INCluding CHEMICAL HazArds and SAFETY PROCEDURES

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INTRODUCTION TO LABORATORY SAFETY
1.1 PREPARING FOR LABORATORY WORK

Before starting to work in a laboratory, familiarize yourself with the following:

- the hazards of the materials in the lab, as well as appropriate safe handling, storage and emergency protocols. Read labels and material safety data sheets (MSDSs) before moving, handling or opening chemicals. Never use a product from an unlabeled container, and report missing labels to your supervisor.
- the agents, processes and equipment in the laboratory. If you are unsure of any aspect of a procedure, check with your supervisor before proceeding.
- the location and operation of safety and emergency equipment such as fire extinguishers, eye wash and shower, first aid and spill response kits, fire alarm pull stations, telephone and emergency exits
- emergency spill response procedures for the materials you will handle
- emergency reporting procedures and telephone numbers
- designated and alternate escape routes

1.2 DURING LABORATORY WORK

- Restrict laboratory access to authorized persons only
- Avoid smoking; eating; drinking; storing food, beverages or tobacco; applying cosmetics or lip balm and handling contact lenses in laboratories.
- Wear lab coats (knee length) and safety glasses in laboratories employing chemicals, biohazards or radioisotopes. Open shoes, such as sandals, should never be worn in the lab.
- Tie back or otherwise restrain long hair when working with chemicals, biohazards, radioisotopes, or moving machinery.
- Keep work places clean and free of unwanted chemicals, biological specimens, radios, and idle equipment. Avoid leaving reagent bottles, empty or full, on the floor.
- Work only with materials once you know their flammability, reactivity, toxicity, safe handling and storage and emergency procedures.
- Never pipette by mouth; use mechanical transfer devices.
- Walk; do not run, in the lab.
- Keep exits and passageways clear at all times.
- Ensure that access to emergency equipment (eyewashes, safety showers and fire extinguishers) is not blocked.
- Working alone is an unsafe practice at any time. However, if the nature of your work makes it unavoidable, take measures to ensure that others are
aware of your location and have someone check in with you from time to time, either in person or by telephone.

- Report accidents and dangerous incidents ("near-misses") promptly to your supervisor.
- Wash your hands thoroughly before leaving the laboratory.
- Conduct procedures involving the release of volatile toxic or flammable materials in a chemical fume hood (See Section 7.4).
- Perform procedures that liberate infectious bioaerosols in a biological safety cabinet.
- Handle all human blood and body fluids as if potentially infectious.

1.3 CLEANING UP BEFORE LEAVING THE LABORATORY

Perform a safety check at the end of each experiment and before leaving the lab. Make sure to:

- Turn off gas, water, electricity, vacuum and compression lines and heating apparatus.
- Return unused materials, equipment and apparatus to their proper storage locations.
- Label, package and dispose of all waste material properly (Refer to Section 9.3, Waste Preparation Procedures).
- Remove defective or damaged equipment immediately, and arrange to have it repaired or replaced.
- Decontaminate any equipment or work areas that may have been in contact with hazardous materials.
- Leave behind protective clothing (lab coats, gloves, etc.) when leaving the laboratory.
- Close and lock the door to the laboratory if you are the last one to leave.

1.4 EVALUATING LABORATORY HAZARDS, AN ONGOING PROCESS

There are many categories of hazards that might be encountered in a laboratory setting, and situations can change frequently. Even after you have identified and controlled all current risks, it is critical that you remain open to the possibility that new unexpected dangers can arise. Hence, carry out weekly inspections on the condition of:

- fire extinguishers
- emergency wash devices such as eyewashes and drench hoses (run these for several minutes and update inspection tags)
- first aid kit contents
- fume hood and other ventilation devices
- tubing for circulating water, vacuum, gases
- chemical storage compartments
- Ensure that fire extinguishers and emergency showers are inspected, tested and tagged annually.
Among potential laboratory hazards, be alert for the following:

- **Chemical products**
  - flammable
  - toxic
  - oxidizing
  - reactive
  - corrosive

- **Microbiological disease-producing agents and their toxins**
  - viruses
  - bacteria
  - parasites
  - rickettsiae
  - fungi

- **Physical or mechanical hazards**
  - ionizing and non-ionizing radiation
  - electrical
  - poor equipment design or work organization (ergonomic hazards)
  - tripping hazards
  - excessive noise or heat

- **Psychosocial conditions that can cause psychological stress**
WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM
WHMIS rule applies to all RRL staff and students who work in areas where hazardous materials, referred to in WHMIS as "controlled products", are used. The purpose of this rule is to ensure that people who handle these controlled products have access to the information that they need in order to work safely. WHMIS requires that this information be conveyed via labels, material safety data sheets (MSDS) and training.

2.1 REGULATORY REQUIREMENTS: LABELS, MATERIAL SAFETY DATA SHEETS, TRAINING

Below you will find a summary of the type of information that is covered by labels, MSDSs and training.

**Labels** for hazardous materials must alert people to the dangers of the product and basic safety precautions.

**MSDSs** provide more details than the labels. They are technical bulletins that provide chemical, physical, and toxicological information about each controlled product, as well as information on precautionary and emergency procedures. They must be readily accessible to anyone who works with, or who may otherwise be exposed to, controlled products.

**Training** provides more detailed instruction on the specific procedures necessary to carry out work safely. Basic training, referred to as core training, provides instruction on the content, purpose and interpretation of information found on labels and in MSDSs for controlled products.

Hazard-specific or job-specific training refers to instruction in the procedures for the safe handling and storage of the controlled products that are unique to each laboratory. Hazard-specific training also covers spill or leak remediation; waste disposal; and basic first aid instructions.
2.2 UNDERSTANDING HAZARD WARNING INFORMATION
2.2.1 WHMIS SYMBOLS

The classes of controlled chemical products and their corresponding symbols or pictograms, as well as general characteristics and handling precautions are outlined in table 1.

Table 1 Safe handling of controlled products

<table>
<thead>
<tr>
<th>Class and Symbol</th>
<th>Characteristics</th>
<th>Precautions</th>
</tr>
</thead>
</table>
| Class A Compressed Gas | • Gas inside cylinder is under pressure  
                           • The cylinder may explode if heated or damaged  
                           • Sudden release of high pressure gas streams may puncture skin and cause fatal embolis | • Transport and handle with care  
                           • Make sure cylinders are properly secured  
                           • Store away from sources of heat or fire  
                           • Use proper regulator |
| Class B Flammable and Combustible Material | • May burn or explode when exposed to heat, sparks or flames  
                                             • Flammable: burns readily at room temperature  
                                             • Combustible: burns when heated | • Store away from Class C (oxidizing materials)  
                                             • Store away from sources of heat, sparks and flame  
                                             • Do not smoke near these materials |
| Class C Oxidizing Material | • Can cause other materials to burn or explode by providing oxygen  
                               • May burn skin and eyes on contact | • Store away from Class B (flammable and combustible) materials  
                               • Store away from sources of heat and ignition  
                               • Wear the recommended protective equipment and clothing |
<table>
<thead>
<tr>
<th>Class D Poisonous and Infectious Material</th>
<th>Division 1: Materials Causing Immediate and Serious Toxic Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>• May cause immediate death or serious injury if inhaled, swallowed, or absorbed through the skin</td>
<td></td>
</tr>
<tr>
<td>• Avoid inhaling gas or vapours</td>
<td></td>
</tr>
<tr>
<td>• Avoid skin and eye contact</td>
<td></td>
</tr>
<tr>
<td>• Wear the recommended protective equipment and clothing</td>
<td></td>
</tr>
<tr>
<td>• Do not eat, drink or smoke near these materials</td>
<td></td>
</tr>
<tr>
<td>• Wash hands after handling</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class D Poisonous and Infectious Material</th>
<th>Division 2: Materials Causing Other Toxic Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>• May cause death or permanent injury following repeated or long-term exposure</td>
<td></td>
</tr>
<tr>
<td>• May irritate eyes, skin and breathing passages: may lead to chronic lung problems and skin sensitivity</td>
<td></td>
</tr>
<tr>
<td>• May cause liver or kidney damage, cancer, birth defects or sterility</td>
<td></td>
</tr>
<tr>
<td>• Avoid inhaling gas or vapors</td>
<td></td>
</tr>
<tr>
<td>• Avoid skin and eye contact</td>
<td></td>
</tr>
<tr>
<td>• Wear the recommended protective equipment and clothing</td>
<td></td>
</tr>
<tr>
<td>• Do not eat, drink or smoke near these materials</td>
<td></td>
</tr>
<tr>
<td>• Wash hands after handling</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Class D Poisonous and Infectious Material</th>
<th>Division 3: Biohazardous Infectious Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Contact with microbiological agents (e.g., bacteria, viruses, fungi and their toxins) may cause illness or death</td>
<td></td>
</tr>
<tr>
<td>• Wear the recommended protective equipment and clothing</td>
<td></td>
</tr>
<tr>
<td>• Work with these materials in designated areas</td>
<td></td>
</tr>
<tr>
<td>• Disinfect area after handling</td>
<td></td>
</tr>
<tr>
<td>• Wash hands after handling</td>
<td></td>
</tr>
</tbody>
</table>
### Class E Corrosive Material
- Will burn eyes and skin on contact
- Will burn tissues of respiratory tract if inhaled

### Class F Dangerously Reactive Material
- May be unstable, reacting dangerously to jarring, compression, heat or exposure to light
- May burn, explode or produce dangerous gases when mixed with incompatible materials

| Store acids and bases in separate areas |
| Avoid inhaling these materials |
| Avoid contact with skin and eyes |
| Wear the recommended protective equipment and clothing |

| Store away from heat |
| Avoid shock and friction |
| Wear the recommended protective equipment and clothing |

### 2.2.2 TOXICOLOGICAL PROPERTIES: LD50 AND LC50:

Despite the limitations of using toxicity data from animal studies to predict the effects on humans, LD50 and LC50 values often comprise a large part of the available toxicity information, and form the bases for many standards, guidelines and regulations.

LD50 (Lethal Dose50) is the amount of a substance that, when administered by a defined route of entry (e.g. oral or dermal) over a specified period of time, is expected to cause the death of 50 per cent of a defined animal population. The LD50 is usually expressed as milligrams or grams of test substance per kilogram of animal body weight (mg/kg or g/kg).

LC50 (Lethal Concentration50) is the amount of a substance in air that, when given by inhalation over a specified period of time, is expected to cause the death in 50 per cent of a defined animal population. Some LC50 values are determined by administration of test substances to aquatic life in water. The LC50 is expressed as parts of test substance per million parts of air (PPM) for gases and vapours, or as milligrams per litre or cubic metre of air (mg/L or mg/m³) for dusts, mists and fumes.
When assessing the hazards of materials used in the laboratory, it is important to remember that substances with lower LD50 or LC50 values are more toxic that those with higher values.

2.2.3 EXPOSURE LIMITS (TLV, PEL)

An exposure limit is the maximum limit of exposure to an air contaminant. The threshold limit value (TLV) or permissible exposure limit (PEL) can be expressed as the following:

- 8-hour time-weighted average (TWA) is the average concentration to which most workers can be exposed during an 8-hour workday, day after day, without harmful effects
- Short-term exposure limit (STEL), is the maximum average concentration to which most workers can be exposed over a 15 minute period, day after day, without adverse effects
- Ceiling (C) defines a concentration that must never be exceeded; and is applied to many chemicals with acute toxic effects

It should be noted that most exposure limits are based on industrial experiences and are not entirely relevant to the laboratory environment. Good laboratory practices and well-designed ventilation systems serve to maintain air concentrations well below these limits.

2.2.4 FLASH POINT

The flash point is the lowest temperature at which a liquid produces enough vapour to ignite in the presence of a source of ignition. The lower the flash point, the greater the risk of fire. Many common laboratory solvents (e.g., acetone, benzene, diethyl ether, methanol) have flash points that are below room temperature.

2.2.5 AUTOIGNITION TEMPERATURE

The ignition or autoignition temperature is the temperature at which a material will ignite, even in the absence of an ignition source; a spark is not necessary for ignition when a flammable vapour reaches its autoignition temperature. The lower the ignition temperature, the greater the potential for a fire started by typical laboratory equipment.

2.2.6 FLAMMABLE LIMITS

Flammable limits or explosive limits define the range of concentrations of a material in air that will burn or explode in the presence of an ignition source such as a spark or flame. Explosive limits are usually expressed as the percent by volume of the material in air:
- The lower explosive limit (LEL) or lower flammable limit (LFL) is the lowest vapour concentration that will burn or explode if ignited. Below this limit, the concentration of fuel is too "lean" for ignition, i.e., the mixture is oxygen rich but contains insufficient fuel.
- The upper explosive limit (UEL) or upper flammable limit (UFL) is the highest vapour concentration that will ignite. Above this limit, the mixture is too "rich" for ignition.
- The flammable range consists of concentrations between the LEL and UEL.

Table 2 lists flash points, lower explosive limits and exposure limits of several flammable or combustible laboratory solvents.

<table>
<thead>
<tr>
<th>Solvent</th>
<th>FPL (oC)</th>
<th>LEL (% by volume)</th>
<th>Autoignition temperature (oC)</th>
<th>TLV-TWA * ppm (mg/m3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>acetic acid, glacial</td>
<td>39</td>
<td>4.0</td>
<td>427</td>
<td>10(25)</td>
</tr>
<tr>
<td>acetone</td>
<td>-18</td>
<td>2.5</td>
<td>538</td>
<td>250(590)</td>
</tr>
<tr>
<td>acetonitrile</td>
<td>5.6</td>
<td>3.0</td>
<td>524</td>
<td>20 (34)</td>
</tr>
<tr>
<td>Diethyl ether</td>
<td>-45</td>
<td>1.9</td>
<td>180</td>
<td>400 (1210)**</td>
</tr>
<tr>
<td>ethanol, absolute</td>
<td>13</td>
<td>3.3</td>
<td>423</td>
<td>1000 (1900)</td>
</tr>
<tr>
<td>ethyl acetate</td>
<td>-4.4</td>
<td>2.0</td>
<td>427</td>
<td>400 (1440)</td>
</tr>
<tr>
<td>methanol</td>
<td>11</td>
<td>6.0</td>
<td>464</td>
<td>200 (260)</td>
</tr>
<tr>
<td>n-pentane</td>
<td>-49</td>
<td>1.5</td>
<td>309</td>
<td>120 (350)</td>
</tr>
<tr>
<td>toluene</td>
<td>4.4</td>
<td>1.1</td>
<td>552</td>
<td>100 (375)</td>
</tr>
</tbody>
</table>
CONTROL OF CHEMICAL HAZARDS
3.1 TOXIC CHEMICALS AND THE FOUR ROUTES OF ENTRY

Chemicals can gain entry into the body by:

- **Inhalation** of gases, vapours and particulate material (e.g. mists, dusts, smoke, fumes)
- **Absorption** through skin of liquids, solids, gases and vapours
- **Ingestion** of chemicals directly or indirectly via contaminated foods and beverages and contact between mouth and contaminated hands (nail-biting, smoking)
- **Injection** of chemicals through needles and other contaminated laboratory sharps

3.2 FLAMMABLE CHEMICALS

Flammable and combustible liquids, solids or gases will ignite when exposed to heat, sparks or flame. Flammable materials burn readily at room temperature, while combustible materials must be heated before they will burn. Flammable liquids or their vapours are the most common fire hazards in laboratories. Refer to Section 5.4 ("Preventing Fires") for specific details on the safe handling of flammable chemicals in the laboratory.

3.3 OXIDIZING CHEMICALS

Oxidizers provide oxidizing elements such as oxygen or chlorine, and are capable of igniting flammable and combustible material even in an oxygen-deficient atmosphere (Refer to Section 5.1, "The Fire Triangle"). Oxidizing chemicals can increase the speed and intensity of a fire by adding to the oxygen supply, causing materials that would normally not burn to ignite and burn rapidly. Oxidizers can also:

- React with other chemicals, resulting in release of toxic gases
- Decompose and liberate toxic gases when heated
- Burn or irritate skin, eyes, breathing passages and other tissues

Precautions to follow when using and storing oxidizers in the laboratory include the following:

- Keep away from flammable and combustible materials
- Keep containers tightly closed unless otherwise indicated by the supplier
- Mix and dilute according to the supplier's instructions
To prevent release of corrosive dusts, purchase in liquid instead of dry form
Reduce reactivity of solutions by diluting with water
Wear appropriate skin and eye protection
Ensure that oxidizers are compatible with other oxidizers in the same storage area

3.4 REACTIVE CHEMICALS

- May be sensitive to jarring, compression, heat or light
- May react dangerously with water or air
- May burn, explode or yield flammable or toxic gases when mixed with incompatible materials
- Can vigorously decompose, polymerize or condense
- Can also be toxic, corrosive, oxidizing or flammable
- Some chemicals may not be dangerous when purchased but may develop hazardous properties over time (e.g. diethyl ether and solutions of picric acid).

Follow these precautions when working with dangerously reactive chemicals:

- Understand the hazards associated with these chemicals and use them under conditions which keep them stable
- Store and handle away from incompatible chemicals
- Keep water-reactive chemicals away from potential contact with water, such as plumbing, fire sprinkler heads and water baths
- Handle in a chemical fume hood
- Wear the appropriate skin and eye protection
- Work with small quantities
- Use up or dispose of these chemicals before they attain their expiry date

3.5 CORROSIVE CHEMICALS

Corrosives are materials, such as acids and bases (caustics, alkalis) which can damage body tissues as a result of splashing, inhalation or ingestion. Also:

- They may damage metals, releasing flammable hydrogen gas
- They may damage some plastics
- Some corrosives, such as sulphuric, nitric and perchloric acids, are also oxidizers; thus they are incompatible with flammable or combustible material
- They may release toxic or explosive products when reacted with other chemicals
- They may liberate heat when mixed with water

Precautions for handling corrosive materials include:

- Wear appropriate skin and eye protection
- Use in the weakest concentration possible
- Handle in a chemical fume hood
• Use secondary containers when transporting and storing corrosives
• Always dilute by adding acids to water
• Dilute and mix slowly
• Store acids separately from gases

3.6 HAZARDOUS CHEMICAL SPILLS

3.6.1 SPILL RESPONSE CONTINGENCIES
Laboratory heads are responsible for predetermining procedures for response to the types of spill situations that may be anticipated for their operations. Individuals requiring assistance in preparing spill response plans should contact the safety officer. In instances where more extensive equipment or technical assistance is needed, backup can be provided by other internal resources.

3.6.2 DEVELOPMENT OF SPILL RESPONSE PLANS
3.6.2.1 COMMUNICATIONS
All laboratories housing hazardous materials are required to provide means of reaching contact people who may be summoned in the event of emergencies involving their laboratory, especially for after-hours situations. This may involve posting the relevant telephone number(s) and/or providing them to the Security Services, who operate the emergency telephone number. Building Directors are also required to provide to the Security Services telephone numbers where they, or alternate contact persons, may be reached during after-hours crises.

3.6.2.2 GENERAL GUIDELINES
The following factors are to be considered when developing spill response procedures:

• Categories of chemicals (e.g. oxidizers, flammable solvents) and their chemical, physical and toxicological properties.
• The quantities that may be released.
• Possible locations of release (e.g. laboratory, corridor).
• Personal protective equipment needed.
• Types and quantities of neutralizing or absorbing material needed.

These guidelines should be followed when initially responding to a spill situation:

• Determine appropriate clean up method by referring to the Material Safety Data Sheet (MSDS). If you are unsure how to proceed, or if you do not have the necessary protective equipment, do not attempt to clean up the spill.
• If the spill is minor and of known limited danger, clean up immediately.
• If the spill is of unknown composition, or potentially dangerous (explosive, toxic vapours), alert everyone present and evacuate the room.
• If the spill cannot be safely handled using the equipment and personnel present, call the emergency telephone number (Downtown Campus local 3000, Macdonald Campus local 7777) to request assistance.
3.6.3 GUIDELINES FOR SPECIFIC TYPES OF SPILLS

This section describes how to clean up some of the chemical spills that may occur in the laboratory. Refer to Section 6.3.1, "Chemical Waste", for details on how to dispose of the absorbed chemical.

3.6.3.1 FLAMMABLE AND TOXIC LIQUIDS

- If you can do so without putting yourself at risk, immediately shut off all potential ignition sources.
- If fire occurs, alert everyone present and extinguish all flames. If the fire cannot be controlled immediately pull the nearest fire alarm.
- If no flames are evident, pour adsorbent around the perimeter of the spill and then cover the rest of the material. Wear an appropriate respirator if toxic vapours are involved.
- Wear gloves resistant to the chemical being handled. Using a plastic utensil (to avoid creating sparks), scoop up the absorbed spill, place it in a plastic bag, seal it, and place in a labeled container.

3.6.3.2 CORROSIVE LIQUIDS

- Alert everyone present. If vapours are being released, clear the area.
- Do not attempt to wipe up a corrosive liquid unless it is very dilute.
- Gloves, boots, apron and eye protection must be used when neutralizing an extensive corrosive spill. Respiratory protection is required if the liquid releases corrosive vapour or gas.
- Pour the required neutralizing or adsorbing material around the perimeter of the spill, then carefully add water and more neutralizing material to the contained area. Carefully agitate to promote neutralization.
- Use pH paper to verify that all contaminated areas are neutralized and safe to wipe up.
- If an adsorbent (e.g. spill control pillows) is used instead of a neutralizer, scoop up the absorbed spill, place it in a plastic bag, seal it, and then place in a labeled box. If neutralized material contains no toxic heavy metals (e.g. chromium), flush down the drain with plenty of water.

3.6.3.3 CORROSIVE SOLIDS

Small spills can be cleaned up mechanically with a dustpan and brush. Larger spills should be cleaned up using a HEPA (high-efficiency articulate) filter vacuum. For spills containing fine dusts, an air-purifying respirator with dust filters is recommended, as are gloves, protective goggles, and a lab coat.

3.6.3.4 TOXIC SOLIDS

Avoid disturbing such solids (e.g. asbestos), which may release toxic dusts. Wet the material thoroughly, then place it in a plastic bag and label it appropriately. If wet removal is not possible, a vacuum equipped with a HEPA (High Efficiency Particulate Air) filter is required.
3.6.3.5 GASES

In the event of the release of a corrosive gas (e.g. chlorine) or gases that are absorbed through the skin (e.g. hydrogen cyanide), a complete chemical resistant suit and a self-contained breathing apparatus are required. There is no practical means of absorbing or neutralizing a gas - the leak must be corrected at the source.

3.6.3.6 MERCURY

If a small amount of mercury is spilled (e.g. broken thermometer), use an aspirator bulb or a mercury sponge to pick up droplets, place the mercury in a container, cover with water, seal it, and label the bottle appropriately. To clean up the residual micro-droplets that may have worked into cracks and other hard-to-clean areas, sprinkle sulphur powder or other commercially available product for mercury decontamination. Leave the material for several hours and sweep up solid into a plastic bag, seal it and label it appropriately.

3.6.3.7 SPECIAL CATEGORIES

It is not within the scope of this manual to list procedures for all possible categories of chemicals. For further information on responses to other categories consult the material safety data sheet.
HANDLING AND STORAGE OF LABORATORY CHEMICALS
4.1 GENERAL GUIDELINES

Guidelines for storage of hazardous chemicals include the following:

- Segregate chemicals according to reactivity and flammability *(see Section 4.4)*
- Minimize quantities and container sizes kept in the lab
- Keep glass containers off the floor, away from possible collisions with people and equipment
- Store chemicals away from sources of heat and direct sunlight
- Store containers of liquids inside secondary containers (such as trays or tubs) that are large enough to hold spills
- Do not store hazardous liquids or large objects on shelves above eye level
- Install edge guards on all open shelves used for storage of chemicals
- Use sturdy shelves whose load capacities exceed that of the chemicals stored on them: regularly inspect clamps, supports, shelf brackets and other shelving hardware
- Maintain labels; check storage areas weekly for faded, missing or loose labels
- Dispose of unwanted chemicals promptly
- Keep inventory records of chemicals

4.2 FLAMMABLE LIQUID STORAGE CABINETS

Flammable chemicals should be stored inside flammable liquid storage cabinets. Only those flammables in use for the day should be outside the cabinet. Guidelines for cabinet use include:

- Use NFPA or UL approved flammable liquid storage cabinets
- Keep cabinet doors of the cabinet closed and latched
- Do not store other materials in these cabinets

4.3 CHEMICAL COMPATIBILITY

The storage scheme outlined in *Section 4.4* below ("Chemical Segregation") may not suffice to prevent mixing of incompatible chemicals. Certain hazardous combinations can occur even between chemicals of the same classifications. *Table 3* shows common examples of incompatible combinations:
<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>KEEP OUT OF CONTACT WITH:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic Acid</td>
<td>chromic acid, nitric acid, hydroxyl compounds, perchloric acid, peroxides, permanganate</td>
</tr>
<tr>
<td>Acetylene</td>
<td>chlorine, bromine, copper, fluorine, silver, mercury</td>
</tr>
<tr>
<td>Alkali Metals (e.g. Sodium)</td>
<td>water, chlorinated hydrocarbons, carbon dioxide, halogens</td>
</tr>
<tr>
<td>Ammonia, Anhydrous</td>
<td>mercury, chlorine, calcium hypochlorite, iodine, bromine, hydrofluoric acid</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>acids, metal powders, flammable liquids, chlorates, nitrites, sulphur, finely divided combustible materials</td>
</tr>
<tr>
<td>Aniline</td>
<td>nitric acid, hydrogen peroxide</td>
</tr>
<tr>
<td>Bromine</td>
<td>same as chlorine</td>
</tr>
<tr>
<td>Carbon, Activated</td>
<td>calcium hypochlorite, all oxidizing agents</td>
</tr>
<tr>
<td>Chlorates</td>
<td>ammonium salts, acids, metal powders, sulphur, finely divided combustible materials</td>
</tr>
<tr>
<td>Chromic Acid</td>
<td>acetic acid, naphthalene, camphor, glycerin, turpentine, alcohol, flammable liquids</td>
</tr>
<tr>
<td>Chlorine</td>
<td>ammonia, acetylene, butadiene, butane, methane, propane (or other petroleum gases), hydrogen, sodium carbide, turpentine, benzene, finely divided metals</td>
</tr>
<tr>
<td>Copper</td>
<td>acetylene, hydrogen peroxide</td>
</tr>
<tr>
<td>Flammable Liquids</td>
<td>ammonium nitrate, inorganic acids, hydrogen peroxide, sodium peroxide, halogens</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>fluorine, chlorine, bromine, chromic acid, sodium peroxide</td>
</tr>
<tr>
<td>Hydrofluoric Acid</td>
<td>anhydrous ammonia, ammonium hydroxide</td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>copper, chromium, iron, most metals or their salts, alcohols, acetone, aniline, nitromethane, flammable liquids, oxidizing gases</td>
</tr>
<tr>
<td>Hydrogen Sulphide</td>
<td>fuming nitric acid, oxidizing gases</td>
</tr>
<tr>
<td>Iodine</td>
<td>acetylene, ammonia (aqueous or anhydrous), hydrogen</td>
</tr>
<tr>
<td>Chemical</td>
<td>Incompatible Materials</td>
</tr>
<tr>
<td>-------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>Mercury</td>
<td>acetylene, fulminic acid, ammonia</td>
</tr>
<tr>
<td>Nitric Acid</td>
<td>acetic acid, aniline, chromic acid, hydrocyanic acid, hydrogen sulphide, flammable liquids, flammable gases</td>
</tr>
<tr>
<td>Oxalic Acid</td>
<td>silver, mercury</td>
</tr>
<tr>
<td>Perchloric Acid</td>
<td>acetic anhydride, bismuth and its alloys, organic materials</td>
</tr>
<tr>
<td>Potassium</td>
<td>carbon tetrachloride, carbon dioxide, water</td>
</tr>
<tr>
<td>Potassium Chlorate</td>
<td>sulphuric and other acids</td>
</tr>
<tr>
<td>Potassium Permanganate</td>
<td>glycerin, ethylene glycol, benzaldehyde, sulphuric acid</td>
</tr>
<tr>
<td>Silver</td>
<td>acetylene, oxalic acid, tartaric acid, ammonia compounds</td>
</tr>
<tr>
<td>Sodium Peroxide</td>
<td>alcohol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulphide, glycerin, ethylene glycol, ethyl acetate, methyl acetate, furfural</td>
</tr>
<tr>
<td>Sulphuric Acid</td>
<td>potassium chlorate, potassium perchlorate, potassium permanganate (or compounds with similar light metals, such as sodium, lithium, etc.)</td>
</tr>
</tbody>
</table>

4.4 CHEMICAL SEGREGATION

- Read the label carefully before storing a chemical. More detailed storage information is usually provided by the MSDS (Material Safety Data Sheet).
- Ensure that incompatible chemicals are not stored in close proximity to each other. Separate the following types of chemicals from each other according to the segregation scheme in Table 3. Note that this is a simplified scheme and that in some instances chemicals of the same category may be incompatible.

For more detailed information refer to the reactivity section of the Material Safety Data Sheet or a reference manual on reactive chemical hazards.
Table 4 Suggested Segregation for Chemical Storage

<table>
<thead>
<tr>
<th>FLAMMABLES</th>
<th>NON-FLAMMABLE SOLVENTS</th>
<th>ACIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Store in grounded flammable liquid storage cabinet</td>
<td>• Store in cabinet</td>
<td>• Store in cabinet of non-combustible material</td>
</tr>
<tr>
<td>• Separate from oxidizing materials</td>
<td>• Can be stored with flammable liquids</td>
<td>• Separate oxidizing acids from organic acids</td>
</tr>
<tr>
<td></td>
<td>• Separate from oxidizing materials</td>
<td>• Separate from caustics, cyanides, sulfides</td>
</tr>
<tr>
<td>Examples:</td>
<td></td>
<td>Examples:</td>
</tr>
<tr>
<td>• Acetone</td>
<td>• Carbon tetrachloride</td>
<td>• Nitric acid</td>
</tr>
<tr>
<td>• Ethanol Glacial acetic acid</td>
<td>• Ethylene glycol Mineral oil</td>
<td>• Hydrochloric acid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sulphuric acid</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CAUSTICS</th>
<th>WATER REACTIVE CHEMICALS</th>
<th>OXIDIZERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Store in dry area</td>
<td>• Store in cool, dry location</td>
<td>• Store in cabinet of non-combustible material</td>
</tr>
<tr>
<td>• Separate from acids</td>
<td>• Separate from aqueous solutions</td>
<td>• Separate from flammable and combustible materials</td>
</tr>
<tr>
<td></td>
<td>• Protect from fire sprinkler water</td>
<td></td>
</tr>
<tr>
<td>Examples:</td>
<td>Examples:</td>
<td>Examples:</td>
</tr>
<tr>
<td>• Ammonium hydroxide</td>
<td>• Sodium</td>
<td>• Sodium hypochlorite</td>
</tr>
<tr>
<td>• Sodium hydroxide</td>
<td>• Potassium Lithium</td>
<td>• Benzoyl peroxide</td>
</tr>
<tr>
<td>Potassium hydroxide</td>
<td></td>
<td>• Potassium permanganate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NON-OXIDIZING COMPRESSED GASES</th>
<th>OXIDIZING COMPRESSED GASES</th>
<th>NON-VOLATILE, NON-REACTIVE SOLIDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Store in well ventilated area</td>
<td>• Separate physically from flammable compressed gases</td>
<td>• Store in cabinets or open shelves with edge guards</td>
</tr>
<tr>
<td>• separate physically from oxidizing compressed gases</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Examples:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Oxygen</td>
<td>• Agar</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sodium bicarbonate</td>
</tr>
</tbody>
</table>
4.5 UNSTABLE CHEMICALS

Many chemicals, most notably ethers (e.g., THF, dioxane, diethyl and isopropyl ether), are susceptible to decomposition resulting in explosive products. Ethers, liquid paraffins, and olefins form peroxides on exposure to air and light. Since most of these products have been packaged in an air atmosphere, peroxides can form even if the containers have not been opened.

- Discard unopened containers of ethers after one year
- Discard containers of ethers within six months of opening
- Never handle ethers beyond their expiry dates; contact your local waste disposal coordinator to arrange to have the material stabilised and removed

The following are common examples of compounds prone to peroxide formation:

- Cyclohexene
- Dicyclopentadiene
- Diethyl ether (ether)
- Dimethyl ether
- Dioxane
- Isopropyl ether
- Tetrahydrofuran (THF)

- The label and Material Safety Data Sheet (MSDS) will also indicate if a chemical is unstable.

4.6 EXPLOSIVE CHEMICALS

Many chemicals are susceptible to rapid decomposition or explosion when subjected to forces such as being struck, vibrated, agitated or heated. Some become increasingly shock sensitive with age.

- Refer to the label and the Material Safety Data Sheet to determine if a chemical is explosive.
- Write the dates received and opened on all containers of explosive or shock-sensitive chemicals
- Discard opened containers after six months, and closed containers after one year, unless
- Wear appropriate personal protective equipment and perform experiments behind face shield.
- Work with small quantities.
• The following are atomic groupings that are associated with the possibility of explosion:

- acetylide
- amine oxide
- azide
- chlorate
- diazo
- diazonium
- fulminate
- N-haloamine
- hypohalite
- hydroperoxide
- nitrate
- nitrite
- nitroso
- N-haloamine
- nitro
- ozonide
- perchlorate
- peroxide
- picrate

• The following are common examples of materials known to be shock-sensitive and explosive:

- ammonium nitrate
- ammonium perchlorate
- copper acetylide
- dinitrotoluene
- fulminate of mercury
- lead azide
- nitroglycerine
- picric acid (when dry)
- trinitrotoluene
FIRE SAFETY
Laboratory fires can be caused by bunsen burners, runaway chemical reactions, electrical heating units, failure of unattended or defective equipment, or overloaded electrical circuits. Familiarize yourself with the operation of the fire extinguishers and the location of pull stations, emergency exits and evacuation routes where you work. In the event that the general alarm is sounded use the evacuation routes established for your area and follow the instructions of the Evacuation Monitors. Once outside of the building, move away from the doors to enable others to exit.

5.1 THE FIRE TRIANGLE

Fire cannot occur without an ignition source, fuel and an oxidizing atmosphere (usually air), the three elements that comprise what is called the “fire triangle”:

Fire will not be initiated if any one of these elements is absent, and will not be sustained if one of these elements is removed. This concept is useful in understanding prevention and control of fires. For example, the coexistence of flammable vapours and ignition sources should be avoided, but when flammable vapours cannot be controlled elimination of ignition sources is essential.

5.2 CLASSES OF FIRE

There are four classes of fire, according to the type of fuel involved. These are:

- Class A fires involve combustibles such as paper, wood, cloth, rubber and many plastics.
- Class B fires entail burning of liquid fuels like oil-based paints, greases, solvents, oil and gasoline.
- Class C fires are of electrical origin (fuse boxes, electric motors, wiring).
- Class D fires encompass combustible metals such as magnesium, sodium, potassium and phosphorus.
5.3 FIRE EXTINGUISHERS

Fire extinguishers are rated as A, B, C or D (or combinations of A, B, C and D) for use against the different classes of fires. Familiarize yourself with the fire class ratings of the extinguishers in your work area so that you will know what types of fire you can attempt to extinguish with them. Learn how to use the extinguisher in your lab, as there will be no time to read instructions during an emergency. Attempt to fight small fires only, and only if there is an escape route behind you. Remember to have the extinguisher recharged after every use. If you do fight a fire, remember the acronym "PASS" when using the extinguisher:

- **P**: Pull and twist the locking pin to break the seal.
- **A**: Aim low, and point the nozzle at the base of the fire.
- **S**: Squeeze the handle to release the extinguishing agent.
- **S**: Sweep from side to side until the fire is out.
- Be prepared to repeat the process if the fire breaks out again

5.4 PREVENTING FIRES

Use the following precautions when working with or using flammable chemicals in a laboratory.

- Minimize the quantities of flammable liquids kept in the laboratory.
- Except for the quantities needed for the work at hand, keep all flammable liquids in a approved flammable liquid storage cabinets. Keep cabinet doors closed and latched at all times. Do not store other materials in these cabinets.
- Use and store flammable liquids and gases only in well-ventilated areas. Use a fume hood when working with products that release flammable vapours.
- Keep flammable solvent containers, including those for collecting waste, well capped. Place open reservoirs or collection vessels for organic procedures like HPLC inside vented chambers.
- Store flammable chemicals that require refrigeration in "explosion-safe" (non-sparking) laboratory refrigerators.
- Keep flammable chemicals away from ignition sources, such as heat, sparks, flames and direct sunlight. Avoid welding or soldering in the vicinity of flammables.
- Use portable safety cans for storing, dispensing and transporting flammable liquids.
- Clean spills of flammable liquids promptly.

5.5 EVACUATIONS

In the event that the general alarm is sounded, follow the evacuation routes established for your area; do not use the elevators. Follow the instructions of the Evacuation Monitors. Once outside the building, move away from the doors to allow others to exit.
HAZARDOUS WASTE DISPOSAL
6.1 WASTE MINIMIZATION

In order to minimize the amount of hazardous waste presented for disposal, it is important to follow these guidelines:

- Avoid overstocking: one of the main sources of laboratory waste is surplus stock - the result of over buying. Recent pricing arrangements with suppliers have greatly reduced the benefits of purchasing chemicals in large volumes. Also, there is little need to store large quantities of chemicals, as orders are generally shipped the day after an order is received.
- Do not accept donations of materials that you don't plan to use.
- Substitute non-hazardous experimental materials for hazardous ones. For example, use aqueous-based, biodegradable scintillation fluids whenever possible.

6.2 HAZARDOUS WASTE DISPOSAL GUIDELINES

- Label all waste materials completely and legibly
- Package waste materials in approved containers.
- Overfilled and/or leaking containers cannot be accepted for disposal.
- Never discharge wastes into the sewer unless you have verified that hazardous wastes regulations permit you to do so.

6.3 WASTE PREPARATION PROCEDURES

6.3.1 CHEMICAL WASTE

6.3.1.1 ORGANIC SOLVENTS AND OILS

- Collect in the containers
- Indicate the composition of the contents as accurately as possible on the attached label.

6.3.1.2 MISCELLANEOUS CHEMICALS AND GAS CYLINDERS

- Complete the lab chemical inventory form and send to Safety Officer.
- Await instructions.
6.3.1.3 CHEMICALS OF UNKNOWN COMPOSITION

- Cannot be accepted.
- Analyse it.

6.3.1.4 PEROXIDE-FORMING CHEMICALS (E.G. ETHER) AND EXPLOSIVE CHEMICALS (E.G. DRY PICRIC ACID)

- Do not mix with solvents or other waste.
- If the material is older than one year, do not attempt to open or move the container.

6.3.1.5. CORROSIVES (ACIDS AND BASES)

- Collect acids (pH<7) and bases (pH>7) separately in the plastic containers. Do not mix acids with bases.
- Indicate the composition of the contents, as accurately as possible, on the attached label.

6.3.2 SHARPS AND GLASSWARE

6.3.2.1 SYRINGES, SCALPEL BLADES, PASTEUR AND SEROLOGY PIPETTES, CAPILLARY TUBES, ETC.

6.3.2.1.1 CONTAMINATED SHARPS

- Never recap or snip syringe needles.
- Label a plastic, puncture proof container (e.g. empty liquid bleach bottle) with the word "SHARPS", the appropriate hazard warning symbol (e.g. biohazard, radioactive) and the name of the Principal Investigator.
- Discard containers of sharps contaminated with infectious materials into biomedical waste containers as per the procedure for Infectious Laboratory Waste.
- Discard containers of sharps contaminated with radioactive materials as per the procedure for solid radioactive waste.

6.3.2.1.2 NON-CONTAMINATED SHARPS

- Label a puncture-proof container (wide-mouth plastic bottle or a heavy-duty cardboard box lined with plastic) with the word "SHARPS", and the name of the Principal Investigator.
- Accumulate in the designated container.
- When full, close and seal the container and place it beside the regular garbage receptacle for pickup by the cleaning staff.
6.3.2.2 BROKEN GLASSWARE (NON-CONTAMINATED)

- Designate a cardboard box for broken glass; label it "BROKEN GLASS", and place glass inside. When the box is full, seal it with tape and place it next to the garbage receptacle for pickup by the cleaning staff.

6.3.2.3 EMPTY CHEMICAL REAGENT BOTTLES

- Remove the cap from the empty bottle and allow volatile materials to evaporate into the fume hood.
- Rinse the bottle three times with tap water and let dry.
- Remove or obliterate the label.
- Place the uncapped bottle next to the garbage receptacle.

6.3.3 RADIOACTIVE WASTE

6.3.3.1 SOLID WASTE (EXCEPT SEALED SOURCES)

- Whenever possible, package alpha emitting radioisotopes separately from other radioisotopes.
- Whenever possible, package long-lived (half life > 10 years) radioisotopes separately from short-lived radioisotopes.
- Accumulate wastes in the solid radioactive waste containers provided.
- Update the information on the label as wastes are placed in the container.

6.3.3.2 SEALED AND ENCAPSULATED SOURCES

- Do not package sealed sources with other types of waste materials.
- Contact your Coordinator for suggestions.

6.3.3.3 LIQUID SCINTILLATION VIALS

- Leave fluids in their vials. Deposit vials into the designated drum in your building’s waste storage area and enter the required information on the inventory sheet attached to the drum.

6.3.3.4 LIQUID RADIOACTIVE WASTE

- Aqueous liquid wastes at or below 0.01 scheduled quantity per litre can be disposed of via the regular drain.
- Containers are available for laboratories that are unable to avoid the generation of liquid radioactive wastes. In order to control costs, you are asked to exercise great care to fill the containers with only such materials.
LABORATORY VENTILATION AND FUME HOODS
7.1 GENERAL VENTILATION

General ventilation, also called dilution ventilation, involves dilution of inside air with fresh outside air, and is used to:

- maintain comfortable temperature, humidity and air movement for room occupants
- dilute indoor air contaminants
- replace air as it is exhausted to the outside via local ventilation devices such as fume hoods
- provide a controlled environment for specialized areas such as surgery or computer rooms

General ventilation systems comprise an air supply and an air exhaust. The air may be supplied via a central HVAC (Heating, Ventilation and Air Conditioning) system or, especially in older buildings, via openable windows. Laboratory air may be exhausted through either local exhaust devices or air returns connected to the HVAC system.

7.2 LOCAL VENTILATION DEVICES

Local exhaust ventilation systems capture and discharge air contaminants (biological, chemical, radioactive) or heat from points of release. Common local exhaust ventilation devices found in laboratories include:

- chemical fume hoods
- canopy hoods
- slotted hoods
- biological safety cabinets
- direct connections

7.2.1 CHEMICAL FUME HOODS

Chemical fume hoods are enclosed units with a sliding sash for opening or closing the hood. They are able to capture and exhaust even heavy vapours, and are preferred for all laboratory procedures that require manual handling of hazardous chemical material. Refer to Section 7.4 below for information on the safe use of chemical fume hoods.

7.2.2 CANOPY HOODS

Canopy hoods are designed to capture heat from processes or equipment, such as atomic absorption spectrophotometers or autoclaves; a canopy or bonnet is suspended over a process and connected to an exhaust vent. The following limitations make canopy hoods poor substitutes for chemical fume hoods, because they:
• draw contaminated air through the user's breathing zone
• do not capture heavy vapours
• provide less containment than chemical fume hoods, and are more affected by air turbulence
• do not provide adequate suction more than a few inches away from the hood opening

7.2.3 SLOTTED HOODS
Slotted hoods, or benches, have one or more narrow horizontal openings, or slots, at the back of the work surface; the slots are connected to exhaust ducting. These special purpose hoods are used for work with chemicals of low to moderate toxicity only, such as developing black and white photographs.

7.2.4 BIOLOGICAL SAFETY CABINETS
Biological safety cabinets are for use with biological material; depending on the cabinet class, they provide protection of the environment, user and/or product. They are not recommended for use with hazardous chemicals because most models recirculate air into the laboratory, and because the HEPA filter that is integral to the protective function can be damaged by some chemicals.

7.2.5 DIRECT CONNECTIONS
Direct connections provide direct exhausting of contaminants to the outdoors and are used for venting:

• flammable liquid storage cabinets
• other toxic chemical storage cabinets
• solvent and waste reservoirs, such as for HPLC solvent systems
• reaction vessels, sample analyzers, ovens, dryers and vacuum pump outlets

7.3 VENTILATION BALANCING AND CONTAINMENT
By regulation, more air is exhausted from a laboratory than is supplied to it, resulting in a net negative pressure (vacuum) in the laboratory. Negative pressure draws air into the laboratory from surrounding areas, and serves to prevent airborne hazardous chemicals, radiation or infectious microorganisms from spreading outside the laboratory in the event of an accidental release inside the laboratory. Balancing of laboratory ventilation must take into consideration the amount of air exhausted by local ventilation devices such as fume hoods. Modern laboratories do not have operable windows, as opening of windows tends to pressurize a room, pushing air from the laboratory into adjacent non-laboratory areas.

7.4 SAFE USE OF CHEMICAL FUME HOODS
Fume hoods properly used and maintained, will render substantial protection, provided the user is aware of its capabilities and limitations. The performance standard for fume hoods is the delivery of a minimum face velocity of 100 linear feet per minute at
half sash height. An anemometer for determining a fumehood's face velocity is available from the Environmental Safety Office. To ensure your fume hood provides the highest degree of protection observe the following guidelines:

1. Only materials being used in an ongoing experiment should be kept in the fume hood. Cluttering the hood will create air flow disturbances.
2. When it is necessary to keep a large apparatus inside a hood, it should be placed upon blocks or legs to allow air to flow underneath.
3. Operate the hood with the sash as low as practical. Reducing the open face will increase the face velocity.
4. Work as far into the hood as possible. At least six inches is recommended.
5. Do not lean into the hood. This disturbs the air flow, and also places your head into the contaminated air inside the hood.
6. Do not make quick motions into or out of the hood, or create cross drafts by walking rapidly past the hood. Opening doors or windows can sometimes cause strong air currents which will disturb the air flow into the hood.
7. Heating devices should be placed at the rear of the hood.
8. Do not use a hood for any function it was not specifically designed, such as perchloric acid, some radioisotopes, etc.
9. Keep hood door closed when not attended.
10. Remember that sinks inside fume hoods are not designed for disposing of chemical wastes.
COMPRESSED GASES AND CRYOGENICS

8
8.1 HAZARDS OF COMPRESSED GASES

Compressed gases are hazardous due to the high pressure inside cylinders. Knocking over an unsecured, uncapped cylinder of compressed gas can break the cylinder valve; the resulting rapid escape of high-pressure gas can turn a cylinder into an uncontrolled rocket or pinwheel, causing serious injury and damage. Poorly controlled release of compressed gas in the laboratory can burst reaction vessels, cause leaks in equipment and hoses or result in runaway chemical reactions. Compressed gases may also have flammable, oxidizing, dangerously reactive, corrosive or toxic properties. Inert gases such as nitrogen, argon, helium and neon can displace air, reducing oxygen levels in poorly ventilated areas and causing asphyxiation.

8.2 SAFE HANDLING, STORAGE AND TRANSPORT OF COMPRESSED GAS CYLINDERS

- All gas cylinders, full or empty, should be securely supported using suitable racks, straps, chains or stands.
- When cylinders are not in use or are being transported, remove the regulator and attach the protective cap.
- An appropriate cylinder cart should be used for transporting cylinders. Chain or strap the cylinder to the cart.
- Verify that the regulator is appropriate for the gas being used and the pressure being delivered. Do not rely upon the pressure gauge to indicate the maximum pressure ratings; check the regulator's specifications.
- Do not use adaptors or Teflon tape to attach regulators to gas cylinders.
- Never bleed a cylinder completely empty; leave a residual pressure.
- Do not lubricate the high-pressure side of an oxygen regulator.
- Do not expose cylinders to temperature extremes.
- Store incompatible classes of gases separately.

8.3 CRYOGENIC HAZARDS

Cryogenics are very low temperature materials such as dry ice (solid CO2) and liquefied air or gases like nitrogen, oxygen, helium, argon and neon. The following hazards are associated with the use of cryogenics:

- asphyxiation due to displacement of oxygen (does not apply to liquid air and oxygen)
- embrittlement of materials from extreme cold
- frostbite
- explosion due to pressure build up
- condensation of oxygen and fuel (e.g. hydrogen and hydrocarbons) resulting in explosive mixtures
8.4 CRYOGENIC HANDLING PRECAUTIONS

The following are precautions for handling cryogenics:

- Control ice build up
- Use only low-pressure containers equipped with pressure?relief devices.
- Protect skin and eyes from contact; wear eye protection and insulated gloves.
- Use and store in well-ventilated areas.
- Keep away from sparks or flames.
- Use materials resistant to embrittlement (e.g. latex rubber tubing).
- Watches, rings, bracelets or other jewelry that could trap fluids against flesh should not be worn when handling cryogenic liquids.
- To prevent thermal expansion of contents and rupture of the vessel, do not fill containers to more than 80% of capacity.
Chapter 9

PHYSICAL HAZARDS AND ERGONOMICS

9.1 ELECTRICAL SAFETY

- Purchase and use only CSA-approved electrical equipment.
- All electrical outlets should carry a grounding connection requiring a three-pronged plug.
- Never remove the ground pin of a three-pronged plug.
- Remove cords by grasping the plug, not the cord.
- All electrical equipment (except glass-cloth heaters and certain models of oscillographs requiring a floating ground) should be wired with a grounding plug.
- All wiring should be done by, or under the approval of, a licensed electrician.
- Electrical equipment that has been wetted should be disconnected at the main switch or breaker before being handled. Familiarize yourself with the location of such devices.
- Know how to cut off the electrical supply to the laboratory in the event of an emergency.
- Maintain free access to panels; breaker panels should be clearly labeled as to which equipment they control.
- Ensure that all wires are dry before plugging into circuits.
- Electrical equipment with frayed wires should be repaired before being put into operation.
- Tag and disconnect defective equipment.
- Be sure that all electrical potential has been discharged before commencing repair work on any equipment containing high voltage power supplies or capacitors.
- Minimize the use of extension cords and avoid placing them across areas of pedestrian traffic.
- Use only CO2, halon, or dry chemical fire extinguishers for electrical fires.
- Use ground fault circuit interrupters for all electrical equipment used for administering electrical current to human subjects or measuring electrical signals from human subjects.

9.2 HIGH PRESSURE AND VACUUM WORK

Pressure differences between equipment and the atmosphere result in many lab accidents. Glass vessels under vacuum or pressure can implode or explode, resulting in cuts from projectiles and splashes to the skin and eyes. Glass can rupture even under small pressure differences. Rapid temperature changes, such as those that occur when removing containers from liquid cryogenics, can lead to pressure differences, as can carrying out chemical reactions inside sealed containers.
The hazards associated with pressure work can be reduced by:

- checking for flaws such as cracks, scratches and etching marks before using vacuum apparatus
- using vessels specifically designed for vacuum work. Thin-walled or round-bottomed flasks larger than 1 L should never be evacuated
- assembling vacuum apparatus so as to avoid strain. Heavy apparatus should be supported from below as well as by the neck
- taping glass vacuum apparatus to minimize projectiles due to implosion
- using adequate shielding when conducting pressure and vacuum operations
- allowing pressure to return to atmospheric before opening vacuum desiccators or after removal of a sample container from cryogenics
- wearing eye and face protection when handling vacuum or pressure apparatus

9.3 REPETITIVE WORK AND ERGONOMICS

Ergonomics is concerned with how the workplace "fits" the worker. Performing certain work tasks without regard for ergonomic principles can result in:

- fatigue
- repetitive motion injuries
- strains, aches and injuries from biomechanical stresses
- eyestrain from video display terminals (VDTs)
- decreased morale

Factors that can increase the risk of musculoskeletal injury are:

- awkward positions or movements
- repetitive movements
- application of force

In a laboratory setting, look for the following when addressing ergonomic concerns:

- Laboratory bench and workbench heights are suitable for all personnel
- Laboratory chairs are on wheels or castors, are sturdy (5-legged), and are adjustable (seat height, angle, backrest height)
- VDTs are positioned at or slightly below eye level, and are positioned so as to avoid glare from lights or windows
- Computer keyboards and pointing devices are positioned so that wrists are kept in a neutral position and forearms are horizontal
- Colour, lettering size and contrast of equipment display monitors are optimized so as not to cause eye strain
- Work station design does not necessitate excessive bending, reaching, stretching or twisting
• Vibration-producing equipment, such as vortex mixers and pump-type pipettors are not used for extended periods of time
• Buttons and knobs on equipment are accessible and of a good size
• Heavy items are not carried or handled
• Laboratory workers are using proper techniques when lifting or moving materials
• Indoor air quality parameters, such as temperature, humidity and air supply are comfortable
• Floors are slip-resistant
• Noise levels are not excessive

9.4 GLASSWARE SAFETY

• Use a dustpan and brush, not your hands, to pick up broken glass.
• Discard broken glass in a rigid container separate from regular garbage and label it appropriately (see Waste Preparation Procedures, Section 6.3).
• Protect glass that is subject to high pressure or vacuum. Wrapping glass vessels with cloth tape will minimize the possibility of projectiles.
• Glass is weakened by everyday stresses such as heating and bumping. Handle used glassware with extra care.
• Discard or repair all damaged glassware, as chipped, cracked or star-cracked vessels cannot handle the normal stresses.

When handling glass rods or tubes:

• fire polish the ends,
• lubricate with water or glycerine when inserting through stopper,
• ensure stopper holes are properly sized, and not too small,
• insert carefully, with a slight twisting motion, keeping hands close together, and
• use gloves or a cloth towel to protect your hands
Whenever lab equipment is purchased, preference should be given to equipment that

- limits contact between the operator and hazardous material, and mechanical and electrical energy
- is corrosion-resistant, easy to decontaminate and impermeable to liquids
- has no sharp edges or burrs

Every effort should be made to prevent equipment from becoming contaminated. To reduce the likelihood of equipment malfunction that could result in leakage, spill or unnecessary generation of aerosolized pathogens:

- Review the manufacturer's documentation. Keep for future reference.
- Use and service equipment according to the manufacturer's instructions.
- Ensure that anyone who uses a specific instrument or piece of equipment is properly trained in setup, use and cleaning of the item.
- Decontaminate equipment before it is sent out for repairs or discarded.

The following sections outline some of the precautions and procedures to be observed with some commonly used laboratory equipment.

**10.1 CENTRIFUGES**

Improperly used or maintained centrifuges can present significant hazards to users. Failed mechanical parts can result in release of flying objects, hazardous chemicals and biohazardous aerosols. The high speed spins generated by centrifuges can create large amounts of aerosol if a spill, leak or tube breakage occurs. To avoid contaminating your centrifuge:

- Check glass and plastic centrifuge tubes for stresslines, hairline cracks and chipped rims before use. Use unbreakable tubes whenever possible.
- Avoid filling tubes to the rim.
- Use caps or stoppers on centrifuge tubes. Avoid using lightweight materials such as aluminum foil as caps.
- Use sealed centrifuge buckets (safety cups) or rotors that can be loaded and unloaded in a biological safety cabinet. Decontaminate the outside of the cups or buckets before and after centrifugation. Inspect o-rings regularly and replace if cracked or dry.
- Ensure that the centrifuge is properly balanced.
- Do not open the lid during or immediately after operation, attempt to stop a spinning rotor by hand or with an object, or interfere with the interlock safety device.
• Decant supernatants carefully and avoid vigorous shaking when resuspending.

When using high-speed or ultra centrifuges, additional practices should include:

• Connect the vacuum pump exhaust to a trap.
• Record each run in a logbook: keep a record of speed and run time for each rotor.
• Install a HEPA filter between the centrifuge and the vacuum pump when working with biohazardous material.
• Never exceed the specified speed limitations of the rotor.

10.2 ELECTROPHORESIS EQUIPMENT

• Ensure that electrophoresis equipment is properly grounded and has electrical interlocks. Do not bypass safety interlocks.
• Inspect electrophoresis equipment regularly for damage and potential tank leaks.
• Locate equipment away from high traffic areas, and away from wet areas such as sinks or washing apparatus.
• Display warning signs.

10.3 HEATING BATHS, WATER BATHS

Heating baths keep immersed materials immersed at a constant temperature. They may be filled with a variety of materials, depending on the bath temperature required; they may contain water, mineral oil, glycerin, paraffin or silicone oils, with bath temperatures ranging up to 300°C. The following precautions are appropriate for heating baths:

• set up on a stable surface, away from flammable and combustible materials including wood and paper
• relocate only after the liquid inside has cooled
• ensure baths are equipped with redundant heat controls or automatic cutoffs that will turn off the power if the temperature exceeds a preset limit
• use with the thermostat set well below the flash point of the heating liquid in use
• equip with a thermometer to allow a visual check of the bath temperature

The most common heating bath used in laboratories is the water bath.

When using a water bath:

• clean regularly; a disinfectant, such as a phenolic detergent, can be added to the water
• avoid using sodium azide to prevent growth of microorganisms; sodium azide forms explosive compounds with some metals
• raise the temperature to 90°C or higher for 30 minutes once a week for decontamination purposes
• unplug the unit before filling or emptying and have the continuity-to-ground checked on a regular basis

10.4 SHAKERS, BLENDERS, SONICATORS

When used with infectious agents, mixing equipment such as shakers, blenders, sonicators, grinders and homogenizers can release significant amounts of hazardous aerosols, and should be operated inside a biological safety cabinet whenever possible. Equipment such as blenders and stirrers can also produce large amounts of flammable vapours. The hazards associated with this type of equipment can be minimized by:

• selecting and purchasing equipment with safety features that minimize leaking
• selecting and purchasing mixing apparatus with non-sparking motors.
• checking integrity of gaskets, caps and bottles before using. Discard damaged items.
• allowing aerosols to settle for at least one minute before opening containers
• covering tops of blenders with a disinfectant-soaked towel during operation, when using biohazardous material
• when using a sonicator, immersing the tip deeply enough into the solution to avoid creation of aerosols
• decontaminating exposed surfaces after use

10.5 OVENS AND HOT PLATES

Laboratory ovens are useful for baking or curing material, off-gassing, dehydrating samples and drying glassware.

• Select and purchase an oven whose design prevents contact between flammable vapours and heating elements or spark-producing components
• Discontinue use of any oven whose backup thermostat, pilot light or temperature controller has failed
• Avoid heating toxic materials in an oven unless it is vented outdoors (via a canopy hood, for example)
• Never use laboratory ovens for preparation of food for human consumption
• Glassware that has been rinsed with an organic solvent should be rinsed with distilled water before it is placed in a drying oven

10.6 ANALYTICAL EQUIPMENT

The following instructions for safe use of analytical equipment are general guidelines; consult the user's manual for more detailed information on the specific hazards:

• Ensure that installation, modification and repairs of analytical equipment are carried out by authorized service personnel.
• Read and understand the manufacturer's instructions before using this equipment.
• Make sure that preventive maintenance procedures are performed as required.
• Do not attempt to defeat safety interlocks.
• Wear safety glasses and lab coats (and other appropriate personal protective equipment as specified) for all procedures.

10.6.1 SCINTILLATION COUNTERS

• Use sample vials that meet the manufacturer's specifications
• Keep counters clean and free of foreign material
• To avoid contaminating the counter and its accessories with radioactivity, change gloves before loading racks in the counter or using the computer keyboard. Verify on a regular basis (by wipe testing) that the equipment has not become contaminated.

10.6.2 ATOMIC ABSORPTION (AA) SPECTROMETERS

Sample preparation for atomic absorption procedures often require handling of flammable, toxic and corrosive products. Familiarize yourself with the physical, chemical and toxicological properties of these materials and follow the recommended safety precautions. Atomic absorption equipment must be adequately vented, as toxic gases, fumes and vapours are emitted during operation. Other recommendations to follow when carrying out atomic absorption analysis are:

• Wear safety glasses for mechanical protection.
• Check the integrity of the burner, drain and gas systems before use.
• Inspect the drain system regularly; empty the drain bottle frequently when running organic solvents.
• Allow the burner head to cool to room temperature before handling.
• Never leave the flame unattended. A fire extinguisher should be located nearby.
• Avoid viewing the flame or furnace during atomization unless wearing protective eyewear.
• Hollow cathode lamps are under negative pressure and should be handled with care and disposed of properly to minimize implosion risks.

10.6.3 MASS SPECTROMETERS (MS)

Mass spectrometry requires the handling of compressed gases and flammable and toxic chemicals. Consult MSDSs for products before using them. Specific precautions for working with the mass spectrometer include:

• Avoid contact with heated parts while the mass spectrometer is in operation.
• Verify gas, pump, exhaust and drain system tubing and connections before each use.
• Ensure that pumps are vented outside the laboratory, as pump exhaust may contain traces of the samples being analyzed, solvents and reagent gas.
• Used pump oil may also contain traces of analytes and should be handled as hazardous waste.
10.6.4 GAS CHROMATOGRAPHS (GC)

Gas chromatography requires handling compressed gases (nitrogen, hydrogen, argon, helium), and flammable and toxic chemicals. Consult product MSDSs before using such hazardous products. Specific precautions for working with gas chromatographs include:

- Perform periodic visual inspections and pressure leak tests of the sampling system plumbing, fittings and valves.
- Follow the manufacturer's instructions when installing columns. Glass or fused capillary columns are fragile: handle them with care and wear safety glasses to protect eyes from flying particles while handling, cutting or installing capillary columns.
- Turn off and allow heated areas such as the oven, inlet and detector, as well as connected hardware, to cool down before touching them.
- To avoid electrical shock, turn off the instrument and disconnect the power cord at its receptacle whenever the access panel is removed.
- Turn off the hydrogen gas supply at its source when changing columns or servicing the instrument.
- When using hydrogen as fuel (flame ionization [FID] and nitrogen-phosphorus detectors [NPD]), ensure that a column or cap is connected to the inlet fitting whenever hydrogen is supplied to the instrument to avoid buildup of explosive hydrogen gas in the oven.
- Measure hydrogen gas and air separately when determining gas flow rates.
- Perform a radioactive leak test (wipe test) on electron capture detectors (ECDs) at least every 6 months for sources of 50MBq (1.35 mCi) or greater.
- Ensure that the exhaust from (ECDs) is vented to the outside.
- When performing split sampling, connect the split vent to an exhaust ventilation system or appropriate chemical trap if toxic materials are analyzed or hydrogen is used as the carrier gas.
- Use only helium or nitrogen gas, never hydrogen, to condition a chemical trap.

10.6.5 NUCLEAR MAGNETIC RESONANCE (NMR) EQUIPMENT

The superconducting magnet of NMR equipment produces strong magnetic and electromagnetic fields that can interfere with the function of cardiac pacemakers. Users of pacemakers and other implanted ferromagnetic medical devices are advised to consult with their physician, the pacemaker's manual and pacemaker manufacturer before entering facilities which house NMR equipment. Precautions for work with NMR include the following:

- Post clearly visible warning signs in areas with strong magnetic fields.
- Measure stray fields with a gaussmeter, and restrict public access to areas of 5-gauss or higher.
- The strong magnetic field can suddenly pull nearby unrestrained magnetic objects into the magnet with considerable force. Keep all tools, equipment and personal items containing ferromagnetic material (e.g., steel, iron) at least 2 metres away from the magnet.
Though not a safety issue, advise users that the magnetic field can erase magnetic media such as tapes and floppy disks, disable credit and automated teller machine (ATM) cards, and damage analog watches.

Avoid skin contact with cryogenic (liquid) helium and nitrogen; wear a protective face mask and loose-fitting thermal gloves during dewar servicing and when handling frozen samples. Refer to Section 11, "Compressed Gases and Cryogenics".

Ensure that ventilation is sufficient to remove the helium or nitrogen gas exhausted by the instrument.

Avoid positioning your head over the helium and nitrogen exit tubes.

NMR tubes are thin-walled; handle them carefully and reserve them for NMR use only.

10.6.6 HIGH-PRESSURE LIQUID CHROMATOGRAPHY (HPLC)

HPLC procedures may require handling of compressed gas (helium) and flammable and toxic chemicals. Familiarize yourself with the hazardous properties of these products, as well as recommended precautionary measures, by referring to MSDSs.

Inspect the drain system regularly; empty the waste container frequently when using organic solvents.

Ensure that waste collection vessels are vented.

Never use solvents with autoignition temperatures below 110°C.

Be sure to use a heavy walled flask if you plan to use vacuum to degas the solvent.

Never clean a flowcell by forcing solvents through a syringe: syringes under pressure can leak or rupture, resulting in sudden release of syringe contents.

High voltage and internal moving parts are present in the pump. Switch off the electrical power and disconnect the line cord when performing routine maintenance of the pump.

Shut down and allow the system to return to atmospheric pressure before carrying out maintenance procedures.

10.6.7 LIQUID CHROMATOGRAPHY (LC/MS)

LC/MS requires the handling of compressed nitrogen and flammable and toxic chemicals. Consult product MSDSs before using them. Specific precautions for working with LC/MS equipment include:

Verify gas, pump exhaust and drain system tubing and connections before each use.

Test the pressure switch for the exhaust line before each use.

Ensure that pumps are vented outside the laboratory.
PERSONAL PROTECTIVE EQUIPMENT
11.1 EYE PROTECTION

Eye protection is required in all laboratories where infectious, corrosive or toxic materials are used or stored, and anywhere near high pressure or high vacuum, or when carrying out work that can generate dusts, spray or other projectiles. Wear protection appropriate for the work being performed:

- Light work: glasses should be of unbreakable lenses (plastic or heat-tempered glass).
- Light-to-moderate work: glasses with side shields.
- Work with significant risk of splash of chemicals, or projectiles: goggles.
- Work with significant risk of splash on face, or possible explosion: full face shield, plus goggles.
- If safety glasses with correction lenses are needed, first consult with your optometrist or ophthalmologist.

11.2 HAND PROTECTION

In the laboratory, gloves are used for protection from radiation, chemical products, biohazardous material and physical hazards such as abrasion, tearing, puncture and exposure to temperature extremes

11.2.1 LATEX GLOVES AND SKIN REACTIONS

Natural latex is derived from the sap of the rubber tree and contains rubber polymers, carbohydrates, lipids, phospholipids and proteins. During the manufacturing process additional chemical agents are added to impart elasticity, flexibility and durability to the latex. Because of these properties, and because of their high tactile strength and low cost, latex gloves are used for many laboratory procedures. Unfortunately, for some people, wearing latex gloves can cause skin reactions; these can be either irritant or allergic in nature, and can be caused by:

- chronic irritation from sweating of hands inside gloves or from gloves rubbing against the skin
- sensitization to the chemical additives used in the manufacturing process
- reaction to naturally-occurring latex proteins

Frequent handwashing, as well as residues from scrubs, soaps, cleaning agents and disinfectants may further irritate the skin. Using one of the following alternatives may reduce the risk of skin problems associated with the use of latex rubber gloves:

- non-latex gloves
- "hypo-allergenic", non-powdered or low-protein latex gloves
- polyethylene, PVC or cloth liners under latex gloves
• non-latex gloves under latex gloves

Occurrences of skin problems (e.g., rash, itching, peeling, red, blistering skin or dry flaking skin with cracks and sores) that seem to be associated with the wearing of latex gloves should be reported to a physician when symptoms first appear.

11.2.2 GLOVE SELECTION GUIDELINES
Base selection of glove material on:

• identification of the work procedures requiring hand protection
• flexibility and touch sensitivity required; a need for high tactile sensitivity, for example, would restrict glove thickness, and some protocols may require the use of gloves with non-slip or textured surfaces
• type and length of contact (e.g., occasional or splash vs. prolonged or immersion contact)
• whether disposable or reusable gloves are more appropriate

Table 5 Recommended glove materials for a variety of laboratory hazards

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Degree of Hazard</th>
<th>Recommended Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrasion</td>
<td>Severe</td>
<td>Reinforced heavy rubberstaple-reinforced leather</td>
</tr>
<tr>
<td></td>
<td>Less severe</td>
<td>Rubberplasticleatherpolyesternyloncotton</td>
</tr>
<tr>
<td>Sharp edges</td>
<td>Severe</td>
<td>Metal meshstaple-reinforced heavy leatherKevlararamid-steel</td>
</tr>
<tr>
<td></td>
<td>Less severe</td>
<td>Leatherterry cloth (aramid fibre)</td>
</tr>
<tr>
<td></td>
<td>Mild with delicate work</td>
<td>Lightweight leatherpolyesternyloncotton</td>
</tr>
<tr>
<td>Chemicals and liquids</td>
<td>Varies depending on the concentrationcontact time etc. Consult MSDSmanufacturer or permeation chart</td>
<td>Choice depends on chemical. <strong>Examples:</strong> natural, nitrile or butyl rubber, neoprene, PTFE (polytetrafluoroethylene), polyvinyl chloride, polyvinyl alcohol, Teflon™, Viton™, Saranex™, 4H™, Chemrel™, Barricade™, Responder™</td>
</tr>
<tr>
<td>Cold</td>
<td></td>
<td>Leather insulated plastic or rubberwoolcotton</td>
</tr>
<tr>
<td>Heat</td>
<td>Over 350 °C</td>
<td>AsbestosZetex™</td>
</tr>
<tr>
<td>----------------------</td>
<td>------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td></td>
<td>Up to 350 °C</td>
<td>Neoprene-coated asbestos heat-resistant leather with linings Nomex Kevlar™</td>
</tr>
<tr>
<td></td>
<td>Up to 200 °C</td>
<td>Heat-resistant leather terry cloth (aramid fibre) Nomex Kevlar™</td>
</tr>
<tr>
<td></td>
<td>Up to 100 °C</td>
<td>Chrome-tanned leather terry cloth</td>
</tr>
<tr>
<td>Electricity</td>
<td></td>
<td>Rubber-insulated goves tested to appropriate voltage (CSA Standard Z259.4-M1979) with leather outer glove</td>
</tr>
<tr>
<td>General duty</td>
<td></td>
<td>Cotton terry cloth leather</td>
</tr>
<tr>
<td>Product contamination</td>
<td></td>
<td>Thin-film plastic lightweight leather cotton polyester nylon</td>
</tr>
<tr>
<td>Radiation</td>
<td>Low to moderate radiotoxicity</td>
<td>Any disposable rubber or plastic glove</td>
</tr>
</tbody>
</table>

11.2.3 CHEMICAL GLOVE SELECTION

No single glove material is resistant to all chemicals, nor will most gloves remain resistant to a specific chemical for longer than a few hours. Determine which gloves will provide an acceptable degree of resistance by consulting the MSDS for the product, contacting glove manufacturers or by referring to a compatibility chart or table for permeation data. These resources may use the following terms:

- "permeation rate" refers to how quickly the chemical seeps through the intact material: the higher the permeation rate the faster the chemical will permeate the material;
- "breakthrough time" refers to how long it takes the chemical to seep through to the other side of the material, and
- "degradation" is a measure of the physical deterioration (for example, glove material may actually dissolve or become harder, softer or weaker) following contact with the chemical

11.2.4 SELECTION, USE AND CARE OF PROTECTIVE GLOVES

Guidelines for glove use include the following:

- choose a glove that provides adequate protection from the specific hazard(s)
- be aware that some glove materials may cause adverse skin reactions in some individuals and investigate alternatives
- inspect gloves for leakage before using; test rubber and synthetic gloves by inflating them
- make sure that the gloves fit properly
• ensure that the gloves are long enough to cover the skin between the top of the glove and the sleeve of the lab coat
• discard worn or torn gloves
• discard disposable gloves that are, or may have become, contaminated
• avoid contaminating "clean" equipment: remove gloves and wash hands before carrying out tasks such as using the telephone
• always wash your hands after removing gloves, even if they appear not to be contaminated
• do not reuse disposable gloves
• follow the manufacturer's instructions for cleaning and maintenance of reusable gloves
• before using gloves, learn how to remove them without touching the contaminated outer surface with your hands

11.3 PROTECTIVE CLOTHING
While protective equipment, such as eyewear (Section 11.1), gloves (Section 11.2) and respirators (Section 11.4), is needed under specific conditions or for specific tasks, laboratory workers must wear lab coats at all times in a laboratory. Instructions for selection and use of protective laboratory clothing are as follows:

• select knee-length lab coats with button or snap closures
• wear a solid-front lab coat or gown with back closures and knitted cuffs when working with highly toxic or infectious agents
• wear protective aprons for special procedures such as transferring large volumes of corrosive material
• remove protective clothing when leaving the laboratory
• remove protective clothing in the event of visible or suspected contamination

11.4 RESPIRATORS
Respirators should be used only in emergency situations (e.g. hazardous spills or leaks) or when other measures, such as ventilation, cannot adequately control exposures. There are two classes of respirators; air-purifying and supplied-air respirators. The latter supply clean air from a compressed air tank or through an air line outside the work area, and are used in oxygen-deficient atmospheres or when gases or vapours with poor warning properties are present in dangerous concentrations. Air purifying respirators are suitable for many laboratory applications and remove particulates (dusts, mists, metal fumes etc.) or gases and vapours from the surrounding air.
11.4.1 SELECTION, USE AND CARE OF RESPIRATORS

Follow proper procedures for selecting and using respiratory protective equipment. Correct use of a respirator is as vital as choosing the right respirator. An effective program for respiratory protection should include the following:

- written standard operating procedures and training
- selecting a respirator that is suitable for the application. Consult the MSDS or the Environmental Safety Office before purchasing and using a respirator
- assigning respirators to individuals for their exclusive use, whenever possible
- fit-testing: evaluation of facial fit for all users of respirators; beards, long sideburns, glasses or the wrong size of respirator may prevent an effective seal between the wearer's face and the respirator
- protocols for using, cleaning and sanitary storage of respirators
- regular inspection of the respirator, and replacement of defective parts
- medical surveillance, before an individual is assigned to work in an area where respirators are required, to verify the person's ability to function under increased breathing resistance.
12.1 FIRST AID

Know how to handle emergency situations before they occur:

- Become familiar with the properties of the hazardous products used in your area.
- Familiarize yourself with the contents of the first aid kit and learn how to use them. Keep instructions readily available and easy to understand.
- Locate and know how to test and operate emergency equipment, such as showers and eyewashes, in your area (Refer to Section 1.4).
- Learn first aid: Contact the Safety Office for a schedule of course dates.

The emergency first aid procedures described below should be followed by a consultation with a physician for medical treatment.

12.1.1 BURNS

In the laboratory, thermal burns may be caused by intense heat, flames, molten metal, steam etc. Corrosive liquids or solids such as bases and acids can cause chemical burns; first aid treatment for chemical burns is described in Section 12.1.4 below. In electrical burns, electrical current passing through the body generates heat.

12.1.1.1 BURNS TO THE SKIN

First aid treatment of skin burns encompasses the following:

- If the burn is electrical in origin, ascertain that the victim is not in contact with the power supply before touching him/her. If the victim remains in contact with a power source, unplug the device or shut off the main power switch at the electrical distribution panel.
- Contact Safety Officer if the burn is serious. Seek immediate medical treatment for all electrical burns, even if they don't appear to be serious.
- Remove jewelry, including watches, from the burned area.
- Expose the burnt area, but avoid removing clothes that are stuck to the skin.
- If possible, immerse burnt surfaces in cold water for at least 10 minutes, or apply cold wet packs.
- Avoid applying lotions, ointments or disinfectants to a burn. First and second degree burns can be washed with soap and water after the cool down period.
- Cover first and second degree burns with a moist bandage; apply dry compresses to third degree burns and to entry and exit wounds of electrical burns.
- Do not burst blisters, as they form a natural barrier against infection.
12.1.1.2 BURNS TO THE EYES

Burns to the eyes may be caused by chemical substances, heat (hot liquids, steam, open flames, molten metal, etc.), or radiation from welding procedures, laboratory lamps and lasers. Burns caused by ultraviolet, visible or near-infrared radiation may not produce symptoms until 6 - 8 hours after exposure. First aid procedures for chemical burns to the eyes are described in Section 12.1.4 below. General first aid procedures for thermal and radiation burns to the eyes are as follows:

- Prevent the victim from rubbing or touching the eyes.
- For heat burns, flush the eyes with cool water until the pain subsides.
- Cover the eyes with dry sterile gauze pads; apply a wet compress to the eyes if it is too painful to close them.
- Send the victim for medical care. If the burn is the result of exposure to a laser beam, advise emergency medical personnel of the characteristics of the laser and the distance between the victim and the laser.

12.1.2 CUTS

First aid treatment for minor scrapes, scratches, cuts, lacerations or puncture wounds include the following:

- wash the wound and surrounding area with mild soap and running water
- remove any dirt around the wound
- cover with an adhesive dressing or gauze square taped on all sides with adhesive tape
- wounds caused by dirty, soiled or grimy objects should be examined by a physician, who will determine whether a tetanus immunization is needed
- if the wound was caused by an object that has contacted human blood or body fluids, the victim must be seen by a physician immediately, as immunization or post-exposure prophylaxis may be required.
- If a wound is bleeding profusely, the first aider should attempt to stop the bleeding as quickly as possible:
  - Elevate the injured area above the level of the heart, if possible, in order to reduce the blood pressure to the area of the wound.
  - Apply direct pressure to the wound unless an object is protruding from it (in this situation, apply pressure around the injury). Direct pressure can be applied with the fingers of the hand, the palm of the hand or with a pressure dressing.
  - If bleeding cannot be controlled with direct pressure, apply pressure to the arteries supplying the injured area. This involves compressing the artery between the wound and the heart, against a bone.
  - Do not remove a dressing that has become soaked with blood, as this may interrupt the clotting process; apply an additional dressing on top of the first.
  - Avoid over-tightening of the dressing; i.e., do not cut off the blood circulation to limbs.
  - As a tourniquet completely stops the flow of blood to beyond the point of application, it should be applied only as a last resort, as in the case of a severed limb.
12.1.3 NEEDLESTICK INJURIES
Treat bleeding needle-related injuries as described in Section 12.1.2 above. Consult a physician immediately, as post-exposure prophylaxis or immunization may be required.

12.1.4 CHEMICAL SPLASHES TO THE SKIN OR EYES
For splashes to the skin:

- If the splash affects a large area of skin, go to the nearest shower and rinse thoroughly for at least 20 minutes; remove contaminated clothing while in the shower.
- For splashes involving a small skin area, proceed to the nearest drench hose, remove contaminated clothing and jewelry and rinse for 15 minutes.

For splashes to the eyes:

- Go to the nearest eyewash and rinse for at least 20 minutes.
- If you are wearing contact lenses, remove them as quickly as possible, while continuing to flush.
- Hold your eyelids open with your fingers.
- Roll your eyeballs, so that water can flow over the entire surface of the eye.
- Lift your eyelids frequently to ensure complete flushing.
- Cover the injured eye with dry sterile gauze pads while waiting for medical attention.

12.1.5 POISONING
As described in section 3.1, toxic substances can enter and poison the body by inhalation, absorption through the skin, ingestion or injection. When assisting a victim of poisoning:

- call for an ambulance for serious poisoning
- ensure that the area is safe to enter before attempting to aid the victim
- move the victim away from the contaminated area and provide first aid as required
- do not induce vomiting unless advised to do so by a reliable authority
- provide emergency medical personnel with the MSDS for the poisonous product. If the victim was overcome by an unknown poison and has vomited, provide the ambulance technicians with a sample of the vomitus.
- always ensure that the victim receives medical attention, even if the exposure seems minor.
12.2 FIRES

The immediate response depends on the size of the fire. Laboratory personnel should attempt to extinguish a fire only if it is clearly safe to do so (Refer to Section 5.3, "Fire Extinguishers").

12.2.1 SUSPECTED FIRES

All members of the Laboratory should familiarise themselves with the locations of the fire alarms and evacuation routes in the areas that they occupy. Anyone discovering smoke, strong smell of burning or smell of an unusual nature, should immediately alert the Laboratory safety officer.

12.2.2 KNOWN FIRES

- Shout "FIRE!" repeatedly to give the alert.
- Pull the fire alarm.
- Telephone the City Fire Department from a safe location.
- Evacuate the premises in a swift, orderly fashion using the stairways and/or fire escapes, but NOT the elevators, and following the instructions of Evacuation Monitors.
- Inform the Building Emergency Warden of the location, magnitude and nature (e.g. electrical) of the fire, the open evacuation routes, individuals requiring assistance, and other pertinent details.
- Once outside the building, move away from the doors to enable others to exit.

12.2.3 CLOTHING FIRES

If your clothing should catch fire, it is important not to run, as this would provide additional air to support the flames. Remember the "Stop, Drop and Roll" rule:

- Stop where you are
- Drop to the floor, and
- Roll to smother the flames

As soon as the flames are extinguished, go to the nearest emergency shower to cool burned areas with copious amounts of water.

If someone else is on fire:

- Immediately immobilise the victim and force him/her to roll on the ground to extinguish the flames.
- Assist in smothering the flames, using whatever is immediately available, such as a fireproof blanket or clothing.
- Give appropriate first aid (refer to Section 12.1.1 above).
12.3 HAZARDOUS CHEMICAL SPILLS

In the event of a spill of a hazardous (volatile, toxic, corrosive, reactive or flammable) chemical, the following procedures should be followed:

- If there is fire, pull the nearest alarm. If you are unable to control or extinguish a fire, follow the fire evacuation procedures, as described in Section 5.5 ("Evacuations").
- If the spill is in a laboratory, shop or chemical storeroom:
  - Evacuate all personnel from the room
  - Be sure the hood/local exhaust is on
  - If flammable liquids are spilled, disconnect the electricity to sources of ignition if possible
- If the spill is in a corridor or other public passageway:
  - Evacuate all people from the area and close off the area to keep others out.

Note: For more detailed information on spill clean-up action, Refer to Section 3.6.3 ("Guidelines for Specific Types of Spills") of this manual.
# Flammability Classification (NFPA) and Permissible Container Sizes (OSHA)

<table>
<thead>
<tr>
<th>Class</th>
<th>Examples</th>
<th>Flash Point Range</th>
<th>Boiling Point Range</th>
<th>Glass</th>
<th>Metal or Plastic</th>
<th>Safety Can</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Acetaldehyde</td>
<td>FP &lt; 22.8</td>
<td>Pentane</td>
<td>BP &lt; 37.8</td>
<td>.5</td>
<td>4</td>
</tr>
<tr>
<td>1B</td>
<td>Acetone</td>
<td>FP &lt; 22.8</td>
<td>Ethanol</td>
<td>BP &gt; 37.8</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Toluene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1C</td>
<td>Isobutanol</td>
<td>FP 22.8</td>
<td>Styrene</td>
<td>FP &lt; 37.8</td>
<td>1</td>
<td>20</td>
</tr>
</tbody>
</table>

## Combustible Liquids

<table>
<thead>
<tr>
<th>Class</th>
<th>Example</th>
<th>Flash Point Range</th>
<th>Boiling Point Range</th>
<th>Glass</th>
<th>Metal or Plastic</th>
<th>Safety Can</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>Kerosene</td>
<td>FP 37.8</td>
<td></td>
<td>4</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Acetic Anhydride</td>
<td>FP &lt; 60</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIA</td>
<td>Aniline</td>
<td>FP 60</td>
<td>Octanol</td>
<td>FP &lt; 93.4</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>IIIB</td>
<td>Ethylene</td>
<td>FP 93.4</td>
<td>Glycol</td>
<td>Benzyl Alcohol</td>
<td>4</td>
<td>20</td>
</tr>
</tbody>
</table>
Laboratory Safety Audit Form

This form has been assembled to enable departments in laboratory disciplines to audit their safety program. Each question can be answered with a simple yes or no.

<table>
<thead>
<tr>
<th>Question</th>
<th>Check one</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are orientation sessions held to advise new students and staff of the applicable emergency and safety procedures?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Have personnel who work with chemicals or infectious materials been provided the training required by the provincial Workplace Hazardous Material Information System (WHMIS) regulations?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Are staff and students advised of the appropriate procedures for the disposal of hazardous wastes?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Do you have laboratory personnel with up-to-date training in first aid and CPR techniques?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Do all of your laboratory personnel have access to first aid kits?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Are your first aid kits checked and the contents replenished on a regular basis?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Does your department maintain an up-to-date list of emergency evacuation monitors?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Are there any staff or students in your department with disabilities which may necessitate assistance in the event of an emergency evacuation?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>• If yes, do you have a contingency plan in place?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Are up-to-date Laboratory Identification Cards posted on the doors of all your laboratories?</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Are your emergency eye washes flushed on a regular (weekly)</td>
<td>☐ ☐</td>
</tr>
<tr>
<td>Question</td>
<td>Yes</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Are your emergency showers tested on an annual basis?</td>
<td></td>
</tr>
<tr>
<td>Does your department have a safety committee?</td>
<td></td>
</tr>
<tr>
<td>Does your department conduct periodic inspections of laboratories?</td>
<td></td>
</tr>
<tr>
<td>Does your department have a mechanism in place to ensure that departing researchers clean up their experimental materials before leaving the University?</td>
<td></td>
</tr>
<tr>
<td>Are radioactive materials used in your department?</td>
<td></td>
</tr>
<tr>
<td>• If yes, have all personnel handling radioactive materials undergone radiation safety training?</td>
<td></td>
</tr>
<tr>
<td>Does your department have a disaster plan in place?</td>
<td></td>
</tr>
<tr>
<td>Is safety a regular agenda item in meetings?</td>
<td></td>
</tr>
</tbody>
</table>
SAFETY AND HANDLING PROCEDURES FOR DIOXINS
# CHEMICAL AND PHYSICAL PROPERTIES

The following abbreviations are used for the chemical and physical properties given for each substance. "NA" indicates that a property is not applicable, and a question mark (?) indicates that it is unknown.

<table>
<thead>
<tr>
<th>ABBREVIATIONS</th>
<th>CHEMICAL AND PHYSICAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>Molecular weight</td>
</tr>
<tr>
<td>BP</td>
<td>Boiling point at 1 atmosphere, °F</td>
</tr>
<tr>
<td>Sol</td>
<td>Solubility in water at 68 °F (unless a different temperature is noted), % by weight (i.e., g/100 ml)</td>
</tr>
<tr>
<td>Fl.P</td>
<td>Flash point (i.e., the temperature at which the liquid phase gives off enough vapor to flash when exposed to an external ignition source), closed cup (unless annotated &quot;(oc)&quot; for open cup), °F</td>
</tr>
<tr>
<td>IP</td>
<td>Ionization potential, eV (electron volts) [Ionization potentials are given as a guideline for the selection of photoionization detector lamps used in some direct-reading instruments.]</td>
</tr>
<tr>
<td>VP</td>
<td>Vapor pressure at 68 °F (unless a different temperature is noted), mm Hg; &quot;approx&quot; indicates approximately</td>
</tr>
<tr>
<td>MLT</td>
<td>Melting point for solids, °F</td>
</tr>
<tr>
<td>FRZ</td>
<td>Freezing point for liquids and gases, °F</td>
</tr>
<tr>
<td>UEL</td>
<td>Upper explosive (flammable) limit in air, % by volume (at room temperature unless otherwise noted)</td>
</tr>
<tr>
<td>LEL</td>
<td>Lower explosive (flammable) limit in air, % by volume (at room temperature unless otherwise noted)</td>
</tr>
<tr>
<td>MEC</td>
<td>Minimum explosive concentration, g/m³ (when available)</td>
</tr>
<tr>
<td>Sp.Gr</td>
<td>Specific gravity at 68 °F (unless a different temperature is noted) referenced to water at 39.2 °F (4 °C)</td>
</tr>
<tr>
<td>RGasD</td>
<td>Relative density of gases referenced to air = 1 (indicates how many times a gas is heavier than air at the same temperature)</td>
</tr>
</tbody>
</table>
When possible, the flammability/combustibility of a substance was determined and listed after the specific gravity. The following OSHA criteria were used to classify flammable or combustible liquids:

<table>
<thead>
<tr>
<th>Class IA flammable liquid</th>
<th>Fl. P. below 73 °F and BP below 100 °F.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class IB flammable liquid</td>
<td>Fl. P. below 73 °F and BP at or above 100 °F.</td>
</tr>
<tr>
<td>Class IC flammable liquid</td>
<td>Fl. P. at or above 73 °F and below 100 °F.</td>
</tr>
<tr>
<td>Class II combustible liquid</td>
<td>Fl. P. at or above 100 °F and below 140 °F.</td>
</tr>
<tr>
<td>Class IIIA combustible liquid</td>
<td>Fl. P. at or above 140 °F and below 200 °F.</td>
</tr>
<tr>
<td>Class IIIB combustible liquid</td>
<td>Fl. P. at or above 200 °F.</td>
</tr>
</tbody>
</table>

**Personal Protection and Sanitation**

This column presents a summary of recommended practices for each toxic substance. These recommendations supplement general work practices (e.g., no eating, drinking, or smoking where chemicals are used).

<table>
<thead>
<tr>
<th>SKIN</th>
<th>Recommends the need for personal protective clothing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EYES</td>
<td>Recommends the need for eye protection.</td>
</tr>
<tr>
<td>WASH SKIN</td>
<td>Recommends when workers should wash the spilled chemical from the body in addition to normal washing (e.g., before eating).</td>
</tr>
<tr>
<td>REMOVE</td>
<td>Advises workers when to remove clothing that has accidentally become wet or significantly contaminated.</td>
</tr>
<tr>
<td>CHANGE</td>
<td>Recommends whether the routine changing of clothing is needed.</td>
</tr>
<tr>
<td>PROVIDE</td>
<td>Recommends the need for eyewash fountains and/or quick drench facilities.</td>
</tr>
</tbody>
</table>

**Respirator Recommendations**

In certain cases, the recommended respirators are annotated with the following symbols as additional information:

<table>
<thead>
<tr>
<th>SYMBOLS</th>
<th>INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>*</td>
<td>Substance reported to cause eye irritation or damage; may require eye protection</td>
</tr>
<tr>
<td>£</td>
<td>Substance causes eye irritation or damage; eye protection needed</td>
</tr>
<tr>
<td>^</td>
<td>If not present as a fume</td>
</tr>
<tr>
<td>†</td>
<td>End of service life indicator (ESLI) required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SYMBOLS</th>
<th>INFORMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>†</td>
<td>Only nonoxidizable sorbents allowed (not charcoal)</td>
</tr>
</tbody>
</table>
1. WHAT IS DIOXIN?

Dioxin is a common name given to a group of persistent and very toxic chemicals, also known as dioxins and furans. These chemicals include 75 chlorinated dibenzo dioxins and 135 chlorinated dibenzo furans. The most toxic of these compounds is 2,3,7,8-tetrachlorodibenzo-p-dioxin, also known as TCDD. The other 209 dioxin and furan chemicals, or congeners, are less toxic than TCDD by orders of magnitude of 0.5, 0.1, 0.01, or 0.001, relative to the toxicity of TCDD. For this reason, dioxin in the environment is measured and reported in terms of TCDD equivalents, which are the actual concentrations of each dioxin or furan congener multiplied by its relative toxicity. The amount of dioxin in a sample is the sum of the concentration of TCDD and TCDD-equivalents.
2. NATURE OF DIOXINS

1. The 2,3,7,8-TCDD isomer has been found to be carcinogenic in laboratory animal studies.

2. The finely divided dry samples contaminated with PCDDs and PCDFs are particularly hazardous because of the potential for inhalation and ingestion. It is recommended that such samples be processed in a confined environment, such as a hood or a glove box. Laboratory personnel handling these types of samples should wear masks fitted with charcoal filters to prevent inhalation of dust.

3. In general, each chemical compound should be treated as a potential health hazard. From this viewpoint, exposure to these chemicals must be kept to a minimum.

4. Each laboratory must develop a strict safety program for the handling of PCDDs and PCDFs. The laboratory practices listed below are recommended.
   
   1. Contamination of the laboratory will be minimized by conducting most of the manipulations in a hood.
   
   2. The effluents of sample splitters for the gas chromatograph should pass through either a column of activated charcoal or be bubbled through a trap containing oil or high boiling alcohols.
   
   3. Liquid waste should be dissolved in methanol or ethanol and irradiated with ultraviolet light at a wavelength less than 290 nm for several days. Analyse the irradiated liquid wastes and dispose of the solutions when 2,3,7,8-TCDD and TCDF congeners can no longer be detected.

3. SAFE HANDLING OF 2,3,7,8-TCDD IN THE LABORATORY

The following statements on safe handling are as complete as possible on the basis of available toxicological information:

The precautions for safe handling and use are necessarily general in nature since detailed, specific recommendations can be made only for the particular exposure and circumstances of each individual use. The 2,3,7,8-TCDD isomer is extremely toxic to certain kinds of laboratory animals. However, it has been handled for years without injury in analytical and biological laboratories. Many techniques used in handling radioactive and infectious materials are applicable to 2,3,7,8-TCDD and are given below:
1. **Protective Equipment** - Disposable plastic gloves, apron or lab coat, safety glasses and laboratory hood adequate for radioactive work. However, PVC gloves should not be used.

2. **Training** - Workers must be trained in the proper method of removing contaminated gloves and clothing without contacting the exterior surfaces.

3. **Personal Hygiene** - Thorough washing of hands and forearms after each manipulation and before breaks (coffee, lunch, and shift).

4. **Confinement** - Isolated laboratory, posted with signs, segregated glassware and tools, **plastic backed absorbent paper on bench tops**.

5. **Waste** - Good technique includes minimizing contaminated waste. Plastic bag liners should be used in waste cans.

6. **Disposal of Hazardous Wastes** - 2,3,7,8-TCDD decomposes above 800°C. Low-level waste such as absorbent paper, tissues, animal remains, and plastic gloves may be **burned in a good incinerator**.

7. **Decontamination of Personnel** - For personal decontamination, use any mild soap with plenty of scrubbing action.

8. **Decontamination of glassware**: For decontamination of glassware, tools, and surfaces, **Chlorotheine Solvent** (Trademark of the Dow Chemical Company) is the least toxic solvent shown to be effective. Satisfactory cleaning may be accomplished by rinsing with Chlorotheine, then washing with a detergent and water. Dish water may be disposed to the sewer after percolation through a **charcoal bed filter**. It is prudent to minimize solvent wastes.

9. **Laundry** - Clothing known to be contaminated should be disposed with the precautions described under "Disposal of Hazardous Wastes". Laboratory coats or other clothing worn in 2,3,7,8-TCDD work area may be laundered. Clothing should be collected in plastic bags. Persons who convey the bags and launder the clothing should be advised of the hazard. The clothing may be put into a washer without contact if the launderer knows the problem. **The washer should be run through one full cycle before being used again for other clothing**.

10. **Wipe Tests** - A useful method for determining cleanliness of work surfaces and tools is to wipe the surface with a piece of filter paper, extract the filter paper and analyze the extract.
11. **Inhalation** - Any procedure that may generate airborne contamination must be carried out with good ventilation. Gross losses to a ventilation system must not be allowed. Handling of the dilute solutions normally used in analytical and animal work presents no significant inhalation hazards except in case of an accident.

12. **Accidents** - Remove contaminated clothing immediately, taking precautions not to contaminate skin or other articles. Wash exposed skin vigorously and repeatedly until medical attention is obtained.

It is recommended that personnel working in laboratories where PCDD/PCDF are handled be given periodic physical examinations (at least annually). Such examinations should include specialized tests, such as those for urinary porphyrins and for certain blood parameters which, based upon published clinical observations, are appropriate for persons who may be exposed to PCDDs/PCDFs.

**REFERENCES**


<table>
<thead>
<tr>
<th>CODE</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye: Irrigate immediately</td>
<td>If this chemical contacts the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.</td>
</tr>
<tr>
<td>Eye: Irrigate promptly</td>
<td>If this chemical contacts the eyes, promptly wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention if any discomfort continues. Contact lenses should not be worn when working with this chemical.</td>
</tr>
<tr>
<td>Eye: Frostbite</td>
<td>If eye tissue is frozen, seek medical attention immediately; if tissue is not frozen, immediately and thoroughly flush the eyes with large amounts of water for at least 15 minutes, occasionally lifting the lower and upper eyelids. If irritation, pain, swelling, lacrimation, or photophobia persists, get medical attention as soon as possible.</td>
</tr>
<tr>
<td>Eye: Medical attention</td>
<td>Self-explanatory</td>
</tr>
<tr>
<td>Skin: Blot/brush away</td>
<td>If irritation occurs, gently blot or brush away excess.</td>
</tr>
<tr>
<td>Skin: Dust off solid; water flush</td>
<td>If this solid chemical contacts the skin, dust it off immediately and then flush the contaminated skin with water. If this chemical or liquids containing this chemical penetrate the clothing, promptly remove the clothing and flush the skin with water. Get medical attention immediately.</td>
</tr>
<tr>
<td>Skin: Frostbite</td>
<td>If frostbite has occurred, seek medical attention immediately; do NOT rub the affected areas or flush them with water. In order to prevent further tissue damage, do NOT attempt to remove frozen clothing from frostbitten areas. If frostbite has NOT occurred, immediately and thoroughly wash contaminated skin with soap and water.</td>
</tr>
<tr>
<td>------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Skin: Molten flush immediately/solid-liquid soap wash immediately</td>
<td>If this molten chemical contacts the skin, immediately flush the skin with large amounts of water. Get medical attention immediately. If this chemical (or liquids containing this chemical) contacts the skin, promptly wash the contaminated skin with soap and water. If this chemical or liquids containing this chemical penetrate the clothing, immediately remove the clothing and wash the skin with soap and water. If irritation persists after washing, get medical attention.</td>
</tr>
<tr>
<td>Skin: Soap flush immediately</td>
<td>If this chemical contacts the skin, immediately flush the contaminated skin with soap and water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.</td>
</tr>
<tr>
<td>Skin: Soap flush promptly</td>
<td>If this chemical contacts the skin, promptly flush the contaminated skin with soap and water. If this chemical penetrates the clothing, promptly remove the clothing and flush the skin with water. If irritation persists after washing, get medical attention.</td>
</tr>
<tr>
<td>Skin: Soap promptly/molten flush immediately</td>
<td>If this solid chemical or a liquid containing this chemical contacts the skin, promptly wash the contaminated skin with soap and water. If irritation persists after washing, get medical attention. If this molten chemical contacts the skin or nonimpervious clothing, immediately flush the affected area with large amounts of water to remove heat. Get medical attention immediately.</td>
</tr>
<tr>
<td>Skin: Soap wash</td>
<td>If this chemical contacts the skin, wash the contaminated skin with soap and water.</td>
</tr>
<tr>
<td>Skin: Soap wash immediately</td>
<td>If this chemical contacts the skin, immediately wash the contaminated skin with soap and water. If this chemical penetrates the clothing, immediately remove the clothing, wash the skin with soap and water, and get medical attention promptly.</td>
</tr>
<tr>
<td>Skin: Soap wash promptly</td>
<td>If this chemical contacts the skin, promptly wash the contaminated skin with soap and water. If this chemical penetrates the clothing, promptly remove the clothing and wash the skin with soap and water. Get medical attention promptly.</td>
</tr>
<tr>
<td>Skin: Water flush</td>
<td>If this chemical contacts the skin, flush the contaminated skin with water. Where there is evidence of skin irritation, get medical attention.</td>
</tr>
<tr>
<td>Skin: Water flush immediately</td>
<td>If this chemical contacts the skin, immediately flush the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water. Get medical attention promptly.</td>
</tr>
<tr>
<td>Skin: Water flush promptly</td>
<td>If this chemical contacts the skin, flush the contaminated skin with water promptly. If this chemical penetrates the clothing, immediately remove the clothing and flush the skin with water promptly. If irritation persists after washing, get medical attention.</td>
</tr>
<tr>
<td>Skin: Water wash</td>
<td>If this chemical contacts the skin, wash the contaminated skin with water.</td>
</tr>
<tr>
<td>Skin: Water wash immediately</td>
<td>If this chemical contacts the skin, immediately wash the contaminated skin with water. If this chemical penetrates the clothing, immediately remove the clothing and wash</td>
</tr>
<tr>
<td>Section</td>
<td>Action</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Skin: Water wash promptly</td>
<td>If this chemical contacts the skin, promptly wash the contaminated skin with water. If this chemical penetrates the clothing, promptly remove the clothing and wash the skin with water. If irritation persists after washing, get medical attention.</td>
</tr>
<tr>
<td>Breath: Respiratory support</td>
<td>If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform mouth-to-mouth resuscitation. Keep the affected person warm and at rest. Get medical attention as soon as possible.</td>
</tr>
<tr>
<td>Breath: Fresh air</td>
<td>If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. Other measures are usually unnecessary.</td>
</tr>
<tr>
<td>Breath: Fresh air, 100% O₂</td>
<td>If a person breathes large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. When breathing is difficult, properly trained personnel may assist the affected person by administering 100% oxygen. Keep the affected person warm and at rest. Get medical attention as soon as possible.</td>
</tr>
<tr>
<td>Swallow: Medical attention</td>
<td>If this chemical has been swallowed, get medical attention immediately.</td>
</tr>
</tbody>
</table>
# 2,3,7,8-TETRACHLORO-DIBENZO-P-DIOXIN

<table>
<thead>
<tr>
<th>2,3,7,8-Tetrachloro-dibenzo-p-dioxin</th>
<th>CAS 1746-01-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁₂H₄Cl₄O₂</td>
<td>RTECS HP3500000</td>
</tr>
</tbody>
</table>

**Synonyms & Trade Names**
- Dioxin; Dioxide; TCDD; TCDD; 2,3,7,8-TCDD
  [Note: Formed during past production of 2,4,5-trichlorophenol, 2,4,5-T & 2(2,4,5-trichlorophenoxy)propionic acid.]

**DOT ID & Guide**
- NIOSH REL: Ca [See Appendix A]
- OSHA PEL: none

**Physical Description**
- Colorless to white, crystalline solid. [Note: Exposure may occur through contact at previously contaminated worksites.]

| MW: 322.0 | BP: Decomposes | MLT: 581°F | Sol: 0.00000002% |
| VP(77°F): 0.000002 mmHg | IP: ? | Sp.Gr: ? |

**Incompatibilities & Reactivities**
- UV light (decomposes)

**Personal Protection & Sanitation**
- Skin: Prevent skin contact
- Eyes: Prevent eye contact
- Wash skin: When contaminated/Daily
- Remove: When wet or contaminated
- Change: Daily
- Provide: Eyewash, Quick drench
- First Aid [See procedures]
  - Eye: Irrigate immediately
  - Skin: Soap flush immediately
  - Breathing: Respiratory support
  - Swallow: Medical attention immediately

**Respirator Recommendations**
- At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration: (APF = 10,000) Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode/(APF = 10,000) Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained positive-pressure breathing apparatus Escape: (APF = 50) Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having a high-efficiency particulate filter/Any appropriate escape-type, self-contained breathing apparatus

**Exposure Routes**
- Inhalation, skin absorption, ingestion, skin and/or eye contact

**Symptoms**
- Irritation eyes; allergic dermatitis, chloracne; porphyria; gastrointestinal disturbance; possible reproductive, teratogenic effects; in animals: liver, kidney damage; hemorrhage; [potential occupational carcinogen]

**Target Organs**
- Eyes, skin, liver, kidneys, reproductive system

**Cancer Site**
- [in animals: tumors at many sites]