NFK Chemical Laboratory Safety Manual

NFK-002
V1.0

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IN CASE OF EMERGENCY (all hours):

Press the **YELLOW EMERGENCY CALL BOX**

or

Call building security:
613-876-2148

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1. Overview

The location of the chemical laboratory and emergency equipment is shown in Figure 1.

Figure 1: Location of the Chemical Laboratory and Emergency Equipment

1.1. Safety in the Chemical Laboratory

- ALWAYS WEAR PROPER EYE PROTECTION FOR THE TASK YOU ARE CARRYING OUT (e.g., SAFETY GLASSES, PRESCRIPTION GLASSES WITH SIDE SHIELDS, GOGGLES)

- ALWAYS WEAR APPROPRIATE PROTECTIVE CLOTHING

- ALWAYS KNOW THE HAZARDOUS PROPERTIES OF THE MATERIALS YOU ARE USING

- ALWAYS WASH YOUR HANDS THOROUGHLY BEFORE LEAVING THE GOWNING ROOM

- NEVER WEAR OPEN-TOED SHOES, HIGH-HEELED SHOES, OR SANDALS

- ALWAYS WEAR LONG PANTS (NO SHORTS, SKIRTS, SHORT DRESSES, OR CAPRIS)

- NEVER EAT, DRINK, OR APPLY COSMETICS IN THE LABORATORY

- DO NOT LEAVE EXPERIMENTS UNATTENDED WITHOUT AN APPROPRIATE SIGN INDICATING HAZARDS, SAFETY RESPONSE, CONTACT INFORMATION, AND DATE AND TIME WHEN THE EXPERIMENT WILL BE REMOVED

- DO NOT BLOCK ACCESS TO EMERGENCY EXITS AND EMERGENCY EQUIPMENT

- ANY WOMAN WHO WORKS IN A LABORATORY WHERE HAZARDOUS SUBSTANCES ARE IN USE AND WHO IS, OR BELIEVES THAT SHE MAY BE, PREGNANT, MUST INFORM HER SUPERVISOR

1.2. Safety Management

Laboratory Management and Queen’s University, including the appropriate Joint Health and Safety Committee, oversee the safety features and policies of the Laboratory. A list of contact information is posted in the Laboratory.

2. Introduction

Safety is the responsibility of everyone who works in the NanoFabrication Kingston (NFK) lab. This includes all staff, students, researchers, visitors, and other users of the NFK.

In this manual, the Laboratory refers to the NanoFabrication Kingston laboratory (NFK), located at Innovation Park, and its management. For work performed at other locations, the safety protocols for those locations apply.

This manual is intended to cover many of the common hazards associated with working in a laboratory and must be read and adhered to by everyone working in the Laboratory. The warnings and procedures presented in this manual do not account for every chemical hazard. Additional information or measures may be required when working with specific chemicals. Consult the appropriate information sources, including any relevant material safety data sheets (MSDS).

The rights and responsibilities of workers, supervisors, and employers are described in the Occupational Health and Safety Act (OHSA) and it is expected that users of the Laboratory have received this training. In brief, the OHSA states that equipment is maintained safely by the Laboratory, and users are obligated to follow the safety rules and policies laid out by the Laboratory (including directions given by the Laboratory Manager), as well as informing the Laboratory of any hazards noticed during use.

Personal safety depends upon a positive attitude towards safety as well as good and informed judgment on the part of each individual working in the Laboratory. Most health and safety problems in the Laboratory can be avoided by practicing good housekeeping and common sense based on informed knowledge of the hazards.

A safe working environment is achieved through responsible, self-motivated activity.

3. General Laboratory Safety

The following is a list of general laboratory rules:

- Know and follow all safety rules, procedures, and protocols.
- Be aware of hazards, and the procedures for dealing with those hazards, before you start your work.
- Keep all doors closed at all times.
- Familiarize yourself with all safety equipment and procedures in your work area including location of the telephone, emergency call box, exits, fire extinguishers, fire alarms, safety shower, eyewash fountain, first aid kit, and evacuation routes.
- Never block emergency exits, emergency equipment, or electrical panels.
- Post suitable warning signs if a specific hazardous situation exists and include the name and phone number of the individual(s) responsible.
- Maintain a tidy workplace.
- Do not bring bicycles, rollerblades, or pets into the building.
- Ensure that you have completed the mandatory WHMIS training before working in the Laboratory.
- Label all chemicals clearly in accordance with WHMIS regulations and store them appropriately.

3.1. Working Alone

Never work alone in the cleanroom at any time. A second qualified person must be present at all times to ensure safety.

3.2. Unauthorized Work

Do not begin new work (i.e., using tools, chemicals, or processes that you have not used before at NFK) without the authorization of your supervisor and the Laboratory.

4. Chemical Laboratory Safety

There are over 10 million known chemical substances, and the hazardous properties of most of these have not been investigated. There are, however, many classes of compounds that are known to present certain hazards, such as:

- Oxidizing agents and reducing agents
- Corrosives such as acids and bases
- Water-reactive chemicals
- Air-reactive chemicals
- Self-reactive chemicals
- Highly toxic chemicals

This manual describes general procedures and protocols for dealing with common hazards in the Laboratory. For detailed information on the handling and disposal of specific chemical substances, consult the appropriate references.

4.1. Material Safety Data Sheets

The provision of material safety data sheets (MSDSs) for hazardous materials is one means of communicating information on chemical hazards. Chemicals purchased directly from a chemical supplier are accompanied by an MSDS. In addition, various electronic MSDS databases are available at Queen’s University through links on the Department of Environmental Health and Safety Website, accessible via computers in the Laboratory.

5. Emergency Equipment

The following emergency equipment is located in the Laboratory:

- Eyewash fountain
- Shower
- Fire extinguishers
- Fire alarm pulls
- Chemical spill kits
- First aid kit

The location and use of this equipment is described during NFK Safety Training. Familiarize yourself with their locations and use before an emergency arises so that you can respond calmly.

5.1. Eyewash Fountain and Shower

The eyewash fountain and emergency shower are located in the wet chemical cleanroom within NFK. Instructions for using them are posted in the Laboratory. Access to this equipment must not be obstructed in any way. If absolutely necessary, additional showers are located in the washrooms at the end of the corridor. If you need to use this equipment, you are encouraged to seek medical attention afterward, even if you think the chemical may have been washed off completely.

To use the eyewash fountain:

1. Hold your eyelids open with your fingers.
2. Roll your eyes back and forth while washing them.
3. Flush your eyes for at least 15 minutes to ensure removal of the chemical.

To use the emergency shower:

1. Activate the shower by pulling down on the handle.
2. Remove any contaminated clothing as rapidly as possible.
3. Remain under the shower long enough to ensure removal of the chemical.

5.2. Fire Extinguishers

The Laboratory is equipped with class “BC” fire extinguishers (residue-free Halotron or CO_2 extinguishers), which are suitable for fluid and electrical fires. These extinguishers are only designed to fight small local fires. Report all use of fire extinguishers to the Laboratory.

5.3. Fire Alarm Pulls

Fire alarm pulls are located at each exit of the Laboratory. Pull where indicated until the stop bar breaks.

5.4. Chemical Spill Kits

Spill kits are located next to the shower in the wet chemistry cleanroom. There is an all-purpose spill kit for flammable, toxic, and corrosive chemicals, and a spill kit dedicated to hydrofluoric acid (HF) solutions. The calcium gluconate gel for treating HF exposure is located with the HF spill kit. Additional spill cleanup equipment is located in the service room – ask NFK staff for instructions on its use.

5.5. First Aid Kits

A first aid kit is located next to the shower in the wet chemistry cleanroom, and a backup first aid kit is located in the office. First aid should be given by someone who has had appropriate training.

6. Emergency Procedures

There are different kinds of accidents that can happen in the lab, ranging from a simple injury that requires basic first aid to a critical injury or death. You need to be prepared.

In many cases, accidents can be prevented. A good accounting of accidents leads to safer equipment and protocols. Report all accidents involving chemicals or equipment to the Laboratory, even if the accident does not result in personal injury.

6.1. Medical Emergencies

Your response to a medical emergency depends on the severity of the emergency.

- When appropriate, apply first aid. The first aid kits are available in the Laboratory. First aid should be given by someone who has had appropriate training.
- In the case of minor injuries that can't be satisfactorily treated by first aid alone, or if there is any doubt, send or take the injured person to the hospital emergency room, or doctor of his/her choice.
- In the case of injuries that are more severe, or if there is doubt about the severity of the injury and emergency assistance is required, call building security by pressing the **yellow call box** or calling **613-876-2148**. Do not move a severely injured person without the advice of medical personnel.
- Report all accidents involving personal injury promptly to your supervisor and the Laboratory.

6.2. Accidents Involving Critical Injury or Death

For emergencies involving critical injury or death:

1. Call building security for assistance by pressing the yellow call box or calling 613-876-2148.
2. As soon as possible, notify your supervisor, the Laboratory, and the Department of Environmental Health and Safety. The latter will notify the appropriate government agencies.
3. Do not touch anything associated with the accident, except for the purpose of saving life, relieving suffering, or preventing unnecessary damage to equipment or property. The scene of an accident must be examined by the appropriate authorities.

6.3. Fire Emergencies

Be aware of the location and proper use of all fire extinguishers, fire alarm pulls, and fire exits in the Laboratory.

If the fire cannot be controlled safely with a fire extinguisher:

1. Alert all persons in the area of the fire emergency.
2. Leave the area while closing doors and windows (where this can be done safely).
3. Activate the nearest fire alarm.

4. When safe to do so, check to ensure that the area has been evacuated and leave the building via the safest route.
5. Assemble at the nearest muster point. Badge out at the gathering pole to indicate to emergency services that you are no longer in the building.
6. If exiting via the main NFK door, the gathering point is labelled “W”.
7. If exiting via the back NFK door to the courtyard, the gathering point is labelled “N”.
8. Phone building security by pressing the yellow call box at the gathering pole or calling 613-876-2148.
9. Be available to inform the Fire Department as to the location of the fire.

6.4. Chemical Spills

Note: Knowing the appropriate spill cleanup procedure to use is part of the preparation for using a chemical.

1. Clean up all spills promptly, efficiently, and properly. Spill kits are available in the Laboratory.
2. Warn all individuals at risk due to the spill immediately.
3. If the spill involves non-volatile, non-flammable, and non-toxic material:
   a. Clean up the spill, as directed.
   b. Use an absorbent material that neutralizes the liquid, where appropriate.
   c. Use a dustpan, brush, and appropriate protective equipment to complete the cleanup.
   d. Wash the spill area following the cleanup.
4. If the spill involves a hazardous chemical such as a flammable, toxic, or highly reactive substance:
   a. Warn everyone in the area immediately.
   b. Shut down all equipment and leave the area.
   c. Call building security by pressing the yellow call box or calling 613-876-2148 and notify your supervisor and the Laboratory immediately.
   d. Remove any clothing that has been contaminated as quickly as possible and decontaminate where possible.
   e. Use the emergency shower or eyewash fountain, if necessary.
   f. Clean up the spill, if safe to do so.
5. Dispose of waste from chemical spills as hazardous waste, as directed by the Laboratory.

7. General Chemical Hazards

The lab has a number of different chemicals that can pose different hazards. You need to know how to work safely with the following:

- Corrosive chemicals
- Flammable chemicals
- Noxious chemicals
- Reactive chemicals
- Toxic chemicals

7.1. Corrosive Chemicals

Corrosive chemicals cause visible destruction or irreversible alteration to living tissue. Common acids and bases are the most common corrosives encountered, but other chemicals such as Br_2 are also extremely corrosive.

- Always dilute concentrated acids and bases by adding them to water because of the large amount of heat that can be generated while dissolving these compounds.
- Use appropriate personal protective equipment and fume hood ventilation when working with corrosive substances.
- Wear appropriate safety goggles or splash shields when working with corrosive substances. Safety glasses don’t provide complete eye protection from chemical splashes.

Note: Some specific acids such as HF (hydrofluoric acid, which is extremely toxic) and $HClO_4$ (perchloric acid, which is a powerful oxidizer of organics) require special handling procedures. Consult the appropriate references, your supervisor, and the Laboratory before working with these chemicals. Get important safety information about handling hydrofluoric acid from the Laboratory or from various websites. HF handling procedures are also posted on the fume hood dedicated to its use.

7.2. Flammable Chemicals

The risk of fire in the chemical laboratory is most often associated with two classes of compounds: common organic solvents, and certain metals, such as metal hydrides and organometallics.

For common organic solvents, note the following:

- Keep all containers of flammable or combustible liquids closed when not in use.
- Do not store bottles of flammable liquids greater than 1L in size in the open laboratory.
- Return the bottle of flammable liquid to the appropriate flammable chemical storage cabinet after decanting to a smaller container.
- Do not collect flammable waste solvents in containers larger than 1L in size in the open lab. Decant these waste liquids into designated waste containers before you leave (see **Waste Disposal**).

- Always use flammable liquids in a fume hood, with the exception of small amounts of solvents for spot cleaning.
- Use only refrigerators and freezers that are approved for flammable storage, and have the appropriate sign posted for flammable chemical storage.

For further details, see **Appendix D Handling, Storage, and Disposal of Flammable Solvents**.

Alkali and alkaline earth metals, certain other metals such as aluminum, metals in a finely divided form, metal hydrides, and many organometallic compounds can ignite on exposure to air and/or water. If considering using such materials, consult the Laboratory.

7.3. Noxious Chemicals

Certain classes of chemicals such as thiols (mercaptans), amines**,** and related compounds are characterized by a particularly noxious odour.

- Use adequate ventilation (fume hoods) with these compounds.
- Notify the Laboratory in advance when using these chemicals and wait for a response before opening the bottle. When they are released through the ventilation system into the local atmosphere, they are often mistaken for a serious chemical release. The Laboratory will contact the appropriate authorities

7.4. Reactive Chemicals

Reactive chemicals fall into several categories:

- Air- or water-reactive
- Self-reactive
- Lachrymators
- Incompatible chemicals

7.4.1. Air- or Water-Reactive and Self-Reactive Chemicals

Chemicals that can ignite on exposure to air or water, or chemicals that may spontaneously polymerize or form explosive compounds when stored, require special handling, storage, and disposal procedures. Consult the Laboratory if considering using such chemicals.

A common example, organic peroxides, may be or become explosive and should be handled with special care. Certain chemical types, particularly active alkenes (e.g., methacrylate) and cyclic ethers (e.g., tetrahydrofuran, THF), are prone to forming explosive peroxides. For more information, see **Appendix B Handling, Storage, and Disposal of Organic Peroxides**.

7.4.2. Lachrymators

Lachrymators are substances that react with moisture in the eyes and mucous membranes to cause tear formation (e.g., halogenated aldehydes, ketones, and esters).

- Use adequate ventilation (fume hood) and store them in well-sealed containers.

7.4.3. Incompatible Chemicals

Accidental contact of incompatible chemicals can lead to fire, explosion, and/or the release of highly toxic substances. The magnitude of the problem usually increases with the quantity of chemicals being stored.

- Store incompatible chemicals in separate locations to minimize the risk of accidental mixing.
  - See **Appendix C Classes of Incompatible Chemicals** for a list of some general groups of incompatible chemicals.
- Store oxidizers (e.g., chromates, halogens, peroxides) and reducers (e.g., metals, metal hydrides, phosphorus, sulfur) in separate cabinets or on separate shelves since they are incompatible with each other.
- Separate strong oxidizers from flammable liquids.

7.5. Toxic Chemicals

A wide range of substances in the chemical laboratory present a risk for chronic or acute toxicity. This includes the presence of carcinogens, mutagens, and teratogens. Toxic substances may enter the body by inhalation, absorption, ingestion, and/or injection.

- Use appropriate protective measures to prevent exposure and to maintain permissible exposure limits for a specific substance.
- Ensure antidotes for poisons are present during usage of these poisons, when available (e.g., calcium gluconate gel should be present when HF is being used).

8. Safe Laboratory Procedures and Techniques

This section describes the safe laboratory procedures and techniques required when using the following types of equipment:

- Glassware
- Electrical equipment
- Static electricity and spark hazards
- UV lamps
- Lasers
- Compressed gases
- Biohazards

8.1. Glassware

In general, glassware used for standard laboratory procedures is made of borosilicate glass.

Prior to carrying out an experiment:

- Check the glassware for cracks, chips, and other flaws.
  - Repair the flaws or replace the glassware before the glassware is used.
- Select the right glassware for the job.
- Shield glassware under pressure or in a vacuum.
- Wear thick leather gloves when applying pressure to glassware.
- Do not heat or apply pressure or vacuum to a chemical in a stock bottle. These bottles are made of a soft glass that breaks readily.

8.1.1. Cleaning Laboratory Glassware

For most cleaning applications:

- Rinse laboratory glassware with an appropriate cleaning solution, depending on the application.
- Powdered detergents (e.g., Sparkleen®, Alconox®) are not permitted in the cleanroom.
- In some situations, use a more chemically aggressive cleaning solution, such as acid/oxidizer baths or base/alcohol baths. Because of the hazards associated with the use of these baths, you must get approval of the Laboratory.

8.2. Electrical Equipment

In addition to the hazards posed by electrical shock, electrical equipment also presents a source of fire hazard when used in conjunction with flammable substances (see Flammable Chemicals).

Note: Only trained or qualified individuals should repair or modify electrical equipment.

Minimize electrical hazards by following these guidelines:

- Do not use electric wires as supports.
- Unplug equipment by pulling on the plug and not the cord.
- Inspect equipment regularly for frayed cords or broken plugs. Repair or replace these immediately.
- Fix any equipment failure or overheating issues immediately.
- Use a “C” class fire extinguisher for electrical fires.

8.3. Static Electricity and Spark Hazards

Protection from static discharge must be addressed in particular when handling flammable solvents. Proper grounding of containers and equipment significantly reduces this risk.

Common potential sources of sparks and static discharges are:

- Ungrounded metal tanks and containers
- Clothing or containers made of plastic or synthetic materials
- High pressure gas cylinders upon discharge
- Control systems on hotplates
- Brush motors and forced-air dryers

8.4. UV Lamps

Radiation of wavelengths below 250 nm poses a considerable risk to eyes and exposed skin.

To minimize these risks:

- Wear UV-absorbing safety glasses and avoid direct eye contact with the UV source.
- Wear protective clothing to prevent burns from UV exposure.
- Work in an enclosed work area when working with UV irradiation to prevent exposure of other workers to the UV source,
- Clean mercury arc lamps thoroughly before use.
  - Handling the glass with bare hands leaves oil deposits on the surface of the outer glass. This oil forms residues that burn into the glass causing a buildup of heat during the operation of the lamp. The lamp may overheat, crack, and release mercury vapor.

8.5. Lasers

The Department of Environmental Health and Safety runs a “Laser Safety Program”. All personnel working in proximity to Class 3b or Class 4 lasers must complete this program before starting work with lasers. The Oxford Laser machining system is considered a Class 1 laser system because of the complete enclosure and interlocks present.

WARNING: Do not attempt to circumvent these safety interlocks.

The type and intensity of radiation available from a laser varies greatly from one instrument to another.

Minimize laser hazards by following these guidelines:

- Always wear goggles that offer protection against the specific wavelength(s) of the laser in use.

  Note: No available goggles protect against all laser wavelengths.
- Never look directly at the beam or pump source.
- Never view the beam pattern directly.
  - Use an image converter or other safe, indirect means to view the beam pattern.
- Do not allow objects that cause reflections to be present in or along the beam.
- Keep a high general illumination level in areas where lasers are in operation.
  - Low levels of light cause pupils to dilate, thereby increasing the danger to the eyes.
- Display a warning sign at the entrance to the lab that a laser is in use.

8.6. Compressed Gases

Gases used in laboratories are supplied in cylinders at high pressure. If required, lecture bottles may be used with permission from the Laboratory. In addition to any potential chemical hazards, compressed gases are a high-energy source and therefore hazardous.

Follow these general rules when working with compressed gases:

- Restrain all cylinders from falling using restraining devices.
- Ensure the cylinder cap is in place during storage or transport.
- Transport cylinders only when strapped to a wheeled cart.
- Do not use a lubricant when connecting the regulator to the cylinder.
- Check new connections for gas leakage.
- Set the cylinder delivery pressure to zero after the main cylinder valve is closed to prevent a rapid release of compressed gas the next time the cylinder is opened.
- For empty cylinders:
  a. Remove the regulator.
  b. Mark with “empty” or “MT”.
  c. Replace the shipping cap.
  d. Return to the loading area.
  e. Notify the Lab Manager when a cylinder needs to be replaced.
- Shut off the supply of a flammable gas in the event of a fire, before any attempt is made to extinguish the flame.
- Use a trap to prevent the back siphoning of solution when a soluble gas is being used.
- Do not expose cylinders to temperatures higher than 50°C.

- Use a fume hood for toxic, flammable, or reactive gases.
- Use the appropriate regulator for the type of gas being used.
- Be aware that special handling procedures are required for certain gases and follow those procedures, (e.g., acetylene).

8.7. Biohazards

Biohazard use is strictly regulated and must adhere to Queen's University guidelines. If you are considering using biohazardous materials, consult the Laboratory.

9. Safety Equipment

A variety of protective measures are available for dealing with the hazards present in the Laboratory. One of the simplest measures to reduce or eliminate a hazard is to use a less hazardous alternative, if possible.

The following safety equipment is available when doing hazardous work:

- Fume hoods
- Personal protective equipment

9.1. Fume Hoods

The most common method used to prevent exposure to hazardous chemicals by inhalation is to work in a ventilated work space provided in a fume hood. Protection is provided by air flow through the fume hood and away from the user. Annual inspection and servicing is carried out on fume hoods to ensure proper operation, however, it is important to note that the protection offered by a fume hood can be compromised if features of the hood are modified, if the sash is opened too high, or if the airflow is obstructed by equipment or chemicals in the fume hood.

Keep the following points in mind when using a fume hood or wet deck:

- Keep all apparatus at least six inches from the front of the hood.
  - Airflow is less likely to be impeded and vapors are less likely to escape.
- Do not use the fume hood to store chemicals and equipment.
- Check that the airflow monitor and alarm are functioning properly.
- Keep doors to the lab closed.
- Keep the sash on the fume hood at a safe operating height.

WARNING: It is an offence under the Occupational Health and Safety Act to disable any protective device such as the airflow monitor and alarms on fume hoods.

9.2. Personal Protective Equipment

The following personal protective equipment is available when doing hazardous work:

- Eye and face protection
- Clothing
- Gloves
- Respirators
- Hearing protection

9.2.1. Eye and Face Protection

The minimum requirement for eye protection is that safety glasses (or prescription glasses) fitted with side shields must be worn beyond the gowning room door. However, safety glasses do not provide complete protection for the eyes from spills and splashes. Where more protection is required, such as when working with corrosive substances, use either safety goggles or a full face shield.

9.2.2. Clothing

Appropriate clothing and shoes are part of your protective equipment. Short pants, open-toed shoes, and sandals offer no protection from spills of hazardous chemicals.

- Wear shoes that cover the feet completely and long pants.
- Wear cleanroom gowning apparel for entry to the cleanroom (see the NFK Gowning Protocol for more information).
  - This apparel does not provide sufficient protection from all chemical hazards. Ensure that the appropriate protective clothing is available for the task you are doing.

9.2.3. Gloves

Cleanroom gloves are required for entry to the cleanroom, but these may not offer sufficient chemical protection. Gloves are available in a variety of materials including natural rubber, neoprene, nitrile, and vinyl. Each type of material is resistant to only a limited range of chemicals; therefore, no single type of glove is suitable for all situations. Wearing the wrong type of glove can cause more damage by keeping chemicals in contact with your skin.

- Consult the manufacturers' data before selecting the appropriate type of gloves.
- When more chemical-resistant gloves are required, wear these over the gloves required for the cleanroom gowning policy.
- Remove chemical gloves before opening any doors and dispose of them as directed by the Laboratory.

9.2.4. Respirators

Respirators are designed to protect the wearer from hazardous vapors or dust. If you are considering using any process that recommends breathing aids, consult the Laboratory.

9.2.5. Hearing Protection

Routine exposure to noise in excess of 90 dB requires the use of hearing protection, such as ear plugs or ear muffs. For extended exposure to noise in excess of 80 dB, hearing protection is advised. If you are considering a process that generates loud noise, consult the Laboratory.

10. Waste Disposal

10.1. Chemical Waste

Proper disposal of chemical waste is critical to preserving the health of personnel and of the environment. Any waste containing a hazardous material, including waste that is contaminated with a hazardous material, must be disposed of in accordance with the Laboratory waste disposal procedure.

Important aspects of this procedure are:

- Do not use sinks and garbage cans for chemical waste disposal.
- Do not assume that all waste goes into the same waste container.
  - Segregate all chemical waste by compatibility (see **Appendix A. Chemical Waste Compatibility Groups**). Further information can be found on the EH&S website: http://www.safety.queensu.ca/hazwaste
- Keep chemicals in their original bottles for disposal, where possible.
  - Dispose of empty containers that held hazardous chemicals as hazardous waste, unless they are defaced and thoroughly cleaned.
- Place solids contaminated with hazardous chemicals (e.g., wipes) in the designated container, respecting segregation of incompatible chemicals.
- Place spent flammable liquids such as common organic solvents in labelled temporary waste containers in the cleanroom as directed by the Laboratory. Laboratory staff will transfer the waste to solvent disposal cans. These cans are red with wide mouths and have a flame arrestor.
  - Do not fill containers to more than 90% of capacity.
  - Notify the Laboratory when the waste container is getting full.
  - As you add waste to the containers, record the type of waste in the log provided. The disposal company can’t transport the material without knowing what it is.
  - Halogenated compounds must be segregated for disposal. If you are considering using such a chemical, consult the Laboratory
- Do not place sharp objects such as syringe needles in conventional waste containers. They must be collected in the designated (“SHARPS”) container for disposal. Separate waste containers are provided for broken glass and pipettes.

Appendix A. Chemical Waste Compatibility Groups

Chemical Code Groups

- **Group A**
  - Inorganic Acids
  - Elements and inorganic salts that don't liberate gaseous products when acidified

- **Group B**
  - Inorganic alkaline chemicals
  - Organic bases
  - Elements and inorganic salts that liberate gaseous products when acidified

- **Group C**
  - Solid organic compounds (excluding bases)

- **Group D**
  - Organic liquids (excluding organic bases)
  - f. Note: Separate containers must be used for halogenated and non-halogenated Group D liquids.

- **Group E**
  - Inorganic oxidizing agents
  - g. Note: Group E chemicals can't be stored or transported with any other chemicals in a common container.

- **Group F**
  - Pesticides

- **Group G**
  - Shock sensitive materials
  - Organic oxidizing agents
  - Pressurized containers, gas cylinders
  - Materials that react violently with water

Appendix B. Handling, Storage, and Disposal of Organic Peroxides

Organic peroxides are a special class of compounds that pose unusual stability problems. These peroxides are among the most hazardous chemicals normally handled in chemical laboratories and in manufacturing. As a class, organic peroxides are low-power explosives and may be sensitive to shock. Peroxides have a specific half-life, or rate of decomposition, under a given set of conditions. A low rate of decomposition may auto-accelerate into a violent explosion, especially in bulk quantities of peroxides. They are sensitive to heat, friction, impact, and light as well as to strong oxidizing and reducing agents. Organic peroxides are extremely flammable and fires involving bulk quantities of peroxides should be approached with extreme caution.

Handling

Use the following precautions when handling organic peroxides and hydroperoxides:

- Study and follow all precautions specified by the manufacturer.
- Limit the quantity of peroxide handled to the minimum amount required.
  - Do not return unused peroxide to the stock container.
- Clean up all spills immediately using the recommended procedures.
- Reduce the sensitivity of most peroxides by diluting with inert solvents such as aliphatic hydrocarbons (e.g., mineral oil), but never with acetone or other ketones.
- Avoid using peroxides in volatile solvents when it is possible that the solvent will vaporize and thereby increase the concentration of the peroxide.
- Use plastic or ceramic spatulas with organic peroxides. A metal spatula can cause explosive decomposition.
- Avoid friction, grinding, and impact.
  - Never use glass containers with screw cap lids or glass stoppers – instead, use plastic bottles and sealers.
- Don't use open flames, sparking equipment, or intense heat sources near peroxides.
- Avoid ingestion, inhalation, and skin contact since many peroxides are irritants.

Storage

- Store the peroxides at the minimum safe temperatures to minimize the rate of decomposition.
  - Do not refrigerate or store liquid or solutions of peroxides at or below the temperature at which the peroxide freezes or precipitates - peroxides in the solid state have increased sensitivity to shock and heat.

Disposal

A common method of disposal of liquid organic peroxides is dilution to <10% by weight in a suitable non-volatile hydrocarbon solvent (often mineral spirits or mineral oil) prior to sending out the material (through Environmental Health and Safety) for disposal by incineration. Check the manufacturer's recommendations prior to disposal of any specific peroxide.

Appendix C. Classes of Incompatible Chemicals

Many chemicals, classed by main types of reactivity, are known to react with other classes of chemicals in various ways. Often, these reactions are associated with the release of gas, heat, or hazardous chemical. Table 1 lists the general classes of chemicals alongside the types of chemicals that they are typically incompatible with. This list can be used to decide which chemicals to store together or how to allow them to come into contact.

Table 1: Classes of Incompatible Chemicals

Class of Chemicals	Incompatible with
Alkali and alkaline earth carbides, hydrides, hydroxides, metals, oxides and peroxides	Water, acids, halogenated organic compounds, halogenating agents, oxidizing agents
Azides, inorganic	Acids, heavy metals and their salts, oxidizing agents
Cyanides, inorganic	Acids, strong bases
Nitrates, inorganic	Acids, reducing agents
Nitrites, inorganic	Acids, oxidizing agents
Organic acyl halides, anhydrides	Bases, organic hydroxy and amino compounds
Organic halogen compounds	Group IA and IIA metals, aluminum
Organic nitro compounds	Strong bases
Oxidizing agents (chlorates, chromates, chromium trioxide, dichromates, halogens, halogenating agents, hydrogen peroxide, nitric acid, nitrates, perchlorates, peroxides, permanganates, persulfates)	Reducing agents, ammonia, carbon, metals, metal hydrides, nitrites, organic compounds, phosphorus, silicon, sulfur
Reducing agents	Oxidizing agents, arsenates, arsenites, phosphorus, selenites, selenates, tellurium salts and oxides
Sulfides, inorganic	Acids

Source: “Prudent Practices in the Laboratory: Handling and Disposal of Chemicals”, National Research Council, National Academy of Sciences, Washington, 1995.

Appendix D. Handling, Storage, and Disposal of Flammable Solvents

The quantities of flammable solvents (flash point ≤ 37.8°C) and combustible solvents (flash point > 37.8° C, ≤ 93.3° C) that may be stored in laboratories are governed by the Ontario Fire Code (OFC). It is the responsibility of research supervisors and NFK to ensure that flammable and combustible solvents present in the Laboratory are handled, stored, and disposed of in accordance with this Code. Classification of flammable solvents can be found in the OFC section 4.1.2.

Handling and Storage

Use the following precautions when handling flammable solvents:

- Containers for storing solvents cannot exceed 5 litres capacity; exceptions are waste solvent (20 litres) containers <u>with</u> flame arrestors, and stainless steel cylinders used in solvent purification systems in accordance with the manufacturer's specifications. (OFC pt 4 sec. 4.12.3.1(1))
- A total of 300 litres of flammable and/or combustible solvents may be stored in the open lab; of this total, the maximum allowable amount of flammable solvents is 50 litres; flammable solvents stored in the open lab cannot be in containers > 1 litre capacity [i.e. 50 one-litre containers are the maximum that can be stored in any research lab] (OFC pt 4 sec. 4.12.3.1(2))
- Flammable waste solvents cannot be collected in the open lab in containers greater than 1 litre capacity, and are part of the capacity listed in sentence (2)
- Quantities in excess of sentence (2) MUST be stored in an approved flammable storage cabinet; all flammable solvents in containers greater than 1 litre must be stored in a flammable storage cabinet, except where noted in sentence (1)
- Quantities described in sentence (4) cannot exceed the storage capacity of the approved flammable storage cabinets in the lab
- All containers for storing flammable and/or combustible liquids must be kept closed when not in use.

Disposal

The following solvents (carried by Science Stores at Queen's University) are examples of flammable solvents covered by this Code, though many other liquids are also covered by the Code.

Table 2: Flammable Solvents

Solvent	Health	Flammability	Reactivity
ACETONE	2	3	1
ACETONITRILE	2	3	1
BENZENE	3	3	1
DIOXANE	2	3	1
ETHANOL	2	3	0
ETHER	2	4	1
ETHYL ACETATE	2	3	0
HEXANES	2	3	0
ISOPROPANOL	2	3	0
LIGROIN	2	3	1
METHANOL	2	3	0
TETRAHYDROFURAN	2	3	1
TOLUENE	2	3	0
XYLENES	2	3	0

For clarification of any of the above solvents, visit: http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_070213_e.htm.

This website for the Office of the Ontario Fire Marshal gives much greater detail with respect to pt. IV of the Ontario Fire Code and your obligations. Questions pertaining to interpretation of the act should be addressed to Environmental Health and Safety.

Appendix E. Additional Policy Statements

In addition to the health and safety standards set by the Laboratory, the Department of Environmental Health and Safety at Queen's University has established a set of policy statements and standard operating procedures for the University that also apply to the Laboratory (implemented since June 2006). For more information, refer to their website at http://www.safety.queensu.ca/.

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