UNIVERSITY OF CYPRUS
DEPARTMENT OF CHEMISTRY

RISK ASSESSMENT FOR COMMON ACTIVITIES: EQUIPMENT AND PROCEDURES

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1. RISK ASSESSMENT: USE OF FUME HOODS

The fume hoods are perhaps the most important piece of equipment protection in the chemical laboratory. They are designed to protect against toxic, hazardous or other harmful materials by sucking airflow away from the user, thus preventing the inhalation of harmful fumes. The fume hoods in the Department of Chemistry are designed to ventilate fumes outside through outlets on the roof.

When to use
A fume hood must be used for all chemical processes involving:

- Chemicals falling into the categories of flammable, dangerous, harmful, toxic, carcinogenic, teratogenic or mutagenic substances.
- Whenever any chemical has a foul odour or can cause a stench.
- Organic solvents.

Ventilation Methods
Ventilation, under normal conditions, provides air flow to several fume hoods located at different points and on different floors of the building. This arrangement endangers all the hoods in the case of failure of the central fan. Additionally, the central ventilator operates with a fixed velocity so that the suction rate of each hood depends on the degree of closure of the sashes of the remaining hoods. In case of an alarm warning, the hoods shall remain operational, sashes closed.

Classification
The suction capability of all fume hoods is regularly inspected. A properly functioning fume hood will draw in at least 0.5 m/sec of air with the sash raised to half height. Air flow is recorded via a digital panel on the upper left side of the hood.

- **Suction air velocity at > 0.5 m/sec:** sufficient suction for safe use with most gases and vapours.
- **Suction air velocity at 0.2 to 0.5 m/sec:** safe but not fully compliant in the event of mass leakage of a dangerous gas or fumes.
- **Suction air velocity at < 0.2 m/sec:** DO NOT USE, INFORM TECHNICAL STAFF.

The suction air velocity of available hoods must be considered when planning any work.

Dangers
Although fume hoods are designed to protect the user from dangers, *e.g.*, toxic or harmful materials or of combustible materials such as solvents, their inappropriate use can result in reduction of their expected protective value or may cause the hoods themselves to become dangerous.

- The classification of the fume hood may not be sufficient to cope with the materials used.

- The efficiency of a fume hood decreases dramatically if the sash is too open or blocked by objects that impede the smooth flow of air.
- The fume hood fans, especially those of the typical models, are prone to failure. This means that the air flow can stop and the hood becomes ineffective.
- The chemicals that accumulate in a fume hood which is in operation for chemical work are an additional hazard in case of accident.

Dangers
The fume hoods are safety equipment but may become less effective due to misuse. Injuries can be caused by misuse due to four causes:

- From poor air suction in relation to the required work.
- Excessive and/or prolonged opening of the sash.
- The installation of equipment in the fume hood in such a manner as to reduce the capacity to safely store harmful material.

In these cases, the risk of injury is minimal, low to moderate level of seriousness, but may increase due to the toxicity of materials that could be released.

- From the device itself, *i.e.* the breaking of the sash cords: the chances are minimal but the possible damage can be moderate to very serious.

Who Might Be Injured?
The person who has the greatest chance of injury is the user, although the leakage of harmful materials in the laboratory can affect others who are present.

Control Measures
Hardware: The maintenance of the fans and regular checks of the intake airflow as well as all the sash cords and pulleys.
Education: Although the use of fume hoods is part of the education of most Chemistry graduates, new entrants in the Department of Chemistry should be treated as unfamiliar with these regulations.

Operation Precautions
- The suction air velocity of the hood should be sufficient for the chemicals used.
- The inside of the fume hood must be kept free of obstructions by devices that obstruct the flow of air. Appliances must be placed more than 10 cm from the front end of the hood.
- Fans must be kept clean and free from dust or blockage by solid materials, *e.g.*, loose paper/tissues.
- Unneeded chemicals should not accumulate or be stored in a hood being used to conduct chemistry.
- The sash must be kept as closed as possible or while it is in operation, while it must be fully closed when the hood is not in use.
- Users must keep their heads OUT of the fume hood while operating.
- A thin strip of paper or other visible airflow indicator can be used to detect and warn of fan failure.

- If airflow stops for any reason, work must be stopped and the sash lowered.

Emergency Procedures

Leakage of toxic or harmful materials:

- Leave the area immediately.
- Close all exit doors.
- Warn all people to avoid the affected area.
- Call the onsite Security.

Fan failure:

- If the warning label of a hood is painted red, it should not be used until it is declared safe.
- If ventilation stops at any of the fume hoods, work must be stopped and the front doors must be closed.

2. RISK ASSESSMENT: USE OF LABORATORY GLASSWARE

This risk assessment refers to the use of conventional laboratory glassware including that used under reduced pressure or in vacuo. This does NOT apply to glassware used at elevated pressure.

Dangers

- Cuts from worn or broken glass.
- Cuts from shattered glass due to explosion due to evacuation or mechanical damage.
- Forced pressure cuts arising from inserting glass tubes into plastic tubes, nipples or rubber stoppers, syringes or condensers that break.
- Cuts from broken glasses thrown in ordinary waste bins.
- Burns from hot glass.
- Poisoning resulting from cuts involving contaminated glass.

Danger

The chances of injury (from a cut) for an untrained person are higher; injuries may be minor to moderate.

Who Might Be Injured?

Due to misuse of laboratory glassware, the most likely casualty is the user. However, in the case of shattered glass, anyone in the area is likely to be injured.

Control Measures

- Vacuum glass containers should be encased in plastic or wire mesh to prevent scattering of pieces after explosion.
- Broken glassware should be disposed of in specially designed waste bins and not in standard waste bins.

Education

- Training students to safely use of the standard laboratory glassware is part of the undergraduate program. Additional training should be provided by responsible tutors when glassware will be used under vacuum.

Operation Precautions

- Depending on the procedure, goggles or face mask should be worn. In some cases, *e.g.*, when the pressure exerted to fit a tube to glass is needed, then the use of thick (leather) gloves to cover the wrists is mandatory.
- Prior to use, all glassware must be inspected to ensure that there are no cracks, defects or abrasions that could cause damage.
- Glassware should be handled with care, and never placed in clothing pockets.
- Glassware should never be left exposed on the floor.
- When fitting tubes to glassware, the glass should be wet with water or lubricated with glycerine and the plastic tubes should be softened by brief immersion in hot water. Excessive pressure should not be applied in the direction which could break the glass. Careful consideration should be given to

the direction of the sharp edges of the glass in case it breaks so that the user can adjust the point where the glass will hold accordingly. When the tubing is removed, a sharp knife can be used to cut the tubing that could not be removed using gentle pressure.

- Hot glassware (which looks like cold glass) should be handled with care and placed in a location where no one can come in contact until it has cooled down.
- Fittings and caps must be lubricated before assembly and disassembled immediately after use. Bottles or containers should not be closed with a lid while hot. If a cap gets stuck, it is extremely dangerous to reheat the container to remove the cap.
- Damaged glassware should be repaired or discarded in the "Broken Glass" bin and not in ordinary waste bins. Care should be taken when removing broken glasses from a sink as water makes the sharp edges invisible: tweezers can be used to remove these pieces.
- Sharp broken glasses should be thrown in special containers and not in ordinary waste bins.

Use of vacuum

- Glassware used in vacuum must be carefully inspected for defects before each use.
- In the case of glassware in vacuo and in quantities of one litre or more they must be enclosed in tape or plastic net to hold any pieces in the event of an explosion. This applies to equipment as such spherical storage containers under vacuum (vacuum storage bulbs), rotary evaporators, high vacuum desiccators etc. See Risk Assessment "Use of Reduced Pressure or Vacuum".

Washing

The use of detergents is the usual way of washing laboratory glassware. More drastic methods, such as the use of chromic acid, must only be used if washing with detergents or solvents proves insufficient. Beware of fires when using solvents for washing or drying.

Training requirements

The safe use of glassware is part of the undergraduate training.

Other Risks

Cutting glass or misusing glassware remains one of the most common forms of injury in the Department of Chemistry. Great care is always required.

Emergency Procedures

- Cuts and burns should be treated immediately. No attempt should be made to remove broken glass from open wounds.
- Excluding some small wounds, they should call for First Aid.

3. RISK ASSESSMENT: USE OF BASIC ELECTRICAL EQUIPMENT

Laboratory power supply is possible through independent sockets which can be either three-phase 415 V, 50 Hz, or single-phase 240 V, 50 Hz. The office supply is usually 240 V, 50 Hz. Most electrical equipment operates at 240 V, 50 Hz.

There is a wide variety of electric equipment in the laboratories including the cooling circulator, vacuum pump, laser, the electrophoresis, and electrochemical devices, stirrers, hotplates, ovens and furnaces, microwaves, computers, printers and audio-visual equipment etc. In the office, there is, among others, computer equipment, fax machines and copiers. There are overhead and slide projectors in the lecture halls. Everyone in the Department of Chemistry uses equipment that runs on electricity.

Dangers

- Electric shock is the result of the passage of electricity through the body and specifically the nervous system. The effects depend on the strength of the current which in turn depends on the electrical voltage and resistance of the body, *i.e.* the length of the engagement and the surface resistance of the skin (which is drastically reduced when the skin is wet). Normal voltage 240 V can be deadly if > 30 mA passes through the body for > 40 ms. Minor electric shocks can also cause injury as a result of involuntary muscle spasms.
- Burns can occur when a high voltage current penetrates the body or when it comes in direct contact with an electrically heated surface.
- Explosion or fire can be caused by electric sparks, short circuit, thermal overload, old wiring in the presence of flammable material.
- Injuries from microwave and radio frequency emission sources and from inductive heating.

Dangers

Electrical equipment is used daily outside the laboratory and users are familiar with safe operation. The risk of injury is therefore minimal. However, injuries can vary from minor to fatal.

Who Might Be Injured?

Electric shock: most likely the user themselves.
Fire and Explosion: Injuries may be extensive.

Control Measures

These precautions are not exhaustive, nor do they cover aspects of repairing or manufacturing electrical equipment. They cover the regular use in laboratories and offices.

Plugs and fuses

- Plugs that are cracked or broken should not be used. Plugs must be properly wired; the power lines must be securely mounted and the cables must be held firmly by a strain relief grip.

- The security rating must be appropriate for the device. Most electrical equipment (computers, measuring instruments etc.) use only a 3 A fuse which can handle up to 720 W. 13 A fuses that can handle 3000 W are used for heavier equipment. The laboratory staff also has an advisory role in case of doubt.

Wiring

- The cables must be in good condition and free of cracks in the insulation. The cables must be durable enough to withstand the wear of laboratory or office use and completely waterproof in cases where the device may come into contact with water.
- Special care is required when electrical cables are covered by moveable objects even when they are rarely moved. It should be ensured that the cables are protected and insured against such risks.
- The cables must not penetrate the floor in such a way that there is a risk of tripping or damage to passers-by. If it is absolutely necessary to lay cables on the floor, they must be covered by a protective cover.

Extensions/Adapters

The use is permissible if it is needed to supply a four-wire extension from an outlet and powers only small device (< 500 W or 2 A). The terminals of the extension must not be tied tightly. Boilers, microwave ovens and heaters with higher power requirements should not be used in such extensions but should be powered by an installed outlet.

Emergency power cut off switch

The location of any power switch must be visible and known so that the power can be cut off immediately in the event of an emergency.

- Ordinary electrical equipment should not be used in close proximity to flammable or explosive gases. Conventional electrical equipment is a potential source of ignition.
- Ordinary electrical equipment should not be used when it may be wet. Water can cause a dangerous short circuit.
- Wet equipment should not be put into operation until it has been inspected. Anyone who inspects the equipment must be informed of what has happened.

Repairs

- Electrical equipment must be repaired only by a qualified technician.
- Equipment must be disconnected from the main switch before starting repairs.
- If in doubt, equipment should be sent to the supplier for repair.

Education

The safe use of electrical equipment is part of the undergraduate students training.

Other Risks

The electrical network will always be a potentially deadly hazard if mismanaged. Adherence to the above precautions reduces the risk to a minimum.

Emergency Procedure
Electric shock: Power must be turned off before anyone can touch the injured person.
Fire: Water should never be used in the event of an electrical fire.

4. RISK ASSESSMENT: TRANSPORTATION, STORAGE AND USE OF COMPRESSED GAS CYLINDERS

Dangers

- Compressed gas cylinders are very heavy, up to 120 kg, and unstable objects and therefore can be very dangerous for those who handle them.
- They contain gas which can be toxic, suffocating or flammable as well as at high pressure.
- Apart from chemical risks, further severe physical damage can occur from any exposure to the full force of gas released (300 bar).
- Compressed gas cylinder valves are very durable and difficult to break. However, gas pressure regulators are less durable and in the event of damage, the gas leak can be catastrophic.

Dangers

For an untrained person the most likely source of injury comes from incorrect application of the pressure regulator allowing gas to leak (possible) or from a defective cylinder (less likely). The resulting injuries can be moderate to severe.

Who Might Be Injured?

A defective cylinder or exposure to high gas pressure may only injure the person using the cylinder. But if the equipment explodes due to excessive pressure or leak toxic or suffocating gases, the damage can expand to the whole the laboratory or beyond.

Control Measures

Cylinder trolleys must be provided as well as secure storage frames for storage. The installation of the gas cylinders should be undertaken only by experienced personnel: must be checked for leaks before delivery to the laboratory and inspected at regular time intervals.
Manual handling: Due to the size/weight of the cylinders it is important that users attempting to collect or move these items are physically fit.

Mounting: Cylinders should be stored in suitable mounting frames or points outside the laboratories but if this is not possible they can be stored in suitable, safe support framework within the laboratory by, in exceptional cases, securing to roller trolley. THE CYLINDERS NOT IN USE SHOULD BE SAFELY RETURNED TO STORAGE. The number of gas cylinders in any space must be kept to a minimum. Flammable gases such as hydrogen and methane should never be stored together with oxygen: they should be three meters apart or separated by a firewall.

Education: New students to the Department should undergo a qualifying program.
Goggles or face shields must be used when adjusting or removing the regulators and when opening the main valve. In addition, closed shoes should be worn when moving the cylinders to avoid crushing the feet.

Functional Precautions

- Cylinders should be checked to ensure that they contain the expected gas by examining the label and (less reliable method) examining the colour code.
- Cylinders must be transported via an approved trolley by pushing, not pulling. If the trolley shows signs of wear or damage, it must be sent for repair or replaced. The cylinder must be securely locked in an approved location.
- CYLINDERS SHOULD NOT BE LEFT EXPOSED IN OPEN SPACE.
- The Pressure Regulator must be checked. It is designed to control the gas. The pressure regulator: is it able to cope with the pressure in the cylinder? The regulator is marked with a red line indicating the maximum pressure that can be exerted on the experimental device. Damaged regulators must be sent for repair or be replaced.
- Proper adjustment tools and tightening wrenches must be used when are used to the pressure valve to prevent damage to the screw fitting.
- Oil or grease should never be used, especially in the case of oxygen cylinders: oil or grease may cause ignition or explosion. NB flammable gas cylinders have a counter clockwise thread.
- Teepol aqueous solution can be used to check for leaks around the regulator.
- The regulator must be closed before opening the valve, which must be done slowly and never with more than one turn; when not to use the tap should be closed.
- Cylinders should NEVER be carried when their regulators are attached.

Other Risks

They are reduced to a minimum if the above precautions are observed.

Emergency Procedures

Gas Leaks: If the gas leak is large, evacuate the space and inform Security immediately. Even inert gases can cause suffocation.

For small, non-toxic leaks, the room must be ventilated, evacuated, sealed and secured. Notify Security. Warning: Hydrogen (H_2) leaks from excessive cylinder pressure can cause spontaneous ignition.

Cylinder drop: When the cylinder is falling down, no one should EVER attempt to catch it. It is very heavy and can cause serious damage. Cylinders are very durable and are unlikely to be damaged although they can make a lot of noise. Technical staff should be called in to help lift it.

5. RISK ASSESSMENT: USING REDUCED PRESSURES OR VACUUM

Glassware

Dangers

Possible explosion and shattered glass can lead to cuts and abrasions. Any piece of glass under vacuum, *e.g.*, rotary evaporators, vacuum desiccators, Schlenk tubes and spherical storage containers under vacuum may cause injuries in case of explosion. The energy transmitted to the ejected objects is proportional to the volume evacuated from the glass container. Therefore, the possibility of injury is also proportional to the volume of the glass vessel and a rotating evaporator with the associated container is a greater risk of a small Schlenk tube.

It is a common misconception that "high vacuum" systems (typically 10^{-3} mbars or better) pose a greater risk than everyday vacuum use such as those caused by, for example, water pumps (~30 mbars). They differ in 4 orders of magnitude but the power to which the glass is subjected is essentially the same. That is:

- High vac > 99.999% of atmospheric pressure.
- Water pump, 97% atmospheric pressure.

Risks and who may be injured

In the event of an explosion of glassware, the immediate user and those working nearby may be injured with possible injuries of moderate (small abrasions) to severe (large abrasions or visual damage).

Precautions

- Laboratory uniforms and safety spectacles must be used. In some cases, *e.g.*, when liquid nitrogen or other cryogenic agents are introduced or when storage bottles are heated, the user must wear a face mask and suitable gloves.
- Only suitable glassware should be used: conical cylinders, with the exception of thick-walled Buchner cylinders, should never be put under vacuum.
- Glassware must have no cuts, cracks or defects which make it dangerous. Particular attention should be paid to the detection of worn surfaces.
- Containers with a volume > 1 L must be wrapped with tape or plastic netting to hold the pieces in the event of an explosion. This usually applies to rotary evaporators, vacuum desiccators and the storage spherical glass containers. Schlenk tubes and other glass tubes usually have a small volume and are sufficiently durable so that they do not require extra protection in the form of tape or plastic netting.
- Vacuum flasks (thermos bottles) should be completely wrapped in tape or preferably enclosed in a metal container.

Metal Vacuum System

Dangers

There is less risk in handling metal vacuum systems due to the low probability of explosion.

Pumps

Dangers

There are many types of vacuum pumps. The most common type are rotary oil pumps as well as diffusion oil pumps (or less commonly mercury pumps).

- Vacuum pumps are electromotive devices.
- The moving belt rotating pumps are a risk of entanglement in the moving belt and the time card pulley (sheave).
- Rotary pumps can be chemically contaminated as well as release oil vapours at the same time.
- There is a risk of explosion if the rotary pumps release a large volume of air or some other gas.
- Diffusion pumps are heated to boil the pumping fluid and therefore pose a risk of burns.
- Glass diffusion pumps are fragile and if they contain mercury the risk of mercury contamination is increased.

Precautions

- When using electrical equipment, the usual precautions must be observed.
- Rotary pumps must have belt protectors to prevent trapping.
- Traps (or cold trap or a molecular sieve) must be used between the system and the pump to prevent contamination of the oil pump and the release of gases in the laboratory.
- The exhaust outlets must be vented to an exhaust ventilation duct through large diameter pipes.
- Where possible, diffusion mercury pumps should be replaced by similar oil pumps. Mercury pumps must have a separate storage area.
- The heaters of the diffusion pumps must have a protective cover to avoid burns after contact.

Pump Maintenance, Oil Change

The maintenance of the pumps, including oil changes, must be performed either by the users or by a member of the technical staff assigned to the specific task.

Dangers

Pump oil may be contaminated with solvents, mercury, corrosive or harmful substances.

Precautions

- Pump oils must be changed in fume hoods.
- Appropriate gloves and laboratory uniform must be used.
- If contamination is suspected, the oil should be considered a hazardous waste.
- Waste oils must be delivered for disposal to the technician responsible for pump maintenance.
- The pumps delivered for overhauling of the technical staff should be accompanied with a warning about potential contaminants.

Blood pressure monitor

Dangers

There are two main types of vacuum manometers: U or MacLeod manometers which are made of glass and contain mercury or another liquid, and the electrical devices which measure characteristics depending upon the pressure such as thermal conductivity or the ionisation current.

- Danger from glassware and possibly mercury.
- Electrical equipment.

Precautions

- Glass indicators must be treated as indicated in the "Glassware" section above.
- Separate storage space should be used for systems containing mercury.
- Where possible, mercury should be replaced by other less hazardous liquids.
- The usual precautions must be observed when using electrical equipment.

Education

The use of vacuum or pressurized glassware is part of the undergraduate course in Chemistry. For the most advanced vacuum systems, users must be trained by an experienced user.

Other Risks

The risk is minimal if the precautions above are followed. However, glass systems remain more dangerous than metal systems due to the possibility of explosion.

Emergency Procedures

In the event of injury or fire, inform the laboratory staff and call Security.

6. RISK ASSESSMENT: USE OF LABORATORY HEATING EQUIPMENT

The equipment in this assessment includes laboratory ovens, Bunsen burners, heating plates, mantles, boilers, sand baths and hot air pistols, *i.e.* temperatures up to 800 °C. The use of high temperatures, blast furnaces, experimental equipment, etc. must be covered by a separate Risk Assessment.

Dangers

- Personal injuries and burns from hot surfaces, liquids, fumes or flames.
- Ignition sources from both hot surfaces, liquids or flames as well as electrical components.

Dangers and who may be injured

- Contact burns are possible and range from minor to severe but most likely only affect the user.
- Ignition or explosion is more likely but can cause extensive injury to other people.

Precautions

Many heaters contain electrical components (see the separate Risk Assessment "Use of Basic Electrical Equipment"). If any heating appliance is damaged or damaged to such an extent that its heating element is exposed, then the appliance must be switched off immediately.
All heating appliances (except steam baths) must be placed away from flammable materials.

Ovens

- Except for vacuum drying ovens, laboratory ovens rarely are able to prevent the removal of material evaporated therein. Thus, it must be considered that these substances will leak into the laboratory atmosphere but are also likely to occur in sufficient concentrations to form explosive mixtures in the furnace itself. This risk is reduced by venting the oven with an exhaust system.
- Ovens should not be used for the purpose of drying any chemical sample that has low volatility and may become hazardous due to acute or chronic toxicity unless the oven is ventilated on a permanent basis with a safe exhaust system.
- Glassware washed with solvents pose an explosion hazard if dried in an oven that is not vented.

Bunsen Burners

- Bunsen burners are becoming less common in laboratories. The naked flame may activate the fire alarm if placed in the optical radius of the flame detector. When used, care must be taken to cover the flame by the detector.
- Bare flames are a particularly dangerous source of ignition and should not be used near flammable liquid containers or in environments where significant concentrations of flammable fumes are present.
- The Bunsen burner flame is not visible in daylight. The window shutters must be lowered to detect the flame.

Hot plates, heating mantles

The condition of the heater must be checked. If the cover breaks or wears out, the equipment must be switched off. If water or other liquids are in the heater, the electrics must be checked before the next use.

Steam, oil and sand baths

- Special care must be taken so that the baths do not reach a point that they will overflow to prevent water from falling into an oil or sand bath causing dangerous splashing. For oil baths, a secondary container must be used to retain any spillage.
- Oil expands in volume when heated: overfilling should be avoided.
- Objects that are heated in such baths must reach such a point that they allow their quick and easy withdrawal from the bath in case of emergency.
- Oil must not overheat to the point where it can create smoke, decompose or ignite.
- Oil must be labelled to indicate the safe working temperature.
- Attention should be paid to the following:
    - The size and location of the heating bath.
    - The operating temperature and temperature control devices.
    - The type of oil used.
    - The available venting.
    - The method of cooling hot oil.
    - Oil storage for reuse.
    - The proximity to water or chemicals.
- Hot steam presents a risk of scalding and thus should be given attention in filling or emptying containers.
- In all cases, when using such devices, the appropriate protective equipment must be used, *i.e.* laboratory uniform, safety spectacles and gloves.

Hot air jets

- Laboratory hot air jets (pistols) contain an electrically heated body which usually emits a red glow. In addition, on and off switches, as well as engines, rarely have sparks. For these reasons, hot air jets are at increased risk of ignition and should never be used near open flammable liquid containers or in an environment where significant concentrations of flammable fumes, *e.g.*, over solvent-washed glassware.
- The air coming from a hot air jet is extremely hot and invisible. Therefore, the front end must be treated the same as the soldering irons.

Training requirements

The use of several heating devices, namely steam baths, Bunsen burners, hot plates and heating mantles, are part of the undergraduate training. In all other cases, training must be provided by an experienced user.

Other Risk Levels

With proper training, the level of risk is low although constant monitoring is required to avoid injuries and potentially serious burns.

7. RISK ASSESSMENT: USE AND DISPOSAL OF "SHARPS"

Metal "sharps" includes hypodermic needles and syringes with fixed needles, scalpels and razor blades while Glass "sharps" include all forms of broken glassware.

Dangers

- Abrasions or injuries from a needle piercing.
- Injection of (unknown) toxic or other harmful material into the body by hypodermic needles or other contaminated sharps.
- Psychological trauma due to phobia of poisoning or infection. Hypodermic needles have specific emotional connotations that should not be underestimated.

Dangers

The risk of wounds resulting from a sharp object is significant and broken glass is the most common source of injury in the Department of Chemistry. The damage varies from small abrasions that require simple first aid treatment to severe wounds that require surgery. Needle trauma is associated with psychological trauma due to a phobia of poisoning or infection.

Who Might Be Injured?

The user may be injured but the careless dumping of sharps also endangers Cleaning Staff and Waste Disposal Staff.

Precautions

Use:

- Sharps should be used as little as possible and treated with care.
- After each use, if not discarded, sharps should be placed in a safe location to avoid possible accidental injury to other persons.
- The use of glassware is covered in a separate Risk Assessment "The Use of Laboratory Glassware".

Disposal:

- Sharps should never be disposed of in a normal waste bin.
- Glass sharps, *i.e.* broken glass, Pasteur pipettes, micro pipettes for spotting TLC plates etc. must be washed prior to their disposal in a Broken Glass bin. Broken glass should never be left on the floor or work surface or in unsuitable containers, *e.g.*, plastic bags or cardboard boxes. A dustpan and brush should be used to collect broken glass. Particular care is taken to clean broken glass from the sink where water makes the sharp edges of the glass invisible: a pair of tweezers should be used in this case.
- Other sharp objects, *e.g.*, metal hypodermic needles, syringes with fixed needles, razors and scalpels should be discarded in solid, impermeable containers that are discarded when filled.

Waste containers can be requested from the Departments technical staff and then returned when full.

Other Risks

Cuts remain one of the most common forms of injury in the Department of Chemistry. Special care is always required. The same goes for metal cutting objects.

Emergency Procedures

- Cuts should be treated immediately. Broken glass should not be removed from wounds. After injury from any needle that leads to bleeding, attempts should be made to determine if any chemical transfer has occurred via the needle to the body.
- With the exception of minor injuries, a First Aider should be called.
- In case of serious injury, the injured person should be transported to the Hospital.

8. RISK ASSESSMENT: USE LIGHT SOURCES UV IRRADIATION

Ultraviolet sunlight is that part of the electromagnetic spectrum that falls in the range of 100 to 400 nm. This range is divided into three areas:
A: 400 to 315 nm known as Near Ultraviolet or UV-A,
B: 315 to 280 nm known as Medium Length Ultraviolet Radiation or UV-B,
C: 280 to 100 nm known as Remote (ultimate) ultraviolet radiation or UV-C.

Dangers
When UV lamps are used, two categories of hazard exist: the inherent hazards of radiation and those associated with lamp operation. Radiation of wavelength < 250 nm must be considered dangerous.

- Damage to the eyes and skin due to exposure to ultraviolet radiation. Repeated overexposure of the skin to UV radiation has been associated with premature aging, wrinkles and, more severely, skin cancer. Damage to the eyes can lead to corneal scarring or cataracts.
- Burns caused by a hot UV lamp.
- Fire from a hot UV lamp.
- Interaction of other nearby chemicals with UV radiation.
- Damage to devices located near an UV lamp.
- Ozone generation.

Dangers
Vision is likely to be damaged after exposure to high-intensity UV radiation.

Who Might Be Injured?
The User or anyone exposed to UV light as a result of incorrect procedure. Injuries can range from minor to severe.

Control Measures
Operation Precautions
It is necessary to wear laboratory uniforms and safety goggles or other suitable protection for the eyes and skin such as a UV protection mask.
Reactions when using UV lamps: external sources of radiation.

- These functions should never be attempted by an untrained person.
- These functions should never be performed solely by one person.
- These functions should never be attempted outside normal working hours.
- The use of UV lamps must be carried out in fume hoods.
- The source of UV radiation should be kept as it can in an enclosed space.
- The fume hood sash must be closed or when the UV lamp is switched on.
- The fume hood should only contain the UV lamp and the presence of related devices, chemicals and chemical reactions should be avoided.
- Reaction vessels containing flammable solvents must be at least 20 cm away from the lamp to prevent overheating.
- Flammable equipment (*e.g.* rubber/plastic tubing) must be placed at least 10 cm away from the lamp.

- When the UV lamp is switched off, the sash of the fume hood must remain shut for 30 min to allow time for the lamp to cool down unless the mixture of chemical reactions requires immediate processing.

Reactions when using UV lamps: Low/medium pressure mercury lamps.

- These functions should never be attempted by an untrained person.
- These functions should never be performed solely by one person.
- Low/Medium Pressure Lamps should ONLY be used on approved, water-cooled immersion devices.
- The UV lamp power supply must incorporate an electrical safety circuit breaker that is activated in the event of a water-cooling interruption.
- The UV lamp should not be lit until:
- Wrap the glassware in foil.
- Protect the immersion device from a suitable metal case.
- Close the raised doors of the hood.
- The UV lamp should NEVER be lit outside the covered immersion device.

Education

For the use of high-power UV sources, new users should be trained by another member of the laboratory who, in the opinion of the staff responsible for the laboratory, is capable of providing guidance on the proper procedure. New users need to be supervised for a specific period of time by an experienced user.

Other Risk Levels

Low level if the above precautions are observed.

9. RISK ASSESSMENT: LASER USE IN THE LABORATORY

Dangers

- Eyes: The entry of even the slightest laser beam into the eye can cause partial to total loss of vision. The danger is real even from surface reflections and it is these reflections that have caused serious accidents in the past.
- Skin: UV radiation can cause burns and carcinoma (such as sunburn). The strongest laser beams of any wavelength can cause skin burns.
- Most basic lasers use high current and voltage. Therefore, the manufacturer's instructions for maintenance procedures are very important.

Precautions

- Use as low a laser output as possible.
- Fully enclose the laser system or use a precaution to limit the laser beams. Note that the protective cover must be checked after the slightest adjustment or repositioning of the optical systems.
- Wear suitable safety goggles against laser beams.
- Clearly define and restrict access to the laser use area exclusively for laser trained personnel (especially where there is eye contact).
- Make sure the laser beams (including surface reflections) are limited to one level (below the field of view).
- Remove all reflective surfaces from the laser area (including wristwatches and similar objects). Raise safely all the optical devices (optics).
- Follow the correct procedures in aligning the laser beams.

Prerequisites for training

Dealing with lasers, except Class I laser, classified in risk category B, so it MUST NOT TAKE MAKE TO WORK WITH LAZER CLASS II AND OVER IF THERE IS preceded by appropriate training.

Other Risk Level

It is impossible to completely eliminate the dangers of using a laser, but the risk is limited if the above procedures are followed.

Emergency Action

Turn off the laser, seek medical advice if you find or suspect damage to the eyes.

10. RISK ASSESSMENT: USE OF HIGH POWER, HIGH FREQUENCY MICROWAVES

Assessed activity

The use of high-power microwave (MW) and radio frequency (RF) for plasma production, heating, etc.

Dangers

- Involving biological effects of microwave heating and radio frequencies, especially in the eyes, *e.g.*, cataract, and soft tissues.
- Electric shock and burns (these vary, and may be much more severe than burns caused by ordinary electrical appliances).
- High temperatures associated with high power equipment.

Precautions

Make sure the equipment is properly:

- Examined and protected. Use an emission monitor to check that the microwave emissions are < 5 $mWcm^2$ @ 5 cm. For radio frequency emissions, a general rule of thumb is that if the lab LEDs or LCDs in the laboratory are blinking then they are affected by excessive radio frequency emissions, and so the power supply or conductors need more protection. Note that in this intervention level, the rest of sensitive electrical equipment that accepts to be adversely affected by the consequent effects on security. For example, mass flow regulators that detect (toxic, explosive) gases are particularly sensitive to radio frequencies, and may give erroneous measurements or be open/closed to the maximum without the user realizing it.
- Left to cool. If used with water cooling, make sure the water supply is properly connected with no possibility of leakage in the supply of electricity.
- Grounded. The cover of all power supplies MUST be earthed, and all electrical conductors must be protected with a coaxial cable.

Training Requirements

Training by an experienced person is essential.

Other Risks

Operating the microwave and radio frequency power supply always involves a certain degree of risk. That is why supervision is always necessary when such use is made.

Emergency Procedures

Stop the power supply and seek First Aid where necessary.

11. RISK ASSESSMENT: GENERAL OFFICE OPERATION

Dangers

- Internal settlement: Waste and temporary storage of items poses a risk of tripping.
- Power: There is risk of electrical damage or stumbling from electric cables.
- Storage: High or uncomfortable shelves, unstable items.
- Machines: Cutting machines, staplers, scissors and other sharp-edged objects.
- Lifting: Heavy or unstable objects.
- Musculoskeletal disorders from poor posture, poor arrangement of equipment and eye fatigue from lack power light, incorrect eyewear, fatigue and stress.

Precautions

- Maintain proper space in the office by paying attention to corridors and emergency exits.
- Electrical equipment, see Risk Assessment "Use of Basic Electrical Equipment". Portable electrical equipment (typewriters, computers, office lights, etc.) must be checked occasionally and bear a sticker to record date that the last check took place. Care must be taken so that the cables are not left exposed in corridors.
- No more than one cabinet drawer should be opened to prevent it from falling. Items should not be stored on high or unstable shelves.
- Dangerous machines such as cutters or shredders must be properly protected to prevent injury to fingers and hands. Special care is recommended with sharp edges. Even the edge of the paper can cause a painful cut.
- Be especially careful when lifting heavy or strangely shaped objects.

Education

In addition to general experience, those who work in an office need regular information and/or training on the use of office computer software.

Other Risk Level

Few risks but significant in the field of musculoskeletal disorders due to poor posture or typing techniques when using computer equipment.

12. RISK ASSESSMENT: AUDIOVISUAL EQUIPMENT

- Light, glow, reflection and noise. These factors are the general office specifications but apply to all work areas. Requirements include adequate but not excessive light, avoidance of glare and reasonable noise levels.
- Video presentation equipment: the screen should be positioned at such an angle that it is convenient to watch.
- Chairs and desks: chairs must have a base with at least five castors (asteroids) for stability and easy movement. They should also be rotated easily and have variable height and back support. Desks must have sufficient space for all equipment and documents, manuals, etc., and have the appropriate height as well as sufficient space for legs / knees.
- Keyboard: the position of the keyboard on the desk should be such that it allows 100 mm distance in front of the keyboard. The keys must be clearly marked.
- Foot rest: may be needed depending on the user's physical posture.
- Floor: The floor covering must be such as to allow easy movement of the wheeled items.

Dangers

- Repetitive strain injuries: a musculoskeletal condition whose symptoms include pain, soft tissue swelling, joint stiffness, loss of function, and possible permanent disability. Keyboard users who are not trained in typing are more prone to such problems.
- Visual Fatigue: Evidence suggests that the use of video presentation equipment is not associated with visual impairment although permanent illness may increase stress due to the use of such equipment.
- Fatigue and stress.

Precautions

- Avoid injuries due to repeated stress. Ensure ergonomically designed chair and posture arrangement when using the keyboard and mouse. Take regular breaks to rest your fingers and wrists or engage in alternative work as it does not involve using the joints in a similar way to typing.
- Eye fatigue. If eye damage is detected, users have the right to a visual examination and a complete ocular examination if necessary. If audio-visual work is assigned, basic eyeglasses can be given but remain the property of the University.
- Fatigue and stress are reduced by having a pleasant work environment. Informatics programs should be as short as possible "friendly for the user" and to allow recovery of lost information/errors. It is accepted that this is not always possible in the case of research but should be taken seriously when using office computing.

13. RISK ASSESSMENT: USE OF LABORATORY CENTRIFUGES, ESPECIALLY HIGH-SPEED CENTRIFUGES, AND OTHER HIGH-SPEED EQUIPMENT

- Laboratory centrifuge: the apparatus used in laboratories to separate different density materials or of different size particles when they are separated in a liquid, by rotation in a suitable container around an axis.
- Rotor: the main component of a centrifuge which holds the material to be subjected to a centrifugal force (in some form of tube/container) and which rotates by the propulsion system.

Dangers

- Mechanical damage to rotating components (often violent).
- Contact with rotating parts.
- Sample leaks leading to aerosol, corrosion due to stress conditions, contamination.
- Sample instability caused by mechanical movement/gait, or damage to components due to stress conditions.
- Fire or explosion.
- Health (contact with contaminated parts/fumes).

Mode

- Only properly trained individuals can operate centrifuges.
- Where necessary, the machine diary should be completed (keep a diary for high speed centrifuges as operating hours determine the life of the rotor).
- Before each use of the rotor, the cover and safety latch must be checked for cleanliness and damage (accumulation of leaked chemicals can clog the rotor tubes or cause corrosion which could lead to damage to the rotor). Damaged rotors should not be used and should be reported to the Supervisor. Contaminated centrifuges must be cleaned by the established method (see instrument manual).
- Never fill centrifuge tubes beyond the manufacturer's specified limit (see instrument manual).
- Never exceed the maximum indicated speed on any rotor.
- Reduce the rotor speed if the loading space exceeds the maximum indicated size.
- Balance the rotor at the indicated levels (make sure that identical weight materials are located at opposite positions on the mixer).
- Do not operate the centrifuge without the proper cover and safety of the rotor being secured.
- Check the compatibility of the tube material with that of the organic solvent (some solvents may cause the stirrer tubes to swell or crack).
- Use only tubes suitable for the application.
- Clean any chemical spills immediately.
- Do not use materials that are explosive, highly flammable or have a high chemical interaction without first consulting the appropriate safety precautions to reduce the risk of fume accumulation.

- Never open the centrifuge cover or lower the stirrer manually or open the cover while the stirrer is running as serious injuries may occur.
- The general inspection or repair the agitator must be made by authorized personnel with appropriate training. Technical faults must be reported immediately. Do not attempt repairs yourself. Do not use centrifuges until they are fully inspected and repaired.

Rotor care

- Corrosion can occur when particular combinations of reactive chemicals are used. If the rotor is not kept clean from chemicals, corrosion will occur. In addition, any moisture left for an extended period of time can cause corrosion. It is important to keep the rotor clean and dry. Wash with a mild detergent and hot water, the careful use of nylon brushes where necessary. Dry the rotor and store it upside down, removing the cover and tubing.
- Do not sterilize at temperatures above 100 °C.
- Do not expose aluminium stirrer components to acids or bases, laboratory alkaline detergents or salts (chlorides) or heavy metals, *e.g.*, caesium, lead, silver or mercury. Using them may cause corrosion.

Safety Checks Before Operation

- Make sure each tube chamber is clean and free of corrosion.
- Make sure the rotor is clean, free of corrosion or cracks and that there are no abrasions around the edges.
- Check that the centrifuge chamber and the agitator motor are clean, and abrasion free.
- Dry the drive surfaces before installing the rotor.
- If the chamber temperature is below room temperature, the rotor must be cooled to the lowest temperature before it can be secured.
- Make sure that any safety cover and any agitator speed control are fully secured before starting the instrument.

Education

New centrifuge users should be trained by an experienced user before attempting to use the centrifuge.

Other Risk Level

Centrifuges are potentially deadly equipment so they always need attention and supervision. Following the procedures described above reduces the risk to low.

14. RISK ASSESSMENT: USE OF VOLTAGE METER (POTENTIOSTAT)

The use of voltage meters in the laboratory involves the application of potentials with consequent passage of waves through soluble electrolytes and in such an application the risks associated with the combination of an electrical device and a conductive liquid medium are always present. In many cases, the voltage meter is guided and controlled by a computer. Therefore, the installation of the second electrical appliance must be considered. The use of conductive soluble ions, many of which are transient heavy metal ions and whose solvents often require the removal of gases, requires the operator to be familiar with the use and transport of compressed gas cylinders.

Dangers

The main hazards arise from the use of electrical appliances in combination with the presence of electrochemically active solvents as follows:

- The Cell contains non-insulated contact points and exposed electrode surfaces and therefore a large electric shock.
- Burns caused when a high-power current penetrates the body.
- Explosion or fire can be caused by electric sparks, short circuits, thermal overload, old wiring near flammable material.
- The derivatives of many electrochemical reactions are gaseous and are released in the limited volume of the cell. As a result, injuries may result from shattered glass and other debris as well as possible injury and contamination from explosion reactions.
- The electrochemical cell is designed to be opaque and glass, being the primary material preferred, poses potential injury from cutting by broken glass and poisoning resulting from cutting by contaminated glass.
- The degassing of solutions with inert gases is a normal operation. As such:
  - Compressed gas cylinders are very heavy and unstable objects and therefore pose a danger to those who handle them.
  - They contain gases which can be toxic, suffocating or flammable and high pressure.
  - In addition to the chemical risk from these gases, serious physical damage can be caused by exposure to high-strength leaking gases.
  - Gas cylinder valves are very durable but a broken valve can turn the cylinder into a deadly projectile. Gas pressure regulators are less resistant when damaged and may leak gas.
- Risks associated with computer use include:
  - Repetitive strain injuries, musculoskeletal disorders whose symptoms include pain, soft tissue swelling, limited joint movement, loss of function and possible permanent disability.
  - Keyboard users who are trained typists are more prone to such problems.
  - Fatigue Eye: The data demonstrate that the use of DSE, (Data Switching Exchange) is not associated with damage to the eyes or eyesight although permanent damage can increase the fatigue of dealing with such equipment.
  - Fatigue and stress.

Precautions

The operator must certify the following:

- The voltage meter, the cell design and the computer software meet the relevant specifications.
- Wiring of the voltage meter in the assembly of the cell was done carefully and with due care.
- Wiring is connected to the appropriate electrodes, the connectors are checked and tightly fastened at their point of application and that no excessive pressure is applied.
- At the start of the experiment, avoid contact with exposed electrically active area.
- All solvents and solutions are purified from the area in and around the tensiometer mode to avoid spillage and contamination and/or shock and explosion and fire from sparks associated with the use of flammable solvents.
- The cell is inspected to prevent pressure build-up due to the development of gaseous products. If harmful products occur, the cell should be placed in a laboratory funnel and appropriate precautions taken.
- The users are familiar with all aspects of gas removal process including the use of compressed gas cylinders and the dangers related to the use of sonication instruments.

Education

No special training is required in the use of voltage meters, although the operator should be aware of the relevant references and user manuals.

Other Risks

There will always be a risk of injuries related to electricity and injuries from sudden and unexpected gas leaks but with the correct handling of the functions the risks are reduced.

Emergency Procedures

Electric shock: If the gas leak is large, follow the procedure described in the Chemistry School Safety handbook with leaks of toxic materials: remember that even the inert gases can kill someone by suffocation. For small, non-toxic spills, contact the staff, ventilate the area, evacuate the area, lock and secure the location.
Cylinder drop: If a cylinder falls, NEVER attempt to catch it. It is very heavy and will cause serious damage. It is very durable and is unlikely to be damaged although it can make a lot of noise during the fall. Experienced staff should be called in to help lift it.
Cuts from glassware: You need to take immediate care of cuts and burns. In case of serious injury, call a First Aider for care.

15. RISK ASSESSMENT: MANUAL HANDLING

If the most well-known injuries (relating to the loss of quality of life) include back pain, which is usually due to manual handling. An additional number of people suffer from other types of injuries due to manual handling. Such as punctures and fractures etc.
It is in your best interest to know the basics of safe manual control and to think about what you and others are doing to avoid an accident that may leave you or others with a chronic condition that is likely to end in a lower quality of life. In this regard, we need to consider two different forms of lifting.

How to Lift Objects Correctly: Stop and Think!

Schedule the lift: Where will the load be placed? Use suitable accessories where possible. Do you need help with the load? Remove obstacles such as useless packaging. To lift an item high, from the floor to the shoulder, be sure to pause halfway on a table or bench to change grip.

Foot placement: The legs should be placed separately, for balance and on a stable base for lifting (tight skirts and inappropriate shoes make this task difficult). Extend the leg as far forward as comfortably possible.

Get the right attitude: Before you take the load on your hands bend the knees so that the hands are as close as possible to the average level but do not kneel nor exert excessive bending of the knees. Keep your back straight (holding your chin in helps). Tilt slightly towards the weight if necessary, to secure a good grip. Keep your shoulders straight and in the same direction as your hips.

Hold a tight grip: Try to keep your hands up to the limits of your feet. The best posture and nature of the grip depends on the conditions and preference of each individual, but it must be safe. The hook handle is less tedious than keeping your fingers open. If it is necessary to change the grip during the lift, make it as smooth as possible.

Avoid sudden push: Lifting must be done slowly, maintaining load control.

Place down, and adjust: If necessary, to adjust the precise positioning of the load, reposition the lifters and then push in the desired position.

Safe Lifting

Lifting and the safe handling requires more knowledge of the lifting method. Training people to lift and proper handling often does not provide enough protection after lifting and handling objects heavier than it should and therefore lose any advantage to provide the correct lifting of objects.

An important guide to safe lifting is that lifting becomes safer when there is cleanliness, when the space is tidy and spotless. It is MOST important to avoid manual manipulation when there is a way to do the job differently. Where possible, use mechanical means. A simple wheelbarrow or a manual buggy can reduce the burden.

Keep in mind that it is very tedious to CARRY loads. It is safer to move them using mechanical means. You should never carry heavy objects for more than 10 m without having previously planned the lifting and stopping points (albeit mentally).
A previous back injury presupposes a predisposition for further injuries. If you injured your back in the past, you must reduce the burdens until the point you consider safe for lifting. This requires to consider how serious was the previous trauma and your predisposition for injuries on the back (it was an isolated incident or injury or if there have been have frequent injuries; the latter is a bigger risk factor than the first).

16. RISK ASSESSMENT: HANDLING, TRANSPORTATION AND STORAGE OF LIQUID NITROGEN AND OTHER CRYOGENIC MATERIALS

Properties: Liquid Nitrogen

- The boiling point of liquid nitrogen is -195.8 °C.
- The volume of expansion of the liquid form into gases (at 15 °C, 1 atm.) = 682.1.
- Sg = 0.808 (at 195.8 K).
- Liquid density (normal boiling point, 1 atm.) = 0.807 g/cc.
- Colourless, odourless liquid similar in appearance to water.

Known or Expected Risks

a) Risks associated with temperature

- Extremely low temperatures of liquid nitrogen can cause severe skin burns either from contact with the liquid, from surfaces cooled by the liquid, or from gases released. The degree of danger is comparable to that of boiling water.
- The low temperature of the fumes can cause damage to soft tissues, *e.g.*, eyes and lungs but does not affect the skin after short exposure.
- The skin may freeze and stick to cooled surfaces of liquid nitrogen causing it to break off in an attempt to detach.
- Soft materials such as rubber and plastics become brittle when cooled with liquid nitrogen and may break unexpectedly.
- Liquid oxygen can be condensed into liquid nitrogen cooled tanks or containers. This is extremely dangerous due to the increase in pressure even at the lowest degree of heating beyond the boiling point of oxygen (-180 °C) as well as the possibility of explosive reactions with oxidizing materials.
- Containers can be damaged by overheating due to large and rapid temperature changes.

b) Hazards related to gases

- Large volumes of nitrogen gas are produced from small volumes of liquid nitrogen (1 L of liquid nitrogen produces 0.7 m^3 of gas) and this can easily displace normal air in poorly ventilated areas with a risk of suffocation. It should be noted that oxygen normally makes up 21% of the air. The atmosphere containing < 10% oxygen can result in brain damage and death (difficulty in breathing due to inhalation of excessive carbon dioxide rather than lack of oxygen).
- Oxygen levels < 18% are considered dangerous and entry into areas with levels < 20% oxygen is to be avoided.
- Compressed oxygen in leaking containers can explode with heating as a result of ice blockage.

Dangers

For an untrained person, the risk of injury is moderate with the most likely form of injury being cold burns. However, in exceptional cases, when large amounts of material are spilled indoors, suffocation can be fatal.

Who Might Be Injured?

The person who uses the material is most likely to be injured, but in the event of a large amount of material being spilled, everyone in the room may be affected.

Precautions

Mode

- Liquid nitrogen should never be used unless the room is adequately ventilated. This is especially true in the case of filling a hot container or transport tube or in the case of adding a hot object as a large volume of nitrogen gas develops. The safe volume of liquid nitrogen stored or used indoors is described below.
- Only containers or adapters which are specially designed for use with cryogenic liquids are permitted as non-specialized equipment may crack or break. In particular, vacuum bottles should not be used as this may cause entrapment resulting in the ejection of shattered glass.
- All vacuum cylinders (Dewar containers) must be protected from the possibility of splashing glass, due to mechanical damage or damage from excessive temperature by securing all exposed glasses either in insulated metal containers or by wrapping them with adhesive tape.
- Hot vacuum flasks should be filled slowly to reduce the possibility of reacting due to high temperature and to minimize leakage. Vacuum storage bottles/flasks should not be over-pressured when filling a spherical vacuum flask. The minimum possible pressure must be applied to maintain the smooth flow of the liquid.
- Liquid nitrogen tanks must be adequately ventilated and must not allow clogging due to ice formation.
- Care must be taken to avoid the formation of liquid oxygen in cold traps that are exposed to the atmosphere or the increase in the liquid oxygen content in a liquid nitrogen container which has been refrigerated for a long time. (Liquid oxygen has a blue appearance). Solid carbon dioxide (dry ice) should be considered as an alternative refrigerant when there is a case of accumulation of liquid oxygen. Most liquid nitrogen containers are closed except for a part of the neck of the bottle so that the nitrogen gas flowing out from the surface to keep the air from the liquid, thereby preventing poisoning by oxygen.
- Skin contact with either liquid nitrogen or objects cooled using liquid nitrogen should be avoided as severe burns may occur. You should wear gloves, safety cuffs or armbands that can trap liquid nitrogen away from the skin.
- Personal Protection Equipment (PPE), special protective glasses must be used to protect against splashes, cold vapours, glass damage devices or crumbling articles are cooled by using liquid nitrogen.

Personal Protection Equipment

The following equipment must be used when handling or disposing of liquid nitrogen:

- Face mask or safety goggles.
- Dry, insulated gloves for handling equipment that came in contact with liquid.
- Lab coats or overalls are recommended to minimize skin contact as well as trousers over the shoe/boot to prevent the shoes from getting wet in the event of a spill.

Avoid lack of oxygen/suffocation

- Liquid nitrogen should normally be used in a well-ventilated area. However, there are cases, *e.g.*, transporting vacuum cylinders to elevators when this is not possible. To avoid the risk of oxygen deprivation, the following should be considered:
  - Safe threshold in unvented spaces: Calculate the volume of the room in m^3 and the maximum nitrogen volume in m^3 (this is found by the volume of liquid in litres × 0.7). If the volume of nitrogen is > 0.15 of the volume of the room, special precautions or ventilation are required.
  - Leak during filling: during filling assume that 10% of the final volume may spill.
  - Loss during storage: the exhaust loss from a Dewar 51 L tank is expected to be 0.21 L/day.
- The transfer of liquid nitrogen via elevators. To avoid the risk of possible evaporation during, for example, prolonged malfunction of an elevator, empty liquid nitrogen cylinders must not be accompanied by elevators. It is best to have two people carry the Dewar bottles. One will be responsible for loading them and the other for picking them up at the destination floor. To prevent other people from entering the elevator, the elevator doors must be strapped.

Education

New users of liquid nitrogen should be instructed in its use by experienced members of the academic or technical staff. Training is required prior to any use of the Department's available liquid nitrogen equipment.

Other Risk Level

There is a significant risk when using liquid nitrogen from inadvertently concentrating oxygen in a closed system. Where possible, use another refrigerant, *e.g.*, solid carbon dioxide/liquid traps or baths. The recommended baths are isopropanol and glycol. It is recommended that these baths be used in place of liquid nitrogen when long-term storage is provided.

Properties: Solid Carbon Dioxide

- Sublimation point -78.5 °C.
- Melting point -56.6 °C.
- Expansion volume from solid to gas ~ 900 .

Risks and precautions

In addition to its inability to condense oxygen, the dangers associated with solid carbon dioxide are similar to those described for liquid nitrogen, *i.e.*, the dangers associated with temperature and gases. During use, the same precautions should be taken in relation to cold burns and suffocation.

Emergency Procedures

Temperature related procedures

- For brief, limited contact with cold material: cover the area with lukewarm water; used due to its high heat capacity. Be sure to get First Aid.
- Prolonged contact will require medical attention. Call for First Aid.

Processes related to gases

- In case a large amount of liquid nitrogen is spilled, evacuate the area and call for help.
- If you suspect that someone is suffering from suffocation, do not enter the affected area alone. Ask for help. Move the victim to fresh air and call for First Aid.
- If the victim is unconscious, call Security immediately.

17. RISK ASSESSMENT: MOVEMENT, STORAGE AND USE OF SOLVENTS AND OTHER FLAMMABLE LIQUIDS

Dangers

The main danger arises from the property of solvents as highly flammable substances but many materials are also described as harmful and/or toxic.

Risk of ignition. The most common risk of ignition in the laboratory is flammable liquids or vapours produced by them. A fire requires: i) an oxidizing atmosphere (usually air); ii) concentrations of flammable gases or fumes within the flammability of the substance; and, iii) a source of ignition. Under normal conditions, oxygen or air is always present and the best way of fire prevention is to isolate the vapours or the gases from ignition sources.

Some specific properties of flammable materials are:

- **Flash point**. The flash point is the lowest temperature at which a liquid has a sufficient vapor pressure to form a flammable mixture with air near the surface of the liquid. Many common organic liquids have a flash point below room temperature, *e.g.*, acetone (-18 °C), diethyl ether (-45 °C). It is important to note that some flammable liquids retain their flammability even at low concentrations of 10% by weight in water. Methanol and isopropanol have significant combustion below -38 °C and at concentrations reach the low points of 30% by weight in water. The typical high-performance liquid chromatography (HPLC) solvent mixture of acetonitrile/water from 15 to 30% acetonitrile becomes flammable.
- **Ignition temperature.** The ignition temperature (self-ignition) and limit is the minimum temperature required to initiate, or to cause self-sustained combustion, irrespective of heat source. It is essential that there is a spark to be provide ignition when the combustible gas arrives at autoignition. Carbon disulfide is particularly dangerous in this sense with an auto-ignition temperature of 90 °C. For diethyl ether, the auto-ignition temperature reaches 190 °C and the material may ignite from a heated plate.
- **The minimum and maximum explosion limits**. These limits determine the range of concentrations in mixtures with air (or oxygen by definition) which will propagate a flame and cause an explosion. The lower values of these limits are normally above the legal limits in the environment of a laboratory and workplace but may increase easily when material is spilled. Maximum flammability limits offer a small margin of safety since when a solvent is spilled in the presence of a flame source, it will reach the maximum limit very quickly and fire or explosion will occur before it reaches the maximum limit.
- **Ignition sources**. The most common sources of ignition in the laboratory are naked flames and heaters, but there are also a number of less obvious electrical sources such as refrigerators, stirrers, microwave ovens, etc. Keep in mind that fumes from flammable liquids are denser than air and may spread over bench and floor surfaces to seemingly distant sources of ignition.

Dangers
Solvents are in constant use and the risk of fire is significant with all the consequent risks to personal safety as well as damage to buildings. The scale of damages can vary from minor burns to death.

Procedures
Movement of solvents: The goal is to move the solvents to and from the laboratory, avoiding the risk of fire and toxicity that may occur when the liquid is spilled.

- Winchester type solvent bottles (2.5 L) should only be transported in carts or on suitable carriers with a maximum load of two carriers per person or on a suitable trolley, preferably with raised sides to secure the bottles.
- They must also be transported to these trolleys and plastic solvent dumpsters.
- A laboratory suit should be used as the first hurdle when spilling liquid.

When collecting solvents from the solvent store: The described procedures for collecting solvents must be followed. The collection of solvents should be done in pairs of individuals.

- Any possible sources of ignition should not be transferred to the solvent storage area.
- Any spills should be cleaned as described below in the "Emergency Procedures" section.

Solvent storage:

- The smallest possible amount of solvents should be kept in the laboratory.
- Solvents should be stored in non-flammable containers.
- Solvent glass bottles should be stored in fireproof cabinets when not in use, and not stored in the laboratory overnight.
- Solvents should not be stored with incompatible materials such as concentrated nitric acid (oxidizing agent).
- Solvent waste, and flammable cleaning solvents should not be left exposed in the open laboratory.

Use of solvents:

- Solvents and other flammable liquids should be used always considering the risk they pose to the lives of people and buildings.
- Under normal circumstances, they should always be used in fume hoods away from possible sources of ignition.
- Flammable solvents should never be disposed of in sinks.

Disposal of waste solvents: See the relevant risk assessment "Disposal of waste solvents".

Education
This assessment should be read by anyone using solvents and should reflect the method of collecting and storing solvents by new entrants. The use of solvents is part of the normal general education in Chemistry.

Other Risk Level
Solvents are used in large quantities in Chemistry and this may not change. This is why the ignition risk remains. Continuous supervision by users is required.

Emergency Procedure

- Spillage, no fire
  - **Serious spillage** – toxic & in large quantities. Evacuate and ventilate the affected room, closing the doors and eliminating sources of ignition if it is safe to do so. Call Security and Activate the NEAREST ALARM. DO NOT ATTEMPT TO CLEAN THE PLACE YOURSELF AFTER a large amount of liquid is spilled.
  - **Small spill.** Ventilate the affected area and neutralize the sources of ignition then evacuation and lock the room.

18. RISK ASSESSMENT: DISPOSAL OF WASTE SOLVENTS

This Risk Assessment should be read in conjunction with the section "Transportation, Storage and Use of Solvents and Other Flammable Liquids".

Additional Risks
Solvents to be disposed of are probably contaminated with unknown substances and should be handled with care.

Dangers
Additional risks of disposing of waste solvents mainly concern personnel who have the task of disposing of the material in metal containers. The hazards arise from the contamination of the solvents.

Organic Liquids Accepted as Waste Solvents
The Department is able to dispose of common organic solvents through a mechanism that is less bulky and expensive than other chemical wastes. A list of permissible solvents is given below.

Non-chlorinated

- Hydrocarbons: C5-C12 alkanes, cyclohexane, toluene, xylene.
- Alcohols C1-C3, ethylene glycol.
- Diethyl ether and tetrahydrofuran.

Chlorinated (halogenated)

- C1: dichloromethane, chloroform, carbon tetrachloride.
- C2: trichloroethylene, tetrachloroethylene, 1,2-dichloroethane, 1,1,1-trichloroethane.
- C3: 1-chlorobutane with small amounts of non-chloride material but without water.

Precautions

- Jars. Acceptable containers for transport of soluble waste are square decilitres barrels with a polyethylene screw cap. No other type of container is acceptable. Containers must not be filled to more than 80% of their capacity with permitted solvents. They must be secured with the original caps, without leaking fumes or liquid or excessive internal contamination.
- Marking. The container should be clearly numbered with serial numbers. Chlorinated or Non-chlorinated. See "Disposable Solvent Waste".
- Save. Separate containers of chlorinated and non-chlorinated solvent waste should ideally be stored in a fume hood. The large polyethylene solvent containers are flammable and highly sensitive to fire and should be kept in closed cabinets when not used for disposal of waste solvents.
- Collection. The waste solvent shall be transported with a suitable trolley to the Waste Storage Room. The technical staff is authorized to refuse receiving receptacles which do not meet the criteria described in the 'Capacities' section.

- Solvent bins are not waste bins and are used exclusively for waste organic solvents with limited amounts of solute, which should not pose a risk to the health of staff in the Department of Chemistry. The Department has a duty to reject the solvents in larger containers.
- Reaction mixtures, oxidants or oxidizing solvents must never be placed in solvent disposal containers.
- Carcinogens of any kind should not be disposed of in solvent wastes.
- Under no circumstances should waste solvent containers contain paper towels, vials, glass pipettes, hypodermic injection needles or any other foreign body.

Education

Training in these procedures should be provided by an experienced person in each laboratory.

Other Risk Level

Careful handling reduces the risk to a minimum. Nevertheless, solvent waste remains flammable and of unknown toxicity and should be treated with extreme caution.

Emergency Procedures

- Spillage, no fire
    - **Serious spill** – toxic in large quantities. Evacuate and ventilate the affected area by closing the doors and neutralizing the ignition sources if this is considered safe. Call Security and ACTIVATE THE NEAREST ALARM. DO NOT ATTEMPT TO CLEAN THE SPILL YOURSELF.
    - **Small spill.** Ventilate the affected area eliminating ignition sources. The liquid can be absorbed by absorbent granules available at fire alarm points or in the laboratory (replace after each use) and then transferred to a fume hood or a suitably secured container for disposal. In a well-ventilated area such as the laboratory, the best procedure is to neutralize the sources of ignition, ventilate, evacuate, close and secure the room.

19. RISK ASSESSMENT: USE OF COMPRESSED SODIUM TO CREATE SODIUM GRID FOR DRYING SOLVENTS

This Risk Assessment should be read in conjunction with the section "Transportation, Storage and Use of Solvents and Other Flammable Liquids".

Known or Expected Risks

- Extensive sodium fire and solvent ignition.
- Fire due to incorrect disposal of unused sodium.
- Violent reaction between sodium and unsuitable solvents.
- Pressure accumulating in solvent flask after sodium addition.

Precautions

- **This function should never be attempted by an untrained person.**
- **This function should never be attempted by a single person.**
- **This function should never be attempted outside of normal working hours.**
- Laboratory uniform, gloves and safety goggles should be used.
- Do not have a naked flame within a radius of 6 m.
- No other flammable chemicals should exist within 3 m.
- If residue remains on the press from a previous operation, great care must be taken in cleaning it.
- Sodium compatible solvents should be used.
- The solvent flask must be held firmly in place.
- After operation, the solvent flask should be placed in a laboratory fume hood for 18 hours with the cap loosely screwed on.
- Unused sodium should be carefully disposed of.
- To keep the press safe for future use, it must be perfectly cleaned. Glass bottles containing sodium and solvents need special care. A related incident occurred in a Department of Chemistry where during the transport of such a flask, the flask fell and shattered on the edge of a bench. The person carrying it slipped into the liquid solvent that was spilled and fell into the pool of liquid created by absorbing the liquid in his clothes. Thanks to the quick reaction of a colleague who handled the exposed sodium a terrible accident with serious burns was avoided.

Other Risks

If the above procedures are followed, the risk of injury is small. But any fire resulting, has the potential to be severe, especially when highly flammable solvents are used. It is therefore important that those undertaking this function be familiar with the proper handling of solvent fires.

20. RISK ASSESSMENT: THE SMALL-SCALE USE OF PYROFORIC CHEMICALS

Dangers

Pyrophoric chemicals are those which ignite spontaneously in air under 45 °C. Therefore, the main hazard arising from the use of these materials is related to fire, either from direct contact with flammable materials or as a result of secondary fires that occur after ignition.

The most commonly used pyrophoric chemicals are alkyl lithium, trialkylaluminum and alkyl borane. *tert*-BuLi is the most pyrophoric material from the organolithium reagents and *n*-BuLi is also pyrophoric in concentrated solution, *i.e.*, ~ 10 M.

These reagents are supplied in the form of a solution, alkane, arene or ether. The pyrophoric risk increases with increased concentration.

Dangers

For an untrained person, the most likely source of injury is fire (possibly) with moderate to severe injuries.

Who Might Be Injured?

Users are most likely to be injured, and if a secondary fire occurs, the damage can be extensive inside and outside the laboratory.

Control Measures

Natural: Materials should be stored in a dry, inert atmosphere in secured containers or preferably in tubes secured with a J-Young type cap. Operation must be carried out in a fume hood above the overflow basin.

Training: All firefighters should be trained by their Research Supervisor or by an experienced person nominated by their Research Supervisor.

Laboratory uniforms, safety goggles and suitable gloves should be used.

Operation Precautions

- Pyrophors should not be used outside of normal working hours, *i.e.*, between 8 am and 6 pm. Monday through Friday.
- The transport of pyrophoric materials must be carried out with a syringe which has a needle that locks to prevent its accidental displacement. For transportation of large quantities, it is preferable to use cannula using inert gas. However, great care is needed to avoid over-pressurisation of the containers.
- Dry sand should always be somewhere close as a means of extinguishing fires. A small amount of sand is able to extinguish any fire that occurs at the tip of the syringe and absorb the last drops of reagent from the syringe.

Other Risks

Even for experienced workers, pyrophoric materials pose a risk of injury. Pyrophors should never be used by undergraduate students without approval by a Supervisor.

Emergency Procedures

- *Fire:* In case material ignites, it must be neutralized with dry sand and left to evaporate/hydrolyze. Activate the Alarm and evacuate the Building. Anyone activating the alarm must notify the University Security IMMEDIATELY.
- *Skin contact:* Wash affected area with water and seek first aid.

21. RISK ASSESSMENT: USE OF FLAMMABLE, EXPLOSIVE AND TOXIC GASES

Dangers

- Leakage or release of flammable gases may pose a serious risk of explosion in the laboratory.
- Acetylene, hydrogen, ammonia, sulfuric acid, propane and carbon monoxide are particularly dangerous substances.
- Hydrogen flames may be invisible and therefore difficult to detect.
- In addition to the risk of explosion, the gases may react, *e.g.*, oxygen and highly toxic gases, carbon monoxide.

Inert gases such as nitrogen, carbon dioxide and argon may cause asphyxiation if released in large quantities.

Dangers

Leakage of any flammable, explosive or toxic gas is very serious and poses an exceptional risk to anyone present in and outside the laboratory.

Precautions

- These gases should only be used in a fume hood or in a well-ventilated laboratory.
- Strictly prohibited the existence of naked flames or sources of ignition in the area.
- Gas cylinders, control valves and pressure regulators must be used carefully in accordance with the manufacturer's specifications. Broken or damaged equipment should not be used but replaced. Only suitable equipment, *i.e.*, one specifically designed for the use of toxic, explosive or corrosive gases, should be used.
- The smallest possible cylinder size that is practical for use should be used.
- Leaks should be checked regularly, especially at joints. However, leak detection fluids should not be used on oxygen lines unless they are considered compatible. NAKED FLAME SHOULD NOT BE USED TO LOCATE LEAKS. The possibility of using a gas detector in the detection of leaks must be considered.
- The possibility of using an automatic gas cylinder shut-off in the event of an emergency must be considered.
- Containers must be able to accept the gas at the required operating pressure.
- Before the insertion of a flammable gas to a reactor vessel, the equipment must be free of oxygen by evacuation or via rinsing with an inert gas, at least 3 times.
- Ventilation ducts must be adequate, *i.e.* in a fume hood.
- Gas (fuel) cylinders must not be placed in the same location as oxygen.
- Where possible, flammable gas cylinders, *e.g.*, hydrogen should not be placed in emergency exits.

Prerequisites for Training

It is necessary for the training to be done by an experienced person.

Other Risks
The handling of flammable and toxic gases will always involve some degree of risk and therefore requires constant monitoring during their use.

Emergency Procedures
Leakage

- If the leak is small, try to close the bottle valve but do not put yourself in danger. Neutralize all ignition sources and evacuate the laboratory. CAUTION when approaching a possible hydrogen leak, as the gas burns with an almost invisible flame. Carry a wrapped newspaper in front of you to locate the flame.
- If the leak is large, evacuate the laboratory and activate the Alarm.
- After a large-scale suffocating gas leak, *e.g.*, nitrogen, argon, do not return to the laboratory without permission. Lack of oxygen may not be obvious but the effects will be fatal. Note that choking gases may be heavier than air and settle to the floor or to low levels.

Fire: Evacuate the room and activate the alarm.

22. RISK ASSESSMENT: USE OF CANCER FIBROGENS, MUTAGENTS AND REPRODUCTIVE TOXIC SUBSTANCES

In this Risk Assessment, the term "Carcinogens" covers all materials that are carcinogenic, mutagenic, or toxic to reproduction (CMRs).

Dangers
Risk of premature death.

Precautions
Avoid Exposure.

As is usual for hazardous materials, the first method of protection is to avoid exposure to these materials using safer alternatives. If there is an alternative whose use is 'reasonably practical' then this should be done. But carcinogens, toxic and other properties of potential chemical substituents must be identified and considered when studying changes. Synthetic materials should be selected to avoid the use of carcinogenic raw materials and to avoid, where possible, the formation of by-products, chemical intermediates, waste or contaminants or carcinogens.

However, if there is no practical alternative to the use of carcinogens, then a written Risk Assessment Form for the substance must be completed, justifying its use and a copy of the assessment must be given to the Department Safety Committee.

Exposure Control
If using a safer alternative substance is not reasonably practicable, then ensure adequate exposure controls are in place. In the case of carcinogens, it is important that the exposure to be under controlled condition and as low as possible, considering the high risk of death associated with many forms of cancer and the fact that the exposure level only affects the incidence of cancer in the exposed population rather than severity of the disease at the individual level.

The following regulations should be implemented or emphasized:

- All users with carcinogens must be familiar with the risks associated with the use of substances and ways in which/the specific substances can penetrate the body, either by inhalation, ingestion or penetration through the skin, through mucosal surfaces or eyes. This requires an extensive study of Security Data Forms and other sources of information.
- The preferred method of controlling exposure is to completely limit the substance or process. This is unlikely in a research environment but should be applied where reasonably applicable.
- The number of people who may be exposed to carcinogens and the duration of exposure should be kept to a minimum.
- The minimum possible amount of carcinogens should be used. This also applies for the storage material that should be minimized.
- Carcinogenic materials should be stored in closed containers with clear markings and obvious warning signs. It is preferable that all containers of carcinogens be

stored in locked, ventilated cabinets with overflow basins and clearly marked hazard warning signs.

- The carcinogenic materials, stored under normal conditions in glass containers, to be carried in resistant, secondary containers that are large enough and able to contain any spillage or breakage.
- Carcinogenic materials must be used in an effective good quality fume hood.
- Appropriate protective clothing should be worn with gloves made of a material that provides genuine protection against skin contact.
- Great care must be taken to prevent the spread of contamination from the site of use. This requires the following precautions:
  - Materials should be weighed exclusively in an efficient fume hood, or other well-ventilated enclosure.
  - Care must be taken to avoid contamination of the outside of the containers. If such contamination occurs, it must be cleaned in the fume hoods before being returned to storage and the cleaning material must be disposed of as carcinogenic waste.
  - Care must be taken to avoid the formation of dust or processes which will produce aerosols.
  - The devices must be cleaned in fume hoods and any washing materials, including solvent, should be from packaged carefully as waste. Alternatively, all carcinogenic residues should be chemically disposed of - in which case the disposal process should be recorded as part of the Assessment.
  - Spills inside the fume hoods must be carefully cleaned and any materials used must be disposed of as chemical waste.
  - Gloves should be disposed of as carcinogenic chemical waste. Users should never touch door handles, light switches or telephones wearing (possibly contaminated) gloves or wear such gloves outside the Laboratory. Gloves should be removed using the appropriate 'surgical' procedure to avoid skin infection.
  - Users must practice careful hygiene, wash and dry their hands thoroughly before leaving the laboratory.
- The use of sharps in laboratory procedures should be avoided due to the additional risk of injury. Disposable cutting objects, including broken glass, must be disinfected before disposal and washing materials must be considered as carcinogenic chemical waste.
- Waste must be stored securely and clearly labelled before disposal. Carcinogenic materials should never be disposed of via the waste disposal method.

Accidents

Spillages: Great care must be taken not to spill any carcinogenic material outside the fume hoods or ventilated area. If this happens, it is necessary to evacuate the area, close all the doors and warn everyone about the danger. Security must be notified.
Loss of Services: The work must be stopped, carefully remove gloves and be leave the place closing the sash of the hood and the laboratory evacuated to restore service.

23. RISK ASSESSMENT: USE OF EXTREMELY TOXIC SUBSTANCES

Notes
The description "Very toxic" is described as follows:

Acute fatal effects:

- R28 'Very toxic if swallowed': LD_{50} (mean lethal dose), oral, rat ≤ 25 mg/kg: less than 10% survival at 5 mg/kg orally, rat.
- R27 "Toxic to skin", LD_{50} (average lethal dose), dermal, rat or rabbit: ≤ 50 mg/kg.
- R26 "Very toxic by inhalation", LD_{50} (average lethal dose), inhalation, rat, for aerosols or particulate matter (powder) ≤ 0.25 mg/L/4 h.
- LD_{50} (average lethal dose), inhalation, for gases and fumes, rat, ≤ 0.5 mg/L/4 h.

Non-lethal, permanent effects after a single exposure:

- R39 "Risk of very serious permanent effects": Permanent damage may be caused by individual exposure by the appropriate route, at the doses generally described above. To indicate the route of exposure, combinations of Risks be used *e.g.*, R39/23, *i.e.* "Risk of very serious permanent effects by inhalation".

Dangers
High risk of death from a single dose. For a husky 80 kg person, ingestion of less than 0.5 g of an R28 substance can be fatal. It should be noted that this is the upper limit – some substances may be more toxic than this. Smaller doses may not be lethal but very harmful.

Precautions
Exposure protection: As is customary for hazardous materials, the first protection method is to avoid exposure to specific materials using safer alternatives. If there is an alternative whose use is 'reasonably practical' then this should be done. But carcinogens, toxic and other properties of potential chemical substituents must be identified and considered when studying changes. Substitute chemicals should be selected to avoid the use of carcinogenic raw materials and to avoid, where possible, the formation of by-products, chemical intermediates, waste or contaminant residues or carcinogens.
Despite this, if there is no practical alternative to using these substances, then a Risk Assessment Form must be completed for that substance, justifying its use of a copy should be given the Departmental Security Committee.

Exposure Control: If the use of a safer alternative is not reasonably applicable, then adequate exposure control must be ensured.

The following regulations should be implemented or emphasized:

- All users of highly toxic substances should be aware of the dangers associated with substance use and the ways in which the substance(s) may enter the body, whether by inhalation, ingestion, or through the skin, through mucosal surfaces or eyes. This requires extensive study of Safety Data Sheets and other sources of information.

- The preferred method of controlling exposure is to completely limit the substance or process. This is unlikely in a research environment but should be applied where reasonably applicable.

The number of people who may be exposed to highly toxic substances and the duration of exposure should be kept to a minimum.

- The least possible amount of highly toxic substances should be used. This also applies to storage material which should be as small as possible.
- Highly toxic substances should be stored in closed containers with clear markings and obvious warning signs. It is preferable that all containers of highly toxic substances be stored in locked, ventilated cabinets with overflow basins and clearly marked hazard warning signs.
- Very toxic materials stored under normal conditions in glass containers must be transported in resistant secondary containers that are large enough and able to contain any spillage of breakage.
- Highly toxic materials must be used in an efficient good quality fume hood.
- Appropriate protective clothing should be worn with gloves made of a material that provides genuine protection against skin contact.
- Great care must be taken to prevent the spread of contamination from the site of use. This requires the following precautions:
    - Materials should be weighed exclusively in an efficient fume hood, or other well-ventilated enclosure.
    - Care must be taken to avoid contamination of the outside of the containers. If such contamination occurs, it must be cleaned in the fume hoods before being returned to storage and the cleaning material must be disposed of as chemical waste.
    - Care must be taken to avoid the formation of dust or processes which will produce aerosols.
    - The devices must be cleaned in a fume hood and any washing materials, including solvents, should be stored carefully as waste. Alternatively, all carcinogenic residues must be chemically destroyed - in this case, the disposal process must be recorded as part of the Assessment.
    - Spillages etc. inside the fume hoods must be carefully cleaned and any materials used should be disposed of as chemical waste.
    - Gloves should be disposed of as chemical waste. Users should never touch door handles, light switches or telephones wearing (possibly contaminated) gloves or wear such gloves outside the Laboratory. Gloves should be removed using the appropriate 'surgical' procedure to avoid skin infection.
    - Users must practice careful hygiene, wash and dry their hands thoroughly before leaving the laboratory.
- The use of cutting objects in laboratory procedures should be avoided due to the additional risk of self-injection.
- Disposable cutting objects, including broken glass, must be disinfected before disposal and the washing materials must be considered as chemical waste.
- Waste must be stored securely and clearly labelled before disposal. Highly toxic material must never be disposed of through waste solvent disposal method.
- **The procedures involving the use of these materials should never be attempted by untrained persons.**

- **Procedures involving the use of these materials should never be attempted outside of normal working hours.**
- **Procedures involving the use of these materials should not be undertaken by someone who works alone and for large-scale ventures, employees should work in pairs.**

Other Risk Level

Continuous monitoring is required when using these materials but the risk is small as the procedures described above are followed.

Emergency Procedures

- Skin contact. Wash immediately with soap and water and remove contaminated clothing. Call First Aid.
- Eye contact. Wash with plenty of water. Call Security.
- Ingestion. Get immediate medical attention. Call Security.
- Inhalation. Get immediate medical attention. Call Security.
- Loss of Services: Work must be carefully stopped, gloves removed and left in place, the fume hood sashes closed and the laboratory evacuated until services are resumed.

24. RISK ASSESSMENT: USE, HANDLING AND CLEANING OF MERCURY PROCEDURES

Dangers

- Mercury is a poison that is easily absorbed through the respiratory tract or through the skin. It acts as a cumulative poison since only small amounts of the element can be neutralized at a time. The existing accepted limit of mercury in the atmosphere is 0.05 mg/m^3 (air saturated with mercury at 20 °C exceeds the toxicity limit by 100 times). High gas concentrations can cause a metallic taste, nausea, abdominal pain, vomiting, diarrhoea and headache. Chronic effects from continuous exposure to low concentrations of mercury can cause nervous disorders, insomnia, memory loss, irritability and depression. Teeth loosening, dermatitis and kidney failure are also possible side effects after prolonged absorption.
- Mercury may react with ammonia to produce an explosive solid. It can cause extensive corrosion problems due to its ease of forming amalgams. Reacts strongly with dry Bromine.

Precautions

- Mercury should only be transported in small quantities in plastic containers (glass bottles are unsuitable as a possible breakage will result in a large area leak).
- Mercury should only be used in a fume hood, above a suitable plastic tray (mercury may react with a metal tray or be absorbed by a porous tray, *e.g.*, wood).
- Skin contact should be avoided. Wash your hands thoroughly after using mercury.
- A secondary storage space should be used for all devices containing Mercury, *e.g.*, manometer, McLeod type meters, mercury switch, mercury diffusion pumps (the general tactic is to gradually withdraw and be replaced by safer oil diffusion pumps). You also need to be careful with mercury in glass thermometers.
- As for the vacuum pumps containing mercury, the pump exhaust must always be ventilated.

Emergency Procedures

Leaks

- All spills must be cleaned up immediately using the specified methods and equipment available exclusively for this purpose. When spilled, mercury breaks into very small drops covering large area avoid the spread of contamination by limiting access to the affected area and using only the predefined cleaning materials (*e.g.*, brush, mop or duster).
- If mercury is spilled on a hot surface (hot plate, heating mantle, electric heater, radiator) evacuate the room as large concentrations of mercury gases may be generated.

Spill Decontamination
TO MINIMIZE THE CONTAMINATION USE ONLY THE SPECIAL EQUIPMENT FOR DISINFECTING MERCURY AND DO NOT USE EQUIPMENT THAT IS MEANT FOR ANY OTHER PURPOSE.

The spill should be cleaned if possible by mechanical means, *e.g.*, either from a manual hood, or for larger spills, using the suction trolley designated for this purpose. The affected area of the small mercury drops (or has been identified as contaminated by the detector of mercury) must be covered by a paste containing equal parts of slaked lime (calcium hydroxide) and of sulfur, mixed with enough water to produce a yellow mixture. The paste shall be applied for 24-48 h and then removed by careful wiping with a dust brush before and cleaned with water to remove all residues (several washings may be required).
Before the next use of the area, a second mercury test must be carried out to ensure that the contamination has been neutralized.
Sometimes a second application is considered necessary. Equipment must be decontaminated after each use.

Waste Disposal

- Liquid mercury for disposal should be carefully transported in clearly labelled plastic bottles and added to the chemical waste.
- The paste and infected items, *e.g.*, paper and small pieces of broken glass must be sealed in suitable containers bearing a clear marking.

Other Risk Level

The level of other risks may be low as the procedures recorded here are followed. It should be clear that items/surfaces in the Department of Chemistry may have been previously contaminated by mercury from prior carelessness.

25. RISK ASSESSMENT: USE OF HYDROFLUORIC ACID (HF), Dangers: CORROSIVE - TOXIC

- Causes severe burns.
- Very toxic by inhalation, in contact with skin and if swallowed.

Hydrofluoric acid has several properties that make it particularly difficult to handle.

- Hydrofluoric acid reacts with glass, cement, some metals and organic compounds.
- Although hydrofluoric acid in gaseous form is one of the most acidic gases in existence, in liquid form it is a very weak acid. Despite this, the definition of 'weak' does not describe in any way the ability of hydrofluoric acid isopropyl ester to destroy living tissue because the fluoride ions are quickly absorbed and penetrates the bones. Hydrofluoric acid damage causes chronic unbearable pain and burns that heal slowly. Burns around the fingertips are considered very painful and may require surgery to remove the nails.
- Fluoride ions are toxic to such an extent that even a 1% hydrofluoric acid solution (or metal fluorides) should be treated carefully performed. However, the ability of hydrofluoric acid to transport fluoride ions to the skin increases dramatically with increasing concentrations. Therefore, 2.5 M hydrofluoric acid must have the same handling required for 10 M H_2SO_4. At concentrations > 10% (5 M), the risk of using hydrofluoric acid increases dramatically and any contact with the skin for more than a few seconds may cause lingering burns that will take hours before causing pain. Manufacturers normally supply hydrofluoric acid as a 48% (28 M) solvent and in some cases as a 73% (44 M) solvent. Handling hydrofluoric acid at such concentrations is more dangerous than handling any other concentrated acid.

Precautions

- Hydrofluoric acid with a concentration of > 10% (5 M) must be stored in cool, well-ventilated space in a polyethylene container (or equivalent) with a screw thread cap. It is not recommended to keep these acids in the laboratory unless an assessment has been made covering the possible use by each of the laboratory workers.
- Users should refer to an updated Material Safety Data Sheet or Security Labs Form.
- A detailed Risk Assessment Form must be completed and approved by the Safety Committee prior to any use of hydrofluoric acid. Even if 5% acid solution is used, the assessment must determine how safely the concentrated commercially available acid solution dissolves. The main danger in this project is the leakage or splashing of the concentrated acid or the inhalation of hydrofluoric acid fumes as only a small amount of heat leads to dissolution.
- The competent First Aider who is trained in hydrofluoric acid burns care should be informed by the Research Supervisor if any researcher will handle hydrofluoric acid > 10%. Supplies of gelatinous calcium gluconate should be made available.

- **Procedures for the use of hydrofluoric acid should never be attempted by untrained persons.**
- **Procedures for the use of hydrofluoric acid should never be attempted outside normal working hours.**
- **Procedures for the use of hydrofluoric acid should never be attempted by someone who works alone and for large-scale ventures, workers should work in pairs.**
- All procedures must be performed in a suitable fume hood.
- It is strongly recommended that pre-test procedures that are new to the hydrofluoric acid user be recorded as a protocol before using the acid.
- Appropriate personal protective equipment should be used, *i.e.* safety goggles (or preferably a face mask), polyvinyl chloride or neoprene gloves which are frequently and carefully inspected for piercing damage, a laboratory suit and preferably a chemical-resistant apron.
- It is recommended to wash your hands and gloves frequently with water when working even with hydrofluoric acid solutions.
- Disposal: < 10 mol of hydrofluoric acid can be slowly added to plenty of water which runs into the sink. The flow of water must be continuous for a sufficient period of time after the acid has been discarded to ensure that the sink has been thoroughly cleaned of all acid.

Education

It is essential that the training be conducted by a experienced person before using this material.

Other Risk Level

Continuous supervision is required when using these materials but the risk may be small if the above procedures are followed.

Emergency Procedures

Skin or eye exposure: Immediate wash with plenty of water. Call for First Aid. Even if there is no obvious immediate pain, the affected areas should be treated with calcium gluconate in gelatinous form. Seek medical attention for any exposure to hydrofluoric acid.

Leaks

- For extensive leaks follow the procedure recorded in Toxic Material Release.
- Small spills (100 mL or less <10% solution) can be neutralized with sodium carbonate or sodium hydroxide solution. You must use gloves, lab coat and eye protection equipment.

26. RISK ASSESSMENT: USE OF CYANIDES: Dangers: VERY TOXIC

Even small amounts of 50-150 mg of these salts or liquid solutions can result in death. Poisoning may occur from inhalation of cyanide solution vapours and from inhalation of hydrocyanic acid (HCN) produced by the reaction of cyanides with acid and water. Symptoms of non-fatal poisoning include weakness, headache, dizziness, shortness of breath, nausea and vomiting.

Dangers

For an untrained person, the risk of injury is high with serious to fatal injuries.

Who Might Be Injured?

The most likely casualty is the person using the material even though the production of hydrogen cyanide in an open laboratory has serious consequences for all those present.

Precautions

- Metal cyanides and the most toxic organic cyanides should not be stored on open shelves in a laboratory. They should be stored in well-ventilated and locked, preferably locked cabinets.
- A Risk Assessment Form must be completed and approved by the Safety Committee before any use of these materials. The materials are distributed exclusively from the Chemistry storage after the approval of the Security Committee.
- First Aiders trained in the treatment of cyanide poisoning, should be informed of the potential user and be informed about any scheduled task.
- Reference should be made to an up-to-date Material Safety Data Sheet or Laboratory Safety Data Sheet.
- **Procedures for using these materials should never be attempted by untrained individuals.**
- **Procedures for the use of these materials should never be attempted outside of normal working hours.**
- **The procedures for using these materials should never be attempted by someone working alone and for large-scale ventures, employees should work in pairs.**
- All operations, including material weighing, must be performed exclusively in an efficient hood.
- Appropriate protective equipment, *i.e.* gloves, laboratory uniform and safety goggles must be used.
- There must be available indirectly to large container of ferric sulfate solution in liquid form for immediate immersion of the entire equipment containing or contacted with this material (paper, spatula, etc.) and for neutralization of small spills.

Education

It is essential that the training be conducted by a trained person before using this material

Other Risk Level

Continuous monitoring is required when using these materials but the risk is small as the procedures described above are followed.

Emergency Procedures

- Skin contact. Wash immediately with soap and water and remove contaminated clothing. Call the First Aider.
- Eye contact. Wash with plenty of water. Call Security.
- Ingestion. Get immediate medical attention. Call Security.
- Inhalation. Get immediate medical attention. Call Security.
- Loss of Services: Work must be carefully stopped, gloves removed and left in place, the hood sash closed and the laboratory evacuated until services are resumed.

27. RISK ASSESSMENT: USE OF GAS DIVORANI (B_2H_6); Dangers: Flammable - TOXIC

Use in conjunction with the Risk Assessment for Toxic, Explosive and Flammable Gases.

- Extremely toxic when inhaled.
- Exposure to the atmosphere or halogenated compounds may result in fire and explosion.

Properties of Diborane

- Diborane is a colourless gas.
- Boiling point at -93 °C.
- Melting point at -165 °C.
- The gas density is 0.96 (air = 1.0). Diborane gas is lighter than air.
- Flash point at -90 °C.
- Auto-ignition temperature at 38 to 52 °C.
- Exposure limit 0.1 ppm.
- The smell of Diborane is not detected below the permissible exposure limit.
- Diborane is a flammable gas that ignites spontaneously in a humid atmosphere at room temperature and forms explosive mixtures with air from 0.8 to 88% by volume. Strong explosions may follow an ignition.
- It explodes when it comes in contact with: fluorine, chlorine (forms an explosive compound dimethyl sulfoxide), halogenated hydrocarbons (*e.g.*, chloroform and carbon tetrachloride), evaporating nitric acid, tetravinyl and trifluoride. Therefore, does not constitute through fire-extinguishing as Halon (halides), or carbon tetrachloride.
- Diborane is a powerful reducing agent that generates hydrogen by heating to a reaction with the water.

Precautions

- Follow the instructions for other toxic gases listed in the Use of Flammable, Explosive or Toxic Gases.
- Procedures for using Diborane should never be attempted by untrained persons.
- Procedures for the use of Diborane should never be attempted outside of normal working hours.
- The procedures for using Diborane should never be attempted by someone working alone and for large-scale ventures, employees should work in pairs.
- Diborane should only be used in a fume hood, free of ignition sources and should be stored in a cool, well-ventilated area separate from incompatible substances and isolated from sources of sparks and naked flame.
- Diborane is incompatible with aluminium, lithium, and other active metals as it forms metal hydrides that may ignite spontaneously. Diborane is incompatible with oxidants, halogens, and halogenated compounds. Diborane reacts with some types of plastics, rubber and coatings.
- Carbon dioxide extinguishers should be used to extinguish fires caused by diborane. Diborane-related fires sometimes release toxic gases such as boron oxide fumes.

Toxicity
Toxicity has not previously had serious effects on skin and mucous membranes, but high concentrations may cause eye irritation, and contact with liquid may cause burns. Chronic exposure to low concentrations of Diborane can cause headaches, dizziness, fatigue, muscle weakness, and tremors. Repeated exposure may cause chronic respiratory problems, especially in sensitive individuals. An existing dermatitis can be aggravated by repeated exposure to the fluid. Diborane has not been reported to have carcinogenic, reproductive or developmental effects in humans.

Education
It is essential that the training be conducted by a trained person before using this material.

Other Risk Level
Continuous supervision is required when using these materials but the risk may be small if the procedures listed above are followed.

Emergency Procedures
Skin or eye contact
- In case of skin contact, rinse immediately with soap and water and remove contaminated clothing.
- In case of contact with eyes, rinse immediately with plenty of water for 15 min (raising upper and lower lashes frequently) and seek medical advice. If the material is inhaled, move the person to fresh air and seek immediate medical attention.

Leakage
- If the leak is small, try to close the bottle valve but do not put yourself in danger. Eliminate all sources of ignition and evacuate the laboratory.
- If the leak is large, empty the laboratory and activate the Alarm. You may need a respirator and clothing.
- People who have been affected by inhalation should seek immediate medical attention.

Fire
- Evacuate the room and activate the alarm.
- Sprinkle the container with water to cool and reduce corrosive fumes, keeping in mind that although the flames have been neutralized, an explosive re-ignition may occur.

28. CHEMICAL STORAGE INSTRUCTIONS

Class of chemicals	Danger Signal	Recommended Storage Conditions	Examples	Incompatibilities
Generally non-reactive chemicals		Store on common lab counters or shelves, preferably behind glass doors, or below the visual level.	Agar, sodium chloride, sodium bicarbonate, and most non-reactive salts.	
Corrosives – Salts		Store in a separate acid storage cabinet.	Mineral acids - Hydrochloric acid, sulfuric acid, nitric acid, perchloric acid, chromic acid, chromium.	Flammable liquids, flammable solids, bases, oxidants.
Corrosive – Bases		Store in a separate cupboard.	Ammonium hydroxide, sodium hydroxide.	Flammable liquids, oxidants, poisons and acids.
Explosives, Shock Sensitive Materials		Store in a safe place away from other chemicals.	Nitric urea, picric acid (in dry form, trinitroaniline, trinitroanisole, trinitrobenzene, sulfonic acid trinitrobenzene, trinitrochlorobenzene, trinitrophenol/picric acid, trinitrotoluene, sodium urea.	Flammable liquids, oxidants, poisons and acids and bases.
Flammable Liquids		In a low flammable storage cabinet.	Acetone, benzene, diethyl ether, methanol, ethanol, toluene, cold acetic acid.	Acids, bases, oxidants and poisons.
Flammable Solids		Store in a separate, cool place, away from oxidizing, corrosive, and flammable liquids.	Phosphorus.	Acids, bases, oxidants and poisons.
Oxidants		Store in an overflow basin in a fireproof cupboard, away from flammable, combustible materials.	Ammonium nitrate, sodium hypochlorite, benzene peroxide, potassium permanganate, potassium chloride, potassium dichromate. The following are considered oxidants: Peroxide, perchlorides, chlorides, nitrates, bromine, peroxidants.	Install separately from flammable media, flammable and brittle materials.
Poisons		Store separately in a ventilated, cold, dry place in secondary unbreakable containers that are resistant to chemicals.	Cyanides, heavy metal compounds, *i.e.* cadmium, mercury, osmium	Flammable liquids, acids, bases and oxidants.
Chemicals that react with water		Store in a cool place and protect from water and fire sprinkler.	Sodium metal, potassium metal, lithium metal, lithium hydride Li.	Apply separately from liquid solutions and oxidants.

29. LABORATORY PRACTICES

The following practices should be applied in the laboratory where possible.

- Warning Signs to highlight dangers in the laboratory.
- Leak control equipment suitable for any chemical spilled in the laboratory.
- Tabulated records of the tasks of laboratory staff.
- Rotary evaporators for exclusive use in solvent distillation, with contact information and attached form.
- Use of safety goggles, gloves and laboratory uniform as well as appropriate footwear at work.
- Record the reaction in the fume hood using water soluble markers.
- Storage cupboard must have lists of chemicals, allowing all the knowledge of the chemical involved.

- New undergraduates shall be supplied electronically via the Chemistry page the form **"Health and Safety Regulations for Chemistry Labs"** before starting any laboratory work. After reading and understanding the document, sign the declaration included in the document and deliver it to the Scientific Coordinator of the Laboratory. At the same time, they are examined in writing and must succeed to participate in the laboratory exercises.

- Before conducting each laboratory exercise, students complete the **"Laboratory Equipment Risk Assessment Form"** and the **"Chemical Reagents Risk Assessment Form"** and submit them to the Scientific Officer of the Laboratory.

- In case of any incident during a laboratory exercise, the Scientific Officer fills in the **"Incident Report Form"** and submits it to the Safety Officer of the Department of Chemistry.