safety (474-6633).

Check the integrity of containers.

Dispose of materials which show evidence of physical change - indicators are:

> *slightly cloudy liquids, changing colour (e.g., darkening), spotting on solids, caking of anhydrous materials, existence of solids in liquids or liquids in solids, pressure buildup in bottles, evidence of reaction with water, damage to the container*.

Compatibility Considerations - Segregation of Incompatible Chemicals:

Physically segregate chemicals according to compatibility (reactive class and flammability).

DO NOT *store chemicals alphabetically as a general group.* Separate chemicals into organic and inorganic families and then into compatible groups; you can store alphabetically only within a compatible group.

Acids
Store concentrated inorganic acids in a non-metal vented cabinet; cabinets specially manufactured for acids/corrosives should be used. Strong organic acids can also be stored in the same cabinet if they are in a separate tray or other secondary storage container.

Separate concentrated oxidizing acids (nitric, sulphuric, perchloric acids) from organic acids.

Separate acids from inorganic bases (caustics/alkaline materials) and from other groups.

Store perchloric acid bottles in glass or ceramic trays.

Separate acids from chemicals that could generate toxic gases upon contact e.g. sulphides, sulphites, bisulphites and cyanides.

Separate acids from active metals such as sodium, potassium, magnesium.

Bases, Caustics/Alkaline Materials

Store in a vented, non-metal cabinet in a plastic tray, separate from acids.

Flammable Liquids

Store flammable liquids in approved containers/cabinets in accordance with the *University of Manitoba Flammable Liquid Storage Procedure.*

Separate from oxidizing materials.

If refrigeration necessary, store flammable liquids only in an explosion-proof or a lab-safe refrigerator (Flammable liquids storage Refrigerator).

Oxidizers

Segregate from organics/flammables and all sources of ignition.

If refrigeration necessary, store in an explosion-proof or lab-safe refrigerator (Flammable liquids storage Refrigerator).

Volatile toxics and odoriferous chemicals e.g. some amines, some organosulphur compounds, should be stored in a ventilated storage cabinet.

Provide ventilated storage near or beneath laboratory hoods.

Highly toxic chemicals including carcinogens *(those capable of inducing cancer)*, mutagens *(those*

causing permanent transmissible alterations in genetic information) and teratogens *(those interfering with normal prenatal development causing abnormalities in the fetus)* need to be stored in unbreakable chemically resistant secondary containers and placed in ventilated storage with appropriate warning signs e.g. *"Caution! Reproductive Toxin Storage!"* Keep only minimum *required amounts of* these chemicals on hand. Storage within the cabinet should segregate any incompatible substances.

Highly reactive chemicals (including water reactives, pyrophorics *and* potential explosives - organic peroxides, perchloric acid, picric acid, azides should be stored separate from each other and other chemicals.

Should have warning labels such as **"Danger! Highly Reactive Materials!"**

Only minimum required amounts (3-6 months supply) should be purchased and stored.

Do not open a container of highly reactive material that is past its expiration date. Call EHSO for special instructions.

Do not open liquid organic peroxide or peroxide form chemical if crystals or a precipitate are present.

Store peroxidizable materials away from heat and light.

Store containers of highly reactive liquids in trays large enough to hold the contents.

Segregate according to incompatibility:

-oxidizing agents from reducing agents and flammables/combustibles,

-perchlorate from reducing agents, organic matter.

-pyrophoric from flammables.

Dispose of these chemicals from inventory every 6-12 months.

Water reactive and flammable solids should be stored away from any source of water.

Store thermally unstable materials in explosion-proof or lab-safe refrigerator.

Controlled chemicals such as barbiturates must be kept in a locked cabinet and a log should be kept of all uses.

Compressed Gas Cylinders

Ensure cylinders have proper labels, do not depend on manufacturer's colour code.

Securely strap or chain gas cylinders to a wall or bench top.

When cylinders are not in use, shut the valves, relieve the pressure in the gas regulators, remove the regulators, and cap the cylinders.

Segregate gas cylinder storage from the storage of other chemicals.

Keep incompatible gases stored separately - keep flammables away from reactives, oxidizers, corrosives and toxics.

Segregate empty cylinders from full cylinders.

Table 1 Compatible Storage Groups

Inorganics	**Organics**
Metals, hydrides	Organic acids, anhydrides, peracids
Halides, sulphates, sulphites, thiosulphates, phosphates, halogens	Alcohols, glycols, amines, imines, imides
Amides, nitrates(except ammonium nitrates), nitrites, azides	Hydrocarbons, esters, aldehydes
Hydroxides, oxides, silicates, carbonates, carbon	Ethers, ketones, ketenes, halogenated hydrocarbons, ethylene oxide
Sulphides, selenides, phosphides, carbides, nitrides	Epoxy compounds, isocyanates
Chlorates, perchlorates, perchloric acid, chlorites, hypochlorites, peroxides	Peroxides, hydroperoxides, azides
Arsenates, cyanides, cyanates	Sulphides, polysulphides, sulphoxides, nitrites
Borates, chromates, manganates, permanganates	Phenols, cresols
Nitric acid and other inorganic acids	
Sulphur, phosphorous, arsenic, phosphorous pentoxide	

Table 2 - **INCOMPATIBLE CHEMICALS (A partial list)**

Substances on the left hand column should be stored and handled so that they cannot accidentally come in contact with those in the right hand column under uncontrolled conditions.

CHEMICAL	**INCOMPATIBLE WITH** *(Do not store near)*
Acetic acid	Chromic acid, nitric acid, permanganates
Acetic anhydride	Hydroxyl-containing compounds such as ethylene glycol, perchloric acid
Acetone	Concentrated nitric acid and sulphuric acid mixtures, hydrogen peroxide
Acetylene	chlorine, bromine, fluorine, copper, mercury
Alkali and alkaline earth metals such as sodium, potassium, lithium, magnesium, calcium, powdered aluminum	Water, carbon dioxide, carbon tetrachloride, other chlorinated hydrocarbons
Ammonia (anhydrous)	Mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride
Ammonium nitrate	Acids, metal powders, flammable liquids, chlorates, nitrites, sulphur, finely divided organics, combustibles
Aniline	Nitric acid, hydrogen peroxide
Arsenical compounds	Any reducing agents
Azides	Acids, heavy metals and their salts, oxidizing agents
Bromine	Ammonia, acetylene, butadiene, butane, other petroleum gases, sodium carbide, turpentine, benzene, finely divided metals
Calcium oxide	Water
Carbon, activated	Calcium hypochlorite, other oxidants
Chlorates	Ammonium salts, acids, metal powders, sulphur, finely divided organics, combustibles
Chromic acid and chromium trioxide	Acetic acid, naphthalene, camphor, glycerol, turpentine, alcohol, other flammable liquids
Chlorine	Ammonia, acetylene, butadiene, butane, other petroleum gases, hydrogen, sodium carbide, turpentine, benzene, finely divided metals
Chlorine dioxide	Ammonia, methane, phosphine, hydrogen sulphide
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids
Fluorine	All other chemicals
Hydrazine	Hydrogen peroxide, nitric acid, any other oxidant
Hydrocarbons (benzene, butane, propane, gasoline, turpentine etc.)	Fluorine, chlorine, bromine, chromic acid, peroxides

.... cont'd **TABLE 2 - INCOMPATIBLE CHEMICALS (A partial list)**

Substances on the left should be stored and handled so that they cannot accidentally come in contact with those in the right hand column under uncontrolled conditions.

CHEMICAL	**INCOMPATIBLE WITH *(Do not store near)***
Hydrocyanic acid	Nitric acid, alkalies
Hydrofluoric acid (anhydrous), hydrogen fluoride	Ammonia (aqueous or anhydrous)
Hydrogen peroxide	Copper, chromium, iron, most metals, or their salts, any flammable liquid, combustible materials, aniline, nitromethane
Hydrogen sulphide	Fuming nitric acid, oxidizing gases
Hypochlorites	Amines, methanol, activated carbon
Iodine	Acetylene, ammonia (aqueous or anhydrous)
Mercury	Acetylene, fulminic acid, ammonia
Nitric acid (concentrated)	Acetic acid, acetone, alcohol, aniline, chromic acid, hydrocyanic acid, hydrogen sulphide, flammable liquids, flammable gases, nitratable substances
Nitroparaffins	Inorganic bases, amines
Oxalic acid	Silver and mercury and their salts
Oxygen	Oils, grease, hydrogen, flammable liquids, solids and gases
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohol, paper, wood, grease, oil (all organics)
Peroxides, organic	Acids (organic or mineral) (avoid friction, store cold)
Phosphorous (white)	Air, oxygen
Phosphorous pentoxide	Alcohols, strong bases, water
Potassium	Water, carbon dioxide, carbon tetrachloride
Potassium perchlorate	Acids (see also perchloric acid)
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulphuric acid
Silver and silver salts	Acetylene, oxalic acid, tartaric acid, fulminic acid, ammonium compounds
Sodium	Water, carbon dioxide, carbon tetrachloride
Sodium nitrite	Ammonium nitrate and other ammonium salts
Sodium peroxide	Any oxidizable substance, such as, ethanol, methanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulphide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulphides	Acids

CHEMICAL INCOMPATIBILITY CHART - SEPARATE BY COMPATIBILITY

The Chart below is the U.S. Coast Guard's **C**hemical **H**azard **R**esponse **I**nformation **S**ystem (**CHRIS**) Incompatibility Chart. An 'X' represents incompatible combination; an accidental mixing can result in vigorous reaction.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
1 Nonoxidizing mineral acids		x			x	x	x	x	x	x	x	x	x			x	x		A	E			1
2 Sulfuric acids	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	2
3 Nitric acid		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		3
4 Organic acids		x			x	x	x	x	C			x				x	x			F			4
5 Caustics	x	x	x	x							x	x				x	x		x	x	x	x	5
6 Ammonia	x	x	x	x						x	x	x	x			x	x		x				6
7 Aliphatic amines	x	x	x	x							x	x	x	x	x	x	x	x	x	x	x	x	7
8 Alkanolamines	x	x	x	x							x	x	x	x	x	x	x	B	x				8
9 Aromatic amines	x	x	x	C							x	x							x				9
10 Amides	x	x	x			x						x									x		10
11 Organic anhydrides	x	x	x		x	x	x	x	x														11
12 Isocyanates	x	x	x	x	x	x	x	x	x	x					D					x		x	12
13 Vinyl acetate	x	x	x			x	x	x															13
14 Acrylates		x	x				x	x															14
15 Substituted allyls		x	x				x	x				D											15
16 Alkylene oxides	x	x	x	x	x	x	x	x															16
17 Epichlorohydrin	x	x	x	x	x	x	x	x															17
18 Ketones		x	x				x	B															18
19 Aldehydes	A	x	x			x	x	x	x														19
20 Alcohols, glycols	E	x	x	F	x		x																20
21 Phenols, cresols		x	x		x		x			x													21
22 Caprolactum solution		x			x		x					x											22
30 Olefins		x	x																				30
31 Paraffins																							31
32 Aromatic hydrocarbons			x																				32
33 Miscellaneous hydrocarbon mixtures			x																				33
34 Esters		x	x																				34
35 Vinyl halides			x																			x	35
36 Halogenated hydrocarbons		G			H		I																36
37 Nitriles		x																					37
38 Carbon disulfide							x	x															38
39 Sulfolane																							39
40 Glycol ethers		x										x											40
41 Ethers		x	x																				41
42 Nitrocompounds					x	x	x	x	x														42
43 Miscellaneous water solutions		x										x											43
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	

A The following aldehydes (19): acrolein, crotonaldehyde, and 2-ethyl-3-propyl acrolein are not compatible with group 1, non oxidizing mineral acids.
B The following ketones (18): isophorone and mesityl oxide are not compatible with group 8, alkanolamines.
C Acrylic acid (4) is not compatible with group 9, aromatic amines.
D Allyl alcohol (15) is not compatible with group 12, isocyanates.
E Furfural alcohol (20) is not compatible with group 1, non oxidizing mineral acids.
F Furfural alcohol (20) is not compatible with group 4, organic acids.
G Dichloroethylether (36) is not compatible with group 2, sulfuric acid.
H Trichloroethylene (36) is not compatible with group 5, caustics.
I Ethylene diamine (7) is not compatible with ethylene dichloride (36).

Adapted from the Chemical Hazard Response Information System, US Coast Guard Commandant Instruction M 1645.11, October, 1978.

CHEMICAL INCOMPATIBILITY*

X Represents unsafe combinations

1	Inorganic Acids	1																					
2	Organic Acids	X	2																				
3	Caustics	X	X	3																			
4	Amines & Alkanolamines	X	X		4																		
5	Halogenated Compounds	X		X	X	5																	
6	Alcohols, Glycols & Glycol Ethers	X					6																
7	Aldehydes	X	X	X	X		X	7															
8	Ketones	X		X	X			X	8														
9	Saturated Hydrocarbons									9													
10	Aromatic Hydrocarbons	X									10												
11	Olefins	X				X						11											
12	Petroleum Oils												12										
13	Esters	X		X	X									13									
14	Monomers & Polymerizable Esters	X	X	X	X	X	X								14								
15	Phenols			X	X			X							X	15							
16	Alkylene Oxides	X	X	X	X		X	X							X	X	16						
17	Cyanohydrins	X	X	X	X	X		X									X	17					
18	Nitriles	X	X	X	X												X		18				
19	Ammonia	X	X					X	X					X	X	X	X	X		19			
20	Halogens			X			X	X	X	X	X	X	X	X	X	X				X	20		
21	Ethers	X													X						X	21	
22	Phosphorous, Elemental	X	X	X																	X		22
23	Sulfur, Molten									X	X	X	X				X						X
24	Acid Anhydrides	X		X	X		X	X							X		X	X	X	X			

* From: *Laboratory Safety Course Manual*, J.C. Young and P. Burnett, Research Branch, Agriculture Canada, 1985.

Table 3 - General Guidelines for Segregation for Chemical Storage

General Guidelines for Segregation for Chemical Storage		
FLAMMABLES ! Store in a cool place away from heat, sun or sources of ignition ! Store in an adequately ventilated area to prevent vapor buildup ! Use flammable storage cabinets ! Automatic fire detection equipment and fire suppression devices (sprinklers etc.) should be available in the storage area ! Store *separate* from **oxidizers**, explosives, materials that react with air or moisture to liberate heat, chemicals capable of spontaneous heating ! If refrigeration necessary, store in explosion-proof refrigerators only	**CORROSIVES** ! Store in a cabinet that is non corroding or metal coated with acid/fume resistant paint **- Acids** ! separate acids from bases (caustics) and active metals ! segregate acids from chemicals that could generate toxic gases upon contact such as cyanides, sulphides ! segregate oxidizing acids from organic acids, flammable and combustible materials ! perchloric acid is potentially explosive and should be stored all by itself ! picric acid is reactive with metals or metal salts and explosive when dry, must contain at least 10% water to inhibit explosion **- Bases** (Caustics) ! store in a dry area separate from acids	**COMPRESSED GASES** ! store in well ventilated designated area, segregate from the storage of other chemicals ! oxidizing compressed gases should be physically separated from flammable and other non-oxidizing compressed gases ! segregate empty cylinders from full cylinders ! when cylinders are no longer in use, shut the valves, relieve the pressure in the gas regulators, remove the regulators, and cap the cylinders
OXIDIZERS ! store in a cabinet of non-combustible material ! separate from flammable, combustible and other reducing materials	**REACTIVES** ! protect from extremes of temperatures and rapid change of temperatures ! separate from organic materials, flammable materials, toxic and corrosive materials ! Label, date, inventory all highly reactive chemicals as soon as received	**Water and Air Sensitive Chemicals** ! store in a cool, dry location ! protect from fire sprinkler water ! separate from water and moist air ! separate from aqueous solutions ! separate from flammable storage area ! separate from reactive chemicals
NON-VOLATILE NON REACTIVE SOLIDS ! store in cabinets or open shelves with edge guards	**NON FLAMMABLE SOLVENTS** ! store in a cabinet ! store separate from oxidizers	**EXPLOSIVES** ! store separate from each other and all other chemicals

Peroxidizable chemicals and Organic Peroxides

Organic peroxides are probably the most hazardous chemicals handled in a chemical laboratory. They are sensitive to shocks, sparks, mechanical friction, heat or other accidental ignition. They are far more shock-sensitive than primary explosives such as TNT. Also potentially hazardous are the compounds which undergo auto oxidation to form organic hydroperoxides and/or peroxides on exposure to air. These must be stored with care and monitored for peroxide formation.

Types of Compounds Known to Auto oxidize to Form Peroxides

- **!** Aldehydes
- **!** Ethers, especially cyclic ethers and those containing primary and secondary alkyl groups (Never distill an ether before it has been shown to be free of peroxide)
- **!** Compounds containing benzylic hydrogens
- **!** Compounds containing allylic hydrogens (C=C-CH), including most alkenes; vinyl and vinylidene compounds
- **!** Compounds containing a tertiary C-H group (e.g., decalin and 2,5- dimethylhexane)

Peroxidizable Compounds - *classes of compounds that can form Peroxide upon aging*

Class I: Unsaturated chemicals, especially those of low molecular weight, may polymerize violently and hazardously due to peroxide initiation - ***discard after 1 year.***

Acrylic Acid	Chlorotrifluoroethylene	Tetrafluoroethylene	Vinyl chloride
Butadiene	Methyl methacrylate	Vinyl acetate	Vinyl pyridine
Chlorobutadiene	Styrene	Vinyl acetylene	Vinylidene chloride

Class II: The following chemicals are a peroxide hazard upon concentration (distillation/evaporation). A test for peroxide should be performed if concentration is intended or suspected - ***discard after 1 year.***

Acetal	Dicyclopentadiene	Methyl acetylene
Cumene	Diethylene glycol dimethyl ether (diglyme)	Methylcyclopentane
Cyclohexene	Diethyl ether	Methyl isobutyl ketone
Cyclooctene	Dioxane (*p*-dioxane)	Tetrahydrofuran (THF)
Cyclopentene	Ethylene glycol dimethyl ether (glyme)	Tetrahydronaphthalene
Diacetylene	Furan	Vinyl ethers

Class III: Peroxides derived from the following compounds *may explode without concentration* - ***discard after 3 months.***

Organic	Inorganic
Divinyl ether	Potassium metal
Divinyl acetylene	Potassium amide
Isopropyl ether	Sodium amide (sodamide)
Vinylidene chloride	

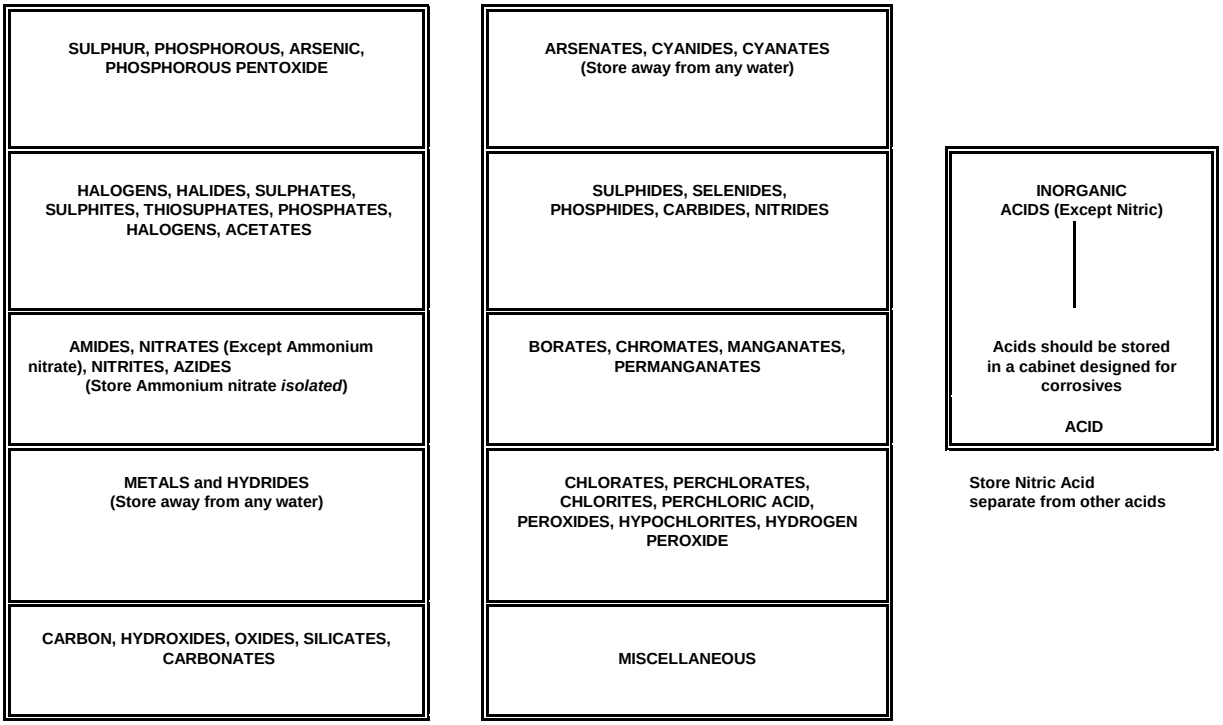
Table 4. High Hazard Chemicals

Given below is a list of a dozen chemicals/agents which have been found from experience in laboratories carrying out moderate to large scale synthetic chemistry to be responsible for more than their share of accidents. Careful pre-planning and caution is required in storage, use and handling of these chemicals.

Chemicals/Agent	Hazards
1. Organic azides	Explosion hazards, especially with ground glass joint
2. Perchloric salts of organic, organo-metallic and inorganic complexes	Explosion hazards
3. Diethyl ether	Fires (see also entry 10 below)
4. Lithium aluminum hydride	Fires on quenching
5. Sodium	Fires on quenching
6. Potassium	Fires on quenching
7. Sodium-benzophenone ketyl still pots	Fires on quenching
8. Palladium on carbon	Fires on removal from the inert atmosphere, especially if wet with organic solvent or when contacting combustible materials such as filter papers
9. Heat	Exothermic reactions causing violent spills on scale-up due to inadequate provision for heat removal
10. Ethers with alpha- hydrogen atoms	Dangerous peroxide concentration during distillation; explosion hazards, especially with ground glass joints
11. Carbon monoxide	Toxicity and role in forming nickel tetracarbonyl from still gas lines and autoclaves
12. Organic peroxides	Sensitivity to shock, sparks, and other forms of accidental detonation; sensitivity to heat, friction, impact, and light, as well as to strong oxidizing and reducing agents

SUGGESTED CHEMICAL STORAGE PATTERN IN SHELVES

FOR INORGANICS



FOR ORGANICS