UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Engineering, Built Environment and Information Technology

Department of Chemical Engineering
University of Pretoria

SAFETY AND LABORATORY PRACTICES BOOK

ACCIDENTS OR INJURIES

Working Hours	**Other Times**
In Emergency:	
Security: x 2310	**Security: x 2310**
Main campus	
Safety Representatives:	**Safety Representative:**
Main Campus - x2625 (G Claassen)	**082 491 3267 (G Claassen)**
South Campus - x4206 (A Devega)	
	• **Never risk your own safety** • **Never move a casualty unless absolutely necessary; always bring the First Aider to the casualty** • **One person should preferably stay with the casualty and another go for help**
First Aider **Main Campus:** **Gerrie Claassen: x2625** **Howard Benade x2675/5412** **Ollie Del Fabbro x4398** **Prof P Crouse x2856** **South Campus:** **Alette Devega x4206** **Isbe vd Westhuizen x4173**	
	• **Once the First Aider arrives, do as instructed, be prepared to assist but do not interfere**

This book was adapted from the document produced in 2007 by the School for Mining and Mineral Sciences.

Date of last revision: 16 February 2012
Legend: .
Black = Finalised
Blue = To be finalised
Red = To be updated annually

CONTENTS

EMERGENCY PROCEDURE 3

1. PURPOSE OF THIS GUIDE *4*

2. STATEMENT OF HEALTH AND SAFETY POLICY *4*

3. HEALTH AND SAFETY POLICY OF THE UNIVERSITY OF PRETORIA *4*

3.1 HEALTH AND SAFETY ASPECTS

3.2 SAFETY INSTRUCTIONS

3.3 RESPONSIBILITY FOR SAFETY

3.4 EMPLOYEE AWARENESS

3.5 UNHEALTHY AND SUBSTANDARD ACTIONS AND WORK PROCEDURES

3.6 LEGAL AND STATUTORY RESPONSIBILITIES

4. OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT STRUCTURE OF THE UNIVERSITY OF PRETORIA 6

5. IMPLEMENTATION OF UNIVERSITY SAFETY POLICY 7

6. OFFICIALS *11*

7. FIRST AID 13

7.1 BASIC FIRST AID

7.1.1 Gassing

7.1.2 Swallowed

7.1.3 Splashes

7.1.4 Eye splashes

7.2 Location of First Aid Boxes

7.3 Health History

8. EMERGENCY EXIT ROUTES *15*

9. FIRE SAFETY *18*

9.1 In the event of fire

9.2 Fire Extinguishers

10. GENERAL HEALTH AND SAFETY INFORMATION *19*

10.1 Smoking

10.2 Gas or Water Leaks

11. RISK ASSESSMENT *19*

11.1 Chemical process risk assessment

12. CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH (COSHH) *22*

12.1 Safety Data Information

12.2 Carrying of Chemicals

12.3 Personal Protection

13. DISPOSAL OF HAZARDOUS CHEMICALS AND LABORATORY WASTE *23*

14. HIGHLY FLAMMABLE MATERIAL *24*

14.1 Flammable compressed gases

14.2 Flammable liquids

14.3 Incompatible chemicals

14.4 Electro-polishing

15. REACTION HAZARDS AND THERMAL RUNAWAY *27*

15.1 Thermal runaway

15.2 Effects of thermal runaway

15.3 Effect of scale
15.4 Causes of incident
15.5 Evaluating reaction hazards
15.6 Safety Measures
15.7 Chemical contamination and spillage
15.8 Inherent Safety
15.9 Incorrect handling procedures
15.10 Process Control
15.11 Protective Measures
16. *SOME HAZARDOUS CHEMICALS* 31
16.1 Poisons
16.2 Cyanides
16.3 Mercury (Hg)
16.4 P.T.F.E (Polytetrafluoroethylene)
16.5 Acids
16.5.1 Hydrochloric Acid (HCl)
16.5.2 Nitric Acid (HNO_3)
16.5.3 Sulphuric Acid) (H_2SO_4)
16.5.4 Hydrofluoric acid (HF)
16.6 Solvents
16.6.1 Acetone (CH_3COCH_3)
16.6.2 Ethyl Alcohol (CH_3CH_2OH) (Ethanol)
16.6.3 Methyl Alcohol (CH_3OH) (Methanol)
16.7 Ammonium Hydroxide (NH_4OH)
16.8 Potassium- (KOH) and Sodium Hydroxide (NaOH)
16.9 Hydrogen Peroxide (H_2O_2)
16.10 Mixtures of Organic Solvents with Oxidising Agents
16.10.1 Ethyl Alcohol – Nitric Acid
17. *RADIOACTIVE MATERIALS* 39
17.1. ADMINISTRATIVE REQUIREMENTS
17.2. HANDLING OF RADIOACTIVE MATERIALS
17.3. STORAGE REQUIREMENTS
17.4. STEPS TO TAKE IN CASE OF ACCIDENTAL RELEASE/SPILLAGE OF RADIOACTIVE MATERIALS
17.5. EMERGENCY PROCEDURES IN CASE OF ACCIDENTAL OVER- EXPOSURE
17.6 INTERNAL RULES FOR CHEMICAL ENGINEERING RADIATION LABORATORY (Room 2-51 Building 2 South Campus)
17.6.1 Radiation Authority Data
17.6.2 Requirements
18. *LASER EQUIPMENT* 50
19. GENERAL HAZARDS *52*
20. GENERAL LABORATORY PRACTICE *53*
20.1 Purchasing Standards
20.2 Training of personnel and students
20.3 Special storage facility
20.4 Chemical waste disposal
21. WORK ETHIC *54*
RISK ASSESSMENT 55
HEALTH HISTORY AND MEDICAL AID DETAILS 59

EMERGENCY PROCEDURE

DON'T PANIC – another few seconds won't make much difference

PROTECT YOURSELF – make sure you are properly clothed. Overall/dustcoat, gloves, gas mask, etc

GET HELP – sound the alarm, call for help, doctor, ambulance, security, etc

RESCUE VICTIMS – get them to a safe area. Apply immediate first aid.

ATTEND TO LEAK / SPILL – make safe, clean up and rehabilitate

1. <u>PURPOSE OF THIS GUIDE</u>

This training guide provides basic information for working safely with laboratory chemicals and equipment.

2. <u>STATEMENT OF HEALTH AND SAFETY POLICY</u>

The University of Pretoria is committed to the highest standards of excellence in education and research. This commitment to excellence applies equally to the way in which the University accepts its responsibilities for the health and safety of all staff, students, visitors and others who may be affected by the activities of the University.

Accordingly, the University will take all reasonable steps necessary to provide a healthy and safe environment for work and study. Compliance with all statutory obligations is the minimum standard. It is the duty of every employee to take care of their own health and safety and that of others who could be affected by their acts or omissions. The University policy on Health and Safety can only be effective if there is commitment by all staff, students, visitors and others at the University.

3. <u>HEALTH AND SAFETY POLICY OF THE UNIVERSITY OF PRETORIA</u>

It is the University's official policy to protect its employees, students, visitors and property at all times through the implementation programme of excellence.

The University acknowledges that specific elements are of importance in the implementation of this policy:

3.1 HEALTH AND SAFETY ASPECTS

The University is responsible for the design and implementation of practical and workable health and safety standards, methods and systems to comply with prescribed legal requirements.

3.2 SAFETY INSTRUCTIONS

Safety training must be part and parcel of the normal in-task training for employees

3.3 RESPONSIBILITY FOR SAFETY

Every employee and student shall be responsible to maintain the health and safety policy in such a manner as to safeguard all people, employees, students and property. Each undergraduate, graduate student, faculty and staff member working in a research laboratory is expected to:

- Attend Laboratory Safety Training provided by the department
- Follow procedures and laboratory practices outlined in this training guide
- Use engineering controls and personal protective equipment, as appropriate
- Report all accidents, near misses, and potential chemical exposures to your supervisor and/or Safety Representative
- Review and approve work with particularly hazardous substances

3.4 EMPLOYEE AWARENESS

Interest of employees in their own and their colleague's safety must be promoted through awareness programmes.

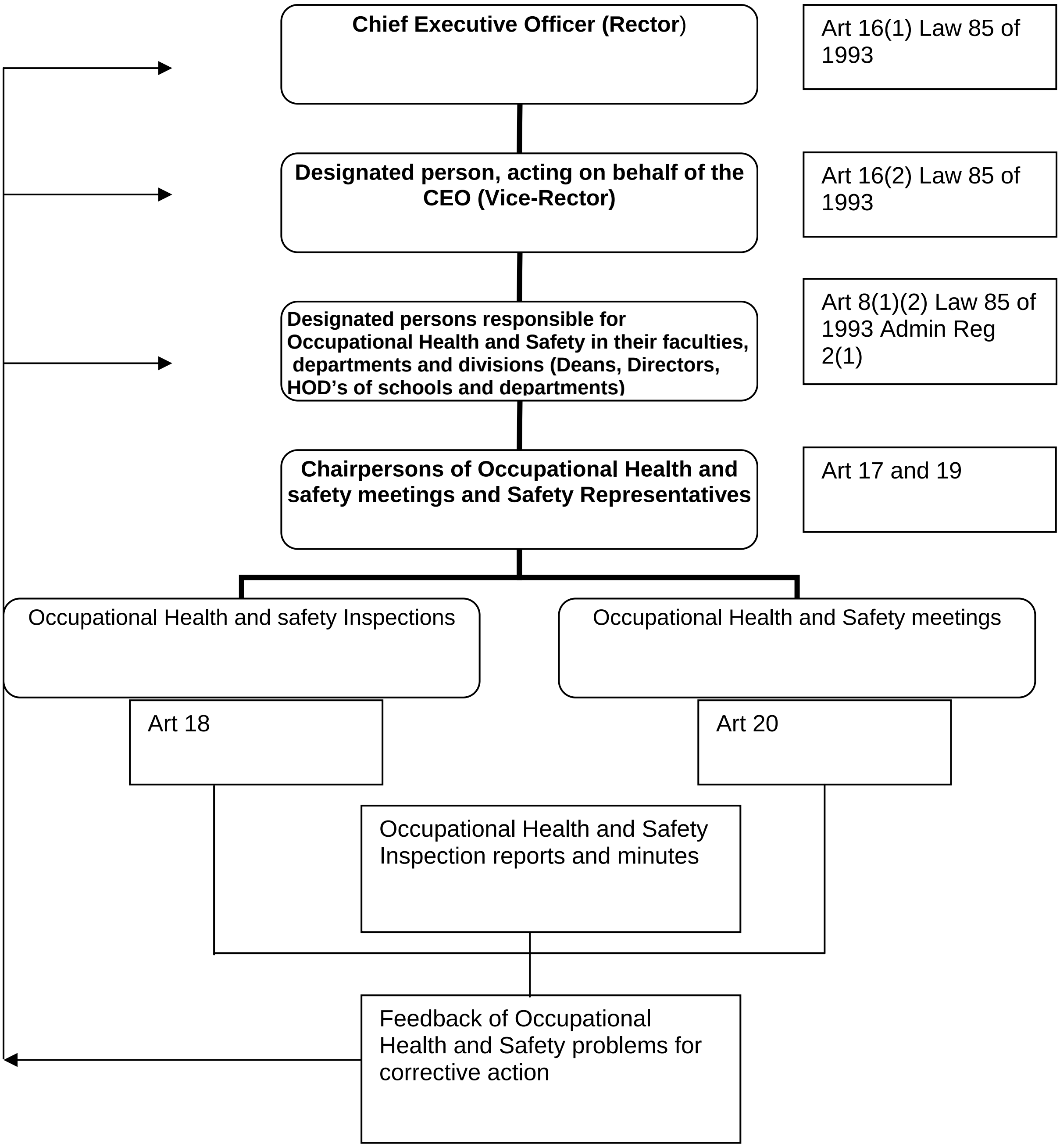
3.5 UNHEALTHY AND SUBSTANDARD ACTIONS AND WORK PROCEDURES

The University, its employees and students are committed to eliminate all unhealthy and unsafe actions and work procedures.

3.6 LEGAL AND STATUTORY RESPONSIBILITIES

The University is responsible to implement all legal and statutory requirements that are required by the law.

4. *OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT STRUCTURE OF THE UNIVERSITY OF PRETORIA*



5. ***IMPLEMENTATION OF UNIVERSITY SAFETY POLICY***

1. The Safety Policy is formulated to enable the Heads of Department to ensure, as far as is reasonably practical, the health, safety and welfare at work of all staff, students and visitors. The arrangements are formulated on the basis that: (a) in much of the Department’s experimental research and teaching, individuals initiate and conduct their work without instruction of management, and (b) in matters of safety, common sense and a sense of personal responsibility are of fundamental importance.

2. Statements relating to hazards in the Department are formulated and made available to all its members through the Safety Book, which is updated annually.

3. Under the authority of the Head of Department, the Safety Committee is constituted of representatives of all staff, under-graduate and post-graduate students. The Committee oversees the compliance with Safety Policy and endeavours to ensure safe practices. It meets at least once each term, issues minutes which are made publicly available, and reports to staff meetings.

4. All members are issued with the Safety Book each year; newcomers including day visitors are notified about the University and Department Safety regulations.

5. The Safety Officer or a nominee meets all new researchers and arranges for appropriate training and tests. Undergraduate students carrying out work in the Department are given Safety instructions before the onset of any practicals or laboratory work. Post-graduate students are instructed on Safety matters both by the University Safety Office and through lectures by the Department Safety Committee. All researchers are required to pass a Safety Test before being authorised to work in a laboratory.

6. Before commencing experimental work, study leaders must ensure that the “Risk Assessment Forms” are completed. The completed forms must be displayed in a conspicuous position and made available to any person in the room or in the vicinity of the activity.

7. Those in a supervisory role are expected to identify the hazards associated with the activities for which he/she bears responsibility, to warn those who may be affected by them and to take steps to ensure that health and safety will not be endangered. All academic and technical supervisors of equipment are required to ensure safe operation, by making risk assessments which are regularly reviewed. The rate of revision of safety assessments will be left to the discretion of the study leader or supervisor of project work.

8. Each individual is required to take responsible care for his/her own health and safety and that of other persons who may be affected by his/her acts or omissions at work. All persons have a duty not to interfere with or misuse anything provided or organised in the interest of health, safety or welfare.

9. All students are responsible to named supervisors for all aspects of their work. A list of supervisors and their students will be compiled and posted on the notice board by the Safety Representative as soon as students have been allocated projects..

10. Building safety inspections are carried out regularly by the Safety Representative. Safety audits are carried as needed by Occupational Health and safety officers. Inspections are followed by reports and recommendations for action.

11. All incidents and accidents must be reported to the Safety Representative.

12. The Safety Representative would then ensure that the incidents are investigated, recommendations made and actions taken to ensure that Safety procedures are properly functioning and the probability of such incidents and accidents occurring again are minimised. The University Safety Officer is informed about the situation and if necessary further investigation is carried out in cooperation with the University Safety Officer.

13. Fire precaution procedures are explained to all newcomers to the department. Students are required to attend lectures which deal with the issue. Fire drills are arranged by the Safety Officer on a regular basis.

14. The safety organisation is available during normal working hours. Additional restrictions apply to essential work done outside normal working hours. The degrees of risk are in three categories: HIGH, MEDIUM and LOW. Any individual *must*, outside normal working hours, register in the "signing-in" book at the Department entrance and comply with the following rules:

    Category "A" Work (HIGH risk): Confined to normal working hours only. At least one colleague should be present within easy hailing distance. Covers the use of:

    - Workshop machine tools
    - Substantial amount of explosive and flammable liquids and gases
    - Molten salt etching of specimen
    - Substantial amount of acids and alkalis
    - Materials or equipment with high explosion potential
    - High voltage supplies
    - Any activity using Hydrofluoric Acid

Category “B” Work (MEDIUM risk): May be carried out at any time BUT one other individual must be present throughout the work. This category covers all work that is not A or C.

Category “C” Work (LOW risk): This may be carried out at any time. It covers reading, writing and the kind of activities which would not require special precautions if conducted alone in one’s home.

EXCEPTIONS

Any exceptions to these rules will require the individual to obtain the prior written authority of his/her supervisor, (after a risk assessment has been carried out), specifying the task, time and any special conditions.

15. Individuals are advised, in their own interest, when entering out of hours to ensure that their names are entered in the book.

16. The supervisor of any new project will be responsible for ensuring that the new activities, together with the operation of any new equipment are planned in accordance with safety standards. For all activities the regular maintenance of safety standards is based on four requirements:
    - Individual adherence to laid down operating and reporting procedures
    - Responsibility of supervisors to see that their subordinates/students have the necessary standard of competence and that they adhere to the laid down safety procedures.
    - Assessment of risks of activities and procedures prior to their being adopted
    - Periodic safety walks by members of the Department’s Safety Committee.

17. Any potentially dangerous activity or equipment observed by any member of the Department should be brought to the immediate

attention of those responsible, and to the Safety Representative. It is the duty of all members of the Department to maintain vigilance on matters concerning safety.

6. OFFICIALS

Head of Department	Prof PL de Vaal	420-2475
Director: IAM	Prof WW Focke	420-3728
Safety Representative(MC)	Mr GJD Claassen	420-2625
Safety Representative(SC)	Mrs A Devega	420-4206
Safety Representative(MC)	Mr O Del Fabbro	420-4398
Safety Representavive(SC)	Mrs I van der Westhuizen	420-4173
First Aider (Eng II,MC)	Mr GJD Claassen	420-2625
First Aider (Eng I , MC)	Prof P Crouse	420-2856
First Aider (Eng II,MC)	Mr H Benade	420-5412/2675
First Aider (Building 2,SC)	Mrs A Devega	420-4206
First Aider (Building 2,SC)	Mrs I van der Westhuizen	420-4173
First Aider (Chemistry , MC)	Mr O Del Fabbro	420-4398

MC – Main Campus

SC – South Campus

UP Safety Officers:

Legal aspects	Mr F Fouche	420-3308
Accidents, First Aid	Mr N Gerber	420-4765
Fire Coordinator and Occupational Health and Safety Officer	Mr B Hand	420-3305
Radiation officer	Ms Yolanda Bekeur	420-6322

Departmental Safety Committee

Responsible lecturer for CLB 321 Laboratory 321 (Dr H Rolfes)

Departmental Safety representative (Mr GJD Claassen)

3rd Year Student: (To be appointed from the group of Class Representatives)

4th Year Student: (To be appointed from the group of Class Representatives)

Post-grad Student: (To be appointed annually)
Representative from IAM: (To be appointed annually)
Representative from South Campus Water & Environmental Engineering: (To be appointed annually)
Representative from UP Occupational Health and Safety Unit: (Mr B Hand)

7. ***FIRST AID***

First aid supplies are available from Mr GJD Claassen (Eng II Building, MC) and Mrs A Devega, Building 2, SC).

MC – Main Campus.

SC – South Campus.

Accidents, however small, should always be treated and if any doubt exists as to the severity of the injury, the Safety Representative must be informed so that the person may be taken to hospital. All injuries sustained, however small, whilst working in the Department's laboratories or offices must be recorded in the Accident Report Book kept by the Safety Representative. All incidents of any kind, even those where no injury is sustained must be reported in the Incident Report Book kept by the Safety Representative.

7.1 BASIC FIRST AID

7.1.1 Gassing

Move victim to fresh air. If necessary give mouth to mouth resuscitation using the proper mouth piece. Treat as stretcher case.

7.1.2 Swallowed

Give plenty of water or milk to drink. DO NOT induce vomiting. For cyanide, breathing apparatus to be used by first aider. Drench the patient with water, take amyl-nitrite with and accompany the patient to the hospital.

7.1.3 Splashes

Strip off affected clothing, take care not to smear more of the chemical onto the patient. Shower/wash for at least 20 minutes. A shower is situated in the foyer at the top of the stairs on level 4

7.1.4 Eye splashes

Rinse with water for 20 minutes

7.2 Location of First Aid Boxes

Main Campus:

- Fourth year laboratory; Room1-57, Eng II building.
- Reactor laboratory; Room1-62 , Eng II building.
- Tribology laboratory; Room1-64.1 , Eng II building.
- Third year laboratory; Room 2-47, Eng II building.
- Fluoro-Materials laboratory; Room3-52 , Eng II building
- Emulsions laboratory; Room3-49,Eng II building
- Particle Technology Laboratory; Room3-45 , Eng II building
- Institute for Applied Materials; Room1-42 , Chemistry building

South Campus:

- Water laboratories; Room 1-9 , Building 2
- Carbon laboratory; Room 1-5, Building 2
- Thermal Analysis Laboratory; Room 2-8, Building 4
- SAPPI laboratory; Room1-5, Building 7

7.3 Health History

All members of staff, as well as students working in the laboratories must furnish the Safety Representative will full medical aid information to be used in case of an emergency.

If any member of the Department, or student, should be aware of a health condition, which might affect the way he/she should be treated in an emergency, he/she is advised to inform the Safety Representative. This information will be treated in the strictest confidence. Examples include allergies, diabetes and epilepsy.

8. EMERGENCY EXIT ROUTES

Main Campus

Engineering 2:

Level I

Fourth year laboratory:

Exit through Door no 1-57, turn left and out at the glass door 1-10 to the outside of the ENG II Building and assemble in front of Eng I Building.

Reactor laboratory:

Exit through Door 1-60, turn right and go up with stairs and assemble in front of Eng I Building.

Level 2

Third year laboratory:

Exit through Door 2-55, turn left in the foyer, down with stairs and out at the glass door 1-10 and assemble in front of Eng I Building.

Third year laboratory

Exit through Door 2-49, turn left, go down with the stairs and assemble in front of Eng I Building.

Postgraduate Laboratory:

Exit through Door 2-43, turn left into the foyer and go out at the glass door 2-2 and assemble in front of Eng I Building.

Process Control laboratory:

Exit through Door 2-62.1, go down with the stairs and assemble in front of Eng I Building.

Level 3

Fluoro-Materials laboratory:

Exit through door 3-52, turn right and left into the foyer, go out at the glass door 3-1 and assemble in front of Eng I Building.

Emulsions laboratory:

Exit through door 3-49 turn right and left into the foyer an go out at the glass door 3-1, and assemble in front of Eng I Building.

Particle Technology Laboratory:

Exit through door 3-45 turn right and left into the foyer an go out at the glass door 3-1, and assemble in front of Eng I Building.

Chemistry Building

Institute for Applied Materials(IAM)

Exit through door 1-42 turn left and go through the passage to the outside of the Building and assemble in front of the Chemistry Building.

South Campus (Water & Env. Eng):

Building 2

Lab 1-12:

Exit by door 1-12, walk down the passage, up the stairs and out by door 1-9 and go to assembly point next to parking area outside building 2, South of the main entrance.

Labs 1-13 and 1-15:

Exit by door 1-13 or door 1-15, turn right down passage, up the stairs and out by door 1-9, and go to assembly point next to parking area outside building 2, South of the main entrance.

Lab 1-24:

Exit by door 1-24, turn right and out by door 1-9, and go to assembly point next to parking area outside building 2, South of main entrance.

Lab 1-23:

Exit by door, turn left and out by door 1-9.

Assembly point next to parking area outside building 2, east of main entrance. If garage door open exit through this door and wait at assembly point.

Sappi lab:

Building 7:

Exit by door 1-5 and walk to the grass outside the laboratory on the North side.

South Campus (Carbon Chair):

Building 5:

Lab 1-5:

Exit by door 1-5, turn right, walk around building 2 to assembly point, next to parking area outside building 2, South of main entrance.

Lab 1-6:

Exit by door 1-6, turn right, walk around building 2 to assembly point, next to parking area outside building 2, east of main entrance.
If garage door open exit through this door and wait at assembly point.

Building 4:

Lab 2-8:

Exit by door 2-8, turn left and down the stairs, out by door 1-42 and around building 2 to the assembly point, next to parking area outside building 2, south of main entrance to Building 2.

9. <u>FIRE SAFETY</u>

It is the responsibility of everyone to be vigilant and report anything they may see as a fire risk to the Safety Representative. Examples include escape routes which may be blocked by equipment or rubbish, un-safe housekeeping practises, etc.

Waste materials and packing should not be left in the laboratories or corridors, but should be disposed of. Polystyrene packing from computers presents a very real risk, as the fumes created by it burning are very toxic.

9.1 In the event of fire

If the fire is small and can be safely extinguished, do so. Laboratory users should be acquainted with the location and use of the extinguishers. It is important to use the correct extinguisher, for example NEVER use water to extinguish a fire in the vicinity of electrical appliances or installations. If it is impossible to extinguish the fire, raise the alarm to initiate evacuation and summon help. In the event of an electrical fire, the electrical power must be switched off first.

9.2 Fire Extinguishers

These are provided as required by legislation and the University insurers, and are chosen to deal with various types of fire. Extinguishers are sited in safe places. When taking the decision to fight a fire, it is important that no personal risks are taken.

10. <u>GENERAL HEALTH AND SAFETY INFORMATION</u>

10.1 Smoking

Smoking is strictly forbidden within the Department

10.2 Gas or Water Leaks

In the event of a gas or water leak, contact the Safety Representative. After hours contact the Security Office on 420-2310.

11. <u>RISK ASSESSMENT</u>

The University of Pretoria is committed to achieving and maintaining the highest standards of health and safety for all employees, students and others who may be affected by the University's activities. This is accomplished by:

- The identification of all workplace hazards
- The identification of all people who may be exposed to the hazards
- The evaluation of the significant risks to which employees, students and others are exposed
- The recognition of the likelihood of foreseeable accidents, injuries or near misses occurring
- The selection of realistic and practical precautions and control measures
- Disaster management protocols

This process is called *Risk Assessment*. A risk assessment is simply a careful examination of anything that may cause harm to anyone during the course of their work. Once the assessment is completed, action can be taken to minimise the likelihood of anyone being hurt. The aim is to prevent accident and illness. It is carried out by identifying risk and using appropriate control measures to minimise or eliminate the risk. **Risk assessment of all activities is required by Law.**

The following terms are referred to in the Risk Assessment form in Appendix I.

Hazard:

A hazard is anything that may cause harm. Although they may not cause harm in one form, there is always a “What if…?”. Glass bottles can be considered a hazard. Normally they are fairly harmless – but what if they are dropped? Electricity is a hazard. Whilst properly contained it is safe, but what if …?

Risk:

The risk is essentially the likelihood of something happening. What if the glass bottle is dropped? – there is a risk that someone could be cut, or the risk of a hazardous chemical spill. How do we minimize the risk? By using suitable control measures.

Control measures:

Often the best control measures will start with the words **DO NOT**. Do not use a glass bottle. This will eliminate the risk altogether. However, there are times when “do not” is not applicable. You must aim to reduce the risk if it is not possible to eliminate it. For example, always carry glass bottles in the carriers to prevent them slipping and breaking.

Approved forms for the assessment can be obtained from the Safety Representative. Work should never commence before the assessment has been completed and approved by the Supervisor or Study Leader.

Risk Assessments must be carried out as part of the safety management process and should include looking at the equipment used, the laboratory used and the system of work that is employed. They must be reviewed at specified times, as agreed upon between the student and study leader. Fitness of the workers/students are of the utmost importance.

Health and Safety performance will be monitored regularly to ensure that Risk Assessments are adequate and that the control measurements are being applied and working effectively.

11.1 Chemical process risk assessment

A typical assessment will involve:

- Defining the process, operating conditions and plant
- Identifying the hazards
- Evaluating the risks arising from the hazards and deciding whether existing precautions are adequate or more should be done
- Selecting and specifying appropriate safety measures
- Implementing and maintaining the selected safety measures
- Emergency procedures

You should start the assessment as early as possible during the development of the process. This assessment should be sufficient to identify the potential hazards and to investigate their causes. Where possible, hazards should be avoided.

A written safe work procedure should culminate from the risk assessment, and must be made available to persons performing the work.

12. <u>CONTROL OF SUBSTANCES HAZARDOUS TO HEALTH (COSHH)</u>

All members of the Department and students working in the laboratories must conform to COSHH (control of substances hazardous to health) regulations. COSHH forms must be correctly completed before starting any work involving chemicals. These forms may be obtained from the Safety Representative. Any guidance about the completion of these forms can be obtained from the Supervisor or a member of the Safety Committee.

12.1 Safety Data Information

Users of chemicals can obtain safety data sheets (MSDS) about these chemicals from the internet.

12.2 Carrying of Chemicals

An appropriate container should be used when carrying chemicals from one destination to another. 2.5 Litre bottles of chemicals should preferably be carried in a suitable basket, and not transported by hand. If, however, a suitable basket is not available, bottles containing acids and alkalis must be carried with both hands – one underneath for support. Cleaning equipment, protective wear, neutralisers and suitable absorbents should be readily available. Spillage, waste and broken equipment must be disposed of using the correct procedure.

12.3 Personal Protection

Various items such as laboratory coats, gloves, eye protection, etc can be obtained from the Safety Representative.

The COSHH regulations are a legal framework for controlling the exposure of workers to hazardous substances. COSHH requires that no work which is liable to expose anyone to substances hazardous to health shall be carried out until an assessment has been made and appropriate control measures taken.

13. ***DISPOSAL OF HAZARDOUS CHEMICALS AND LABORATORY WASTE***

Strict legislation controls the disposal of chemical waste and clearly defines the Duty of Care of all waste producers regarding the identification, segregation, packaging and transport of waste.

Waste must not be disposed of by discharging into the drains.

Always remember to minimize quantities of reagents used in order to minimize waste.

Hazardous chemicals and laboratory waste for disposal should be in secure containers, clearly labelled as to their contents and also numbered (on lids if in bottles, jars, etc) according to the item number given to them on the disposal application form.

Bottles, jars, etc should be placed upright in a robust box (eg. A photocopier paper box with the base reinforced using the lid). Any waste in bags should be doubled bagged.

An application form should be completed in full, no abbreviations are formulae should be used. Brand names are inadequate, consult the MSDS for product constituents.

14. <u>HIGHLY FLAMMABLE MATERIAL</u>

14.1 Flammable compressed gases

Gas cylinders must be secured in a gas bottle stand or chained to the wall. Care must be taken to ensure there are no ignition sources (including sparks) when gases are liberated into the room. All laboratories must have adequate extraction systems and good ventilation. Ensure that there are no leaks and close the valve when not in use. A mild soap detergent and a soft paintbrush must be used to test for leaks. The correct tubing must be used. Greases and oils must never be allowed to come into contact with compressed oxygen as they can ignite spontaneously.

There must be adequate separation between flammable gases and gases capable of supporting combustion. Everyone working with compressed gas cylinders must take the following precautions:

- Always transport cylinders in a trolley with regulators removed
- Always clamp or chain cylinders. When changing cylinders, never have more loose cylinders than people to control them safely
- Always use the appropriate reduction and safety valves
- Always turn off the main cylinder valve when it is not in use, and use the minimum opening when necessary
- Always test the valves on new cylinders of toxic gases in the open air before removal to a laboratory
- Never lay acetylene cylinders flat

Oxygen: grease must not be used on fittings or allowed to contaminate them as oxidation and spontaneous ignition may occur

Hydrogen: Extreme care should be taken when using hydrogen at a concentration of greater than 4% by volume in air forms an explosive mixture.

14.2 Flammable liquids

The quantity of any highly flammable liquid stored should be kept to a minimum. Any such liquid not required for use should be stored in a safe manner. Unnecessary transport of highly flammable liquids should be avoided.

Large quantities of highly flammable liquids should not be stored in laboratories, but in suitable closed containers in a purpose-built storeroom of fire resisting construction. Small quantities of highly flammable liquids may be stored in suitable closed containers kept in a cupboard in the laboratory.

Highly flammable liquids should always be handled in a fume cabinet.

Do not leave containers of flammable solvents on bench tops, open shelves or fume cupboards – always store them in a safe manner. When using such solvents, make sure that all flames are extinguished and display a warning notice.

14.3 Incompatible chemicals

Take care when mixing chemicals, as many chemicals are highly reactive. This is also important to remember when disposing of unwanted chemicals.

Ensure that a good quality fume cupboard is used when working with chemicals which have fumes heavier than air. These fumes may accumulate in a ventilation system where extraction is incomplete.

14.4 Electro-polishing

An electro-polishing solution containing perchloric acid has been the cause of fatal explosions and great care is necessary when preparing and using solutions containing this reagent. Provided the perchloric acid stock solution used has a specific gravity of 1.48 or less, mixtures with glacial acid cannot be within the explosive zone; more care however, is required with mixtures using acetic anhydride as the explosive zone is closely approached if too much perchloric acid is present.

The following rules must be obeyed for safe working with electro-polishing:

- Always wear PPE (Personal Protective Equipment) such as gloves, overall or dust coat and a face shield
- The perchloric acid stock solution kept in the laboratory must have a density not exceeding 1.48 (60%)
- Organic plastic fittings or carbon electrodes MUST NOT be used with the solution. Great care must be exercised if electro-polishing solutions come into contact with organic compounds. Stopping off solutions should be allowed to dry thoroughly before polishing is started. Care must also be taken to avoid spilling polishing solutions on wooden benches as this makes them liable to spontaneous ignition.
- An electro-polishing apparatus should always include a switch and this must be used in making or breaking a circuit.
- The polishing solution must be kept in a stoppered bottle when not in use. Screwed top bottles may be used but the tops must be loose. The bottle must be clearly labelled and carry the date of preparation.
- In order to avoid risk of over-heating, a sufficient volume of liquid must be used in the bath. It is essential to keep the liquid cool both during the mixing of the perchloric acid with acetic acid (or anhydride) and also during the *polishing operation* itself.
- During the mixing, the eyes of the operator must always be protected by means of a face shield. The perchloric acid must always be added to the other solutions so that the overall concentration is never stronger than the final solution.
- Polishing must always be carried out in a fume cupboard with an efficient fan. The polishing cell must be behind a Perspex sheet, which is sufficiently large to completely protect the operator’s face. The circuit must include a switch, which is used for making or breaking a circuit. If the circuit is broken by lifting a specimen out of the solution without first actuating the switch, the sparking may set fire to baths of certain compositions.

- A carbon dioxide extinguisher must be kept in each laboratory where electro-polishing is carried out.
- Electro-polishing baths must be kept clean. Do not allow them to accumulate substances such as metal or carbon particles, which could potentially provide a catalytic site for ignition or explosion.

These regulations are detailed for the common perchloic acid-type solutions but they must also be obeyed for other electrolytic or chemical polishing solutions which are potentially explosive, inflammable or poisonous.

15. REACTION HAZARDS AND THERMAL RUNAWAY

During the manufacture of a chemical, raw materials react together to give the product. Such a chemical process often releases energy, in the form of heat, and the reaction is described as *exothermic*. A reaction may be exothermic even if you have to heat the reaction mass initially to get the reaction started.

15.1 Thermal runaway

An exothermic reaction can lead to thermal runaway, which begins when the heat produced by the reaction exceeds the heat removed. The surplus heat raises the temperature by the reaction mass, which causes the rate of reaction to increase. This in turn accelerates the rate of heat production. An approximate rule of thumb suggests that reaction rate – and hence the rate of heat generation – doubles with every 10 ^{0}C rise in temperature.

Thermal runaway can occur because, as the temperature increases, the rate at which heat is *removed* increases linearly but the rate at which heat is *produced* increases exponentially. Once control of this reaction is lost, temperature can rise rapidly leaving little time for correction. The reaction vessel may be at risk from over-pressurisation due to violent boiling or rapid gas generation. The elevated temperatures may initiate secondary, more hazardous runaways or decompositions.

15.2 Effects of thermal runaway

A runaway exothermic reaction can have a range of results from the boiling over of the reaction mass, to large increases in temperature and pressure that lead to an explosion. Such violence can cause blast and missile damage. If flammable materials are released, fire or a secondary explosion may result. Hot liquors and toxic materials may contaminate the workplace or generate a toxic cloud that may spread off-site.

15.3 Effect of scale

The scale of which you carry out a reaction can have a significant effect on the likelihood of runaway. The heat produced increases with the volume of the reaction mixture, whereas the heat removed depends on the surface area available for heat transfer. As scale, and the ratio of volume to surface area increases, cooling may become inadequate. This has important implications for scale-up of processes from the laboratory to production. You should also consider it when modifying a process to increase the reaction of quantities.

15.4 Causes of incident

- Inadequate understanding of the process chemistry and thermo-chemistry
- Inadequate design for heat removal
- Inadequate control systems and safety systems; and
- Inadequate operational procedures, including training

In order to deal with chemical reaction hazards, first you need to identify them, then to decide how likely they are to occur and how serious their consequences would be. Always carry out a risk assessment of your process.

15.5 Evaluating reaction hazards

In order to determine the hazards of a reaction, you need information on the chemistry and thermo-chemistry of the reaction. This includes:

- The possibility of thermal decomposition or raw materials, intermediates, products and by-products
- Where exothermic runaway can occur

- The rate and quantity of heat and gas produced by the reaction

There is no standard procedure that can be followed for all reactions – the aim is to obtain the data you need to assess the risk adequately. To avoid undue time and effort, any investigation should reflect the complexity of the reaction and the size of the risks involved.

15.6 Safety Measures

Once you know what the risks are, you can select the measures to ensure safe operation. You can ensure safe operation in a number of ways by using:

- Inherently safer methods, which eliminate or reduce the hazard
- Process control, which prevents a runaway reaction occurring
- Protective measures, which limit the consequences of a runaway
- Pro-active approach

15.7 Chemical contamination and spillage

Regard all chemicals as poisonous

Wear protective clothing and appropriate footwear. Before using any chemical ascertain what kind of first aid treatment would have to be administered in the event of an accident. Certain chemicals require specific antidotes which should be clearly labelled and easily accessible. A second person should always be present at a safe distance when work using poisonous substances is being carried.

15.8 Inherent Safety

Where possible, you should first identify, eliminate or reduce hazards by inherently safer design. Inherently safer methods can fundamentally affect the process. It will be easier to use such methods if you consider them in the early stages of process development.

15.9 Incorrect handling procedures

- Never touch a chemical with your bare hands
- Do not pour hot solutions into reagent bottles
- Always use funnels or glass rods when pouring concentrated acids or alkalis
- Funnels should not be too small for the work being carried out
- Never pour water onto acid
- Suitable precautions must be taken when opening bottles
- Take care which direction the opening of a container is facing when there might be a violent reaction
- Any procedure involving toxic gases and vapours must be carried out in a suitable fume cupboard
- Use mechanical pipettes AND NOT mouth pipettes
- Do not smell chemicals to aid identification. Apart from an immediate reaction e.g from ammonia, the long term consequences can be far more serious.
- Use the correct procedure for the disposal of chemical waste

15.10 Process Control

Process control includes the use of sensors, alarms, trips and other control systems that either take automatic action or are manual intervention to prevent the conditions for uncontrolled reactions occurring. Specifying such measures requires a thorough understanding of the chemical process involved, especially the limits of the safe operation.

15.11 Protective Measures

Protective measures do not prevent a runaway but reduce the consequences should one occur. They are rarely used on their own as some preventative measures are normally required to reduce the demand upon them. As they operate once a runaway has started, a detailed knowledge of the reaction under runaway conditions is needed for their effective specification.

16. ***SOME HAZARDOUS CHEMICALS***

16.1 Poisons

Scheduled poisons should be labelled as such and everyone handling them has a moral obligation to ensure that they are not improperly used and cannot go astray. It is essential that a close control should be kept on the most dangerous poisons in use in the laboratory. They should be issued only when required for specific experimental purposes and then only in the quantities immediately required. Any material transferred to a secondary container must be clearly labelled and include hazard warning labels, and should be disposed of immediately it is no longer required.

16.2 Cyanides

Potassium cyanide (KCN) and sodium cyanide (NaCN) are extremely dangerous while potassium ferricyanide ($K_3Fe(CN)_6$), although poisonous, is relatively safe to use. The vapours from NaCN and KCN are intensely poisonous. Poisoning can also result from skin contact with NaCN or KCN. They are particularly hazardous when brought into contact with acids or acid fumes because of liberation of hydrogen cyanide, which is extremely toxic and highly flammable.

The following precautions must be observed:

- Only an approved fume-cupboard may be used
- The first aider trained for cyanide safety must be informed of where and when the chemical is used, as well as the amount
- Provision of fresh cyanide antidote should be made
- Never pour cyanide down the drain. Advice on disposal can be obtained from the Safety Representative
- Never allow any acid to come into contact with cyanide, under any circumstances
- No chemical should ever be pipetted by mouth, and this applies to cyanide in particular
- Cyanide should not come into contact with the skin at all. The danger of this is sometimes under-estimated.

- Never leave cyanide lying around in the laboratory after use.
- Great care should be taken to ensure there is no spillage. Even so, after using cyanide, the work surface should be washed down thoroughly with an alkaline solution followed by water. Any possible spillage should be managed by containment.
- The unused cyanide remaining after the experimentation is complete should not be kept but should be disposed of using a separate, marked waste container.

16.3 Mercury (Hg)

Spilled mercury gives rise to a dangerous concentration of vapour. Avoid spillage by working carefully over a tray or dish if possible. Report any spillage to the safety representative. The following preventative measures are recommended:

- Good general ventilation
- Where fairly large quantities of mercury are handled a fume cupboard should be used
- Any heating of mercury should be done in an enclosed system.
- Storage of mercury should be in airtight or water sealed containers
- Containers of mercury should be kept in trays to avoid spillage of mercury over a wide area on the floor or work bench.
- Contact with the skin should be avoided, protective clothing being useful where appropriate.

16.4 P.T.F.E (Polytetrafluoroethylene)

When P.T.F.E or "Teflon" is heated above 200 ^{0}C, toxic compounds are evolved which can result in serious injury or death to personnel who do not treat this material with proper respect.

16.5 Acids

Mineral acids are highly corrosive and poisonous. They should be stored in a cool, well ventilated location away from potential fire hazards and open flames.

16.5.1 Hydrochloric Acid (HCl)

A colourless gas or fuming liquid with a choking odour. It is very dangerous to the eyes and irritating to the nose and throat. It attacks the skin strongly.

16.5.2 Nitric Acid (HNO_3)

A colourless or yellowish fuming liquid which is highly toxic and dangerous to the eyes. If it contacts organic material or other easily oxidizable materials, it can cause fires and possibly explosions. When it reacts with other materials, toxic oxides of nitrogen are produced. The oxides include nitrous acid, nitrogen dioxide, nitric oxide, nitrous oxide and hydroxylamine.

A commonly encountered problem involves pouring nitric acid into a graduated cylinder which contains some methanol or ethanol from prior use. The brown fumes given off are quite harmful. Mixtures of nitric acid and alcohols higher than ethanol should not be stored. Mixtures of concentrated nitric and sulphuric acids are extremely dangerous, while strong mixtures of nitric acid and glycerin or glycols can be explosive. Aqua regia, a mixture of one part nitric acid and two to four parts hydrochloric acid, forms several products including nitrosyl chloride, an exceptionally toxic gas. Aqua regia is a popular etchant but must be used with care under a hood.

Fuming nitric acid is nitric acid with additional NO_2 and N_2O_4. it is more toxic and more reactive that ordinary nitric acid. Although recommended in certain etching and chemical polishes, it is extremely hazardous to use and is not recommended.

16.5.3 Sulphuric Acid) (H_2SO_4)

A colourless, oily liquid which is highly corrosive and dangerously reactive and is a strong oxidizing agent. It reacts with water and organics, with evolution of substantial heat. The acid should be added slowly while the solution is being stirred. It should be cooled, if necessary, to minimize heating. If sulphuric acid is added to water without stirring, it can collect at the bottom of the beaker and enough local heating can occur to throw the contents out of the beaker.

Contact with the concentrated acid produces rapid destruction of tissues and severe burns. Repeated contact with dilute solutions produces dermatitis, while repeated inhalation of the vapours can lead to chronic bronchitis.

16.5.4 Hydrofluoric acid (HF)

A clear, colourless, fuming liquid of gas with a sharp, penetrating odour. It is very dangerous to the eyes, skin, and upper respiratory tract. Although it is a relatively weak mineral acid, it will attack glass or silicon compounds, and because of the toxicity of its fumes and drastic attack on the skin, it is very dangerous to handle. Fluorides in general are very toxic, almost as dangerous as cyanide and can be *fatal*, even in small concentrations. If exposed, do not wait for pain or symptoms, which can be delayed up to 24 hours. Treat immediately.

HF should be used only in a fume cupboard, and the fume cupboard must be turned on. Protective clothing must be worn and tubes of calcium gluconate jelly must be available. The area should be kept very tidy and clean, and users are required to ensure that they clean up after use. There should be no HF spillage; any drops which are spilled, including drips that run down the side of the bottle, should be neutralised with saturated sodium hydrogen carbonated solution and washed down. All HF work must be carried out in a plastic tray to contain all spillages.

Preventative measures

Face protection and PVC or rubber gloves should be worn at all times when handling HF. If decanting quantities of acid into containers it is strongly recommended that a rubber apron and rubber boots should be worn. Manipulations with HF acid should always be carried out in a fume cupboard approved for such work. This should be used for all activities involving HF: both making up the solutions and using them. Do not carry HF around the Department unnecessarily.

Smoking, drinking and eating are strictly forbidden while using hydrofluoric acid, (as is the rule in all laboratories) in order to avoid the possibility of facial burns or ingestion of the chemical.

Contamination

Any acid on the skin should be diluted immediately with copious quantities of water for one minute – direct waste water away from body. Calcium gluconate jelly should then be applied promptly to the area of the burn and massage a whole tube full well into the area with clean fingers. Small skin burns can be effectively and successfully treated by prompt treatment such as this. Always follow up by seeking professional medical attention.

If acid is splashed into the eyes they should be carefully flushed with copious quantities of water for at least twenty minutes or as long as it takes for suitable transport to be arranged to take the person to hospital.

Inhalation

HF acid vapour must be kept to a minimum as it is very irritating to the eyes, nose, mouth and lungs. Atmospheric concentrations of the vapour between 50 and 250 ppm are dangerous, even for brief exposure. In the even of inhalation: Remove the affected person from exposure and remove any contaminated clothing by cutting and peeling away from body, not by dragging over limb or head. If necessary apply artificial respiration (not mouth to mouth!) and, if necessary, cardiac massage.

Contact the Safety Department to organise an ambulance.

Ingestion

If any HF acid has been ingested **do not induce vomiting**. Give fluids such as water or milk. The person must be admitted to hospital as soon as possible.

16.6 Solvents

16.6.1 Acetone (CH_3COCH_3)

Is a colourless liquid with a fragrant mint-like odour. It is volatile and very flammable and a dangerous fire hazard. It is an irritant to the eyes and mucous membranes.

16.6.2 Ethyl Alcohol (CH_3CH_2OH) (Ethanol)

Also known as ethanol. It is a colourless, inoffensive solvent. It is a dangerous fire hazard, and its vapours are irritating to the eyes and upper respiratory tract. High concentrations of its vapour can produce intoxication. Solutions containing additions of up to 2% nitric acid (natal) can be safely mixed and stored in small quantities. Higher concentrations result in pressure build-up in tightly stoppered bottles. Explosions of 5% nitric acid in ethanol have occurred as a result of failure to relieve the pressure. If higher concentrations are desired, they can be mixed daily, place in an open dish, and used safely. The etch should be discarded at the end of the day.

Pouring a small amount of concentrated nitric acid into a bottle containing a small quantity of aged nital can result in formation of nitrous oxide fumes and spewing of the liquid from the bottle.

16.6.3 Methyl Alcohol (CH_3OH) (Methanol)

It is an excellent solvent, but it is a cumulative poison. Ingestion or absorption damages the central nervous system, kidneys, liver, heart, and other organs. Blindness has resulted from severe poisoning. It is particularly dangerous because repeated low-level exposures can also cause acute poisoning as a result of accumulation.

Whenever possible, ethanol should rather be used.

When using methanol, one should always work under a ventilation hood. Mixtures of methanol and sulphuric acid can form dimethyl sulphate, which is extremely toxic. Solutions of methanol and nitric acid are more stable than mixtures of nitric acid and higher alcohols. Mixtures of up to 5% nitric acid are safe to use and store in small quantities. Mixtures with more than 5% nitric acid, if heated are subject to violent decomposition.

16.7 Ammonium Hydroxide (NH_4OH)

A minor fire and explosive hazard.

16.8 Potassium- (KOH) and Sodium Hydroxide (NaOH)

Is not flammable. A strong base which will destroy tissue, causing severe burns. Also very dangerous to the eyes. Inhalation irritates and injures the upper respiratory tract, while ingestion causes serious damage to the digestive system. It is obtained as solid pellets. When it is added to water much heat is liberated. It should never be dissolved in hot water, since the heat liberated can produce boiling and spattering of the solution.

16.9 Hydrogen Peroxide (H_2O_2)

Is available as a liquid in concentrations of either 3 or 30%. The 3% solution is reasonably safe to use, while the 30% solution is a very powerful oxidant whose effect on the skin is as harmful as that produced by contact with sulphuric acid. It is not by itself combustible, but if brought into contact with combustible materials, it can produce violent combustion. It is very damaging to the eyes. Because release of oxygen can cause high pressures to develop within the container, the container caps are vented. Hydrogen Peroxide must be stored in plastic bottles and in quantities not exceeding one litre. As it is a powerful oxidising agent it should never be stored in the same cupboard as organic materials.

16.10 Mixtures of Organic Solvents with Oxidising Agents

Most mixtures of organic solvents with oxidising agents are potentially unstable. When required, these solutions should be made up in the smallest quantities required. They should not be stored for longer than necessary, and no longer than one (1) month.

Two other classes of etchants which can explode are those containing glycerol or perchloric acid.

16.10.1 Ethyl Alcohol – Nitric Acid

These solutions are unstable. Ethyl alcohol (ethanol) should not be used instead of methyl alcohol (methanol) in solutions based on nitric acid since solutions of the former with nitric acid are very unstable and tend to decompose violently.

Hazards also exist with methyl alcohol – nitric acid if the alcohol is allowed to evaporate with an increase in the concentration of acid. In order to reduce these dangers, ethyl alcohol must not be used in etchants, and all solutions containing methyl alcohol must be kept in *stoppered* bottles with a label giving the name of the person who made them up, the contects and the date of mixing.

After one (1) month, or if the solution becomes contaminated with metal particles which might act as a catalyst, the solutions should be discarded according to the chemical waste disposal instructions provided by the Safety Representative.

17. ***RADIOACTIVE MATERIALS***

Safe handling of naturally occurring radioactive material

Introduction:

NORM (Naturally Occurring Radioactive Materials):

NORM is an acronym for naturally occurring radioactive materials comprising radioactive elements found in the environment. Long-lived radioactive elements of interest include uranium, thorium and potassium and any of their respective radioactive decay products such as radium and radon. Some of these elements have always been present in the earth's crust and within the tissues of all living beings. Although the concentration of NORM in most natural substances is low, higher concentrations may arise as the result of human activities

Internal exposure results from the absorption, ingestion or inhalation of radioactive material. This material can be incorporated in the body in several ways: (1) by breathing radioactive gases, vapors or dust; (2) by consuming radioactive material transferred from contaminated hands, tobacco products, food or drink; (3) by entering through a wound; and (4) by absorption through the skin.

Note (As stated in MSDS):

- **Thorium** is a suspected carcinogen. Taken internally as ThO_2, it has proven to be carcinogenic due to its radioactivity.
- Mineral sands ore contains very low levels (below 0.05% by weight) of naturally occurring radioactive elements of the uranium and thorium series. Internal exposure via inhaled dust is the main exposure

pathway. Mineral sands ore contains quartz, (up to 25%) and precautions should be taken to avoid inhaling the dust.

The fundamental objectives of radiation protection measures are: (1) to limit entry of radionuclides into the human body (via ingestion, inhalation, absorption, or through open wounds) to quantities as low as reasonably achievable and always within the established limits; and (2) to limit exposure to external radiation to levels that are within established dose limits and as far below these limits as is reasonably achievable.

On the premises of the University of Pretoria there are naturally occurring low-levels radioactive materials such as uranium & thorium contained in:

- Chemical substances (radiochemical) such as Thorium oxide, Uranyl Acetate, Uranyl Nitrate.
- Geological/Mineral samples such as Mineral Salts, Pyrochlore Minerals & Zircon.

The radioactive materials used may constitute a significant health hazard (radioactive and toxic) unless adequately shielded and handled with proper care.

This safety guideline contains standards that have been set in order to limit the risk of radiation exposure as well as of the operators as well as the public to ionizing radiation, and to ensure that radiation doses are kept as low as reasonably achievable (ALARA principle).

17.1. ADMINISTRATIVE REQUIREMENTS:

- Keep an inventory of all radioactive material identified as such in your department.
- No one should acquire/sell/dispose/transfer/lend out any radioactive material, without first notifying the Radiation Control Officer in the OHS-division.

- Ensure material safety data sheets (MSDS) of radioactive materials are available in the department.
- Ensure compliance with safe handling &storage procedures as outlined in the MSDS.
- Compile written safety guidelines for those working with the radiochemicals & radioactive samples in your department.
- All material suspected to be radioactive must be measured/ surveyed with a radiation detector upon arrival on the premises.
- All containers of radioactive materials must be labeled with a radiation warning sign.
- Control the transfer of radioactive material between departments/areas to ensure that all individuals and the environment are protected against the potential risks of the hazardous material.
- Provide training/information session to staff& students working with radioactivity; on the safe handling of the radioactive materials.
- Every department should keep a record of the name and job category of each occupationally exposed worker.

17.2. HANDLING OF RADIOACTIVE MATERIALS:

- Containers with NORM radioactive material should be labeled with a radiation warning sign and the words:" low level radioactive material".
- The name, quantity, date of measurement, measurement level and form of radioactive material should be displayed, where possible.
- Personnel must wear protective clothing when handling the radioactive material: laboratory coats, gloves, safety goggles & masks.
- Wash hands before eating and drinking to minimize inhalation or ingestion from hands.
- Avoid inhaling/ingesting dust and vapors from radioactive material. Work with radioactive material in fume hood cabinet when likelihood of dust formation.
- Ensure proper and safe handling of the radioactive material. Operators must work fast and extend distance from material when finished with task.

- Ensure good housekeeping& sanitation practices.

17.3. STORAGE REQUIREMENTS

- Ensure that the primary container with radioactive materials is placed in a secondary container to prevent possible spillage.
- Radioactive material should not be stored with flammable, explosive or corrosive materials.
- Radiation warning signs should be displayed at the storage area to indicate the presence of radioactive material.

17.4. STEPS TO TAKE IN CASE OF ACCIDENTAL RELEASE/SPILLAGE OF RADIOACTIVE MATERIALS:

- Ensure to notify the Radiation Control Officer immediately.
- Monitor the area with a radiation survey meter, before and after removal of radioactive spill.
- Limit movement of people in the area
- Handle situation as a radioactive spill.
- Wear personal protective clothing that includes wearing double gloves, feet covers.
- Place contaminated clothing & waste material in radioactive waste containers.
- Methods for cleaning up spill:
    - Powder form: Sweep-up, place in container and hold for waste disposal. Avoid raising dust. Ventilate area and wash spill site after material pickup is complete.
    - Liquid Form: Prevent spreading of radioactive material. Use absorbent paper to remove spill, working from outwards towards the centre.

17.5. EMERGENCY PROCEDURES IN CASE OF ACCIDENTAL OVER-EXPOSURE:

- Ensure to notify the Radiation Control Officer immediately.

- Eye exposure: If uranium or an insoluble uranium compound gets into the eyes, immediately flush the eyes with large amounts of water for a minimum of 15 minutes, lifting the lower and upper lids occasionally. If irritation persists, get medical attention as soon as possible.
- Skin exposure: If uranium or an insoluble uranium compound contacts the skin, the contaminated skin should be washed with soap and water. Contaminated body surfaces should immediately be decontaminated in accordance with radiation procedures. Get medical attention.
- Inhalation: If uranium or an insoluble uranium compound is inhaled, move the victim at once to fresh air and get medical care as soon as possible. If the victim is not breathing, perform cardiopulmonary resuscitation; if breathing is difficult, give oxygen. Keep the victim warm and quiet until medical help arrives.
- Ingestion: If uranium or an insoluble uranium compound is ingested, give the victim several glasses of water to drink and then induce vomiting by having the victim touch the back of the throat with the finger or by giving syrup of ipecac as directed on the package. Do not force an unconscious or convulsing person to drink liquids or to vomit.
- Get medical help immediately

Definitions:

Radioactivity: Is the spontaneous emission of radiation, most often alpha or beta particles, which is often accompanied by gamma-rays, from the nucleus of an unstable radionuclide. The radionuclide is then charged or decays into the nuclide of a different element.

Specific Activity (Radioactive Concentration): The number of becquerels per unit of mass of a material. Units: Bq/g and kBq/kg.

Contamination (Radioactive Contamination): Radioactive material present in excess of natural background quantities in a place it is not wanted.

Beta Radiation (Beta Decay): The ejection of a high-energy negatively charged subatomic particle from the nucleus of an unstable atom. A beta particle is identical in mass and charge to an electron.

Alpha Radiation (Alpha Decay): A high-energy positively charged particle ejected from the nucleus of an unstable (radioactive) atom, consisting of two protons and two neutrons. An alpha particle is a helium nucleus.

Gamma Radiation: After a decay reaction, the nucleus is often in an excited state. The nucleus still has excess energy it must get rid of. This energy is lost by emitting a pulse of electromagnetic radiation called a gamma ray. Gamma radiation is similar to light and radio waves, but with shorter wavelengths. Gamma rays interact with material by colliding with the electrons in the shells of atoms. They can travel from one to several hundreds of meters through air and can easily go through people. Gamma radiation is highly penetrative according to its energy. It is shielded with lead.

X-ray Radiation: X-ray is the electromagnetic radiation with wavelengths just shorter than those emitted by ultraviolet light. (Also know as “bremsstrahlung”) X-rays are produced using high voltage electricity in medical diagnostic and research devices. Devices that produce x-rays are not radioactive when the power is on or off.

Contamination: Is the radioactive material in any place where it is not desired.

Fixed Contamination: Is contamination that cannot be removed using common cleaning methods.

Removable Contamination: Is contamination on a surface that can be removed so that any remaining contamination is below allowable limits.

Personnel Contamination: Is contamination on a person's body or clothing.

17.6 INTERNAL RULES FOR CHEMICAL ENGINEERING RADIATION LABORATORY (Room 2-51 Building 2 South Campus)

17.6.1 Radiation Authority Data:

File Number	Authority Number	Authority Expiry Date	RPO (Radiation Protection Officer)	ARPO (Assistant Radiation Protection Officer)
0031/15	**09/0323**	**31 May 2013**	**Y. Bekeur**	**A Devega**

The Department of Chemical Engineering has an authority to possess and use the following radioactive nuclides at the Research Radiation Lab. It is a Category B-Lab:

RADIOACTIVE NUCLIDES & Activity			
C-14: 5730 yr half-life **UNSEALED SOURCE**	**C-14: 5730 yr half-life** **Reference Source: Unquenched Standard used with LSC-unit**	**H-3: 12.3 yr half-life** **Reference Source: Unquenched Standard used with LSC-unit**	**Ba-133 : 10.5 yr half-life** **Reference Source: Sealed source inside LSC-unit**
1 GBq/ 27mCi	**3.7kBq / 0.1µ Ci**	**3.7kBq/ 0.1µ Ci**	**740kBq/20 µ Ci**
Do not handle more than 37MBq/1mCi at a time!			***Leak Tests not required***

17.6.2 Requirements

- **Administrative Responsibilities of the RPO and ARPO :**

1. Ensure that <u>all</u> radio-isotopes are authorized for possession and use. Renew authority when it expires. *Use RN 787 form obtainable from RPO/ARPO to apply/renew the authority. Comply with the Conditions attached to the Authority.*

2. <u>Before</u> implementing any changes to the authority data, such as, unsealed source not used anymore; ensure to communicate with the RPO, who must first obtain approval from Directorate Radiation Control.

3. An RPO and ARPO must always be appointed. They are responsible to ensure legal compliance, proper use, storage and disposal of radiation sources under safe conditions. *Complete an RN785 form for change of the RPO/ARPO*.

4. Wherever possible a Radiation-laboratory should be dedicated exclusively for work with radioactive material. Where this is not practicable, demarcate specific areas of the laboratory reserved for work with radioactive material.

5. Ensure to place radiation warning labels on all areas, equipment and materials involved with radioactivity.

6. Record the following data in the Radiation Source Register: Name of Radioactive Nuclide, Amount of Stock, and Amount of activity used at a time, Amount of waste Created and Person/s involved in the project.

7. The ARPO/ delegated Assessor must ensure that the Radiation Isotope Inspection Checklist is completed on a regular basis when the radiation lab is in active use. If any faults/ problems are identified in the Checklist, the RPO and ARPO must ensure that it is rectified.

8. Departmental Internal rules, DOH -Code of Practice for safe use of unsealed radioactive nuclides, and a copy of the Regulations relating to Group IV Hazardous Substances, must always be available in the radiation laboratory. (DOH = Department Of Health)

9. Keep records of all persons working with radioactivity in the radiation laboratory

10. Radiation workers must attend an information session presented by the RPO concerning Radiation Safety.

11. Monitoring of active radiation work- areas must be performed regularly:

    - Radiation surveys with the Radeye B20 portable monitor to assess for gross radioactive contamination on work/handling surfaces, normally 2-3 times above background.
    - Radiation surveys in the form of wipe-tests/smear tests over 100cm² areas, and assessed in the Liquid Scintillation Counter for alpha/beta contamination.
    - Contamination levels should not exceed 200DPM above background.
    - The area must be contamination -free when cleaners come to clean the lab, such as mopping of the floor.

Type B-laboratories must comply with the following additional safety requirements:

➢ **Personnel Monitoring and Protection**

- An area near the exit of the laboratory must be demarcated to provide space for changing coats, shoes, gloves, etc. A contamination survey monitor and basin for hand washing should be available in this area.

- Unless they are specifically exempted, all workers in B laboratories must be provided with personal dosimeters, obtainable from the SABS Radiation Protection Service.

- Routine bioassays (e.g. whole body or urine analysis etc) should be considered if large quantities of volatile nuclides are handled. All work involving radioactive material must be carried out in such a manner as to ensure that doses of radiation received are as low as reasonably achievable and do not exceed the limits reflected in the Chemical Engineering Radiation Authority Data.

- When quantities of material exceeding "C- lab limits" are handled, work must be performed in a fume hood. Radioactive nuclides that are volatile must be handled in a fume hood.

- **Working surfaces must be covered with disposable material (e.g. Benchkote).** Manipulations must be carried out over trays made of non-absorbent substances (e.g. stainless steel), lined with absorbent material (e.g. paper towel). Wherever possible radioactive material must only be moved or carried within secondary containment.

- **Appropriate protective clothing, such as laboratory coats, gloves, safety glasses, overalls, plastic overshoes/closed shoes, etc. must be worn by all radiation workers in the lab.**

- No eating, drinking, smoking, application of cosmetics, pipetting by mouth, or any other activity which may lead to the ingestion of active material, may be permitted where unsealed radionuclides are handled or stored.

- **Working techniques must be well thought out and understood before work is undertaken**. A balance should be struck between hurried manipulations, which may cause accidents, and prolonged operations, which may lead to excessive exposure.

- **If a small radiation spillage/exposure occurs, attend to decontamination process immediately**

- A Poster and a written procedure concerning decontamination process, should be displayed in the radiation laboratory.

➢ **Storage and Disposal of unsealed radioactive material**

- ***Long half-life waste such as C-14 and H-3 is sent to NECSA. Approval must first be obtained from DOH- Directorate: Radiation Control for disposal to NECSA.***

- Liquid and Solid Radioactive Waste must be stored separately.

- The liquid waste is stored in a plastic 25 Litre container whilst the solid waste is stored in a 160 Litre metal drum provided by NECSA. *Radiation labels with data of the nuclides inside must be displayed!*

- All containers must be properly sealed when full.

- A radiation survey with a portable survey meter must be done on the surface and 50 cm away. This reading result must be recorded for completion on the RN 523/RN524 DOH-forms.

➢ **Monitoring equipment**

- Regulation 2 of the Regulations Relating to Group IV Hazardous Substances requires that a B-lab authority holder must measure radiation and contamination levels. In the case of a nuclear medicine department where unsealed radionuclides are being used, the authority holder must have a radiation monitor able to measure dose rate and counts/sec.

- **Floors, walls and working surfaces**

  - Floors, walls and work surfaces must be smooth and non-absorbent to facilitate cleaning and decontamination. Ceilings should be similarly surfaced. Floor covering must be "non-slip" and must (after welding if necessary) be in one continuous sheet.

  - The junction of floors, walls and work surfaces must be rounded off in order to facilitate cleaning. Corners, cracks and rough surfaces must be avoided. Where joints are unavoidable they should be placed where the risk of spills and splashes is small and must be filled with a sealing compound.

- **Sinks and Plumbing**

  - One sink must be allocated for liquid radioactive waste (and so marked). This sink must have a resilient non-permeable surface e.g. polypropylene, PVC or stainless steel. The drains must be connected as directly as possible to the main sewer. Connections to open channels, and the use of large traps, must be avoided. All traps must be accessible for monitoring.
  - A separate (non-active) hand wash basin, fitted with foot-, knee- or elbow-operated taps must be provided near the exit of the laboratory, as specified in paragraph 5.

- **Fume Hoods**

  - A well-ventilated fume hood must be provided with the gas, water and electrical controls operable from the outside of the fume hood. The air velocity in the fume hood must be at least 0.5 m/s in the normal working position. Extractor fans should be positioned close to the outlet in order to maintain a negative pressure throughout the duct, and the motor should be outside the duct.

  - The surfaces of the fume hood and the ventilation duct must be smooth and non-absorbent and consist of materials which withstand the chemicals which are normally used in the fume hood.

- **Lighting and ventilation**

  - The laboratory must be well lit and ventilated, with a ventilation rate of at least 12 air changes/hour. A laboratory provided with a fume hood is normally ventilated by continuous movement of air into the fume hood. If work is to be permitted in the laboratory when the fume hood is switched off, additional ventilation must be provided to ensure that the required air change rate is met.

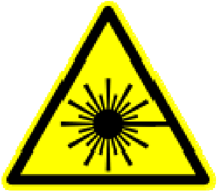
  - Lights should preferably be of the recessed type so that they can be mounted flush with the ceiling.

- **Air conditioning**

  - Room ventilation and air conditioning must be of such a nature to prevent recirculation of exhausted air from rooms where radionuclides are used, and which could under accident conditions become contaminated, into inactive areas or into the central air conditioning system of the hospital

*****ENSURE TO CONSULT THE DOH-CODE OF PRACTICE: "REQUIREMENTS FOR THE SAFE USE OF UNSEALED RADIOACTIVE NUCLIDES"**

18. ***LASER EQUIPMENT***



The presence of Class 3B and Class 4 Laser Units at the University of Pretoria

Laser equipment, if classified as a Class 3B or Class 4, can case permanent eye damage, if used without caution.

The Class 3B or Class 4 Laser Units must obtain a user license from the National Department of Health: Directorate Radiation Control. Thus UP must thus have a user licence for each laser unit on the premises.
If laser systems in an area makes use of laser equipment falling in this category, the UP safety officer shpould be provided with the relevant information in order to apply for and issue an apppropriate licence to use such equipment in a suitably equipped laboratory, (The current repsonsible UP person is: Ms Yolanda Bekeur, Occupational Health and Safety Division, Facilities Management Department, Tel: 012-420 6322, Fax: 012- 420 4009, yolanda.bekeur@up.ac.za).

The following safety measures should be in place before any work on a laser system can be done.

- Any employee or student working with a laser system MUST attend a laser safety course at the CSIR, Laser Division. If not that person is not allowed to work with a laser system.
- Key control / Interlocks
- Red warning light outside door to warn when laser is in use
- Access restriction
- Protective eyewear / beam stops and barriers
- Warning signs in the laser lab as well as on the door outside the lab
- Exhaust ventilation

Everybody working with a laser system should also read through and understand what is written in the following document “Requirements for the safe use of Class 3B and Class 4 Lasers or laser systems” from the Department of Health, Directorate: Radiation Control.

The document will be available in the laser laboratory.

19. ***GENERAL HAZARDS***

- Do not overfill bottles or flasks. A space equivalent to at least 10% of the total volume should be left to allow for expansion and for safe pouring. Bottles of capacity one litre or smaller are easier to handle than Winchesters. Winchesters should be avoided where possible, and certainly for dangerous chemicals and solvents.
- Never carry bottles by the neck or in the pocket. Winchesters must always be carried in the carriers provided; when removed from the carriers, they must be supported with both hands; one being beneath the bottle.
- Whenever possible, hazardous chemicals should be dispensed from a bottle or other container small enough to be held securely and safely in one hand.
- All containers must be clearly labelled including the user's name and the date. Highly poisonous, corrosive or reactive substances or mixtures should have this indicated. Protect labels with transparent adhesive tape and replace immediately any that are damaged.
- Solutions drawn into a pipette should never be sucked up by mouth. Always use a rubber teat or automatic pipette.
- Users of fume cupboards should check that the fume extraction system is working properly prior to use.

20. GENERAL LABORATORY PRACTICE

20.1 Purchasing Standards

- A signature must be obtained from study leader (in project book) before any orders will be placed
- An MSDS to be drawn from the Internet before any chemicals will be ordered – either from internal store or from outside companies
- Special precautions or protective clothing necessary must be taken into account

20.2 Training of personnel and students

- The Departmental Safety Book to be made accessible to each student
- Chemical Safety training course early in the new year
- UP Safety Personnel discussion early in the new year
- Safety Test to be successfully passed before being given access to the laboratories
- MSDS will be discussed with student before work may start
- Control of substances hazardous to health (COSHH) form to be completed before starting any work involving chemicals

20.3 Special storage facility

- All hazardous chemicals and substances will be locked in the store room in the various chemical stores. For each store, a list of contents will be pasted on the door and the key will be kept by the Safety Representative. Hazardous substances will only be signed out if student can satisfactorily prove his/her awareness of and treatment of such substances.

20.4 Chemical waste disposal

- Special drums are marked and placed in the labs. This is also covered during the Chemical Safety and UP Safety discussions.

21. <u>WORK ETHIC</u>

- Medical Aid Scheme information must be obtained for each student working in the laboratories in the event of an incident or injury.
- A detailed list of equipment, consumables, material, etc must be compiled after comprehensive planning of the project or project phase
- Work space must be clearly labelled with students' names and contact telephone numbers
- Work space must be kept tidy. All spillages must immediately be cleaned up, all dirty glassware must be washed immediately. Equipment and consumables must be packed away as soon as they are no longer being used.
- Hazardous chemicals must be locked in the store room, other chemicals being used must be kept neatly in a box or other suitable container.
- No students may help themselves from other experimental setups.
- Students may not use any laboratory equipment unless they have satisfactorily proven their competence on the equipment.
- As soon as the project has been completed, the work space must be cleaned up. The experimental setup will be dismantled, washed and packed away. All chemicals will be returned to the chemical store. All glassware will be washed and packed away.
- **The project supervisor, in the case of Postgraduate Students, or the Laboratory Manager, in the case of final year undergraduate students,** will sign off in the project document that the project workspace has been dismantled and cleaned.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Engineering, Built Environment and Information Technology

Department of Chemical Engineering
University of Pretoria

RISK ASSESSMENT

Project title:	
Location(s):	
Brief description of the work:	

Declaration

We the undersigned have assessed the activity and the associated risks and declare that the risks will be controlled by the methods listed. Those participating in the work have read the assessment. The work will be reassessed whenever there is significant change and at least annually.

Signed:
____

Name of Supervisor:
____

Name(s) of Researcher(s)/ Student (s):
____

____

____

Date: ______________________________

Review date for risk assessment: ______________________________

Purpose

The purpose of this document is to establish the safe working procedures to be followed to control the hazards, and the risks which could arise from them, of the work in the planned dissertation/research project.

The risk assessment document identifies a set of hazards which may be relevant to the project. For each relevant hazard category the risk should be identified and the appropriate control measure(s) described.

Environment	***Hazards involved with environment must be considered***	
Hazard *(s)*	**Risk*(s)***	**Control Measure*(s)***

Manual Handling	***Do manual handling activities take place? (Tick relevant box)***	**NO** / **YES**	***Move to next hazard -***
Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***	

Chemical/Biological	***Are chemical or biological hazards involved? (Tick relevant box)***	**NO** / **YES**	***Move to next hazard -***
Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***	

Working on or near water	***Does the work involve being near or on water? (Tick relevant box)***	NO YES	***Move to next hazard -***

Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***

Lone, isolated or out of hours working	***Is lone working involved? (Tick relevant box)***	NO YES	***Move to next hazard -***

Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***

Ill Health	***The possibility of ill health must be considered***

Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***

Equipment	***Will equipment be used? (Tick relevant box)***	NO YES	***Move to next hazard -***

Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***

Dealing with the Public	***Will you be dealing with the public? (Tick relevant box)***	NO YES	***Move to next hazard -***

Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***

Other Hazards	***Have you identified any other hazards? (Tick relevant box)***	**NO** / **YES**	______________

Hazard*(s)*	**Risk*(s)***	**Control Measure*(s)***

I have read, understood and agree to abide by the risk assessments and the safe working guidance provided for the project detailed overleaf.

Print Name	Signature	Date

Health History and Medical Aid details

Name of student: ……………………………………………………………………………..

Name of Medical Aid: ………………………………………………………………………..

Medical Aid number: ………………………………………………………………………….

Initials and Surname of Medical Aid member: …………………………………………..

Address to which medical aid accounts must be sent: …………………………………...

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………..

Health History

Allergies ………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………….

Medical conditions ……………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Anything else we should know concerning your health …………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

……………………………………………………….. ……………………………

Name & Signature Date