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In Case of Emergency Action

Radiation Protection Service - Contact Numbers

Radiation Protection Adviser
Dr Brian Heaton Aberdeen Radiation Protection Services

University Radiation Protection Officer
Dr. P.W.S. Szawlowski Internal Tel. Number 2753
Home Tel. Number 01333 450014
Mobile Tel: Number 07715 843061

University Safety Adviser
Mr Angus Clark Internal Tel. Number 2751

General Enquiries - Radiation Protection Service 2750
(Environmental, Health and Safety Services)

This sign should be displayed at the entrance to all areas where ionising radiations are used or where radioactive materials are stored or discharged.
Preface

Ionising radiations are a natural component of the environment in which we live. They come from constituents of the air we breathe, the ground we walk on and the food we eat. We are also bombarded by a never-ending stream of cosmic radiation from the sun and space. Today, we may also be exposed to varying levels of man-made radiation, the most significant of which is medical X-rays, and everyone appreciates the benefits which they have brought us. You, by the nature of your work, may be exposed to higher levels of radiation than the general public, and an important principle of radiation protection is that the benefits of the work that you do should far outweigh any risks involved.

The University has outlined how it will comply with relevant health and safety legislation and guidance in this publication. The purpose of this document is to provide radiation workers at the University with useful information on ionising radiations and details of the procedures they should follow to ensure safe working practices and compliance with the law. If the procedures are strictly adhered to, then the risks associated with your work with ionising radiations and your exposures to them should be minimal.


Guidance Documents

The Association of University Radiation Protection Officers (AURPO) has produced the following publications which have been used as references throughout this document:

- AURPO Working With Ionising Radiations in Research and Teaching (July 2010 update). This publication provides general guidance on all aspects on compliance with relevant governing legislation.
University of St. Andrews

Guidelines For Commencing Work With Ionising Radiation

**Research Worker or Student**

Attend Radiation Protection Course or go through Moodle training at [https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905](https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905) and do the test at the end of the programme

Consult project supervisor about the scope of the work – Register on the RadProt Management programme at: [https://portal.st-andrews.ac.uk/radprot/open/](https://portal.st-andrews.ac.uk/radprot/open/)

**Member of Staff**

Meet the DRPS to discuss the following aspects of the project:
1. Where the work can be carried out;
2. Check whether the radionuclide(s)/quantity are within the Building’s SEPA Registration;
3. Check that there is an appropriate SEPA Authorisation for the disposal of the radionuclide(s)/quantity and for the route of disposal.

Does the radionuclide(s) and quantity to be used in the work comply with the SEPA Registration and Authorisation?

- **YES**
  - Have you worked with Ionising radiation before?
    - **YES**
      - Then you must attend the University Radiation Protection training course OR obtain permission from the URPA.
    - **NO**
      - You should provide the URPA with evidence of:
        1. Suitable training in Radiation Protection;
        2. If requested, the dose records from your previous employer.
      - If the project **exceeds** limits set by the SEPA Registration and/or Authorisations for the Building, then **WORK CANNOT PROCEED.**
        You must then consult the Director of EHSS or their Depute

- **NO**
  - The following forms should now be completed:
    - Personal Registration Form on Radprot at [https://portal.st-andrews.ac.uk/radprot/open/](https://portal.st-andrews.ac.uk/radprot/open/)
    - Appropriate risk assessment form on the RadProt system at [https://portal.st-andrews.ac.uk/radprot/open/](https://portal.st-andrews.ac.uk/radprot/open/)
  - These electronic forms will then be automatically signed and passed onto the DRPS and RPO for the University

Project Supervisors/Workers/DRPS will be notified when the URPA approves their project and advised that the project can commence.

If deemed necessary by the URPA/DRPS, an appropriate personal dosimeter will be supplied to the worker.

Training in the School/Unit procedures for handling, using and disposal of radionuclide(s) will be provided locally. Workers should familiarise themselves with the School/Unit Rules for Working with Ionising Radiation.

The University undertakes an annual review of all ratified ionising radiation projects.
Guidelines For Commencing Work With X-ray Generators

**Research Worker or Student**
Consult project supervisor about the scope of the work activity

**Member of Staff**
Meet the DRPS to discuss the following aspects of the project:
1. Where the work can be carried out;
2. The equipment that will be used
3. The procedures that will be carried out using the equipment

Check the X-ray equipment complies with the Health and Safety Executive’s ‘Prior Authorisation for the Use of Electrical Equipment Intended to produce X-rays’
http://www.hse.gov.uk/radiation/ionising/authorisation.htm

If NO, then WORK CANNOT PROCEED.
You must then consult the URPA.

**Have you worked with Ionising radiation before?**

**YES**
You should provide the URPA with evidence of:
1. Suitable training in Radiation Protection;
2. Complete the test at the bottom of the Moodle Programme at https://moody.st-andrews.ac.uk/moodle/course/view.php?id=3506
3. If requested, the dose records from your previous employer.

**NO**
Then you must attend the School/Unit training course on the use of X-ray equipment OR pass through the Moodle Programme at https://moody.st-andrews.ac.uk/moodle/course/view.php?id=3506. You must complete the Test on the Moodle Programme before you can start.

The following forms should now be complete:
- Personal Registration Form on RadProt system at https://portal.st-andrews.ac.uk/radprot/open/ **NOTE:** You will only be allowed to be registered to use radioactivity if you have completed the Moodle test https://moody.st-andrews.ac.uk/moodle/course/view.php?id=3506 **AND**
- Appropriate Project Assessment Form on the RadProt system https://portal.st-andrews.ac.uk/radprot/open/
These forms will be sent to the DRPS and the University Radiation Protection Officer for approval.

Project Supervisors/Workers/DRPS will be notified when the URPA ratifies their project and advised that the project can commence.

If deemed necessary by the URPA/DRPS, an appropriate personal dosimeter will be supplied to the worker.

Training in the School/Unit procedures for the use of X-ray equipment will be provided locally. Workers should familiarise themselves with the School/Unit Rules for Working with Ionising Radiation.

The University undertakes an annual review of all ratified ionising radiation projects.
Local Rules for Working with Ionising Radiations

The following are the Local Rules for working with Ionising Radiations to ensure compliance with all statutory requirements.

The Local Rules for the University are as follows:

1. The Principal’s Office has ultimate authority for regulating work with ionising radiations within the University;
2. The Head of School/Unit has the responsibility for ensuring the Local Rules are implemented within their School/Unit;
3. The Departmental Radiation Protection Supervisors (DRPSs) are tasked with ensuring workers comply with the local rules;
4. All supervisors of those working with ionising radiations are have a duty to ensure the workers under their control comply with all the local rules and guidances for work with ionising radiations;
5. All workers have a responsibility for ensuring their own safety and the safety of others working who may be affected by their acts or omissions;
6. A University Radiation Hazards Management Group will be formed from all the DRPSs, lasers safety adviser, Director and Deputy Director of Environmental, Health and Safety Services (EHSS). This Group will review ionising radiations policies and report back to the Principal’s Office
7. A suitably qualified University Radiation Protection Adviser will be appointed to provide advice to staff and students on all matters relating to radiation protection;
8. Prior to any work starting with ionising radiations, the following must be obtained to meet legal requirements:
   a. Notification to the Health and Safety Executive of the First Use of the Premises under the Ionising Radiations Regulations 1999;
   b. Certificate of Registration from the Scottish Environment Protection Agency which identifies the buildings where work with radioactive materials will be undertaken, which radionuclides can be used in these buildings and how much of each radionuclide can be stored at the University at any one time;
   c. Certificate of Authorisation from the Scottish Environment Protection Agency which identifies how much radioactivity can be disposed of and by which route
9. All orders for radioactive material must be approved in writing by the DRPS or a named Depute prior to the order being placed;
10. On delivery a radioactive sources, the package must be taken to the DRPS or a named Depute who will ensure
    a. The correct amount of radioactivity has been delivered
    b. There is no contamination of the packaging
    c. The source container is not leaking
    d. The DRPS or a named Depute will then log the source onto the Radiation Management System (RadProt)
11. All radioactive sources will be stored in a secure facility. If any sources are found to be missing or significant quantities of radioactivity cannot be accounted for, the Director of EHSS must be notified as soon as practicable
12. All workers with ionising radiations must be competent in radiation protection techniques and in the local rules & procedures before they can start work. To ensure this, all workers must attend the University Radiation Protection Course or undertake the University e-learning radiation protection course at: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905 or X-ray equipment https://moody.st-andrews.ac.uk/moodle/course/view.php?id=3506
13. All workers who wish to use Ionising radiations (radioactivity and X-ray equipment) must be registered on the RadProt system. Before a worker can be registered to use ionising radiations, they must pass the test on the University e-learning radiation protection course.
14. Any worker who may be working in a ‘Controlled Area’ ie a ‘Classified Worker’ must undergo appropriate health surveillance which will be organised by the University Occupational Health Adviser.
15. Any expectant mothers or breastfeeding mothers must notify their Supervisor and DRPS and an appropriate review of the risk assessment of their work will be undertaken to ensure the safety of the mother, foetus and new born child.

16. Prior to any work with ionising radiations starting, the project work must be risk assessed using the RadProt system. This project will be approved by the Director of EHSS or a named Depute on behalf of the University and the University Radiation Protection Adviser. Projects which cause concern will be submitted to the University Radiation Protection Adviser for approval.

17. The Director of EHSS will ensure that suitable Geiger Counter probe and Scintillation probe contamination monitors will be provided to all areas where work with ionising radiations is undertaken.

18. The Director of EHSS will ensure that all contamination monitors are suitable calibrated and if necessary repaired on an annual basis.

19. Monitoring of relevant surfaces (workbenches, floor, fridges, door handles etc) using appropriate contamination monitors must be undertaken prior to and after any work with unsealed radioactive sources. Records of all such contamination monitoring must be kept for at least 2 years.

20. All usage and disposal of radioactive materials will be recorded onto the RadProt Radiation Management Programme.

21. Personal dosimeter radiation badges will be issued to all workers with ionising radiations (except those only working with 3H) by Environmental, Health and Safety Services.

22. If any single personal dosimetry dose measurement exceeds 0.5 mSv, or an annual dose of greater than 1 mSv is detected, an investigation will be carried out by the Director of Environmental, Health and Safety Services or a named Depute. The investigation report will be presented to the University Radiation Hazards Management Group;

23. Dosimetry Records for workers with radiation will be kept for 40 years.

24. All X-ray equipment will be inspected on an annual basis.

25. If any contamination monitoring shows that any X-ray machine is leaking radiation at three times background or greater or the interlocks have failed the equipment should be shut down, the DRPS or a named Depute notified and the equipment fixed by a suitable contractor.

26. If any X-ray equipment fails to shut down for whatever reason, the Director of EHSS must be notified as soon as practicable as this is reportable to the Health and Safety Executive.

27. All sealed sources will be notified to the Director of EHSS or a nominated Depute. Records of all such sources will be kept by the Director of EHSS;

28. All sealed sources will be wipe tested to determine if they are leaking on an annual basis by those working with the sources. If the leak testing shows contamination of greater than 3 times the background level, the source should be locked away in a secure place, and the Director of EHSS or their named Depute and the DRPS must be notified as soon as reasonably practicable.

29. If a radioactive source or a significant part of a unsealed source is lost, the Director of EHSS must be notified as soon as the loss of the source is noted.

30. The Director of EHSS must be notified as soon as reasonably practicable of all items found which are known to be radioactive or are believed to be radioactive and which have not been previously notified to the Director.
Guidance on the University of St Andrews Local Rules for Work with Ionising Radiations

1. Legislation & Codes of Practice

Work with ionising radiations is now covered by three main Acts of Parliament and their accompanying regulations. These are:-

(a) Health and Safety at Work etc. Act 1974 - Ionising Radiations Regulations 1999;

(b) Radioactive Substances Act 1993 Amendment (Scotland) 2011 and the Radioactive Substances Exemption (Scotland) Order 2011; and

(c) Carriage of Dangerous Goods Regulations 2009

The Health and Safety at Work etc. Act 1974 introduced the concept of risk assessment into safety legislation, for the first time. In this, the employee as well as the employer has responsibilities to himself and to others who may be affected, not only by the work he performs, but also by any failure to perform his duties.

The detailed requirements for work with ionising radiations under the Health and Safety at Work etc. Act are provided by the Ionising Radiations Regulations 1999 and the Approved Code of Practice for the protection of persons against ionising radiations arising from any work activity. This guidance can be found at: http://www.hse.gov.uk/pubns/books/l121.htm

The Radioactive Substances Act 1993 is designed to control the use of radioactive materials in all University buildings where radioactive materials are used. The University holds Registration Certificates, issued to them by the Scottish Environment Protection Agency (SEPA). These spell out the radioisotopes which are allowed to be used and the amounts which can be held in store at any one time. The SEPA also issue Authorisation Certificates for the disposal of radioactive waste, which place limits on the amounts which can be disposed of at any one time, and also specify the permitted means of disposal. Copies of the University Certificates must be posted in all areas where there is work with radioactive substances within a building.

The 2011 Amendment to this act slightly changed the definitions of what is deemed radioactive and thus needs appropriate Certificates of Registration and/or Authorisations

All School/Units will be given an allocation from the University SEPA Registration and Authorisation Certificates, and this should be prominently displayed in the appropriate work area with the University Certificates. It is important that all School/Units keep within the limits of their SEPA Certificates, but when necessary, these can be revised, with the help of the Radiation Protection Service.

There are Exemptions to the requirements to have Certificates of Registration /Authorisation and these are given in the Radioactive Substances Exemption (Scotland) Order 2011.

Carriage of Dangerous Goods Regulations 2009 – These Regulations enacts the Pan-European ADR Transport Guidance into legislation. This guidance is used to enact European standards for the transport of all hazardous materials including radioactive materials. The 2013 ADR guidance can be found at the following website: http://www.unece.org/trans/danger/publi/adr/adr2013/13contentse.html

Guidance on the implementation of these Regulations can be found at in the following document - AURPO Transport of Radioactive Materials by Road - Guidance Note (September 2010)

The ADR Regulations are updated on a regular basis and thus should always be checked prior to transporting any radioactive materials.
There are other pieces of legislation which will be mentioned in the relevant sections of the guidance below.

**There are enforcement agencies** - The Health and Safety Executive (HSE) and Scottish Environment Protection Agency (SEPA) - which, from time to time, inspect work with ionising radiations at the University to ensure that the Regulations are complied with. They have the power to enter premises unannounced, to withdraw licences or issue prohibition notices if they find an unsatisfactory situation and to prosecute with possible fines of up to £20,000 per offence.

**Note:** Some Universities have been successfully prosecuted for failure to comply with the above legislation.

2. **Radiation Safety Organisation and Individual Responsibilities**

2.1 **Management of Radiation Protection within the University**

The ultimate responsibility for radiological protection within the University lies with the Office of the **Principal**. This responsibility derives from the Health and Safety at Work etc., Act 1974 and cannot be devolved.

The University is legally required to appoint a qualified Radiation Protection Adviser (URPA) under the Ionising Radiations Regulations 1999. The duties of the URPA are defined in Appendix 1.

A University Radiation Protection Service will be organised by the Director of EHSS or a named Depute from Environmental, Health and Safety Services. The duties of this service are detailed in Appendix 4 to this document.

It is, the responsibility of the Head of the School/Unit to ensure that all University policies and guidances on ionising radiations are implemented within their School/Unit.

The Head of School/Unit can delegate some of these duties to a Departmental Radiation Protection Supervisor who can provide advice and monitor work activities in the School/Unit. The duties of a DRPS is given in Appendix 5 of this document.

The development and approval of Radiation policies is undertaken by the Radiation Hazards Management Group. The remit for this Group is given in Appendix 2 and the members of the Group are given in Appendix 3. The Radiation Hazards Management Group also undertakes the monitoring of governance of radiation risks at the University.

In addition to the Health and Safety at Work etc. Act, the Radioactive Substances Act 1993 and the Ionising Radiations Regulations 1999 require the University to establish an administrative structure to ensure that the radiation exposure of workers and the general public alike is kept as low as reasonably achievable (ALARA). This structure is shown in Figure 2.1.
All employees have a responsibility to look after their own safety and the safety of others by the employee’s acts or omissions. Employees also have a responsibility to comply with management instructions, wear personal protective equipment issued under appropriate risk assessments and notify their employer of any radiation hazard which has not been suitably assessed for risk.

2.2 Appointments

2.2.1 University Radiation Protection Adviser (URPA)

A University Radiation Protection Adviser (URPA) is appointed by the Office of the Principal to advise on compliance with statutory and other relevant health and safety legislation in connection with ionising radiation as required by the Ionising Radiations Regulations 1999. The duties of the URPA are given in Appendix 1.

Under the Ionising Radiations Regulations, the URPA must be deemed ‘Competent’ and thus must be registered with the RPA2000 organisation as an accredited RPA or be accredited by a similar organisation.

Advice on radiation matters will be provided to Heads of School/Unit and/or to project supervisors and/or to radiation workers by the URPA on request.

The URPA must be kept informed of any plan to use ionising radiation by a School/Unit or other person working within University premises.
2.2.2 University Radiation Hazards Management Group

The terms of reference for this Management Group are given in Appendix 2.

The Radiation Hazards Management Group will be convened by the Director of EHSS and for it to be quorate, it must have the Convenor plus more than 50% of other members present. The Membership of the Radiation Hazards Management Group is given in Appendix 3.

2.2.3 The University Radiation Protection Service (URPS)

The URPS comprises the URPA, Director of EHSS and the Deputy Director of EHSS (who acts as a Radiation Protection Officer for the University). The Deputy Director of EHSS is also the Radioactive waste adviser (RWA) for the University in conjunction with the URPA. The URPS undertakes the day-to-day work of the Radiation Hazards Management Group. The duties of the Radiation Protection Service are given in Appendix 4.

2.2.4 Appointed Doctor

An ‘Appointed Doctor’ will be employed and registered with the Health and Safety Executive if any University employees are designated as a ‘Classified Worker’ within the Ionising Radiations Regulations 1999. The Appointed Doctor will perform appropriate health surveillance on such Classified Workers.

2.2.5 Qualified Person

A Qualified Person will carry out or supervise the (i) testing of monitoring equipment before the equipment is taken into use for the first time, (ii) periodic testing of equipment and (iii) checks on equipment while in use.

2.2.6 The Director of EHSS

The Director of EHSS has specific ionising radiation protection duties. These duties include:

- Convene the Radiation Hazard Management Group meetings
- To liaise with SEPA and the HSE:
- To retain copies of the Certificates of Registration and Authorisation issued to the University;
- To retain the following records and reports (i) Radiation dose reports, (ii) Closing Reports, (iii) Transfer Records;
- To retain the health surveillance records issued by an Appointed Doctor;
- To arrange for the disposal of radioactive waste from the authorised stores and make and retain records of such disposals.

2.2.7 Deputy Director of EHSS (University Radiation Protection Officer)

The Radiation Protection Officer has the following duties:

- Undertake regular inspections of all areas working with ionising radiations;
- To investigate with the URPA if necessary, all significant incidents involving ionising radiations
- To provide radiation protection training to staff, students and DRPSs
- To manage the RadProt Radiation protection management computer programme
- To monitor all users and projects on the RadProt programme
- To collect and transport solid and liquid radioactive waste from Schools/Units to SEPA Registered waste stores;
- To record and keep Records of Waste held in Registered waste stores;
- To assist in the transport of solid radioactive waste to the local SEPA Authorised landfill site.
- Any other activities the Director of EHSS deems appropriate
2.2.8 Departmental Radiation Protection Supervisors (DRPS)

The Head of School in which ionising radiation is used shall appoint from the academic member of staff (or members of staff) of his School/Unit a Departmental Radiation Protection Supervisor(s) (DRPS). This appointment should then be submitted for approval to the URPA. The terms of reference for a DRPS is given in Appendix 5. The form for the appointment of a DRPS is given in Appendix 6.

The name of the DRPS should be included in the local School/Unit health and safety policy.

Each DRPS is required to familiarise himself/herself with all ionising radiation work taking place within the School/Unit or with specified work as described in his terms of reference. The DRPS will advise the Head of the School/Unit on routine matters of radiation safety.

The Head of the School may also appoint a Laboratory Radiation Protection Supervisor (LRPS) (see section 2.2.9)

2.2.9 Laboratory Radiation Protection Supervisor (LRPS)

In larger Schools/Units, the DRPS is unlikely to be the immediate line manager or supervisor overseeing the work with ionising radiation in all laboratories. In such a situation, the Head of the School/Unit may appoint a LRPS for a defined area or laboratory. This appointment will then be submitted for approval to the URPA. The terms of Reference for a LRPS are given in Appendix 7.

The form for the appointment of a LRPS is given in Appendix 8

2.2.10 Project Supervisor

It is the responsibility of all Project Supervisors/Principal Investigators who wish to use ionising radiations to be a registered radiation worker. The Project Supervisor/Principal Investigator has the following additional responsibilities:

- Register and undertake a risk assessment of the work involved on the project by completing the relevant form on RadProt (https://portal.st-andrews.ac.uk/radprot/open/). Approval of such work will automatically be sought by the system when the project is submitted.
- Obtaining prior approval from the University Radiation Protection Service for any significant changes to a previously approved ionising radiations project;
- The experimental procedures used by those under his/her supervision conform to the University and School/Unit Rules;
- Ensuring workers under his/her supervision have received suitable and sufficient training and instructions in the techniques that will be used.
- To suitably monitor the activities of those under their control to ensure they are using best practices and are complying with legislation as well as University policies and guidances.
- Notify the DRPS of any incidents involving radioactivity as soon as reasonably practicable

2.2.11 Radiation Worker

It is the duty of a radiation worker to carry out their work in a responsible manner with due consideration to others. The worker must never knowingly expose himself/herself or other persons to a significant level of ionising radiation. The working procedures used shall be designed to ensure that the radiation dose exposure is kept as low as reasonably achievable (ALARA). The duties of a Radiation Worker are given in Appendix 9.

Each radiation worker must be familiar with:

(i) The appropriate safety procedures applicable to the work being carried out;
(ii) The emergency procedures to be implemented in the event of an accident;
The notification procedure to be followed in the event of the loss of a quantity of radioactive substance or of its release into the atmosphere, or spillage or theft.

For a worker to be able to be registered as a user of radioactive substances, they must complete the test on the Moodle University Radiation Protection Course programme at: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905 and pass the test by 60% or greater. Once they have undertaken this test, they should register their name on the ‘Registration Details’ section of the RadProt programme at: https://portal.st-andrews.ac.uk/radprot/open/

Once the user is a ‘Registered Worker’ with ionising radiations, they should ask their Supervisor to add their name to an approved project, or they should complete the Assessment form on RadProt themselves. This will then be submitted to the University radiation protection Service for monitoring and approval process.

NOTE: Female radiation workers who become pregnant are subject to more stringent radiation dose limits and should notify the URPA, via the DRPS, of their pregnancy without delay (see Section 9). Strict confidentiality will be respected. It is not a legal requirement that expectant mothers inform the Head of the School/Unit and they can choose to keep this information private, however, in our view, it is not in your best interests to do so.

2.2.12 Visiting Radiation Workers

All visiting radiation workers come into the category of University of St. Andrews Registered Radiation Worker (other than those who are self-employed workers or those required by their employer to undertake work involving the use of ionising radiation). Approval of registration and permission to carry out specified work within University premises must be sought from the University Radiation Protection Service well in advance of the proposed starting date.

Only persons who have been designated as ‘Classified Workers’ by their own employer may act as Classified Workers within the University. Visiting ‘Classified Workers’ should have a suitable radiation dose ‘passport’ which details the dose received by that person. Such persons must provide the URPA with a copy of their current radiation dose ‘passport’.

Visiting research workers should complete the RadProt-Reg-1 form (see Appendix 10) which should then be signed by the local DRP. They will then be registered on the RadProt programme like any other worker and will be required to keep the appropriate records of their radioactive material use.

It should be noted that it is expected that visiting researchers undergo the Moodle programme entitle’ University Radiation protection Course’ (URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905)

2.2.13 University of St. Andrews Radiation Workers Visiting Other Establishments

Radiation workers who intend to carry out work involving the use of ionising radiations in premises other than those of the University of St. Andrews should notify the local RPA of this intention and provide such information as the RPA may require. You should also notify this University’s Radiation Protection Service and the local DRPS here. In compliance with Regulation 15 of the Ionising Radiations Regulations 1999, the URPS will arrange with the Controlling Authority for the premises to be visited and will supply information concerning the worker’s designation and current radiation dose record.
3. Notifications

3.1 Notifications to the Health and Safety Executive (HSE)

Note: All Notifications and Authorisations to the HSE must be carried out via the Radiation Protection Service on behalf of the University.

In accordance with Regulation 6 of the Ionising Radiations Regulations 1999, the HSE must be notified 28 days prior to work with ionising radiation (either radioactive sources or X-ray generators) for the first time in a School/Unit or if there is a significant change to the original notification.

3.2 Generic Authorisations for X-ray and Linear Accelerator Equipment

Authorisation is required from the HSE under the Ionising Radiations Regulations 1999 prior to the use of X-ray equipment and for research, exposure of persons for medical treatment, processing of products and industrial radiography and for the use of accelerators (though not for electron microscopes).

The European radiation protection legislation requires that all X-ray equipment is licenced. For low risk equipment, the HSE has produced generic authorisations for such equipment and School/Units should ensure that their equipment complies with these legal requirements. This generic Authorisation for X-ray equipment and linear accelerators can be found at: http://www.hse.gov.uk/radiation/ionising/authorisation.htm. Appendix 11 gives the details of the generic authorisation for X-ray equipment. Where equipment does not comply with generic authorisations, then a specific application will have to be made to the HSE.

3.3 Notifications to the Scottish Environment Protection Agency (SEPA)

Note: All applications for Registration and Authorisations must be carried out by the Radiation Protection Service.

3.3.1 Registration for the Keeping and Use of Radioactive Substances

Under the Radioactive Substances Act 1993, all Schools/Units wishing to work with radioactive substances must obtain a Certificate of Registration with SEPA prior to work with radioactive substances. This registration will detail which radionuclides may be stored at a specific site and how much of each radionuclide maybe stored. A ‘Single-Site’ Certificate of Registration has now been issued to the University. If however a new building is to be used which is not on the University Certificate of Registration, then a new Registration notification will have to be submitted to SEPA. All workers should be aware that it is a criminal offence to exceed the Registration Limits set for the University. Each School/Unit will be allocated a set limit for holding radioactive materials from the University limit by the URPS.

The Certificate of Registration should be posted in a prominent place in all ‘Controlled’ / ‘Supervised’ areas in the School/Unit.

3.3.2 Authorisation for the Disposal of Radioactive Substances.

Under the Radioactive Substances Act 1993, all Schools/Units working with radioactive substances need a Certificate of Authorisation from SEPA for the accumulation and disposal of waste radioactivity. This Certificate will detail what radionuclides and how much of each radionuclide can be accumulated and disposed of per month. A copy of the Certificate must be posted in a prominent position in all ‘Controlled’ / ‘Supervised’ areas in the School/Unit. A ‘Single-Site’ Certificate of Registration has now been issued to the University. Each School/Unit will be allocated a set limit for the disposal of waste radioactive materials from the University limit by the URPS.

All workers should be aware that it is a criminal offence to accumulate and dispose of radionuclides without a Certificate of Authorisation.
3.4 Notification of Loss, Theft or Significant Spillage of Radionuclides

Whenever there are reasonable grounds for believing or suspecting that a registered source or any amount of a registered radioactive substance has been lost or stolen, or there is a significant release of radioactivity due to an accident, then the URPS must be informed immediately. The URPS will ensure that:

- Notification to that effect is given forthwith by the quickest means available to SEPA and to a member of the police force and in writing as soon as possible to HSE;
- Take all practicable measures to recover the source or contain the spillage.

4. Radiation Units

With the introduction of the Ionising Radiations Regulations 1999, it has been obligatory to adopt the International System of Units (SI) for use with ionising radiations. These will be used throughout the local rules, and in all information or data collection for compliance with legislation. Conversion factors to the old units will be found in Appendix 28

Note: SI units must be used in drain records to summarise monthly cumulative totals and for storage records.

4.1 Activity

The SI unit of activity is the Becquerel (Bq), and is equal to one disintegration per second (dps). The previous unit used (and still occasionally used) is the Curie, which is the activity of 1 gram of radium, equivalent to $3.7 \times 10^{10}$ Bq.

4.2 Absorbed Dose

When ionising radiations pass through matter, some or all of the energy they possess is given up, and the absorbed dose is a measure of this energy deposition. In the SI units, 1 Gray (Gy) is defined as the energy deposition of 1 joule per kilogram.

4.3 Equivalent Dose

For the same as absorbed dose of radiation, some types of ionising radiations have a greater biological action. To allow for this, radiation weighting factors have been introduced which reflect the ability of different ionising radiations to cause damage, and if we multiply the absorbed dose by the appropriate factor, we arrive at what is called the Equivalent Dose. This is measured in Sieverts. For work with:

<table>
<thead>
<tr>
<th>Type of radiation</th>
<th>Radiation Weighting Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta Gamma &amp; X-ray emissions</td>
<td>1</td>
</tr>
<tr>
<td>neutrons</td>
<td>5-20</td>
</tr>
<tr>
<td>protons</td>
<td>5</td>
</tr>
<tr>
<td>alpha particles</td>
<td>20</td>
</tr>
</tbody>
</table>

5. Dose Limits and Assessments

One great difficulty in working with ionising radiations is that one cannot sense their presence, and one can be subjected to obvious harmful effects and not be aware of it until sometime after the event, in some cases years later. Early workers found, to their cost, the hazards of working with ionising radiations, and international concern led to the setting up of the International Commission on Radiological Protection (ICRP) in 1928. The Commission has brought together all the information available on the biological effects of ionising radiations, and has then recommended dose limits and good working practices in order to minimise the risks from working with ionising radiations. ICRP recommendations form the basis of all the national regulations.
Detailed information on the biological effects of radiation can be found in the Radiation Protection Moodle Course e-learning package which can be found at: [https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905](https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905)

### 5.1 Dose Limits

The dose limits recommended by the ICRP, and adopted by our own legislators, are constantly under review as our knowledge of the effects of radiation improves. They are set on the basis that a lifetime's exposure to the maximum dose limits will not result in any deterministic effects, and that the risk of stochastic effects can be kept to an acceptable level for the average exposure of a radiation worker (1 mSv/annum). Exposure up to the dose limits is not considered acceptable, however all doses should be kept AS LOW AS REASONABLY PRACTICABLE regardless.

**Dose Limits For Radiation Workers**

<table>
<thead>
<tr>
<th>Exposure Type</th>
<th>Maximum Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole body exposure</td>
<td>20 mSv/annum</td>
</tr>
<tr>
<td>Individual organ or tissue or hands</td>
<td>500 mSv/annum</td>
</tr>
<tr>
<td>Lens of the eye</td>
<td>150 mSv/annum</td>
</tr>
</tbody>
</table>

**Special Limits for women**

<table>
<thead>
<tr>
<th>Special Limit</th>
<th>Maximum Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdomen of woman of reproductive capacity</td>
<td>13 mSv/3 months</td>
</tr>
<tr>
<td>Dose constraint for foetus during the term of pregnancy</td>
<td>1 mSv</td>
</tr>
</tbody>
</table>

Dose constraint is a new concept and is not strictly a limit, but a reasonably achievable target to keep below that indicates best practice. There is no reason why, in a University context, that all radiation workers should not keep to within a dose constraint of 1 mSv. This target is reasonably achievable and means that men and women can then be treated the same with no undue concern should a woman become pregnant.

As a consequence of setting up a dose constraint of 1 mSv per year, the URPS will always undertake an investigation of any personal dosimeter readings of 0.4 mSv/2 month wear period or above.

The dose limit for members of the general public from artificial sources has now been set at 1 mSv/annum above background, except in exceptional circumstances. It is worth noting that the average individual exposure from background radiation is 2.6 mSv/annum. This is predominantly from natural sources, and can vary considerably depending upon where you live.

### 5.2 Personnel Dose Assessments

Any person who is likely to receive a dose of radiation in excess of three-tenths of any relevant dose limit of 20 mSv / annum (whole body dose) or 3/10th of the extremity or eye dose limit, is required to be categorised as a classified radiation worker and must have his exposure to radiation monitored.

Also, any worker who works in a controlled area (see Laboratory Designation Section 7) either has to be a ‘Classified Worker’ or work under a written System of Work, and this normally entails personal monitoring. At St. Andrews University, we go further than these basic requirements, and issue personal dosimeters to all staff who work with penetrating radiations (see Section 11.1), unless their possible exposure can be shown to be negligible. Work with alpha emitters or weak beta emitters, such as H-3, does not require the wearing of personal dosimeters as these radiations cannot penetrate the dosimeter badge. It is important that, if you are issued with a personal dosimeter, it should be worn at all times whilst working with ionising radiations, and worn correctly (see Section 11). A few people who come into close contact
with particularly high doses of penetrating radiations will also be requested to wear finger personal dosimeters and they will be given guidance as to their usage at the time.

Personal dose records are kept by the University Radiation Protection Service and a person’s record can be viewed at any reasonable time on request by that individual.

5.3 Dose Investigation Levels

The minimum detectable level of radiation on a personal dosimeters is 0.01 mSv. The University Radiation Protection Service may investigate any exposure significantly above the minimum detectable amount, but must investigate any reading of 0.4 mSv/2 month dosimeter wear period to ensure that all personnel exposure to ionising radiations is kept as low as reasonably practicable. Notification of the Health and Safety Executive and a subsequent official investigation will take place for a radiation exposure of 15 mSv and above.

5.4 Dose Limits for Pregnant Women

As the dose limits for pregnant women are significantly lower than for other workers, it is important that if a woman becomes pregnant, they should inform the Head of the School/Unit as soon as reasonably practicable. This will allow a risk assessment of their work with radiation sources to be performed so that appropriate control measures can be put in place to ensure their exposure is kept As Low As Reasonably Achievable (ALARA) (See Section 10).
6. Radioactive Substances Act 1993 and Associated Legislation

The Radioactive Substances Act 1993 is aimed to controlling potential effects to the environment and therefore this comes under environmental protection which means it is devolved legislation. This legislation is now different from the legislation in England and Wales which use the Environmental Permitting (England and Wales) Regulations 2010.

The Radioactive Substances Act in Scotland requires the University to apply for a Certificate of Registration, which defines the radionuclides and the quantities that can be held at the University and a Certificate of Authorisation which identifies have the radioactive materials can be disposed of, what routes can be used and how much can be disposed of per month. Copies of these certificates must be placed in the areas where radioactive work is undertaken.

The certificates only relate to radioactive materials (where as the English legislation are certificates for all hazardous materials). These certificates are issued by the Scottish Environment Protection Agency (SEPA) and are enforced by SEPA. The University is usually inspected by SEPA on an annual basis.

It is vital that accurate records are kept to comply with this legislation. It is therefore vital; that people record the delivery, storage, use and disposal of radioactive materials on the University’s computerised programme for radiation management called ‘RadProt’. Failure to do this exposes the University to enforcement action by SEPA.

The University has Certificates of Registration and Authorisation for the whole campus. The URPS has therefore allocated a certain percentage of the total to individual buildings. Copies of these allocations should also be posted with the University’s Certificates of Registration and Authorisations. The allocations can be altered if research groups change their needs as long as the total for the University does not change.

If you wish to use a radionuclide not on the University Certificates or you wish to use an activity greater than is presently on University Certificates, then you will need to contact the URPO who will start the process of applying for a new University Certificates. This does have a significant cost and also will take some time (SEPA can take up to 12 months to approve such applications).

6.1 Radioactive Substances Exemption (Scotland) Order 2011

There are exemptions to the requirement to obtain Certificates of Registration and Authorisation which is given in the Radioactive Substances Exemption Order 2011. This piece of legislation rationalises 21 pieces of older legislation under one unified control system. It is aimed at simplifying the exemption requirements of the Radioactive Substances Act. Detailed guidance on the Exemption Order can be found at URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69357/pb13624-rsl-guidance-110914.pdf

The Radioactive Substances Act 1993 Amendment (Scotland) Regulations 2011 defines what is deemed radioactive under legislation. Where items do not meet the definition of radioactive in this legislation are not covered by the Radioactive Substances Act. Items which are defined as radioactive by this legislation but are lower than the limits set by the Exemption Order are exempt.

All radioactive substances regardless of whether they are included in the exemption order must be notified to the UPRO and must be maintained and inspected regularly. Written records of the presence, maintenance and inspection of such sources must be kept by the School/Unit and be made available to the URPA, URPO and enforcing agencies.

The basis of the Exemption Order are where the dose to a person from artificial radiation sources is less than 10 mSv per Year from constant use or 300 mSv per year for Normally Occurring Radioactive Materials (NORM). The NORM dose is significantly higher as it is not practicable to regulate it below this level.
The Exemption Order specifies the limits of radioactivity which can be where exemption from a Certificate of Registration is allowed.

<table>
<thead>
<tr>
<th>Substance or Article</th>
<th>Maximum Activity per single radionuclide item</th>
<th>Maximum total quantity of radionuclides</th>
</tr>
</thead>
<tbody>
<tr>
<td>A sealed source of a type not described in any other part of this table</td>
<td>$4 \times 10^6$ Bq</td>
<td>$2 \times 10^8$ Bq</td>
</tr>
<tr>
<td>Any sealed source which is solely radioactive material or radioactive waste because it contains tritium.</td>
<td>$2 \times 10^{10}$ Bq</td>
<td>$5 \times 10^{12}$ Bq</td>
</tr>
<tr>
<td>A tritium foil source</td>
<td>$2 \times 10^{10}$ Bq</td>
<td>$5 \times 10^{12}$ Bq</td>
</tr>
<tr>
<td>A smoke detector affixed to premises</td>
<td>$4 \times 10^6$ Bq</td>
<td>No limit</td>
</tr>
<tr>
<td>An electrodeposited (Ni-63 or Fe-55)</td>
<td>$6 \times 10^8$ Bq of Ni-63 OR $2 \times 10^8$ Bq of Fe-55</td>
<td>$6 \times 10^{11}$ Bq for both Ni-63 and Fe-55</td>
</tr>
<tr>
<td>A Ba-137m eluting source</td>
<td>$4 \times 10^8$ Bq Cs-137+</td>
<td>$4 \times 10^9$ Bq Cs-137+</td>
</tr>
<tr>
<td>A uranium or thorium compound</td>
<td>Up to 5 kg of uranium or thorium</td>
<td>Up to 5 kg of uranium or thorium</td>
</tr>
<tr>
<td>A substance or article which is or contains magnesium alloy or thoriated tungsten in which the thorium concentration does not exceed 4% by mass</td>
<td>No Limit</td>
<td>No Limit</td>
</tr>
<tr>
<td>Other items which may be Exempt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A Class A gaseous tritium light device (does not exceed $2 \times 10^{10}$Bq of $^3$H)</td>
<td>$2 \times 10^{10}$Bq</td>
<td>$5 \times 10^{12}$Bq</td>
</tr>
<tr>
<td>A Class B gaseous tritium light device (each sealed container does not exceed $8 \times 10^{10}$Bq and device does not exceed $1 \times 10^{12}$Bq)</td>
<td>$1 \times 10^{12}$Bq</td>
<td>$3 \times 10^{13}$Bq</td>
</tr>
<tr>
<td>A Class C gaseous tritium light device(Installed in a vessel or aircraft or vehicle used by the armed forces)</td>
<td>$1 \times 10^{12}$Bq</td>
<td>No Limit</td>
</tr>
<tr>
<td>A luminised article</td>
<td>$8 \times 10^8$ Bq $^{147}$Pm- or $4 \times 10^9$ Bq of $^3$H</td>
<td>$4 \times 10^{10}$Bq $^{147}$Pm- or $2 \times 10^{11}$ Bq of $^3$H</td>
</tr>
<tr>
<td>A substance or article (other than a sealed source) which is intended for use for medical or veterinary diagnosis or for medical or veterinary trials</td>
<td>$1 \times 10^9$ Tc-99m and in respect of the total for all other radionuclides i). $1 \times 10^9$Bq if the substance or article is radioactive material OR ii). $2 \times 10^9$Bq if the substance or article is radioactive waste</td>
<td>$1 \times 10^9$ Tc-99m and $2 \times 10^9$Bq of all other radionuclides (no more than $1 \times 10^9$Bq of which is contained in radioactive materials)</td>
</tr>
</tbody>
</table>

Under the Radioactive Substances Act 1993, the University must poses a Certificate of authorisation for the disposal of radioactive waste unless it is deemed ‘Exempt’. The maximum activity limits for radioactive waste are given in the following table:
<table>
<thead>
<tr>
<th>Radioactive waste</th>
<th>Maximum concentration of radionuclides</th>
<th>Maximum quantity of waste to be disposed of in the period stated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid radioactive waste, with no single item &gt; 4 x 10^4 Bq.</td>
<td>4 x 10^7 Bq for the sum of all radionuclides per 0.1m^3.</td>
<td>2 x 10^8 Bq/year</td>
</tr>
<tr>
<td>Solid radioactive waste containing tritium and C-14 only, with no single item &gt; 4 x 10^5 Bq.</td>
<td>4 x 10^6 Bq of tritium and C-14 per 0.1m^3.</td>
<td>2 x 10^9 Bq/year</td>
</tr>
<tr>
<td>Individual sealed sources.</td>
<td>2 x 10^7 Bq for the sum of all radionuclides per 0.1m^3.</td>
<td>1 x 10^7 Bq/year</td>
</tr>
<tr>
<td>Individual sealed sources which are radioactive waste solely because they contain tritium.</td>
<td>2 x 10^10 Bq of tritium per 0.1m^3.</td>
<td>1 x 10^13 Bq/year</td>
</tr>
<tr>
<td>Luminised articles with no single item containing &gt; 8 x 10^7 Bq of Pm-147 or &gt; 4 x 10^9 of tritium.</td>
<td>8 x 10^7 Bq per 0.1m^3 of Pm-147 or 4 x 10^9 Bq per 0.1m^3 for tritium.</td>
<td>2 x 10^8 Bq/year of Pm-147 or 1 x 10^11 Bq/year of tritium.</td>
</tr>
<tr>
<td>Solid radioactive waste which consists of magnesium alloy, thoriated tungsten or dross from hardener alloy in which the thorium concentration does not exceed 4% by mass.</td>
<td>No limit.</td>
<td>No limit.</td>
</tr>
<tr>
<td>Solid uranium or thorium compound.</td>
<td>No limit.</td>
<td>0.5 kg of uranium or thorium per week.</td>
</tr>
<tr>
<td>Aqueous liquid uranium or thorium compound.</td>
<td>No limit.</td>
<td>0.5 kg of uranium or thorium per year.</td>
</tr>
<tr>
<td>Radioactive waste in aqueous solution being human excreta.</td>
<td>No limit.</td>
<td>1 x 10^10 Bq/year of Tc-99m and 5 x 10^9 Bq/year for the sum of all other radionuclides.</td>
</tr>
</tbody>
</table>

### 6.2 Management of Low Activity Unsealed Sources

Where work with unsealed radioactive sources is used under the Exemption Order, it will be required that a risk assessment for the work proposed must be completed on the RadProt radiation management programme. It is vital that the Director of EHSS is informed of such work prior to it being submitted to the URPA.

This work will then be assessed by the URPA to determine if it meets with the requirements of the Exemption Order.

The research Group must inform the Deputy Director of EHSS and the local DRPS when the source is ordered and has arrived. No work can begin until it is agreed this meets with relevant requirements of the Exemption Order.

All usage and disposals of the source must be recorded using the RadProt system. The quantity and disposal of radioactive material must all come within the Exemption order requirements.

If the source is used at a remote site where there is no access to internet, then paper records must be kept and then when the group returns the paper records must be added to the RadProt system. No further ordering of the source can be undertaken without the records showing that all the source has been used.

The general conditions for the storage, handling and disposal of radioactive materials and waste under the Radioactive Substances Exemption (Scotland) Order 2011 are as follows:
• Comply with all requirements of the University’s Local Rules for Work with Ionising Radiations;
• An adequate record must be kept of the arrival, storage use and disposal of all radioactive materials;
• All containers used to store radioactive materials or radioactive waste was must be clearly labelled with a unique mark;
• All records must be available for view by a Scottish Environment Protection Agency (SEPA) Inspector;
• Exempted sealed sources, electrodeposited and tritium foil sources must not be mutilated or modified such there is no loss of containment;
• All exempted sources must be held safely and securely to prevent exposure of others to the radiation, accidental removal or theft from premises or a loss of containment;
• Notify the Director of Environmental, Health and Safety Services if it is suspected that a source has been lost or stolen;
• Dispose of all radioactive waste as soon as is practicable through Environmental, Health and Safety Services.

7. Restriction of Exposure - Hazard Control

In order to minimise the exposure to ionising radiations, one needs to appreciate the properties of the ionising radiations and the two principal hazards which they can present.

7.1 Risk Assessment for working with Ionising Radiation

The risk assessment for working with ionising radiations is based on the standard HSE 5 Steps to risk assessment. These are:

1. Identify Hazard – The Hazard of the radionuclide will be the energy of the radioactive radiation, the type of radiation ($\alpha$ particle of $\gamma$ particle) or the energy of the X-ray radiation and the potential biological effects the radiation may have. Please do not forget the non-ionising effects of the radionuclide eg the chemistry of the compound for example Radium replacing calcium in bones;

2. Who is harmed – Identify those who may be harmed by the radiation. Remember the people you cannot see – eg cleaners and maintenance staff (ir plumbers who may be affected by disposals to drain). Also, do not forget those at especial risk eg expectant mothers

3. Probability Persons will be harmed – In this case you are looking at the probability that the radiation will have a biological effect, thus you will need to know the activity of the radionuclide, how much is being used (for chemical effects etc), where it is being used, the form it is in (eg gaseous form will be more of a risk of inhaling the radionuclide), potential routes of causing harm etc

4. Control Measures – How will you control the risks of the ionising radiations. These control measures are prioritised as follows:

   a. Eliminate - Do not use radioactive materials or X-rays if other systems can do the experiment more safely;
   b. Substitute – Substitute the radionuclide / X-ray radiation for something which has less energy and penetrating power (eg substitute 32P with 33P)
   c. Engineering Controls – Work behind shielding;
   d. Procedural Controls – Hold the source as far from the body as practicable, be exposed to radiation for as short a period as possible. Always have good laboratory practice to avoid contamination or exposing others to radiation;
   e. Personal Protective Equipment (PPE) - PPE as a primary control measure should always be a last resort as it will only protect the worker wearing it (other controls above will protect workers plus others in the area).
5. **Monitor Risk Assessment** - Monitor and review the risk assessment on a regular basis

Details on the energy of radiation from certain commonly used radionuclides can be found at: [https://www.ehs.uci.edu/programs/radiation/RADIONUCLIDEFeb04.pdf](https://www.ehs.uci.edu/programs/radiation/RADIONUCLIDEFeb04.pdf). Further information can be obtained from the Deputy Director of EHSS.

We can be irradiated by a source of radiation which is outside the body - this presents us with an external hazard, or we can accidentally incorporate radioactive materials into the body - this presents us with an internal hazard. All hazards from ionising radiations can be minimised by using the lowest activity source or energy of X-rays consistent with experimental requirements.

7.2 **Basic Control Measures**

7.2.1 **Inverse Square Law**

The dose rate associated with any point source of gamma or X-radiation is inversely proportional to the square of the distance from the source.

\[ D \propto \frac{1}{r^2} \]

Therefore, doubling the distance from the source, reduces the dose rate by a factor of 4. Therefore hold a source at arms-length gives more protection than holding it close to the body.

Always remember **closeness endangers - distance protects**.

7.2.2 **Dose Rate Calculations**

A useful expression for calculating the approximate dose rate from a gamma source is:

\[ D = \frac{ME}{6r^2} \]

- \( D \) is dose rate in \( \mu \text{Svh} \)
- \( M \) is activity in MBq
- \( E \) is energy/disintegration in MeV
- \( r \) is distance from source in metres

This of course assumes no shielding, and a monitor should always be used to establish the true dose rate.

The table below gives some examples of dose rates at 1 m from 10 MBq sources, using information on the energy and intensity of their gamma emissions from ICRP publication 38.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Gamma dose rate at 1 metre in ( \mu \text{Svh} ) for 10 MBq source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na-22</td>
<td>3.65</td>
</tr>
<tr>
<td>Cr-51</td>
<td>0.05</td>
</tr>
<tr>
<td>Fe-59</td>
<td>1.98</td>
</tr>
<tr>
<td>Co-57</td>
<td>0.21</td>
</tr>
<tr>
<td>Co-60</td>
<td>4.17</td>
</tr>
<tr>
<td>I-125</td>
<td>0.07</td>
</tr>
<tr>
<td>I-131</td>
<td>0.63</td>
</tr>
</tbody>
</table>
A rough way of calculating the dose from $\beta$ sources with energy of 0.5 MeV to 3 MeV is as follows:

$$\text{Dose (mGrays) at 10cm from } \beta \text{ source} = 800 \text{ Activity (GBq)}$$

The dose from a particular X-ray equipment is derived empirically due to the nature of the target and the voltage and ampage of the equipment. For example:

Information on X-ray dose rates and X-ray shielding can be found at:  
http://www.ionactive.co.uk/technical_guidance-parts.html?type=1

7.2.3 Shielding

Beta particles are best shielded by materials of low atomic number to prevent the production of Bremsstrahlung radiation. Perspex makes good shields, because it is robust and easily worked. Glass is also very effective, and thick walled glass vessels are particularly useful.

The amount of shielding for beta radiation can be calculated as follows:

$$\text{Absorber Thickness (cm)} = \frac{\text{Absorber Linear Density (for } \beta \text{ of specific maximum energy) (mg/cm}^2\text{)}}{\text{Absorber density (mg/cm}^3\text{)}}$$

The table below shows the thickness required for complete shielding. Beta particles are completely stopped in the shielding material as they have a maximum energy, therefore, if an appropriate thickness of shield is used, all $\beta$ are stopped irrespective of the activity present.

Note: The small amount of Bremsstrahlung radiation produced when beta particles interact with the relevant shielding should not be ignored.
Gamma rays and X-rays are far more penetrating than beta particles of the same energy and require dense shielding materials - lead is the material which is usually used. They are attenuated exponentially. A knowledge of the half-value layer (HVL) or tenth-value layer (TVL) is useful in determining the amount of shielding required. 1 HVL is the thickness required to reduce the intensity to one half the incident value and 1 TVL is the thickness needed to reduce the intensity to one tenth the incident value. Some approximate values of HVL and TVL are given in the table below.

<table>
<thead>
<tr>
<th>E max (MeV)</th>
<th>HVL</th>
<th>TVL</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>4</td>
<td>12.5</td>
</tr>
<tr>
<td>1.0</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>1.5</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>2.0</td>
<td>19</td>
<td>60</td>
</tr>
</tbody>
</table>

Gamma rays and X-rays cannot be completely stopped, thus shielding only reduces the dose received.

More detail can be found in the Radiation Protection Moodle site at: [https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905](https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905) and in the X-ray safety awareness Moodle site at: [https://moody.st-andrews.ac.uk/moodle/course/view.php?id=3506](https://moody.st-andrews.ac.uk/moodle/course/view.php?id=3506). Details on the amount of shielding needed for specific X-rays can be found at: [http://www.ionactive.co.uk/technical_guidance-parts.html?type=1](http://www.ionactive.co.uk/technical_guidance-parts.html?type=1).

The good working practices required for work with sealed sources are given: in the Laboratory Rules (see Appendix 12); in the conditions of individual Project Application; and in some cases in additional detailed operating instructions. Detailed precautions for work with X-ray crystallographic equipment are given in Appendix 14.

### 7.3 External and Internal Hazards

#### 7.3.1 External Hazards

External hazards can arise from any source of penetrating radiation, e.g. X-ray sets, gamma emitters, neutron sources and hard beta emitters. The more penetrating the radiation, generally the greater the hazard. In some ways hard betas and soft X-rays, which are absorbed by the surface layers of tissue, can be more hazardous than more penetrating radiations which might go straight through the body (medical X-rays). Weakly penetrating particles do not pose an external hazard. There can only be a hazard from X-ray sets whilst the set is switched on. Sealed sources, used under normal conditions, should only present an external hazard, but this will always be present. Open sources can also present an external hazard. Doses can be minimised by:

(a) use of effective shielding;

(b) keeping one's distance and

(c) exposing oneself for the minimum of time.
### 7.3.2 Internal Hazard

When working with open or unsealed sources of radioactive material, as well as having a possible external hazard to contend with, one is faced with the possibility that radioactive material might find its way into the body. One would then be faced with an internal radiation hazard, and shielding, distance and time would no longer afford protection. Only by a combination of physical half-life and biological half-life can the material be eliminated from the body - some may remain there forever. It can easily be appreciated that small amounts of radioactive material inside the body can be more harmful than much larger amounts outside the body. Every effort must be made, therefore, to prevent radioactive material from entering the body. Routes of entry into the body are via the mouth by inhalation or ingestion and through the skin via cuts or absorption. Internal contamination can be avoided by adopting good working practices, and by following some basic precautions, such as:

1. use of materials of minimum radiotoxicity;
2. presence in the laboratory of the minimum quantities;
3. containment, to prevent spread of contamination;
4. cleanliness and good housekeeping; and
5. use of appropriate protective equipment.

The good working practices required for work with unsealed sources are spelt out in the Laboratory Rules (see Appendix 13) with further information in the guidance notes.

A useful indication of the radiotoxicity of an isotope is its annual limit of intake (ALI). This is the amount which, if taken into the body in a year, will result in the individual receiving the full annual dose limit of 20 mSv from this source of radiation alone. A list of the most restrictive ALI's for the common isotopes is given below:

<table>
<thead>
<tr>
<th>Isotope</th>
<th>ALI (Bq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3(water)</td>
<td>$1.1 \times 10^9$</td>
</tr>
<tr>
<td>H-3</td>
<td>$4.7 \times 10^8$</td>
</tr>
<tr>
<td>Cr-51</td>
<td>$5.3 \times 10^8$</td>
</tr>
<tr>
<td>C-14</td>
<td>$3.4 \times 10^7$</td>
</tr>
<tr>
<td>S-35</td>
<td>$1.5 \times 10^7$</td>
</tr>
<tr>
<td>P-33</td>
<td>$1.4 \times 10^7$</td>
</tr>
<tr>
<td>P-32</td>
<td>$6.2 \times 10^6$</td>
</tr>
<tr>
<td>I-125</td>
<td>$1.3 \times 10^6$</td>
</tr>
</tbody>
</table>

The importance of regular monitoring cannot be overstressed as it is the only way of ensuring that the other precautions you have taken have been effective in minimising contamination.
7.4 Security of Sources

Researchers should also be aware that High Activity Sealed Sources come under the High Activity Sealed Radioactive Sources and Orphan Sources Regulations 2005 (HASS). These must be registered with SEPA and will be inspected by SEPA and Police Scotland for security of the sources. The activities of different radionuclides which come under these HASS regulations can be found at URL: http://www.sepa.org.uk/media/103650/rs-g-012-hass-record-guidance-final.pdf

High activity radioactive sources also come under the control of the Anti-Terrorism, Crime and Security Act 2001 as amended. Thus there are significant security issues which must be complied with under this Act to hold high activity radioactive sources. This will include the physical security of the site but Police Scotland may require specific checks on workers who will have access to this site.

7.5 Contamination Monitoring

There should always be a suitable contamination monitor available in areas where unsealed sources are used. Every time you handle radionuclides, you should use the appropriate contamination monitor to monitor yourself and your immediate work area - bench top, equipment, bench front and floor - at the end of each work session and complete the appropriate form (see Appendix 24). Any contamination found should be removed immediately, or if this is not practicable, a suitable warning notice should be displayed. On no account should contamination be left unmarked which would pose a hazard to others.

At regular intervals, a full monitoring survey should be carried out to establish that:-

(a) the area is correctly designated (on grounds of contamination); and

(b) any contamination that has occurred has been dealt with efficiently and has not been spread to - fridge doors, cupboard doors, floors, door handles, etc.

These monitoring surveys have to be recorded.

If you are working with tritium, then conventional monitoring will not be any use, as the very weak beta emissions from tritium cannot be detected by the contamination monitors. You therefore have to perform wipe tests using moistened filter papers and sampling a known area then measuring the samples using liquid scintillation counter.

7.6 Decontamination Procedures

All contamination should be removed as soon as possible after it has occurred.

For all personal decontamination, it is possible that there may be a need to seek medical advice and this should be borne in mind.

For contamination of the skin e.g. arms, hands etc., the first step is to wash the affected area with soap and water as normal. If the contamination persists, it should be washed and scrubbed gently, using a soft brush, with a deep cleansing soft soap or liquid soap e.g. ‘Clearasil’ or ‘Dermactyl’. Care must be taken not to break the skin.

If the contamination still persists after several wash and scrub treatments and the contamination is restricted to parts of the hands you should seek medical advice. If any other parts of the body are contaminated and the contamination is not easily removed by ordinary washing, then specialist help should be obtained.

If serious injury, cuts and wounds are associated with the contamination, these should be irrigated and first-aid measures taken before dealing with the contamination. Body openings such as eyes, ears, nose and mouth should always be decontaminated first. Decontamination of any ‘hot spots’ on other parts of the
body should be dealt with next. Care should be taken to ensure that washings do not contaminate other areas. If the casualty has to go to hospital for treatment of wounds, only superficial contamination should be removed as a first-aid measure.

Emergency showers are rarely the best solution for dealing with a contaminated person as this can spread the contamination. For hand, arm and head contamination, it is better to use a hand wash basin and for legs a foot bath

If an individual is heavily contaminated the person should be decontaminated as far as reasonably practicable and the emergency procedures outlined on the back page should be followed.

7.7 Testing and Maintenance of Engineering Controls

Where any design features and/or devices are used as control measures in limiting exposure to radiation, then the School/Unit should draw up and implement a testing and maintenance program and keep written records.
8 Laboratory Designation

8.1 Designation of Areas

All areas where ionising radiation sources are located must be identified and described in the School/Unit local rules. These areas must be designated as either a ‘Controlled area’, ‘Supervised area’ or a ‘General Laboratory area’ (see below). All such designations must be approved by the URPA.

There are three types of radiation area defined in the Ionising Radiations Regulations 1999. These are:

- Controlled Area
- Supervised Area
- Non-designated Area (General Laboratory Area)

The definitions of these areas are given in Appendix 15.

Working at the University, you are unlikely to receive any significant dose of radiation in any laboratory, providing you follow the information and instructions that you are given. The University is not allowed to designate all our laboratories as non-designated because the likelihood of receiving a dose of radiation as defined by a number of factors which are laid down in the Ionising Radiations Regulations. Bearing this fact in mind, we need to consider four distinct types of work when determining the grade of laboratory:

1. Work where there is only an external hazard.
2. Work with X-ray equipment.
3. Work where there is only an internal hazard.
4. Work where there is both an internal and external hazard.

8.1.1 External Hazard only

A controlled area is required where the instantaneous dose is greater than 7.5 µSvh\(^{-1}\) to the whole body for more than 16 hours a week and greater than 75 µSvh\(^{-1}\) to the hands.

A supervised area is required where the instantaneous dose rate exceeds 2.5 µSvh\(^{-1}\) to the whole body and 25 µSvh\(^{-1}\) to the hands.

A general laboratory area can be used where the instantaneous dose rates do not exceed 2.5 µSvh\(^{-1}\) to the body or 25 µSvh\(^{-1}\) to the hands and exposure times are limited to less than 8 hours a week at this exposure rate.

The above is a slight simplification, as one is allowed to use further time-averaging to allow higher dose rates than those stated for a supervised area. If this flexibility is required, then the Radiation Protection Adviser should be consulted.

Researchers should also be aware that High Activity Sealed Sources come under the High Activity Sealed Radioactive Sources and Orphan Sources Regulations 2005 (HASS). These must be registered with SEPA and will be inspected by SEPA and Police Scotland for security of the sources. The activities of different radionuclides which come under these HASS regulations can be found at URL: [http://www.sepa.org.uk/media/103650/rs-g-012-hass-record-guidance-final.pdf](http://www.sepa.org.uk/media/103650/rs-g-012-hass-record-guidance-final.pdf)

High activity radioactive sources also come under the control of the Anti-Terrorism, Crime and Security Act 2001 as amended. Thus there are significant security issues which must be complied with under this Act to hold high activity radioactive sources.
8.1.2 X-ray Laboratories

A controlled area is required for X-ray work, when beam paths are not enclosed, or where the enclosure does not prevent access to areas where the dose rate exceeds the limits specified in para 7.1.1.

A supervised area is required when all beam paths are normally enclosed, but where some overriding of interlocks is required for alignment procedures, or where only the X-ray camera itself is providing the local enclosure.

A general laboratory area classification can be used when a totally enclosed system is employed with no override provision on interlocks, such that it is not normally possible to gain access to dose rates in excess of 2.5 μSv h⁻¹.

8.1.3 Internal Hazard only

One has to consider the need for a controlled or supervised area on the basis of a risk assessment.

The Public Health England (URL: https://www.phe-protectionservices.org.uk) analysed operational scenarios and exposure pathways to calculate the maximum quantity of different isotopes that could be handled in different categories of laboratories. The University has considered this analysis when setting specific limits for the storage and use of unsealed sources. These limits are given in Appendix 16 which is titled ‘Maximum Permitted Activity of Unsealed Radionuclides which may be Stored/Used at One Time’.

If more than one isotope is used, then the amount that can be used/stored is calculated using the Quantity Ratio. This is determined using the calculation:

\[ \frac{\sum Q_p}{Q_{\text{lim}}} = q \]

\[ Q_p = \text{Quantity of radionuclide present} \]

\[ Q_{\text{lim}} = \text{Quantity of the radionuclide specified in Appendix 16} \]

NOTE: The quantity ratio must NOT exceed 1

Using the most restrictive ALIs for inhalation or ingestion the above quantities equate to the following activities for the common radionuclides used in universities.

Table X - ALIs/Activities for the Common Radionuclides

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>1 ALI</th>
<th>30 ALI</th>
<th>120 ALI</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3 (water)</td>
<td>1.1 GBq</td>
<td>33 GBq</td>
<td>132 GBq</td>
</tr>
<tr>
<td>H-3 (OBT)</td>
<td>470 MBq</td>
<td>14 GBq</td>
<td>56 GBq</td>
</tr>
<tr>
<td>C-14</td>
<td>34 MBq</td>
<td>1 GBq</td>
<td>4 GBq</td>
</tr>
<tr>
<td>S-35</td>
<td>15 MBq</td>
<td>450 MBq</td>
<td>1.8 GBq</td>
</tr>
<tr>
<td>P-32</td>
<td>6.2 MBq</td>
<td>186 MBq</td>
<td>744 MBq</td>
</tr>
<tr>
<td>P-33</td>
<td>14 MBq</td>
<td>420 MBq</td>
<td>1.7 GBq</td>
</tr>
<tr>
<td>I-125</td>
<td>1.3 MBq</td>
<td>39 MBq</td>
<td>156 MBq</td>
</tr>
<tr>
<td>Cr-51</td>
<td>530 MBq</td>
<td>16 GBq</td>
<td>64 GBq</td>
</tr>
</tbody>
</table>
8.1.4 Designation where there are both internal and external hazards

Where radionuclides present both an internal and an external hazard then a realistic assessment should be made of the likely doses that will result from the proposed work and every effort must be made to reduce these by the use of appropriate shielding. Working to an internal dose constraint of 0.2mSv, it will be the control of the external hazard, and whether special procedures are required to ensure this, that will determine the need, or otherwise, for a controlled area.

8.2 Suitability of Laboratories

Permission will only be granted for work with ionising radiations if a suitable laboratory is available. This is particularly important for work with unsealed sources, for which special surface finishes may be required to the walls, floors and bench tops, and special facilities may be required for hand-washing, waste disposal and to guard against air contamination. Further information on the design requirements of laboratories for unsealed sources is available from the University Radiation Protection Service.

8.3 Access to Laboratories

Only those laboratories specified on the project application or ‘System of Work’ may be used for radioactive work up to the levels permitted therein. The entrance to all areas specified must bear the appropriate warning notice and, if required, a notice limiting access. Access to radiation areas is restricted as follows:-

(a) controlled areas - classified radiation workers and other registered radiation workers following a written system of work. An example of a ‘Scheme of Work’ is given in Appendix 17.

(b) supervised areas - registered radiation workers and other persons whose presence, work or duties can be so controlled that they will not be exposed to significant amounts of radiation. The latter must be advised as to how they may fulfil this requirement.

(c) general laboratory areas no restriction on the grounds of radiation hazard.

8.3.1. Access to Service Personnel

School/Unit staff must give special consideration to service/maintenance personnel, who are unfamiliar with ionising radiation and the hazards involved.

When access is required to a controlled area by non-classified personnel who are not covered by a written system of work, then that area should be de-designated by the DRPS or another person who has the authority of the Head of School/Unit, prior to entry being permitted.

Any person de-designating a laboratory should ensure that: the area has been monitored and found to be free from contamination; all sources of ionising radiations are either in store or shut down (X-rays and neutron generators); and nowhere in the area does the instantaneous dose-rate exceed 7.5μSv h⁻¹. They should then put an appropriate notice on the entrance to the laboratory.

Before cleaning staff are allowed to start their duties, they must be told which areas have been monitored and cleared, and not to clean any other area. It may well be convenient for the cleaning staff to deal with the floor areas, and designated laboratory staff, bench tops and other surfaces. If this is the case, the cleaner must be instructed accordingly. Adequate instruction must be given over the segregation of radioactive and non-radioactive waste and the cleaner instructed not to deal with waste in the former category. If cleaning of glassware or other contaminated apparatus is necessary, steps must be taken to ensure there is no contamination hazard to the cleaning staff.

Each situation clearly presents its own particular problems and these cannot be dealt with adequately here. The DRPS should formulate plans, guided by the above, and seek the advice of the University Safety Adviser on any matters which are not clear.
8.4 Signage

The appropriate sign for identifying material or areas that may contain radioactive materials is the trefoil. An example of this is shown here:

![Signage Image]

Appendices 18 and 19 show the University of St. Andrews signs that identify areas designated as ‘Controlled Areas’ and ‘Supervised Areas’ respectively. The sign to show where radioactive substances are being used in a ‘General Laboratory Area’ is given in Appendix 20. Sinks which are designated for the disposal of aqueous water miscible radioactive waste is given in Appendix 21.

9. Registration of Personnel and Work

9.1 Research Work

All workers intending to use ionising radiation should submit a Personal Registration form AND a Project Work Registration form (See flow charts on pages 7 and 8). The University uses a Radiation Management programme called RadProt for recording all data relating to personal registrations, Risk Assessments and the amounts of radioactivity used (URL: https://portal.st-andrews.ac.uk/radprot/open/). This is to ensure compliance with the University Certificates of Registration and Authorisations.

9.1.1 Personnel Registration

Every person who wishes to become registered as a user of radioactive materials must undertake the University Radiation Protection Course (either in person or the Moodle Site URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905). Once they have attended this course or done it on the Moodle site, then workers must undertake the test at the end of the Moodle site and pass this test by 60% or greater. This shows the basic competence of the worker.

Once the worker has passed the Moodle test, they should then complete the User Registration form on the RadProt system. You can also use the paper registration form RadProt-Reg-1 Form (see Appendix 10) and then send this via the local DRPS (who should approve all applications) to Environmental, Health and Safety Services (e-mail: ehss or pwss).

It is expected that the Project Supervisor and/or the DRPS will ensure that an adequate level of instruction and training in the University’s radiation safety procedures is provided. The Project Supervisor should also monitor the standards of the workers under their control to ensure they are complying with University Local Rules, Guidances and with relevant legislation.

All users of X-ray equipment must also be registered on the RadProt programme as above and also registered on an appropriate work risk assessment form.

Only those people who need to be designated as ‘Classified Radiation Workers’ are required to have blood counts and medical examinations prior to commencing their work with ionising radiations, although these facilities are available to any radiation worker, on request.

Personnel intending to work with penetrating radiations may be required to wear a personal dosimeter device and, depending on the nature of their work, a finger personal dosimeter (see section 5.3).
Any personnel who need to be designated as Classified Radiation Workers will have an annual review of health, which may entail their having to attend for additional blood counts and medical examinations. Arrangements for these examinations will automatically be made by the University Safety Office, and those concerned will be duly notified.

9.1.2 Project Registration

It is the responsibility of the project supervisor to register and undertake an appropriate risk assessment of all work with ionising radiations. An assessment of the radiation risks should be performed before the work can begin. In this risk assessment the hazards of the work should be identified, the risks determined, the people at risk identified and appropriate controls implemented to reduce the dose received to as low as reasonably achievable. This assessment is done by completing the appropriate form on the RadProt programme. These risk assessments will then be approved by the University Radiation Protection Officer on behalf of the URPA. The completed risk assessment should be signed by the relevant radiation workers and the project supervisor. All workers must be notified of the risk assessments they are named on.

NOTE: The work must not commence until the URPO has ratified the project.

Permission for work with ionising radiations will only be given if adequate facilities are available. In some instances, approval may be required from SEPA, or prior notification may have to be given to the Health and Safety Executive. It is, therefore, advisable to contact the Radiation Protection Service at an early stage when planning a new line of research.

All work with X-ray equipment must have an appropriate risk assessment for the work. This should be undertaken on the RadProt programme.

The use of radioactivity will not be allowed by the RadProt system until an approved work risk assessment is activated on the RadProt system. Work must not start until all the relevant workers are approved, that all workers are on an approved project and there is an approved radiation risk assessment for the work.

9.2 Teaching

Undergraduates may come into contact with radiation work either on projects or as part of practical courses.

9.2.1 Personnel Registrations

Undergraduates will not normally be required to register as radiation workers on the RadProt system, unless they are carrying out project work involving one of the following:

(a) X-ray crystallographic work with the students operating the equipment with all the interlocks on the equipment in place;

(b) sealed source work involving sources with activities in excess of 0.5 MBq, where the dose rates to which the students may be subjected could exceed an instantaneous dose rate of 7.5µSvh⁻¹; or

(c) unsealed source work where the students will be using more than the activity specified in column 4 of the table in Appendix 22

Such students, should register as radiation workers. Where the risk assessment requires it, students will be issued with personal dosimeters if appropriate for the duration of their project and will be issued with copies of all relevant local rules, etc as for postgraduate students.
9.2.2 Work Registration

The DRPS should be aware of all undergraduate work with radioactive materials in his School/Unit. Formal registration of individual projects will normally be necessary using the RadProt programme.

For all undergraduate work with ionising radiations, remember that, prior to any demonstration or experiment, the students should be given:

(a) instruction in the basic aspects of radiation protection as it affects their work, with the importance of keeping dose rates as low as reasonably achievable being stressed;

(b) reassurance with regard to possible health hazards; and

(c) in the case of an experiment, written instructions as to its conduct.

Adequate supervision of undergraduates is also essential, and is particularly important when they are inexperienced in work with ionising radiations.

Guidance on undergraduate work with sealed and unsealed radioactive sources can be found in Appendices 22 and 23.

9.3 Risk Assessments for Pregnant Women

As the dose limits for pregnant women are significantly lower than for other workers, it is important that undergraduate women who become pregnant inform the Head of the School/Unit as soon as reasonably practicable. This will allow a risk assessment of their work with radiation sources to be performed so that appropriate control measures can be put in place to ensure their exposure is kept As Low As Reasonably Achievable (ALARA) (See Section 10).
10. Expectant and Breastfeeding Mothers

10.1 Introduction

There are many sources of natural background radiation (for example from the Earth, from Radon gas, from cosmic radiation and from traces of natural radioactive isotopes in food). In general this radiation will not pose a significant risk to the foetus in the womb. On average the background dose is between 1-8 mSv per year (variation is due to different quantities of radon gas).

On average, individuals are exposed to about 0.4 mSv per year of diagnostic radiation (e.g. X-rays). Although many X-ray examinations will not give rise to a significant dose to the mother and/or foetus/baby, some may do. It is, therefore, very important that expectant mothers should notify their doctor before the mother is exposed to any diagnostic radiations.

10.2 Expectant Mothers

The Ionising Radiations Regulations 1999 require employers to ensure that the dose received by an expectant mother is kept As Low As Reasonably Achievable (ALARA) and an expectant mother must not receive a dose of 1mSv or more during the pregnancy or a woman of reproductive capacity must not receive a dose of 13 mSv to the abdomen in any consecutive three months (with a maximum of 20 mSv annually).

To ensure that an expectant mother is not exposed to significant doses of radiation, the mother should inform the Head of the School/Unit, in writing, that she is pregnant as soon as reasonably practicable.

Note: It is not a legal requirement that expectant mothers must tell the Head and mothers can choose to keep this information private.

Once the Head has been notified, the School/Unit should perform a specific risk assessment of the radiation work being carried out by the mother. This risk assessment should involve the expectant mother and she should be provided with a copy of this document. Guidance on completing this risk assessment can be found at URL: http://www.st-andrews.ac.uk/staff/policy/healthandsafety/publications/neworexpectantmothers/

The risk assessment should identify the hazards (i.e. the radionuclides, the type of radiation being emitted etc) and determine the risks (i.e. internal or external risk, dose rate, potential annual dose etc). Once the risks have been determined, control measures to ensure the dose of radiation received by the foetus/baby is ALARA should be implemented. Examples of such control measures are:

- stopping work with certain radionuclides;
- stopping work on certain high risk procedures;
- reducing the amounts of radiation the mother can work with;
- reducing the time that a mother is exposed to radiation;
- increasing the amount of shielding being used.

Care should be taken that the measures implemented to reduce the risks from radiation should not pose a different significant risk e.g. moving or wearing lead shielding may now pose a significant manual handling operation for the expectant mother.

If an expectant mother receives a significant dose, the mother will be informed and the URPA will conduct an investigation.

Where personal dosimeters have been issued to a worker, records of the doses received are kept by Environmental, Health and Safety Services. If an expectant mother wishes to see the dose she has received, then she should contact the University Safety Adviser.

Further information regarding the risks to Expectant and Breastfeeding Mothers can be obtained from the University Safety Adviser.
10.3 Breastfeeding Mother

External radiation sources such as X-rays do not contaminate the body and thus pose no risk for breastfeeding. If you are working with unsealed radioactive sources, however, these may enter the mother’s body or may enter the baby’s body thus posing a significant risk of contamination. To ensure that the dose received by the baby is kept to As Low As Reasonably Achievable (ALARA), the mother should notify the Head of the School, in writing, that she works with unsealed sources of radioactivity and that she intends to breastfeed her baby.

**Note:** It is not a legal requirement that expectant mothers must tell the Head and mothers can choose to keep this information private.

Once a Head has received this notification, they should ensure that an appropriate risk assessment of the work is done and suitable control measures implemented to ensure the baby is exposed to a dose of radiation that is ALARA. The assessment should involve the mother concerned and she should be provided with a copy of this document.

Controls on exposure will be implemented for six months as this is the normal period of breastfeeding. If you intend to breastfeed for longer, you should notify the Head.

Further information regarding the risks to Expectant and Breastfeeding Mothers can be obtained from the University Safety Adviser or from the following URL: [http://www.st-andrews.ac.uk/staff/policy/healthandsafety/publications/neworexpectantmothers/](http://www.st-andrews.ac.uk/staff/policy/healthandsafety/publications/neworexpectantmothers/)
11. Emergencies

11.1 Accidents Involving Radioactive Substances

Accidental spillage, fire or explosion in an area where work with radioactivity is performed may give rise to internal/external radiation hazards. The quantities presently being stored and used within University premises could result in:

1. Dose rates approaching or exceeding the legal limits for radiation workers;
2. The air concentration of a radionuclide rising above the level specified in column 4 of Schedule 8 of the Ionising Radiations Regulations 1999.

No attempt should be made to remove radioactive sources from School/Unit in the event of a fire or flood. In the event of a fire, the Fire Service should be warned of the presence, the radionuclides present, the activities of the sources and location of radioactive sources. All this information is available on the RadProt programme which can be opened on laptops, Tablets or Smartphones.

11.2 Accidents Involving X-ray Generating Equipment

Failure of a safety device on x-ray generating equipment e.g. deviation of the beam, failure of interlock systems etc., could result in a radiation worker being exposed to a significant amount of x-ray radiation. This exposure may lead to significant biological damage e.g. severe localised skin burns that are slow to heal and may require surgery. All such accidents should be reported to the Director of EHSS as certain types of incidents have to be reported to the HSE by the Reporting Injuries, Diseases, Dangerous Occurrences Regulations 2013 (RIDDOR)

11.3 Reporting Accidents and Dangerous Occurrences/Near Misses

All accidents that may have exposed an individual to ionising radiation or Dangerous Occurrence/Near Miss that may lead to a significant accidental exposure of a worker to ionising radiation, should be reported to the URPO, or if he is not available then contact the Director of EHSS as soon as reasonably practicable. The URPO will take charge of such emergencies. Examples of such accidents include:

- An incident, however minor, in which it is suspected that a person may have been exposed to ionising radiation;
- Any incident in which a person or his clothing may have been significantly contaminated;
- An incident where this is a possibility of radioactive material having entered a worker through an open wound, ingestion or inhalation;
- An incident involving a fire or explosion with damage to the fabric of a room in which radioactive materials are stored;
- A spill involving an activity of > 5 MBq.

A spill of unsealed radioactive source of less than 5 MBq should be reported to the DRPS as soon as reasonably practicable. The School/Unit local rules should specify the names of those who need to be informed of spills of < 5 MBq and it should also include a list names of personnel who will take charge of emergency actions.

Records of all such accidents, Dangerous Occurrences/Near Misses and any subsequent decontamination procedures must be kept.
11.4 Emergency Procedures

For Major Accidents / Incidents See ‘Emergency Action’
On The Back Page Of This Booklet.

11.4.1 Immediate Measures

In an emergency it is important to consider the radiation field that may be present, the potential for the ingestion and/or inhalation of radioactivity, the potential for spreading radioactive contamination and the non-radiation hazards (e.g. chemical hazards).

The area/building should be cleared of all unnecessary personnel and the following measures taken as and when appropriate after assistance from the URPA and, if necessary, the emergency services has been summoned:

- **Fire or Explosion**

  The emergency procedures in the School/Unit local rules should be complied with.

  Where it is necessary to obtain the assistance of the University services or any Emergency Services, the DRPS should pass on all relevant radiological information to these services on their arrival. This will include knowledge of the radionuclides present at the time and also where these would be located.

- **Radiation Exposure**

  Persons suspected of receiving a significant radiation dose should be treated as if they were suffering from shock. The circumstances of the exposure should be written down without delay. This information should include (i) the position of the person when exposed, (ii) the duration of the exposure, (iii) the instrument settings if the source is a radiation generator. If possible, contamination monitor readings should be quickly taken. All workers who may have received a dose of greater than 0.5 mSv should be taken to A&E Unit of the nearest hospital with the data above.

- **Personal Contamination**

  For all personal decontamination, the possible need to seek medical advice should be borne in mind.

  For contamination of the skin e.g. arms, hands etc., the first step is to wash the affected area with soap and water as normal. If the contamination persists, it should be washed and scrubbed gently, using a soft brush, with a deep cleansing soft soap or liquid soap e.g. ‘Clearasil’ or ‘Dermactyl’. Care must be taken not to break the skin.

  If the contamination still persists after several wash and scrub treatments and the contamination is restricted to parts of the hands, the person should be taken to the local A&E to get the skin cleaned with more aggressive agents.

  If serious injury, cuts and wounds are associated with the contamination, these should be irrigated and first-aid measures taken before dealing with the contamination. Body openings such as eyes, ears, nose and mouth should always be decontaminated first Decontamination of any ‘hot spots’ on other parts of the body should be dealt with next. Care should be taken to ensure that washings do not contaminate other areas.

  Emergency showers are rarely the best solution for dealing with a contaminated person as this can spread the contamination. For hand, arm and head contamination, it is better to use a hand wash basin and for legs a foot bath.
11.5 Decontamination of Surfaces

Guidance on decontamination of surfaces can be found on the following Moodle site URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4375

It is important to delineate the boundaries of contamination before any actions are taken.

a) Very small liquid spills should be dealt with in the following manner:
   i) Put on disposable gloves;
   ii) Use paper tissues to absorb the spillage;
   iii) Monitor to confirm decontamination;
   iv) Dispose of contaminated tissues in the appropriate designated container.

b) Very small solid spills should be dealt with in the following manner
   i) Put on disposable gloves;
   ii) Cover the contaminated area with damp paper tissues;
   iii) Mop up with same and dispose of in an appropriate designated container;
   iv) Monitor to confirm decontamination.

If there is a major spillage of radioactivity, then the URPO should be notified as soon as practicable and the decontamination will be organised by the URPO.
12. Monitoring

12.1 Personal Dosimeter Badges

12.1.1 Personal Whole Body Dosimeter

Personal dosimeters are issued on a 2-monthly basis. The whole body dose rate badge is now designed as a single integrated unit, so please do not attempt to disassemble it.

Your badge should be worn at all times when exposure to ionising radiations is likely. Personal Dosimeters should be worn on lapel or breast pocket of your laboratory coat.

Please assist your DRPS by ensuring that your badge is available for changing at the end of the wear period. Prompt changing of badges helps all concerned and makes the dose results available sooner.

It is very important that whole body dosimeter badges are not left on lab wear which goes for washing. The detergents affect the fluorescence from these badges to appear to give a massive dose of radiation. If you think your badge may have been treated in the wash, please let the URPO know as soon as possible.

12.1.2 Personal Finger Dosimeter

These ring badges are used to monitor the hands of personnel who come into close contact with high activity radioactive material or are engaged in other activities where their extremities may be exposed to an X-ray beam. Typically they are issued to people working with significant amounts of P-32 or other ‘hard’ beta-gamma emitters.

They are issued on a 2-monthly basis and are available in 3 sizes - small, medium and large. Unless otherwise instructed the standard medium size will be issued.

The personal dosimeter is encapsulated inside the identification cover. The whole ring is returned at the end of the wear period, please do not disassemble.

Note: Personal dosimeters are issued for use by the named person at the University of St-Andrews only. They are not to be used by any other person or to be taken to be used at any other establishment. If monitoring is required at another establishment it should be provided at that establishment.

12.2 Monitoring Surface Contamination

The most common types of instrument used for monitoring contamination is a count-rate meter that measures counts per second (cps). Many different types of probes can be used with such a meter. The main types of probes used are:

- **Scintillation Probes** - which are best for detecting x-rays and gamma rays in the range of a few KeV to several MeV. These work by the $\gamma$ or X-ray radiation interacting with a NaI crystal in the probe which then generates a photon of light:
• **Geiger-Muller Tubes (G-M tubes)** - Glass walled G-M tubes are best for detecting high energy β and γ-emitters. Thin-end G-M tubes can detect low energy β particles such as those emitted from $^{35}$S and $^{14}$C.

Geiger counters only work with radiation which can ionise the gas in the Geiger Muller Tube. Radiation which cannot ionise this gas will pass through the equipment without detection thus these monitors have a low background but have a very specific set of radionuclides that it can detect.

If such contamination count rate meters cannot be used e.g. for very low energy β (e.g. particles from $^3$H) or for α particles, then a ‘Wipe Test’ should be performed. The procedure for such a test includes:

- Mark out a defined area where the contamination is suspected;
- Moisten filter paper with 70% ethanol;
- Wipe the defined surface with the filter paper;
- Repeat the procedure over different areas of the potentially contaminated surface;
- Put the filter paper in an appropriate scintillant vial with scintillant and count the number of disassociations per minute.

Even the most efficient contamination monitors will only be detecting about 10% of the radiation present. Thus to determine the true amount of contamination present, the contamination monitor results should be multiplied by 10 to give an approximation to the number of Bequerels present.

12.3 Air Monitoring

Airborne contamination can be one of the main risks in a radiochemical laboratory. If any dust or spray producing operation is carried out then some form of airborne contamination monitoring should be carried out. The most common form of such monitoring is to collect a known volume of air and pass it over a filter which is then counted in a scintillation counter.

12.4 Thyroid Monitoring

Measurement of the amount of radioactive iodine in the thyroid can be performed with a contamination monitor with a Type-42 scintillation probe for detection X-rays and γ-emissions. This probe will detect small amounts of iodine in the thyroid (e.g. 3.7 KBq of $^{125}$I will give a measurement of 25-35 cps on such a system).
All persons using radioactive iodine should regularly monitor their thyroid and record their results. It is very important to carry out such monitoring if workers are performing iodination type reactions using large quantities of 125-Iodine. Written records of all such monitoring should be kept.

12.5 Dose Rate Monitoring

Regular ‘Dose-Rate’ monitoring of ‘Controlled’ and ‘Supervised’ areas should be performed and written records of such monitoring kept.

The instrument for such monitoring is a ‘Dose-Rate’ meter which is made of a compensated Geiger-Muller tube or an Ionisation Chamber detector. It should be noted that using ionisation chambers can significantly underestimate the dose-rate if the beam does not fully traverse the chamber.

An estimation of the ‘Dose-Rate’ can be obtained using a contamination ‘Count-Rate’ monitor. This procedure should always be carried out some distance away from known radioactive sources. For β particles, a dose of approximately 1 μSv hr⁻¹ is the equivalent of 2-4 counts per second on a Count-Rate meter. For γ emissions of > 0.15 MeV, 2 to 4 counts per second is the equivalent of 1 μSv hr⁻¹. For γ emissions of < 0.15 MeV, the sensitivity of the machine will depend on the peak energy of the γ emissions e.g. 125I which has a photon energy of 0.03 KeV, approximately 6 cps will be equivalent to a dose of 1 μSv hr⁻¹.

Radiation surveys for pencil beam X-ray equipment should be performed with a very small sized Geiger-Muller tube with a thin window end capable of detecting low energy beams.

12.6 Monitor Testing / Repair

The University Radiation Protection Service (URPS) will ensure that all contamination monitors from Schools/Units are tested at regular intervals by a ‘Qualified Expert’ and arrange for repair work on damaged / faulty units.
13. Ordering and Receipt of Radioisotopes

13.1 Ordering Radioisotopes

Only a person authorised by their Head of School/Unit (e.g. the DRPS) is permitted to order radionuclides. All orders for radionuclides must be recorded in the RadProt Radiation Management computer programme. No order should be placed which may exceed the limits set by the SEPA Certificates of Registration or Authorisation. Only when the DRPS has approved can a purchase order be raised for the substance.

13.2 Receipt of Radionuclides

Arrangements must be made with the supplier (or delivery company) that the radionuclide(s) are received by the DRPS or a designated member of staff.

NOTE: SOURCES MUST NEVER BE DELIVERED AND LEFT UNATTENDED AS THIS IS A CONTRAVENTION OF THE REQUIREMENTS OF THE SEPA CERTIFICATE OF REGISTRATION AS THIS MAY RESULT IN PROSECUTION.

It is vital that the School/Unit DRPS or Nominated Depute produce specific written procedures for the acceptance of radionuclide sources. These procedures should include:

- Check that appropriate documentation has arrived with the source;
- Check the source is that which was ordered;
- The amount present is that which was ordered;
- There is an appropriate label on the source identifying the radionuclide and the activity of the source;
- The source is not leaking from its container;
- The source is given an appropriate identification mark (as set by the RadProt radiation Management programme) as soon as possible;
- The source is then placed in a safe place under lock and key.

When a source is received, the accompanying documents should be examined and the source unpacked as soon as possible to ensure that is as ordered.

Once the package has been properly checked, the source can then be added to the RadProt programme by the DRPS. This will then allow aliquots of radiation to be removed by workers.
14. **Storage of Radionuclides**

It is essential that radioactive materials should be kept under conditions which present no radiation hazard, particularly to non-radiation workers. A requirement of the Radioactive Substances Act 1993, also demands that all necessary measures be taken to prevent any person having access to radioactive materials without authority, and that when not in use materials be, where this is reasonably practicable, securely stored in a locked store / room.

This means that a locked store(s) / room(s), suitably shielded, and if necessary suitably ventilated, must be provided in each School/Unit. This should be constructed so as to minimise the risk from fire or flooding and be set aside solely for the purpose of storing radioactive material. Every effort must be made to prevent sources being damaged, broken open or spilled, and steps must be taken to minimise the effect of any accident which might occur.

Suitable shielding, usually lead, should be sufficient to keep the dose rate on the outside of the store below 7.5 µSvh⁻¹ and if reasonably practicable, below 2.5 µSvh⁻¹.

Under certain circumstances it may be necessary to store materials at reduced temperatures. Such materials may be stored in suitable refrigerators or deep-freeze units which, whenever possible, must be set aside solely for this purpose and be fitted with locks. Materials stored in this fashion must be stored in polythene or other suitable plastic containers and glass vessels must not be used for this purpose. The only exception to this regulation will be those cases where the radioactive material has been supplied by the manufacturers in a glass container. As an additional precaution the vessels themselves should be kept in unbreakable containers.

The number of cupboards, refrigerators, or other approved places of storage must be kept to the minimum consistent with safe working. The siting of a central store, or stores, in positions which involve excessive transportation of material between store and place of use is to be discouraged however, and it is also recognised that under certain circumstances it may be safer practice to leave a source within the laboratory in which it is normally used rather than to return it to the store. The advice of the DRPS or URPA can always be sought upon such matters.

Any room, cupboard, refrigerator, or other unit used for the storage of radioactive materials, must be indicated by the International Radiation Symbol radiation – The Trefoil symbol.

An inventory giving the specific radionuclide(s) and quantity held must also be accessible at the store.
15. Usage of Radioactive Materials

When aliquots of radioactivity are taken, it is vital that care be taken not to contaminate surfaces.

All surfaces used for work with radioactive materials should be easily cleanable or be covered with a disposable covering (eg Benchkote).

Before you start any work with radioactive materials, you should check the surfaces and floor area in the immediate vicinity prior to starting the work. A record should be kept of the contamination monitoring results from a Geiger-Muller tube probe and from a scintillation probe.

When using an automatic pipette, it is very important to check for any contamination of the pipette prior to starting the work.

Care should be taken not to splash the pipette when withdrawing the radioactive materials.

Always remove pipette tips which have had radioactive material immediately you have used them. Never leave a contaminated pipette tip on a surface or at the edge of a bench.

Once the work has been completed, the amount of radioactivity should be recorded on the RadProt system. It should identify which stock was used, how much (activity and volume) and under what risk assessment the work was done. Guidance on the RadProt system can be obtained from the Moodle site of the University Radiation Protection Course at URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905

16 Use of Radioactive Materials in Fieldwork

It is important to realise that the University’s Certificates of Registration and Authorisation only cover the University’s buildings in St Andrews. Any work outside the University buildings will require a specific Certificate of Registration and Authorisation. These are very complex submissions depending on the proposed work activity and take quite some time to undertake and can take up to 12 months to get approved. Such an application will be undertaken by the URPA on behalf of the University and the submission will cost the research group (at present in 2015 - £2000).

All proposed fieldwork which requires the use of radioactive materials should be discussed with the Director of EHSS well in advance of the project work starting. There will be issues regarding:

- How the radioactivity will be transported to the work site;
- How the radioactivity will be stored in a secure manner
- How records of aliquot usage will be undertaken at the field site
- What the work activity will be;
- How radioactivity will be disposed of;
- How contamination of a site will be dealt with
- How contaminated items (eg pipette tips) will be dealt with
- What emergency plans will need to be put in place eg in the event of a road traffic accident

All of these issues will need to be clarified before a submission is made to SEPA for these certificates.
17 Waste Disposal

The prime purpose of the Radioactive Substances Act 1993 is to ensure that members of the general public are not affected by the deliberate or accidental discharge, or disposal, of radioactive material or waste. To achieve this end, all users of radioactive materials are required to:

1. obtain a Registration Certificate or certificates from SEPA for the radioactive materials which they have, or intend to have, on the premises; and

2. obtain a waste disposal Certificate of Authorisation from SEPA which details the conditions which must be observed for the disposal of radioactive waste.

The University, through the Radiation Protection Service, applies for, and obtains, such documents from SEPA. The documents are issued to the University as a whole. Individual buildings are given allocations from the total for the University by the URPS. All Certificates of Registration and Authorisation and internal allocation limits should be posted in the main area where radioactive work is undertaken. The maintenance of records to demonstrate compliance with the terms of the Certificates of Registration and Authorisation is kept on the RadProt radiation management programme. Any discrepancy in the usage should be brought to the attention of your local DRPS immediately. If there are any questions regarding waste disposal, these should be raised with the local DRPS or the URPO.

All waste disposal on the RadProt system will relate to a specific aliquot of radiation taken. Thus there should be a ‘Cradle to Grave’ record of all radioactivity used in the University buildings.

17.1 Solid Waste

Up to two methods are available for the disposal of solid waste, and it is important that you use the one appropriate to your work -

1. Disposal to landfill sites
2. Disposal via a specialist contractor.

A record of all solid waste disposal should be kept on the RadProt programme. A written record of the transport of radioactive waste should be kept on the form in Appendix 25.

At present, the University does not have a macerator for the disposal of radioactive items. If such a macerator is required, it will require the University’s Certificate of Authorisation to be updated. This could take up to 12 months to undertake and therefore such a requirement should be brought to the attention of the Director of EHSS as soon as practicable before the work needs to be undertaken.

17.1.1 Disposal to Landfill sites

Low level radioactive contaminated waste produced by Schools/Units is disposed of at a SEPA Registered landfill site. All containers of waste must be correctly labelled with details of School/Unit, radionuclides and approximate activities clearly marked.

The waste will be collected from School/Units by the Radiation Protection Service and kept in a SEPA Registered University store. When a suitable quantity has been accumulated, it will be transported to the landfill site.

17.1.2 Disposal using Specialist Contractor

Material which by virtue of its total activity or special toxicity cannot be disposed of at the landfill site must be disposed of via a specialist contractor. All containers of waste must be correctly labelled with details of School/Unit, radionuclides and approximate activities clearly marked.

The School/Unit producing such waste should contact the Radiation Protection Service who will make the necessary arrangements for transport and disposal.
17.2 Liquid Waste (Water Soluble)

Only those sinks or sluices specially designated by the URPA for the purpose and appropriately identified, may be used for the disposal of liquid waste (see Appendix 21). Non-designated sinks must not be used under any circumstances.

NOTE: The quantity of liquid waste disposed of to drain in a Building must never exceed the limits set by the University from the SEPA Certificate of Authorisation.

Where practicable all liquid wastes must be diluted with the appropriate carrier before disposal. In many instances this may just be water, but some compounds tend to stick to the surface of the drains, and in this case you will need to use a carrier which will help to take up the available sticking sites so that you are not left with a 'hot' sink or sluice.

Sinks should be rinsed before and immediately after the discharge, and sluices must be flushed at least three times - once before and twice after. For all materials other than tritium, the sink or sluice must be monitored after disposal, and any residual activity removed if reasonably practicable. When using significant quantities of 3H, then the sink should be swabbed with a paper filter paper, and then counted in a liquid scintillation counter.

A written record of all disposal to drain should be kept on the RadProt system.

17.3 Liquid Waste (Organic Solvents)

This mainly concerns the disposal of organic scintillant waste in counting vials though may include organic solvents used to extract radioactive derivatives. On no account must organic solvents be flushed down a sluice or the drain. All such waste should be stored in appropriate containers e.g. vials with scintillant present should be stored in appropriate plastic drums. The contents of the container should described in terms of the radionuclide(s) present, the total activity in it and the date.

The producer of radioactive liquid organic waste should contact Radiation Protection Service who will collect this waste and put it into a SEPA Registered store. The waste will then be disposed of by a ‘Specialist Contractor’.

Collection of bulk radioactive solvent waste is on a ‘As Requested’ basis and anyone needing collection should make arrangements with Radiation Protection Service at the time.

17.4 Gaseous Waste

Any operation that is likely to produce radioactive gas, vapour or dust, must be carried out with an appropriate Certificate of Authorisation to dispose of gaseous waste, a University ratified Radiation Project and in an approved fume cupboard.

NOTE: At present, the University does not have a Certificate of Authorisation for disposal of gaseous radioactive wastes. If there is an intention to undertake this work, the University would have to get a modification of its Certificate of Authorisation. This could take up to 12 months. Workers who may need such a facility must contact the Director of EHSS as soon as practicable before the work needs to start.

In certain special cases involving powders glove boxes may be required and the advice of URPA should be sought.

NOTE: In the above circumstances, the quantity of gaseous waste disposed via a fume cupboard in a Building must never exceed the limits set by SEPA in the Authorisation Certificate.
The fume cupboard must always be operated with an air-flow sufficiently great to ensure the contents cannot leak back into the laboratory - normally a minimum of 0.5 m/s across the face opening is required. The sash must always be kept clear so that it can be closed in the event of an emergency.

The point at which effluent air is discharged must be sited to prevent, as far as it is practicable, its entry into any part of any premises by way of windows, air-intakes etc. In certain cases, filters may be necessary. Radiation Protection Services will advise accordingly.

It should be noted that radioactive gas or fumes might sometimes be generated unwittingly. For instance the tritium sources used in vapour phase chromatography units will release tritium if over-heated, and the outlets from such units must always be vented to the outside atmosphere rather than into the laboratory. Similarly it is not unknown for some stock materials to undergo radiation decomposition with the release of fumes. Stores where such materials are held must be suitably ventilated.

**NB.** Vials containing any isotope that could release volatile compounds during storage should be vented in a fume cupboard before use on the open bench can be considered. This affects the use of H-3, C-14, S-35 and I-125 labelled material.

**Note:** The law requires the maintenance of suitable records for the discharge of any form of radioactive waste. Each and every user must ensure that such records are properly kept. Failure to do so, or to comply with the other requirements of the Radioactive Substances Act 1993, could result in prosecution with penalties of fines and imprisonment.
18 Transport and Movement of Radioactive Substances

The legislation which regulates the transport of radioactive materials is the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (CDG-2009). This legislation enacts the European guidance entitled ‘Accord européen relatif au transport international des marchandises Dangereuses par Route’ (ADR) into UK legal framework. The ADR guidance is annually updated and thus any transport of radioactive materials must take into account the modifications to the ADR. A copy of the ADR and guidances can be found at URL: http://www.unece.org/trans/danger/publi/adr/adr2015/15contentse.html. The ADR identifies the category of hazard and also the control measures which have to be taken with regard to packaging and the transport of the agents.


NOTE: You should not transport any radioactive materials in your personal car without informing your insurance company.

18.1 Definitions

'Movement' shall be taken to mean all movements of radioactive substances by hand inside a University building and outside a University building, so long as the movement is not in a public place.

'Transport' shall be taken to mean all movements of radioactive substances through a public place, whether on a conveyance or not. This, therefore, includes movements by hand through a public place.

'Radioactive substance' in relation to movement is covered by the Ionising Radiations Regulations 1999.

'Radioactive substance' in relation to transport is covered by the and regulations enacted under it and means any substance having an activity concentration of more than 0.1 kBq kg\(^{-1}\).

‘Transport Index’ - Maximum dose rate at 1 metre from the package measured in mSv/hr then multiplied by 100

18.1.1 Exempt Package - Transport by Road

A consignment may be exempt from the ADR where the values in the columns 2 and 3 of the table below are not exceeded

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Activity concentration for exempt material (Bq/g)</th>
<th>Activity limit for an exempt consignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>3H</td>
<td>1 x 10(^6)</td>
<td>1 GBq</td>
</tr>
<tr>
<td>14C</td>
<td>1 x 10(^4)</td>
<td>10 MBq</td>
</tr>
<tr>
<td>22Na</td>
<td>1 x 10(^1)</td>
<td>1 MBq</td>
</tr>
<tr>
<td>32P</td>
<td>1 x 10(^3)</td>
<td>100 kBq</td>
</tr>
<tr>
<td>33P</td>
<td>1 x 10(^3)</td>
<td>100 MBq</td>
</tr>
<tr>
<td>35S</td>
<td>1 x 10(^3)</td>
<td>100 MBq</td>
</tr>
<tr>
<td>36Cl</td>
<td>1 x 10(^4)</td>
<td>1 MBq</td>
</tr>
<tr>
<td>42K</td>
<td>1 x 10(^2)</td>
<td>1 MBq</td>
</tr>
<tr>
<td>45Ca</td>
<td>1 x 10(^4)</td>
<td>10 MBq</td>
</tr>
<tr>
<td>51Cr</td>
<td>1 x 10(^3)</td>
<td>10 MBq</td>
</tr>
<tr>
<td>60Co</td>
<td>1 x 10(^3)</td>
<td>100 kBq</td>
</tr>
<tr>
<td>63Ni</td>
<td>1 x 10(^3)</td>
<td>100 MBq</td>
</tr>
<tr>
<td>86Rb</td>
<td>1 x 10(^2)</td>
<td>100 kBq</td>
</tr>
<tr>
<td>Tc99m</td>
<td>1 x 10(^2)</td>
<td>10 MBq</td>
</tr>
<tr>
<td>125I</td>
<td>1 x 10(^4)</td>
<td>1 MBq</td>
</tr>
</tbody>
</table>
This table covers the radionuclides that the University has a Certificate of Registration for. If other nuclides are to be transported, you should contact the Director of EHSS. 

NOTE: The limits apply to a consignment and are not package limits or vehicle limits.

### 18.1.2 Excepted Packages - Transport by Road

As long as the amounts of radioactive material are less than in the following table and the surface dose does not exceed $5 \mu\text{Sv/hr}$, the package may be transported as an ‘Excepted’ package.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Ordinary Solid Form</th>
<th>Liquid Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^3\text{H}$</td>
<td>40 GBq</td>
<td>4 GBq</td>
</tr>
<tr>
<td>$^{14}\text{C}$</td>
<td>3 GBq</td>
<td>300 MBq</td>
</tr>
<tr>
<td>$^{22}\text{Na}$</td>
<td>0.5 GBq</td>
<td>50 MBq</td>
</tr>
<tr>
<td>$^{32}\text{P}$</td>
<td>0.5 GBq</td>
<td>50 MBq</td>
</tr>
<tr>
<td>$^{33}\text{P}$</td>
<td>1 GBq</td>
<td>100 MBq</td>
</tr>
<tr>
<td>$^{35}\text{S}$</td>
<td>3 GBq</td>
<td>300 MBq</td>
</tr>
<tr>
<td>$^{36}\text{Cl}$</td>
<td>0.6 GBq</td>
<td>60 MBq</td>
</tr>
<tr>
<td>$^{42}\text{K}$</td>
<td>0.2 GBq</td>
<td>20 MBq</td>
</tr>
<tr>
<td>$^{45}\text{Ca}$</td>
<td>1 GBq</td>
<td>100 MBq</td>
</tr>
<tr>
<td>$^{51}\text{Cr}$</td>
<td>30 GBq</td>
<td>3 GBq</td>
</tr>
<tr>
<td>$^{60}\text{Co}$</td>
<td>400 MBq</td>
<td>40 MBq</td>
</tr>
<tr>
<td>$^{63}\text{Ni}$</td>
<td>30 GBq</td>
<td>3 GBq</td>
</tr>
<tr>
<td>$^{86}\text{Rb}$</td>
<td>500 MBq</td>
<td>50 MBq</td>
</tr>
<tr>
<td>$^{99m}\text{Tc}$</td>
<td>4 GBq</td>
<td>400 MBq</td>
</tr>
<tr>
<td>$^{125}\text{I}$</td>
<td>3 GBq</td>
<td>300 MBq</td>
</tr>
<tr>
<td>$^{137}\text{Cs}$</td>
<td>600 MBq</td>
<td>60 MBq</td>
</tr>
</tbody>
</table>

The packaging requirements for an ‘Excepted Package’ are as follows:

1. The surface dose of the package must be less than $5 \mu\text{Sv/hr}$;
2. Non-fixed contamination of the external surface of the ‘Excepted’ package shall not exceed:
   - 4 Bq/cm$^2$ for $\beta$ and $\gamma$ and low toxicity $\alpha$ emitters (e.g. natural uranium and thorium)
   - 0.4 Bq/cm$^2$ for all other $\alpha$ emitters
3. The package shall bear the marking of ‘Radioactive’;
4. The package shall have a size and weight which allows for easy manual handling
5. There must be no protruding objects from the package;
6. The package should be easily decontaminated;
7. The outer package should be designed to avoid the accumulation of water;
8. The materials of the package should not interact with the radioactive materials / radioactively contaminated samples
9. The properties of the materials must be clearly labelled (e.g. if sample is toxic, then the package must be labelled to show this);
10. The package must be sturdy enough not to allow any leakages of to be easily damaged while in transit

It is not permissible to take a vial, flask or sample tube containing radioactive substances from one laboratory to another without first putting it in a suitable receptacle.

A suitable receptacle must provide adequate shielding for the person carrying it, and be robust enough not to break on being dropped. If there is the possibility of a spill, then sufficient absorbent material should be enclosed in the receptacle to contain it, or the receptacle should be adequately sealed to prevent leakage.

The following containers, or combinations of them, could be considered suitable:-
- (a) a screw top plastic or metal container - Amersham cans ideal;
- (b) a plastic snap top container;
- (c) a push fit plastic or metal container adequately taped up;
(d) a lead pot adequately taped up (would require absorbent packing for liquids in glass vials if used on its own); and
(e) for sealed sources, the lockable money boxes already in use would be suitable.

Although the radioactive substance itself should be adequately labelled, no additional information or specific labelling of the receptacle is required for the movement of radioactive substances. However, if the material is likely to remain in its receptacle for some time, or left unattended, then some indication of its contents would be advisable.

The package should then have attached details of the contents and the consignors etc. This sign is given in Appendix 27.

The vehicle used for transporting Excepted packages should have a non-combustible sign on the dashboard with an appropriate TREMCARD to show the emergency actions that would need to be taken in the event of an accident.

18.1.3 Type A Package - Transport by Road

If the amount of radioactivity exceeds the limits for an Excepted Package but are less than the table below, then the radioactivity must transported in a ‘Type A Package’.

<table>
<thead>
<tr>
<th>Nuclide</th>
<th>Special Form A₁</th>
<th>Other Forms A₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>3H</td>
<td>40 TBq</td>
<td>40 TBq</td>
</tr>
<tr>
<td>14C</td>
<td>40 TBq</td>
<td>3 TBq</td>
</tr>
<tr>
<td>22Na</td>
<td>0.5 TBq</td>
<td>0.5 TBq</td>
</tr>
<tr>
<td>32P</td>
<td>0.5 TBq</td>
<td>0.5 TBq</td>
</tr>
<tr>
<td>33P</td>
<td>40 TBq</td>
<td>1 TBq</td>
</tr>
<tr>
<td>35S</td>
<td>40 TBq</td>
<td>3 TBq</td>
</tr>
<tr>
<td>36Cl</td>
<td>10 TBq</td>
<td>0.6 TBq</td>
</tr>
<tr>
<td>42K</td>
<td>0.2 TBq</td>
<td>0.2 TBq</td>
</tr>
</tbody>
</table>
Nuclide | Special Form A₁ | Other Forms A₂
---|---|---
45Ca | 40 TBq | 1 TBq
51Cr | 30 TBq | 30 TBq
60Co | 0.4 TBq | 0.4 TBq
63Ni | 40 TBq | 30 TBq
86Rb | 0.5 TBq | 0.5 TBq
125I | 20 TBq | 3 TBq
137Cs | 2 TBq | 0.6 TBq

Design Specifications for a Type A Package - A Type A package will be designed in a similar manner to an Excepted Package but must meet key specific tests set in the ADR guidance which Excepted packages are not legally required to meet. In particular, the package must be able to survive intact at temperatures from -40°C to +70°C and must survive a change in pressure of 60 kPa, it must survive a water spray test (simulation of rainfall), a free drop test of 1.2m and a penetration test by a 6kg bar. As can be seen, it means that very specific packaging from a reliable supplier is the only way to meet these standards.

If you plan to use a Type A package, you should contact the Director of EHSS or the URPO for details.

Categorisation of Type-A Packages - Type A packages have three categories based on the Transport Index and the dose rate at 1 metre from the surface.

<table>
<thead>
<tr>
<th>Category Label</th>
<th>Transport Index</th>
<th>Maximum Dose Rate on External Surface</th>
<th>Sign to be used</th>
</tr>
</thead>
<tbody>
<tr>
<td>I - White</td>
<td>0</td>
<td>&lt;0.005 mSv/hr</td>
<td><img src="image1.png" alt="Sign" /></td>
</tr>
<tr>
<td>II - Yellow</td>
<td>0 - 1</td>
<td>&gt;0.005 but &lt; 0.5 mSv/hr</td>
<td><img src="image2.png" alt="Sign" /></td>
</tr>
<tr>
<td>III - Yellow</td>
<td>&gt;1 but &lt; 10</td>
<td>&gt;0.5 but &lt; 2 mSv/hr</td>
<td><img src="image3.png" alt="Sign" /></td>
</tr>
</tbody>
</table>

Depending on the category of the Type-A package, different transport hazard diamond signs need to be attached - see table above.

There are also other restrictions when transporting a Type A package by road which include:

1. Non-fixed contamination of the external surface of the ‘Excepted’ package shall not exceed:
   - 4 Bq/cm² for β and γ and low toxicity α emitters (eg natural uranium and thorium)
- 0.4 Bq/cm$^2$ for all other $\alpha$ emitters
2. Dose rates external to the vehicle shall not exceed 2 mSv/hr at any point and shall not be greater than 0.1 mSv/hr at 2m from the vehicle
3. Travel inside the vehicle should be restricted to authorised people who are trained in handling radioactivity
4. The vehicle should never be left unattended or if it does, then it should not be left for any significant period with the stowage compartment suitably locked
5. A vehicle of 3.5 tonnes or less should carry 2 x 2kg dry powder fire extinguishers
6. Written instructions for the actions to take in an emergency should be provided.
7. Dangerous Goods Safety Adviser (DGSA) must approve the transport of Type A packages.

18.1.4 Type B Package - Transport by Road

If the radioactive materials have an activity greater than that from a Type A package, then the sample must be packaged in a Type B container.

There are very complex and detailed requirements for Type B packages. Researchers who wish to transport such large quantities of radioactivity should first discuss this matter with the Director of EHSS.

18.2 - Transport by Air or Sea

Where researchers plan to send radioactive materials by air or by sea will have to comply with the IATA (for air) or the IMDG (for maritime transport of Dangerous Goods) codes of practice. If you wish to transport radioactive materials by these routes, you should first discuss the matter with the Director of EHSS.

18.3 Driver Training

The ADR guidances contain special provisions relating to the carriage of radioactive material.

Those people who are only involved in the transport of excepted packages only are not affected as there is no legal requirement for training - it is at the discretion of the employer. It is however, good practice to ensure that all those who transport any form of radioactive materials are given basic training in their driving skills and informed on the actions to be taken in an emergency.

Those people transporting up to 10 Type A packages at any one time require training and must hold a certificate provided by the employer confirming that they have received suitable instruction and training.

Such driver training will be provided to all those who require it.

18.4 Dangerous Goods Safety Adviser (DGSA)

A DGSA must approve transport of Type A and Type B packages. If such approval is required, then you should contact the Director of EHSS.
19 Geological Samples

A geological specimen is only deemed a radioactive material if it exceeds the specific activities stated in the legislation entitled ‘Radioactive Substances Act 1993 Amendment (Scotland) Regulations 2011’ (URL: http://www.legislation.gov.uk/sdsi/2011/9780111012031/pdfs/sdsi_9780111012031_en.pdf). Table 3 of this legislation gives the specific activities of radionuclides which are deemed radioactive.

If the radioactive geological ore contains natural uranium or thorium then it is exempt from the Radioactive Substances Act as amended (see URL: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69357/pb13624-rsl-guidance-110914.pdf). If the source of the radioactivity ion the ores is due to another radionuclide, then you should check the Radioactive Substances Exemption (Scotland) Order 2011 (see section 6.1 of this guidance).

If a radioactive ore which does not include uranium or thorium, it may be classed as NORM (Naturally Occurring Radioactive Material) material and thus exempt from the Radioactive Substances Act requirements for Certificates, but if the radionuclides are being purified then it maybe necessary to get an appropriate Certificate of Registration to hold the ore and a Certificate of Authorisation if you wish to dispose of this ore. If you do propose to purified radionuclides from an ore you must check with the Director of EHSS PRIOR to starting the work.

19.1 Decay of Radioactive Ores

The decay of radioactive ores which contain uranium and thorium can produce significant quantities of radon. As a consequence, these ores must be stored in a well ventilated area with limited access. All those wishing to access this area must wear a dosimeter badge at all times.

Regular measurements of the levels of Radon should be undertaken. Radon measurement badges can be obtained through Environmental, Health and Safety Services. If the levels of Radon exceed 400 Bq/m², there is then a requirement to put in place measures to reduce this activity.

Due to the potentially high activities of radiation, only those with specialised training may access these ores.

19.2 Risk Assessment for Working With Radioactive Ores

An appropriate risk assessment must be undertaken when working with such ores. This will assess the radioactive hazard as well as potential chemical hazards associated with these agents. Appropriate control measures should then be put in place to protect workers. The prioritisation of the control measures will be:

- Eliminate
- Substitute
- Engineering controls including shielding
- Procedures (eg working at a distance from the source – Dose is proportional to the invers square of the distance from the source)
- Wearing personal protective equipment (this will include the use of gloves and appropriate masks eg PP3 particulate masks to avoid inhaling dust from such ores)

This risk assessment must be shown and signed by all workers to show that they agree to comply with the control measures identified. The supervisor will be the owner of the risk assessment and will be responsible for ensuring the control measures are being applied.
19.3 Dose Limitations

The dose limitations for geological ores are the same as for work with unsealed sources (see section 5). The dose for ores can be worked out very approximately using the following equations:

For $\beta$ Radiation of 0.5 MeV and 3 MeV

**Dose Rate (mGrays per Hour) in air at 10 cm from source = 800 x Activity (GBq)**

For $\gamma$ Radiation in the range of 0.1 MeV and 3 MeV

**Dose Rate ($\mu$Grays per Hour) in air at 1m from $\gamma$ Source = 140 x Activity (GBq)**

As an example, for depleted Uranium:

The following table provides an indication of external exposure rates in $\mu$Sv/h from depleted uranium (Radiation Protection Dosimetry, Delacroix et al 2002 – URL: https://www.nuc.berkeley.edu/sites/default/files/resources/safety-information/Radionuclide_Data_Handbook.pdf);

<table>
<thead>
<tr>
<th>Weight of Compound (g)</th>
<th>External Body Dose (from an open source @30cm) ($\mu$Sv/h)</th>
<th>Hands (contact with stock bottle) ($\mu$Sv/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.00034</td>
<td>0.026</td>
</tr>
<tr>
<td>10</td>
<td>0.0034</td>
<td>0.26</td>
</tr>
<tr>
<td>100</td>
<td>0.034</td>
<td>2.6</td>
</tr>
</tbody>
</table>

Shielding must be appropriate (see section 7) thus for gamma radiation heavy metals or dense material like concrete will be needed but shielding for beta radiation will be perspex.

19.4 Purification of Fissile Radionuclides

No work purifying fissile radionuclides from geological ores can start without the approval of the University Radiation Protection Adviser and the Director of EHSS. Thus any experiments which might enrich U-235 will have to be notified to the appropriate authorities. Such purification will require accurate record keeping and will require security plans and approvals before the work can begin.

Fissile material is defined as:

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>CATEGORIES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I/II</td>
</tr>
<tr>
<td></td>
<td>III</td>
</tr>
<tr>
<td>1. Plutonium (other than plutonium with an isotopic concentration exceeding 80% in plutonium-238) which is not irradiated</td>
<td>More than 500 grammes</td>
</tr>
<tr>
<td></td>
<td>More than 1 kilogramme</td>
</tr>
<tr>
<td>2. Uranium-233 which is not irradiated</td>
<td>500 grammes or less, but more than 15 grammes</td>
</tr>
<tr>
<td></td>
<td>1 kilogramme or less, but more than 15 grammes</td>
</tr>
<tr>
<td>3. Previously separated neptunium-237 which is not irradiated</td>
<td>More than 1 kilogramme</td>
</tr>
<tr>
<td></td>
<td>1 kilogramme or less, but more than 15 grammes</td>
</tr>
<tr>
<td>4. Previously separated americium-241, previously separated americium-242m or previously separated americium-243, which are not irradiated</td>
<td>More than 1 kilogramme</td>
</tr>
<tr>
<td></td>
<td>1 kilogramme or less, but more than 15 grammes</td>
</tr>
<tr>
<td>5. Uranium-235 in enriched uranium containing 20% or more of uranium-235, which is not irradiated</td>
<td>More than 1 kilogramme</td>
</tr>
<tr>
<td></td>
<td>1 kilogramme or less, but more than 15 grammes</td>
</tr>
<tr>
<td>MATERIAL</td>
<td>CATEGORIES</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>6. Uranium-235 in enriched uranium containing 10% or more, but less</td>
<td>10</td>
</tr>
<tr>
<td>than 20%, of uranium-235, which is not irradiated</td>
<td>kilogrammes</td>
</tr>
<tr>
<td></td>
<td>or more</td>
</tr>
<tr>
<td>7. Uranium-235 in enriched uranium containing less than 10% but more</td>
<td>10</td>
</tr>
<tr>
<td>than 0.711% of uranium-235, which is not irradiated</td>
<td>kilogrammes</td>
</tr>
<tr>
<td></td>
<td>or more</td>
</tr>
<tr>
<td>8. Irradiated reactor fuel being used, stored or transported within the</td>
<td>Any</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>quantity</td>
</tr>
<tr>
<td>9. Irradiated reactor fuel being transported outside the United Kingdom</td>
<td>Any</td>
</tr>
<tr>
<td>other than such fuel which, prior to being irradiated, was uranium</td>
<td>quantity</td>
</tr>
<tr>
<td>enriched so as to contain 10% or more, but less than 20%, of uranium-235</td>
<td></td>
</tr>
<tr>
<td>10. Irradiated reactor fuel being transported outside the United Kingdom</td>
<td>Any</td>
</tr>
<tr>
<td>which, prior to being irradiated, was uranium enriched so as to contain</td>
<td></td>
</tr>
<tr>
<td>10% or more, but less than 20%, of uranium-235</td>
<td>quantity</td>
</tr>
<tr>
<td>11. Other irradiated nuclear material</td>
<td>Any</td>
</tr>
</tbody>
</table>

“enriched uranium” means uranium enriched so as to contain more than 0.711% of uranium-235;

“irradiated” and “previously separated” have the meanings given in regulation 3(2) of the Nuclear Industries Security Regulations 2003

Inventories of NORM must be maintained to satisfy ‘Euratom’ Regulation 302/2005 regulated in the UK by the ‘safeguards’ division of the Office for Nuclear Regulation (ONR).

If there is a plan to work with such agents, there must be appropriate levels of security which must be discussed with the University Security manager before any work can start.

20 Record Keeping

The following records are required by the Ionising Radiations Regulations 1999 and its Approved Code of Practice, or by Certificates of Registration or Authorisation issued under the Radioactive Substances Act 1993, or by the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009. They have to be kept for a varying number of years, and for some the School/Unit has a responsibility.

<table>
<thead>
<tr>
<th>Record</th>
<th>Time to be retained</th>
<th>Keeper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classified Personnel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health Record</td>
<td>50 years after last entry</td>
<td>Radiation Protection Service</td>
</tr>
<tr>
<td>Radiation Dose Record</td>
<td>50 years after last entry</td>
<td>Radiation Protection Service</td>
</tr>
<tr>
<td>Non-Classified Personnel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dose assessment records</td>
<td>2 years from date of report</td>
<td>Radiation Protection Service</td>
</tr>
<tr>
<td>Monitor tests (14 monthly)</td>
<td>2 years from date of test</td>
<td>Radiation Protection Service</td>
</tr>
<tr>
<td>Leakage tests (26 monthly)</td>
<td>3 years from date of test</td>
<td>Radiation Protection Service</td>
</tr>
<tr>
<td>Laboratory monitoring</td>
<td>2 years from date of report</td>
<td>School/Unit</td>
</tr>
</tbody>
</table>
Isotope records relating to ordering, storage 2 Years from date of last entry On RadProt system
Waste disposals 5 years from date of last entry Radiation Protection Service
Transport document or record of transfer 5 years from date of transfer Radiation Protection Service

Of particular importance here are those records where the School/Unit and the individual radiation worker have a major role to play, i.e. in laboratory/equipment monitoring, and in the maintenance of isotope records.

20.1 Monitoring Records

Information on monitoring techniques and requirements is available. All radiation workers have a role to play in monitoring and in keeping satisfactory records.

20.2 Isotope Records

20.2.1 - Unsealed sources

All records relating to the arrival, storage, use and disposal of unsealed radioactive sources must be kept using the RadProt radiation management programme. There should be no paper record of work with unsealed radioactive sources.

20.2.2 Sealed Sources

A record of all sealed sources in a School/Unit should be kept by the DRPS. Where School/Units hold a large number of sealed sources, they may wish to have a sealed source register. All sealed sources are affected by this record keeping requirement - even reference sources and those in liquid scintillation counters. The exemption limits of the Radioactive Substances Act are very low indeed (0.4 Bq/g) and, therefore, of no help in easing this requirement.

21 Training

All workers at the University should attend the Induction training sessions and also can use the Moodle e-learning system University induction training - URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2864

All researchers who wish to work with radioactive materials must attend either the University radiation Protection Course in person or undertake the Moodle e-learning University radiation Protection Course at URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=2905 It is University policy that once workers have undertaken these courses they should then undertake the test at the University Radiation Protection Course Moodle site and pass this test by 60%.

Researchers should also be aware of the procedures for contamination monitoring and also for the procedures for decontaminating areas as well as reporting such incidents. Such guidance can be found at the following Moodle site -URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4375

Those who wish to be registered to work with X-rays only, should undertake the University X-Ray Safety Course on the Moodle site at URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=3506

Researchers should also undertake other training programmes for work that may be associated with the use of radioactive materials, for example
- Work with hazardous chemicals - Training can be found at Moodle site - URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4263

- Work with hazardous pathogens or genetically modified organisms - Training can be found at the Biosafety Moodle site at URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4340

- Work with Lasers - Training can be found at Moodle site - URL: https://moody.st-andrews.ac.uk/moodle/course/view.php?id=4404

It is expected that the Principal Investigator will provide detailed information, training and supervision in specific work activities. This will be ongoing training.

Training will be required for all those who may be transporting radioactive materials. Where you wish to transport a Type A radioactive package on the roads, you will have to receive an external training session and obtain a certificate of competence from this provider. Guidance on this matter should be sought from the Director of EHSS.

Where other specific training is required, you should contact the Director of EHSS.
Appendix 1

Duties of a University Radiation Protection Adviser (URPA)

The scope of advice which the URPA may be called upon to give includes the following:

- Providing the Principal’s Office with advice on radiation protection;
- Providing advice and guidance to the University Radiation Protection Service;
- Undertake annual inspections of radiation protection procedures in relevant Schools/Units;
- Identification of ‘Controlled’ and ‘Supervised’ areas;
- Designation of any person as a ‘Classified person’;
- Control of access to ‘Controlled Areas’;
- Investigation of excessive doses of radiation;
- Contingency and emergency arrangements;
- Hazard survey reports;
- Selection criteria for Departmental Radiation Protection Supervisors and the technical aspects of their work;
- Guidance on the production of ‘Local Rules’;
- Prior examination of plans for new equipment, installations and processes or modifications which may have a radiation safety implication;
- Prior examination and review of operational procedures, or modifications, having a safety implication;
- Acceptance of new installations, processes and equipment, or modifications, having a radiation safety implication;
- Provide guidance on the provision and maintenance of safety features;
- Provide guidance on the provision, testing and maintenance of Personal Protective Equipment (PPE) and Respiratory Protective Equipment (RPE);
- Establishing monitoring procedures;
- Interpretation and significance of radiation exposures;
- Ratification of new projects;
- Investigation of notifiable incidents;
- Methods of complying with the requirements of the relevant statutory provisions and codes;
- Process applications for and amendments to the necessary certificates for the storage, use and disposal of radioactive materials;
- Such other aspects of radiation safety as the University Court considers necessary or as the URPA advises to be so.
Appendix 2

Terms of Reference for the Radiation Hazards Management group

The terms of reference for this sub-committee are:

- To monitor and provide policy guidance on the health and safety aspects of the use of ionising and other electromagnetic radiations and radioactive substances within the University;
- To ensure that safe working practices are followed;
- To establish and review a policy for the provision of information, instruction and training in the field of radiation protection;
- To report regularly and submit recommendations to the Principal’s Office;
- To draft ‘Local Rules’ and guidance for the approval of the Principal’s Office as and when necessary or desirable;
- To ensure that notifications are submitted to the Health and Safety Executive or the Scottish Environment Protection Agency in compliance with legal requirements;
- Review inspections of workplaces which use radioactivity, other electromagnetic radiations (eg Lasers), Ionising radiations and area where there is a significant magnetic field.
- To consult Scottish Environment Protection Agency (SEPA), Health and Safety Executive and any other enforcement agency as and when necessary or desirable.
Appendix 3

Membership of the Radiation Hazards Management Group

Members

Director of EHSS (Convenor)
Deputy Director of EHSS
URPA
University Laser Safety Adviser
DRPS - Centre for Biomolecular Sciences
DRPS - Bute Medical Building, School of Biology
DRPS - Gatty Marine Laboratory, School of Biology
DRPS - Sir Harold Mitchell Building, School of Biology
DRPS - School of Chemistry
DRPS - X-ray Equipment in Chemistry and BMS /BSRC Complex
DRPS - School of Geography and Geosciences
DRPS - School of Physics and Astronomy
DRPS - School of Psychology

Convenor - URPA
Secretary - URPA
Appendix 4

Duties of the University Radiation Protection Service.

The duties of this service include the following:

- Provide competent advice to Schools/Units on radiation protection
- To ensure continuing compliance with the governing legislation and Codes of Practice and with new directives or instructions issued by the Health and Safety Executive or any other relevant Agency;
- To provide the radiological protection advisory service to all employees of the University working with ionising radiation;
- To produce Local Rules, guidance notes, for relevant Schools/Units;
- To manage the Radiation Management programme RadProt;
- Will manage Radioactive materials and X-ray ‘User’ registrations using the RadProt system;
- Will ensure that all projects involving radioactivity or X-ray equipment have appropriate risk assessments, can be justified and are appropriately approved;
- To provide, as required by the regulations, a structure for the implementation of contingency arrangements in the event of an accident;
- To provide personal dosimeters and arrange for their processing and record keeping to be carried out by an Approved Laboratory;
- To arrange for medical examinations for Classified Workers to be carried out by an Appointed Doctor;
- To liaise with outside Agencies on matters concerning designation of personnel, personal monitoring, personal dose records, registration and authorisation of premises, testing and calibration of monitoring equipment, leakage testing of sealed sources, records of stocks of radioactive substances held and disposed of, provision for the disposal of radioactive waste;
- To provide training in radiological safety through Radiation Protection Courses and providing e-learning training courses for all staff and students;
- To arrange for the removal of radioactive waste from Schools/Units and its transport to the appropriate authorised store;
- Will ensure that all contamination monitors and dose rate meters are properly calibrated and maintained in good working order;
- Will undertake periodic inspections of all areas using radioactive materials and X-ray equipment;
- Will investigate all significant radiation incidents at the University, and prepare reports on such incidents to the URPA and Principal’s Office.
Appendix 5

The Duties of a Departmental Radiation Protection Supervisors (DRPS).

The terms of reference for a DRPS are as follows:

- To provide advice on radiation protection matters to the Head of the School/Unit and all relevant personnel within the School/Unit;
- To liaise with Principal Investigators, Researchers and students within the School/Unit to ensure the School/Unit complies with governing legislation and Local Rules;
- To liaise with the URPA as required;
- To recommend the designation of radiation workers;
- To manage Users and Radiation risk assessments for their School/Unit on the University’s Computerised radiation management Programme RadProt.
- Using the RadProt system, to monitor and where necessary manage the storage, use and disposal of radioactive materials in their School/Unit
- Be responsible for approving all purchases of radioactive materials for the School/Unit. Such orders must be recorded on the RadProt system.
- When radioactive sources arrive, it is the duty of the DRPS to check that the source is correct (correct volume, activity, radionuclide ordered) and also to ensure that it has not leaked and contaminated any of the packaging. When the source has been checked, the DRPS should add it to the RadProt system as an active source which can be used by other workers.
- To maintain the records of sealed sources. These records must show the nature and activity of the material, the date of receipt, the place of storage and the method and route of disposal;
- To supply the URPA, whenever requested, with a summary of the current School/Unit holdings of radioactive substances;
- To ensure the annual leakage testing of sealed sources is carried out and to keep a copy of such tests and to supply a copy of such tests to the URPA;
- To arrange for appropriate contamination monitoring to be carried out at regular intervals in designated radiation areas within the School/Unit and to keep records of their results;
- To arrange for the distribution of personal dosimeters which are issued by the University Radiation Protection Service;
- To draw up and issue ‘Systems of Work’ to unclassified radiation workers after consultation with the University radiation Protection Service;
- To ensure that the requisite certificates, warning signs and notices are posted;
- In the event of an accident which involves radiation exposure, radioactive contamination or significant release or loss of radioactive materials, the DRPS should take immediate measures as he/she deems necessary and to inform the Head of the School/Unit and the URPS as a matter of urgency.
University of St. Andrews

Appointment of Departmental Radiation Protection Supervisors

I wish to nominate ..................................................................................................................
as the Departmental Radiation Protection Supervisor for the

School/Unit .................................................................................................................................

Signed ................................................................................................................................. (Head of the School)

Date ........................................................................................................................................

I agree to act as DRPS in accordance with the duties outlined in the University of St. Andrews
Local Rules and Guidance for Work with Ionising Radiation

Name .........................................................................................................................................

Signed ....................................................................................................................................... 

Date .........................................................................................................................................

I ratify this nomination

Name of URPA ............................................................................................................................

Signed (URPA) ............................................................................................................................

Date .........................................................................................................................................
Appendix 7

The Duties of a Laboratory Radiation Protection Supervisor (LRPS).

The duties of a LRPS are as follows:

- To report to the nominated DRPS for the School/Unit
- To liaise with each project supervisor who works within the specified area or laboratory under the LRPS’s responsibility to ensure that work is carried out in compliance with the Local Rules;
- To maintain safe working conditions by ensuring that good radiological safety practices are being followed;
- To inform the URPA, via the DRPS, of any plan to transport radioactive substances outwith the University;
- To advise the DRPS, of any equipment entering the laboratory area which may produce ionising radiations either directly or adventitiously;
- To notify the DRPS, of any modification to equipment which may have a radiation safety implication;
- To inform the DRPS, of any intention to bring a sealed source into the laboratory area;
- To carry out regular radiation and contamination monitoring;
- The LRPS should perform all reporting duties through the DRPS.
Appendix 8

University of St. Andrews

Appointment of Laboratory Radiation Protection Supervisors

I wish to nominate .................................................................................................................................

as the Laboratory Radiation Protection Supervisor for the Rooms

.........................................................................................................................................................

School/Unit ....................................................................................................................................... in the

Signed ................................................................................................................................................ (DRPS for School/Unit)

Date ....................................................................................................................................................... 

__________________________________________________________________________________________

I agree to act as LRPS in accordance with the duties outlined in the University of St. Andrews
Local rules and Guidance for Work with Ionising Radiation

Name ....................................................................................................................................................

Signed ....................................................................................................................................................

Date ....................................................................................................................................................... 

__________________________________________________________________________________________

I ratify this nomination

Name of URPA .....................................................................................................................................

Signed (URPA) ....................................................................................................................................

Date ....................................................................................................................................................... 
Appendix 9

Duties of a Radiation Worker

The duties of a radiation worker are as follows:

- To ensure their own safety and the safety of others by their actions or omissions when working with ionising radiations;
- To work with due diligence when handling radioactive materials;
- To undertake the University Radiation Protection Course and pass the test on the e-learning Moodle University radiation Protection Course;
- To become registered as a University of St. Andrews radiation worker;
- To be working on a radiation project that has been approved by the URPA;
- To be familiar with the University and School/Unit Local Rules and Guidances for work with ionising radiation;
- To be aware of the main chemical and physical properties of any radioactive substance being used;
- To be familiar with the physical properties and biological effects of the radiations generated or emitted;
- To take all necessary precautions to reduce to a minimum work-associated hazards e.g. radiation, fire etc.;
- To make full and proper use of any personal Protective Equipment (PPE) provided;
- To report without delay to the LRPS and DRPS any known defect in the PPE provided;
- To have available adequate monitoring equipment which they know how to use and can correctly interpret the readings of such equipment;
- To carry out such radiation, contamination and thyroid monitoring as is recommended in the Local Rules and Guidance;
- To submit orders for radioactive materials only to the DRPS for their approval prior to ordering materials;
- To inform the DRPS in advance whenever radioactive substances from a source other than a commercial supplier are to be brought into the School/Unit;
- To wear personal dosimeters in the position stipulated by the University Radiation Protection Service;
- To record the nature and activity of all the radionuclide disposals in the form of (i) Solid and Liquid waste deposited in a designated container (ii) Aqueous Liquid waste discharged via designated sink via the University’s Radiation Hazard Management programme RadProt.
- To obtain approval from the URPA, via the DRPS, before transporting any radioactive substances outwith the School/Unit;
- To notify the LRPS and DRPS before carrying out equipment modifications which may have a radiation safety implication.
- Notify the DRPS as a matter of urgency if there has been any incident involving radioactive materials.
Appendix 10  Radiation User Registration Form Radprot-Reg-1

<table>
<thead>
<tr>
<th>University of St Andrews - Radiation Register Application Form</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Your details</strong></td>
</tr>
<tr>
<td>Login Name (e-mail username)</td>
</tr>
<tr>
<td>Title</td>
</tr>
<tr>
<td>Surname</td>
</tr>
<tr>
<td>Firstname</td>
</tr>
<tr>
<td>Gender</td>
</tr>
<tr>
<td>Date of Birth (dd/mm/yy)</td>
</tr>
<tr>
<td>National Insurance No.</td>
</tr>
<tr>
<td>Position held</td>
</tr>
<tr>
<td>If Other please specify</td>
</tr>
<tr>
<td><strong>Where you are working</strong></td>
</tr>
<tr>
<td>Department</td>
</tr>
<tr>
<td>Group (Supervisor)</td>
</tr>
<tr>
<td>Tel. Extension</td>
</tr>
<tr>
<td>Expected Start date (dd/mm/yy)</td>
</tr>
<tr>
<td><strong>What you are working with</strong></td>
</tr>
<tr>
<td>Sources (radioisotopes)</td>
</tr>
<tr>
<td>Maximum activity worked with (Bq)</td>
</tr>
<tr>
<td>Sealed / Unsealed</td>
</tr>
<tr>
<td>Radiation Generators</td>
</tr>
<tr>
<td>Hazard Category</td>
</tr>
<tr>
<td><strong>Previous experience with radioisotopes</strong></td>
</tr>
<tr>
<td>Sources</td>
</tr>
<tr>
<td>Place(s) worked</td>
</tr>
<tr>
<td>Number of years</td>
</tr>
<tr>
<td><strong>Previous experience with radiation generators</strong></td>
</tr>
<tr>
<td>Source</td>
</tr>
<tr>
<td>Place(s) worked</td>
</tr>
<tr>
<td>Number of years</td>
</tr>
<tr>
<td><strong>Radiation training</strong></td>
</tr>
<tr>
<td>When (year)</td>
</tr>
<tr>
<td>Where (institution)</td>
</tr>
<tr>
<td>Previous dose records available from</td>
</tr>
<tr>
<td>(Please list previous institutions here)</td>
</tr>
</tbody>
</table>

Once completed please return to:  pwss@st-andrews.ac.uk
APPENDIX 11

Health and Safety Executive

Ionising radiations regulations 1999

Prior authorisation for the use of electrical equipment intended to produce X-rays

1. For the purposes of regulation 5(2) of the Ionising Radiations Regulations 1999, the Health and Safety Executive (HSE) hereby authorises the type of practice referred to in paragraph 3 subject to any such practice being carried out in accordance with the conditions hereby approved by HSE as set out in paragraph 4.

2. Notwithstanding the prior authorisation given in paragraph 1, radiation employers must comply with all other relevant requirements of these Regulations, including notifying HSE of their intention to work with radiation in accordance with regulation 6.

3. The type of practice referred to in paragraph 1 is:

The use of electrical equipment intended to produce X-rays ("X-ray sets") for: industrial radiography; processing of products; research; or exposure of persons for medical treatment.

4. The conditions referred to in paragraph 1 are as follows. The radiation employer shall:

4.1 as part of satisfying the general requirement in regulation 8 of the Ionising Radiations Regulations 1999 to keep exposure as low as reasonably practicable, take specific steps before starting the work to provide engineering controls, design features, safety devices and warning devices which include at least the following:

a. adequate shielding as far as reasonably practicable; and
b. except in the use of X-ray sets for radiotherapy at or below 50kV, interlocks or trapped key systems or other appropriate safety devices in order to prevent access to high dose rate areas (eg in which employed persons could receive an effective dose greater than 20 mSv or an equivalent dose in excess of a dose limit within several minutes when radiation emission is underway). The control system for such safety devices should comply with paragraphs 4.4 or 4.5;

4.2 arrange for adequate and suitable personal protective equipment to be provided where appropriate;

4.3 arrange for suitable maintenance and testing schedules for the control measures selected;

4.4 provide safety devices, as referred to in 4.1(a), which for routine operations should be configured so that the control system will ensure that an exposure:

a. cannot commence while any relevant access door, access hatch, cover or appropriate barrier is open, or safety device is triggered;

b. is interrupted if the access door, access hatch, cover or barrier is opened; and
c. does not re-commence on the mere act of closing a door, access hatch, cover or barrier; and

4.5 for non-routine operations such as setting up or aligning equipment, where the safeguards for routine operation are not in use, provide a procedure for an alternative method of working that affords equivalent protection from the risk of exposure which should be documented and incorporated into the local rules.
Signed
Margaret Clare
A person approved by the Health and Safety Executive to perform the functions under regulation 6(2) of the Ionising Radiations Regulations 1999.
Dated
6 March 2000
Notes:

a. Work referred to in paragraph 3 when carried out in accordance with the conditions in paragraph 4 is not subject to the requirement for individual prior authorisation pursuant to regulation 5(1) of the Ionising Radiations Regulations 1999.

b. This authorisation is without prejudice to the requirements or prohibitions imposed by any other enactment, in particular, the Health and Safety at Work etc. Act 1974 and the Ionising Radiations Regulations 1999, and to the provisions of the Approved Code of Practice on the Ionising Radiations Regulations 1999.
APPENDIX 12

LABORATORY RULES - SEALED SOURCES

1. Always USE the MINIMUM ACTIVITY SOURCE required for the experiment.

2. SOURCES EMITTING PENETRATING RADIATIONS SHOULD NEVER BE MANIPULATED DIRECTLY BY HAND.

3. To CONTAIN PENETRATING RADIATIONS use appropriate SHIELDING to keep DOSE RATES BELOW 2.5μSv hr\(^{-1}\) whenever reasonably practicable.

4. WEAR YOUR PERSONAL DOSIMETER AND FINGER DOSIMETERS if these have been issued to you.

5. Any SOURCE NOT PERMANENTLY MOUNTED should be KEPT in properly LABELLED CONTAINERS and in an APPROVED LOCKED STORE when not in use.

6. All SOURCES should be ENGRAVED or otherwise permanently marked with a UNIQUE IDENTIFICATION CODE derived from the RadProt programme. If permanently mounted in a source holder, this should bear the identification mark along with details of the isotope, activity and a radiation trefoil, if this is reasonably practicable.

7. If a SOURCE is PERMANENTLY MOUNTED in a piece of equipment, it should NOT BE READILY REMOVABLE and the EQUIPMENT should have a suitable WARNING LABEL.

8. DO A FULL MONITORING SURVEY of the LABORATORY when directed by your DRPS. The results of these surveys should be recorded for future reference.

9. KEEP ACCURATE RECORDS OF ALL RECEIPTS AND CURRENT STOCK. It is an offence under the Radioactive Substances Act 1993 not to have these UP-TO-DATE AT ALL TIMES.

10. LOCATION OF SOURCES should be CHECKED on at least a MONTHLY basis.

11. In the event of any ACCIDENT or INCIDENT involving radioactive materials INFORM your D.R.P.S. or the URPA or if these are not available the University Safety Adviser IMMEDIATELY.

Further information can be found in the local rules, and help and guidance is always available from...
APPENDIX 13

LABORATORY RULES - UNSEALED SOURCES

1. EATING, DRINKING, SMOKING, APPLYING COSMETICS etc. are FORBIDDEN.

2. NO MOUTH OPERATIONS, pipetting etc.

3. WEAR LABORATORY COATS and other protective clothing if necessary.

4. WEAR GLOVES when there is a possibility of the hands becoming contaminated. Then USE TISSUES when handling taps and switches etc.

5. WEAR YOUR PERSONAL DOSIMETER and FINGER DOSIMETERS if these have been issued to you.

6. KEEP PERSONAL BELONGINGS AWAY FROM RADIOACTIVE AREAS.

7. TO CONTAIN CONTAMINATION use BENCHKOTE and TRAYS. Keep CONTAMINATION AS LOW AS REASONABLY ACHIEVABLE and BELOW PRESCRIBED LIMITS.

8. TO CONTAIN RADIOACTIVE GAS, DUST or FUMES use an APPROVED FUME CUPBOARD or GLOVE BOX.

9. TO CONTAIN PENETRATING RADIATIONS use appropriate SHIELDING to keep DOSE RATES BELOW 2.5µSvh\(^{-1}\) whenever reasonably practicable.

10. MONITOR YOURSELF and the immediate WORK AREA at the end of EACH WORK SESSION, whenever radioactive substances have been used.

11. ALWAYS WASH YOUR HANDS after working with radioactive substances.

12. DO A FULL MONITORING SURVEY of the LABORATORY when directed by your D.R.P.S.. The results of these surveys should be recorded for future reference.

13. THE MINIMUM OF EQUIPMENT should be kept in the RADIOISOTOPE AREA. Wherever possible, equipment should be clearly marked and set aside solely for use with radioisotopes.

14. SEGREGATE CONTAMINATED ITEMS and CLEAN THOROUGHLY. DO NOT REMOVE ANY ITEM from the radioisotope area until it has been MONITORED and found to be FREE OF CONTAMINATION.

15. KEEP RADIOACTIVE MATERIALS IN PROPERLY LABELLED CONTAINERS IN AN APPROVED STORE

16. KEEP ACCURATE RECORDS OF ALL RECEIPTS, STOCK AND WASTE. It is an offence under the Radioactive Substances Act 1993 not to have these UP-TO-DATE AT ALL TIMES.

17. In the event of any ACCIDENT or INCIDENT involving radioactive materials INFORM your D.R.P.S. or URPA or if these are not available then contact the University Safety Adviser IMMEDIATELY.

Further information on monitoring, dealing with spills and the disposal of waste etc. can be found in the Local Rules, and help and guidance is always available from Radiation Protection Service.
APPENDIX 14

GUIDANCE IN THE USE OF X-RAY CRYSTALLOGRAPHIC EQUIPMENT

Introduction

Particular care is needed in the use of X-ray crystallographic equipment, because the very high dose rates near the target can cause injury in a very short time. A rough approximation of the dose rate to be found at a distance 'D' cms from the tungsten target of a tube running at 'V' kVp and ‘I’ mA with 1 mm Be filtration is given by the formula:-

\[
\text{Dose rate} = \frac{0.5 \times V \times I}{D^2} \text{ grays/s}
\]

For other targets the expression should be multiplied by Z/74 where Z is the atomic number of the target material.

An example of this is at 10 cm from a tungsten target with the tube running at 50 kVp and 20 mA, you will have a dose rate in the beam of 5 Gy/sec.

The main principle of radiation protection is to keep all doses AS LOW AS REASONABLY ACHIEVABLE (ALARA). Although the potential hazard from this type of X-ray equipment is high, providing the following precautions are followed, together with any specific operating instructions that you may be given, there is no reason why ALARA in this case should not mean no detectable doses at all.

X-Ray generating equipment should comply with the Health and Safety Executive document ‘Prior Authorisation for the Use of Electrical Equipment Intended to Produce X-Rays’. Where equipment does not comply with this document, then the Project Supervisor should contact the URPA.

An assessment of the risks of the work with X-rays should be performed before work begins. This risk assessment should identify the hazards of the work, determine the risks of the work and who may be at risk and implement appropriate control measures to ensure that the exposure to radiation is kept to ALARA.

Most activities with X-rays will be performed behind interlocked guards such that the exposure to radiation will be minimal.

Certain activities, however, will have a foreseeable risk of exposure to X-rays e.g. alignment of X-Ray beams etc. All such high risk activities should be carried out under a written ‘Scheme of Work’. Such ‘Schemes of Work’ should be approved by the URPA.

Precautions

1. Guards (local or total enclosures) must be provided where necessary to ensure that the fingers and other parts of the body cannot be inserted into the useful beam or areas of significant scattered radiation. These guards must be either permanently fixed or interlocked to either the shutter or X-ray generator. They should be made of a suitable material of suitable thickness (see note 1) to ensure that the dose rate outside the guards is kept below 7.5µSvh\(^{-1}\) and, where reasonably practicable, below 2.5µSvh\(^{-1}\). In some cases it may be practicable to use an interlocked light screen or a capacitance shield as an alternative to physical barriers.

2. A beam stop of suitable material should be incorporated into an enclosure where it is possible for the primary beam to strike the wall of the enclosure in the absence of an accessory.

3. If it is necessary to move samples or other materials during irradiation, this must be done by remote control. If this is not possible and access is required to areas where the instantaneous dose rate in the beam averaged over 1 cm\(^2\) exceeds 2.0mSvh\(^{-1}\) then a permit to work system should be instituted and followed (See your Radiation Protection Supervisor for guidance.)

4. Each port or aperture of the X-ray tube housing must be provided with an automatic beam shutter so arranged that it can only be opened when the collimating system, or other apparatus providing adequate shielding, is in place. Any unused ports should be blanked off.

5. Monitoring equipment should be available in every room where X-ray optics work is done, and monitoring should be carried out -
(a) immediately an assembly is ready for use or after any change to an accessory or enclosure;
(b) immediately before commencing operations that require a permit to work system to establish the position of any high dose rate areas; and
(c) periodically around equipment and enclosures to ensure that the shielding remains effective. (This should be done at least once per month when the set is in use.)

Records of monitoring should be kept for the monthly surveys and at other times whenever any radiation is detected which would indicate investigatory or remedial action to be taken (see note 2 for further guidance on monitoring).

6. Personal dosimeters are not required by people who only operate totally enclosed systems. All other X-ray equipment will be individually evaluated. If personal dosimeters are issued these should be positioned on the body at the same height as the X-ray generators being used. If operations are being performed which require access to the open beam, then finger personal dosimeters should be worn if thought appropriate by the Radiation Protection Supervisor or the Radiation Protection Adviser.

7. A warning sign with the legend "X-RAYS NOW ON" must be clearly displayed above the equipment, and in close proximity to it. This should be automatically switched on when the X-ray tube is energised.

8. There should be clear indication of whether a shutter is open or closed. This can be indicated by light emitting devices, coloured flag legends or pointers.

9. The mains supply to the equipment must be provided with an emergency isolation switch outside the door leading into the laboratory. This should be provided with a red indicator light and clearly labelled. It should have a warning notice by its side stating that it must be switched off in the event of a fire.

10. In the event of any accident or incident involving the use of X-ray sets, the Radiation Protection Supervisor or URPA should be informed immediately.

NOTE 1

Shielding materials needed for beam stops, guards and enclosures.

A. For the Primary Beam - 2-3 mm of lead or equivalent will be required.

Transmission for Lead at 50 kV

<table>
<thead>
<tr>
<th>Thickness in mm</th>
<th>Transmission Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.50</td>
<td>0.2527 x 10^-3</td>
</tr>
<tr>
<td>1.00</td>
<td>9 x 10^-5</td>
</tr>
<tr>
<td>2.00</td>
<td>10^-6</td>
</tr>
</tbody>
</table>

Lead Equivalents for Brass and Steel at 60 kV

1mm brass = 0.36 mm lead
1mm steel = 0.15 mm lead

B. For Scattered Radiation

Dose rates are dependent upon the scattering material, area irradiated, energy of primary beam and the scattering angle. In most cases the level of scattered radiation is low and an enclosure to prevent access to the main beam is all that is required. 6-10 mm of perspex is often the best material to use. It also affords some protection to low energy X-rays:

6 mm perspex has a transmission factor of

- 10^2 at 10 kV
- 10^3 at 20 kV

10 mm perspex has a transmission factor of

- 10^2 at 10 kV
Where additional protection is required, up to 0.25 mm of lead or lead equivalent may be needed. This could take the form of aluminium or steel plate, or lead bonded in plywood or leaded perspex, e. g.:

1 mm of aluminium has a transmission factor of $10^{-2}$ at 20 kV

0.3 mm of steel has a transmission factor of $10^{-3}$ at 30 kV

1 mm of steel has a transmission factor of $10^{-4}$ at 40 kV

0.254 mm of lead has a transmission factor of $3.20 \times 10^{-7}$ at 30 kV $1.06 \times 10^{-5}$ at 40 kV

H7 'Premac' 7 mm thick = 0.3 mm of lead (* Premac - transparent leaded acrylic sheet made by Premise Engineering)

**NOTE 2 - MONITORING**

N.B. Above response curve for MX168 geiger tube with protective plastic cap fitted.

Radiation incident normally on window.

As can be seen in the above diagram, the response of the Mini X to X-rays increases rapidly over the region of interest (10-50 keV) from 7.5 cps for 7.5µSvh at 10 keV up to 100 cps for the same dose rate at 50 keV. (The response of the Mini E is very similar and of the same order).

Only very rough estimates of dose rates can, therefore, be made. The safest policy is, therefore, to eliminate all X-ray leakage where possible and keep scattered radiation down to a minimum and less than 7.5 cps on a Mini X outside any enclosure.

Monitoring Records

We are required to keep records of monitoring in order to demonstrate the efficacy of the methods used to restrict exposure of personnel to ionising radiations. All routine monitoring, however, does not need to be recorded, but periodically a record should be made. It is important, the first time a new set up is used on an X-ray set, that a record is made of the radiation levels around the set to give a baseline comparison for future monitoring. The frequency of further recorded monitoring will be dependent upon work being in progress and should then ideally be on at least a monthly basis.

A record book/sheet should be kept in each laboratory where X-ray sets are used. Information should be recorded that identifies the x-ray machine, the operating conditions and any accessory used, the date of the survey and the findings (any leakage detected in cps). One sensible approach is to incorporate the monitoring record within a log of X-ray set usage.
# Appendix 15

## Designation of Work Areas

<table>
<thead>
<tr>
<th>Area Designation</th>
<th>Worker Designation</th>
<th>Area Classification In Relation to External and/or Internal Radiation Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROLLED</td>
<td>CLASSIFIED WORKER</td>
<td>Dose Rate: &lt;br&gt; &gt; 7.5 $\mu$Sv hr$^{-1}$ Instantaneous or liable to receive an effective dose of 6 mSv or more in a year.</td>
</tr>
<tr>
<td>e.g. Radioisotope room, Dispensing Area, Fume Cupboard, Cabinet, Fridge</td>
<td>Classified Workers, Workers under a ‘Scheme of Work’ etc. NO UNDERGRADUATES</td>
<td>Usage Quantity at Any One Time &lt;br&gt;Fume Cupboard - &lt;100 ALI &lt;br&gt;Open Bench - &lt; 10 ALI &lt;br&gt;Storage Quantity &lt;br&gt;See Registration Certificate</td>
</tr>
<tr>
<td>SUPERVISED</td>
<td>All Radiation Workers, Undergraduates 18 years and over</td>
<td>Dose Rate &lt;br&gt;2.5 - 7.5 $\mu$Sv hr$^{-1}$ Instantaneous or likely to receive an effective dose of greater than 1mSv in a year.</td>
</tr>
<tr>
<td>e.g. Research laboratory, Fume Cupboard, Fridge</td>
<td></td>
<td>Usage Quantity at Any One Time &lt;br&gt;Open Bench - See Table in Appendix 20 &lt;br&gt;Storage Quantity Upper Limits are given in Appendix 20</td>
</tr>
<tr>
<td>GENERAL LABORATORY AREA</td>
<td>All Radiation Workers, Non-Radiation Workers, All undergraduates</td>
<td>Dose Rate &lt;br&gt;&lt; 2.5 $\mu$Sv hr$^{-1}$ Instantaneous or is not likely to receive an effective dose of 1mSv in a year</td>
</tr>
<tr>
<td>e.g. Teaching laboratory</td>
<td></td>
<td>Usage Quantity at Any One Time &lt;br&gt;Open Bench - See Table in Appendix 20 &lt;br&gt;Storage Quantity No Storage is permitted</td>
</tr>
</tbody>
</table>
Appendix 16

The Maximum Permitted Activity of Unsealed Radionuclides which may be Stored/Used at One Time.

NOTE: All radioactivity must be stored in a locked cabinet or room.

The activity of a radionuclide given under STORAGE is the cumulative total and must never be exceeded. The maximum activity of a radionuclide stored in an individual vial must never exceed the activity for that nuclide given under USAGE.

Where more than one radionuclide is involved, the Quantity Ratio must be used. This ratio is derived from the equation

\[
\sum \frac{Q_b}{Q_{lim}}
\]

\[Q_b = \text{Quantity of radionuclide present}\]
\[Q_{lim} = \text{Quantity of the radionuclide specified in this table}\]

NOTE: The quantity ratio must NOT exceed 1

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>STORAGE</th>
<th>Supervised Area (MBq)</th>
<th>Supervised Area (MBq)</th>
<th>Teaching Laboratory (MBq)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USAGE</td>
<td>Supervised Area (MBq)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3H</td>
<td>1000</td>
<td>100</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>14C</td>
<td>500</td>
<td>50</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>22Na</td>
<td>50</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>24Na</td>
<td>50</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>32P</td>
<td>50</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>35S</td>
<td>500</td>
<td>50</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>36Cl</td>
<td>50</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>45Ca</td>
<td>50</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>51Cr</td>
<td>500</td>
<td>50</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>59Fe</td>
<td>50</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>86Rb</td>
<td>50</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>125I</td>
<td>10</td>
<td>5</td>
<td>0.1</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 17

System of Work for Entry into a ‘Controlled Area’.

System of work for the use of the following workers:

..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................
..................................................................................................................

The ‘Controlled Area’ may be sued by the above named workers for the purposes of keeping and using radioactive substances subject to the following conditions:

1. Permission to enter is obtained from all other workers presently operating in the ‘Controlled area’;

2. On entering the area, a radiation survey is performed in order to verify that (i) the radiation dose rate does not exceed 7.5 μSv hr⁻¹ (<20 cps on a Mini monitor with an end window Geiger-Muller tube) and (ii) the working surface to be used has no unfixed contamination;

3. That only one radioisotope is involved and that the quantity of stock solution and the quantity to be dispensed and used do not exceed the values given below;

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>3H</th>
<th>14C</th>
<th>32P</th>
<th>35S</th>
<th>86Rb</th>
<th>125I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Activity (MBq)</td>
<td>200</td>
<td>200</td>
<td>50</td>
<td>200</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>Dispensed Aliquot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Activity (MBq)</td>
<td>100</td>
<td>50</td>
<td>5</td>
<td>50</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

4. All manipulations are carried out in accordance with the School/Unit local rules and any instructions specified below.

Signed ........................................................................... (DRPS)        Date ..............................
Radiation Controlled Area

DRPS: ...........................................................................................................................................

Area Responsible Person: ..............................................................................................................

Area Boundaries: ............................................................................................................................

......................................................................................................................................................

......................................................................................................................................................

Source of Radiation: .........................................................................................................................

......................................................................................................................................................

Persons Authorised to Use Radiation Source(s) ...................................................................................

......................................................................................................................................................

......................................................................................................................................................

......................................................................................................................................................

......................................................................................................................................................

......................................................................................................................................................

Room No  .......... was inspected by the URPA and the above details agreed with the DRPS and the
‘Area Responsible Person’ on  ......................... If subsequently it is considered necessary to modify
any of the above details, the URPA MUST be consulted and approval obtained before changes are
permitted.
Appendix 19

Radiation Supervised Area

DRPS: ..........................................................................................................................................

Area Responsible Person: ...........................................................................................................

Area Boundaries: ........................................................................................................................
........................................................................................................................................................
........................................................................................................................................................

Source of Radiation: ...................................................................................................................
........................................................................................................................................................

Persons Authorised to Use Radiation Source(s) ...........................................................................
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................
........................................................................................................................................................

Room No .............. was inspected by the URPA and the above details agreed with the DRPS and the ‘Area Responsible Person’ on ................. If subsequently it is considered necessary to modify any of the above details, the URPA MUST be consulted and approval obtained before changes are permitted.
Radioactive Substances Being Used

DRPS: .................................................................................................................................

Area Responsible Person: ....................................................................................................

Area Boundaries: ...............................................................................................................
.................................................................................................................................
.................................................................................................................................
.................................................................................................................................

Source of Radiation: ............................................................................................................
.................................................................................................................................

Persons Authorised to Use Radiation Source(s) ..................................................................
.................................................................................................................................
.................................................................................................................................
.................................................................................................................................
.................................................................................................................................
.................................................................................................................................

Room No .......... was inspected by the DRPS and the above details agreed with the ‘Area
Responsible Person’ on ................. If subsequently it is considered necessary to modify any
of the above details, the DRPS must be consulted and approval obtained before changes are permitted.
Designated Sink

Disposal Procedure for Water-Miscible Radioactive Waste

1. Carefully pour liquid into sink outlet. (Try to prevent the liquid from touching the bottom of the sink or the sides of the plug hole).

2. Stopper the sink and fill with water.

3. Partially withdraw the stopper. (Hold in this position until the sink is nearly empty).

4. Depending on the amount being disposed of, flush the sink with copious amounts of water.

5. Enter activity disposed of on log sheet.

NOTE: PRIOR TO DISPOSAL, CHECK THE DRAIN LOG SHEET TO VERIFY THAT THE MONTHLY LIMIT WILL NOT BE EXCEEDED
These guidelines have been drawn up in order to restrict the exposure from radiation to undergraduates to the maximum recommended level for members of the general public, i.e. less than 1 mSv per year. The quantities of the isotopes given in the table below are not greater than one-tenth of the minimum level which would require a controlled area in relation to the internal hazard and are also, therefore, not greater than the annual limit of intake for each isotope respectively. Where there is additionally an external hazard, the amount of isotope permitted has been further reduced, but some shielding may still be needed to ensure that the instantaneous dose rate, whenever practical, is kept below 2.5 µSvh⁻¹.

If the conditions specified for class experiments and project work can be met, then the students will not require individual registration as radiation workers. However, there will still be a requirement on the member of teaching staff responsible for the work to register it, through their DRPS, with the URPA, and indicate the number of students involved.

Prior to any demonstration or experiment involving ionising radiations, the students should be given:

a) instruction in the basic aspects of radiation protection with the importance of keeping doses as low as reasonably achievable (ALARA) being stressed;

b) reassurance with regard to the possible health hazards;

c) a copy of the 'Laboratory Rules - Unsealed Sources' (Appendix 17) - the importance of adhering to these cannot be over-emphasised;

d) the conditions specified in the ratified project application should be complied with.

The provision of information, instruction and training is a specific requirement of Regulation 14 of the Ionising Radiations Regulations 1999.

It is important to remember that all experiments should be carried out with the minimum amount of activity that is practical.

**Class Experiments**

The amounts specified in column 2 of Table 1 should not normally be exceeded for any one class experiment.

### Table 1

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Suggested limit for Undergraduate Work. MBq</th>
<th>Limit for Supervised Laboratory MBq</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-3</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>C-14</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Na-22</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Na-24</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>P-32</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>S-35</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Cl-36</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Ca-45</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Cr-51</td>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>Fe-59</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Rb-86</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>I-125</td>
<td>0.1</td>
<td>5</td>
</tr>
</tbody>
</table>

Where more than one isotope is being used, then a quantity ratio should be calculated, e.g.
80% of P-32 limit

20% of C-14 limit

The dispensing of the stock material should be performed by a registered radiation worker who should be familiar with the hazards associated with the particular isotope in use and the precautions that need to be taken when handling it.

The students should be under supervision at all times whilst radioactive work is in progress.

Project Work

The use of amounts in excess of those specified in column 2 of Table 1 in any one calendar year will not be permitted for any one student who is not registered as a radiation worker. Where more than one isotope is being used, then a quantity ratio should be calculated as above. If greater amounts are required, then the student should register as a radiation worker and the work will have to be performed under the project approved by the URPA.

If the work is performed in a Supervised, then the School/Unit would have a responsibility under Regulation 8(2) of the Ionising Radiations Regulations 1999 to provide the student with 'suitable personal protective equipment'.
APPENDIX 23

UNDERGRADUATE WORK INVOLVING SEALED SOURCES

Introduction

With sealed sources we are concerned with the external hazard that they produce. The potential magnitude of the external hazard can most simply be described in terms of the dose rates to be found in an area, and by doing this it is possible to recognise three types of area:

i) non-designated area where the instantaneous dose rate is <2.5µSvh\(^{-1}\) to the body and <25µSvh\(^{-1}\) to the hands.

ii) supervised area where the instantaneous dose rate is >2.5µSvh\(^{-1}\) <7.5µSvh\(^{-1}\) to the body and >25µSvh\(^{-1}\) <75µSvh\(^{-1}\) to the hands.

iii) controlled area where the instantaneous dose rate is >7.5µSvh\(^{-1}\) to the body and >75µSvh\(^{-1}\) to the hands.

The limit for the non-designated area is equivalent (at the maximum permitted dose-rate) for somebody working 8 hours a week 50 weeks a year, to an annual dose of 1mSv, i.e. the maximum recommended level for a member of the general public. These guidelines have been drawn up in order to ensure that doses to undergraduates are kept AS LOW AS REASONABLY ACHIEVABLE (ALARA) and below this level. This can be achieved by either restricting the work to a non-designated area or, where a supervised area is required, restricting the time spent in that area.

General Guidelines

The minimum source strength necessary should be used. This should be below 0.5MBq/source where students are 'handling' the sources. All sources should either be fitted with integral handles not less than 15 cms long or handled with forceps or remote handling tools.

It should be remembered that under Regulation 6.5 the employer shall ensure that:

"No radioactive substance in the form of a sealed source is held in the hand or manipulated directly by hand unless the instantaneous dose rate to the skin of the hand does not exceed 75µSvh\(^{-1}\)."

Even small gamma reference sources can have surface dose-rates as high as 13.5mSvh\(^{-1}\) for a 0.5MBq source.

Where sources with an activity greater than 0.5MBq are used then the undergraduates should not have access to the source or any area in which the instantaneous dose rate exceeds 7.5µSvh\(^{-1}\). Any handling of the source, installing in equipment etc. should be performed by a registered radiation worker who is familiar with the hazards associated with the particular isotope in use and the precautions that need to be taken when handling it.

A suitable lockable store should be provided for each laboratory where teaching sources are used and stored. It should be adequately shielded such that the dose rate at the surface of the store is less than 2.5µSvh\(^{-1}\) wherever reasonably practicable. The store should be marked with a radiation warning symbol.

A responsible person (senior technician) should be put in charge of: the store; an inventory of contents; and the issue and return to stock of the sources. The responsible person should also check, at least once a month, that all the sources are present and correct and an entry to that effect shall be made in a record book kept in the laboratory.

Prior to any demonstration or experiment involving radiations the students should be given

a) instructions in the basic aspects of radiation protection appropriate to their work, with the importance of keeping doses as low as reasonably achievable (ALARA) being stressed

b) reassurance with regard to the possible health hazards

c) in the case of an experiment, written instructions as to its conduct - and these should have been approved by the appropriate DRPS.

The provision of information, instruction and training is a specific requirement of the Ionising Radiations Regulations 1999.
If the work is performed in a Supervised Area then the School/Unit would have a responsibility under the Ionising Radiations Regulations 1999 to provide the student with 'suitable personal protective equipment' when necessary.

**Class experiments**

For many experiments it may not be possible to keep down to non-designated levels, i.e. below the levels specified in Table 1 and with instantaneous dose rates below 2.5µSvh\(^{-1}\). It is likely therefore that some supervised areas will be required.

<table>
<thead>
<tr>
<th>Isotope</th>
<th>MBq of activity present above which a supervised area may be required in relation to the external hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sr-90</td>
<td>1.7</td>
</tr>
<tr>
<td>Cs-137</td>
<td>1.7</td>
</tr>
<tr>
<td>Cs-137 (betas effectively shielded)</td>
<td>28</td>
</tr>
<tr>
<td>Ra-226</td>
<td>1.7</td>
</tr>
<tr>
<td>Na-22</td>
<td>7.6</td>
</tr>
<tr>
<td>Co-57</td>
<td>133</td>
</tr>
<tr>
<td>Co-60</td>
<td>1.7</td>
</tr>
<tr>
<td>Co-60 (betas effectively shielded)</td>
<td>6.7</td>
</tr>
<tr>
<td>Fe-55</td>
<td>10,000</td>
</tr>
<tr>
<td>Am-241</td>
<td>514</td>
</tr>
<tr>
<td>Sn-110m</td>
<td>1,450</td>
</tr>
</tbody>
</table>

It is hoped, however, that undergraduates will not require registration as individual radiation workers provided it can be demonstrated that they are unlikely to receive doses in excess of the general public limit of 1mSv per year. In order to do this a list should be drawn up each academic year for each class of student listing all the practicals they may perform during the year involving all types of ionising radiations. As long as the students are not likely to spend more than 120 hours/annum in a Supervised Area for Sealed Sources or X-rays then it should be a simple matter to demonstrate that the 1mSv dose limit will not be exceeded.

The students should be under supervision at all times whilst radioactive work is in progress.

**Project Work**

The use of amounts in excess of 0.5MBq per source will not be permitted for any student who is not registered as a radiation worker unless the source is installed in a piece of equipment and the student does not have access to a radiation field where the dose rate exceeds 7.5µSvh\(^{-1}\).

Where the dose rates exceed 7.5µSvh\(^{-1}\) or where the student is required to gain 'hands on' experience with sources of strength greater than 0.5MBq then he/she should be registered as a radiation worker and the work will have to be performed under a work certificate/scheme of work issued by Safety Services. If the work is with penetrating radiations then the student will be issued with an appropriate personal dosimeter.
Contamination Monitoring of Work Surfaces

Work Area / Room Number ...........................................................

Notes:  
(i). Using an appropriate monitor, check the work surface(s) for any radioactive contamination before and after use.

(ii). Where the counts per second detected is above 3 times background, this should be regarded as significant contamination and reasonably practicable measures taken to remove it.

(iii). Any high count rates (>40 cps) should be reported to the LRPS / DRPS.

<table>
<thead>
<tr>
<th>Date</th>
<th>Name of Worker</th>
<th>Radio-Nuclide</th>
<th>Type of Monitor Probe</th>
<th>Counts per Second (CPS)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Before Work</td>
<td>After Work</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
### Appendix 25

**TRANSPORT FORM**

**WASTE RADIOACTIVE MATERIAL - EXCEPTED PACKAGE**

**UN2910 - Limited Quantity of Material**

<table>
<thead>
<tr>
<th>School / Unit</th>
<th>Despatched By (Name)</th>
<th>Tel. No.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Container Ref. No.</th>
<th>Radionuclide(s)</th>
<th>Total Activity</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Dispatched to**

- Solid Waste Store (Westburn Lane)
- Liquid Waste Store (The Scores)

**Person Transporting Waste** ........................................ (Name) .......................... (Date)

THIS COPY TO BE RETAINED BY THE SCHOOL /
### Example of Label for External Surface of Excepted Package

<table>
<thead>
<tr>
<th>Radioactive Material, Excepted Package</th>
<th>UN 2910 - Limited Quantity of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date ...........................................</td>
<td>Radionuclide</td>
</tr>
<tr>
<td>Physical Form ..................................</td>
<td>Chemical Form</td>
</tr>
<tr>
<td>Activity .......................................</td>
<td></td>
</tr>
<tr>
<td>Dispatched by:- University of St. Andrews</td>
<td>School / Unit</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact .......................................</td>
<td>Telephone</td>
</tr>
<tr>
<td>Deliver to or Destination ........................</td>
<td></td>
</tr>
</tbody>
</table>

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name, and are classified, packed, marked and labelled and are in all respects in proper condition for transport by road according to the applicable international governmental regulations.
Radioactive Material - Excepted Package Transport Form

University of St. Andrews

Radioactive Material - Excepted Package

Transport Form
UN2910 - Limited Quantity of Radioactive Material

<table>
<thead>
<tr>
<th>Date</th>
<th>Radionuclide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Form</th>
<th>Chemical Form</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

Despatched by University of St. Andrews

From School/Unit/Building

Despatched by (Name)   Tel. No.

Transported by (Name)

Despatched To

I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name, and classified, packed, marked and labelled and are, in all respects, in proper condition for transport by public road according to the applicable international governmental regulations.

Signed by Person Transporting

(Transport within the University of St. Andrews)

Signed by Dispatcher

(Transport outwith University of St. Andrews)
### Appendix 28

#### CONVERSION TABLES

**Bq - Ci and Ci - Bq**

**Conversion from Bequerels to Curies**

<table>
<thead>
<tr>
<th>mBq</th>
<th>pCi</th>
<th>Bq</th>
<th>pCi</th>
</tr>
</thead>
<tbody>
<tr>
<td>kBq</td>
<td>µCi</td>
<td>MBq</td>
<td>µCi</td>
</tr>
<tr>
<td>GBq</td>
<td>Ci</td>
<td>TBq</td>
<td>Ci</td>
</tr>
</tbody>
</table>

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.027</td>
<td>1</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>.054</td>
<td>2</td>
<td>54</td>
</tr>
<tr>
<td>3</td>
<td>.081</td>
<td>3</td>
<td>81</td>
</tr>
<tr>
<td>4</td>
<td>.108</td>
<td>4</td>
<td>108</td>
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<tr>
<td>5</td>
<td>.135</td>
<td>5</td>
<td>135</td>
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<td>6</td>
<td>.162</td>
<td>6</td>
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<td>7</td>
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<td>7</td>
<td>189</td>
</tr>
<tr>
<td>8</td>
<td>.216</td>
<td>8</td>
<td>216</td>
</tr>
<tr>
<td>9</td>
<td>.243</td>
<td>9</td>
<td>243</td>
</tr>
<tr>
<td>10</td>
<td>.27</td>
<td>10</td>
<td>270</td>
</tr>
<tr>
<td>15</td>
<td>.405</td>
<td>15</td>
<td>405</td>
</tr>
<tr>
<td>50</td>
<td>1.35</td>
<td>20</td>
<td>540</td>
</tr>
<tr>
<td>100</td>
<td>2.7</td>
<td>25</td>
<td>675</td>
</tr>
<tr>
<td>200</td>
<td>5.4</td>
<td>30</td>
<td>810</td>
</tr>
<tr>
<td>250</td>
<td>6.75</td>
<td>35</td>
<td>945</td>
</tr>
<tr>
<td>500</td>
<td>13.5</td>
<td>40</td>
<td>1080</td>
</tr>
<tr>
<td>750</td>
<td>20.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1000</td>
<td>27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conversion from Curies to Bequerels**

<table>
<thead>
<tr>
<th>pCi</th>
<th>mBq</th>
<th>pCi</th>
<th>Bq</th>
</tr>
</thead>
<tbody>
<tr>
<td>nCi</td>
<td>Bq</td>
<td>nCi</td>
<td>kBq</td>
</tr>
<tr>
<td>µCi</td>
<td>kBq</td>
<td>µCi</td>
<td>MBq</td>
</tr>
<tr>
<td>mCi</td>
<td>MBq</td>
<td>mCi</td>
<td>GBq</td>
</tr>
<tr>
<td>Ci</td>
<td>GBq</td>
<td>Ci</td>
<td>TBq</td>
</tr>
</tbody>
</table>

| 0.1 | 3.7 | 30 | 1.11 |
| 0.2 | 7.4 | 40 | 1.48 |
| 0.25 | 9.25 | 50 | 1.85 |
| 0.3 | 11.1 | 60 | 2.22 |
| 0.4 | 14.8 | 70 | 2.59 |
| 0.5 | 18.5 | 80 | 2.96 |
| 1 | 37 | 90 | 3.33 |
| 2 | 74 | 100 | 3.7 |
| 2.5 | 92.5 | 125 | 4.625 |
| 3 | 111 | 150 | 5.55 |
| 4 | 148 | 200 | 7.4 |
| 5 | 185 | 250 | 9.25 |
| 6 | 222 | 300 | 11.1 |
| 7 | 259 | 400 | 14.8 |
| 8 | 296 | 500 | 18.5 |
| 9 | 333 | 600 | 22.2 |
| 10 | 370 | 700 | 25.9 |
| 12 | 444 | 750 | 27.75 |
| 15 | 555 | 800 | 29.6 |
| 20 | 740 | 900 | 33.3 |
| 25 | 925 | 1000 | 37 |

---

Environmental, Health and Safety Services - 2015

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# Appendix 29

## Radiation Units

<table>
<thead>
<tr>
<th>Type of radiation</th>
<th>Radiation Weighting Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beta Gamma &amp; X-ray emissions</td>
<td>1</td>
</tr>
<tr>
<td>neutrons</td>
<td>5-20</td>
</tr>
<tr>
<td>protons</td>
<td>5</td>
</tr>
<tr>
<td>alpha particles</td>
<td>20</td>
</tr>
</tbody>
</table>

### Summary of Units

<table>
<thead>
<tr>
<th>Quantity</th>
<th>New SI Unit</th>
<th>Old Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity</td>
<td>Becquerel - Bq (1 disintegration s⁻¹)</td>
<td>Curie - Ci (3.7 x 10¹⁰ dps)</td>
</tr>
<tr>
<td>Absorbed</td>
<td>Dose gray - Gy (1 J.kg⁻¹)</td>
<td>Rad - (0.01 J.kg⁻¹)</td>
</tr>
<tr>
<td>Equivalent Dose</td>
<td>Sievert - Sv (Gy x weighting factor)</td>
<td>Rem - (rad x weighting factor)</td>
</tr>
</tbody>
</table>

### Prefixes used with SI Units

<table>
<thead>
<tr>
<th>Factor</th>
<th>Prefix</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>10¹²</td>
<td>tera</td>
<td>T</td>
</tr>
<tr>
<td>10⁹</td>
<td>giga</td>
<td>G</td>
</tr>
<tr>
<td>10⁶</td>
<td>mega</td>
<td>M</td>
</tr>
<tr>
<td>10³</td>
<td>kilo</td>
<td>K</td>
</tr>
<tr>
<td>10⁻³</td>
<td>milli</td>
<td>m</td>
</tr>
<tr>
<td>10⁻⁶</td>
<td>micro</td>
<td>µ</td>
</tr>
<tr>
<td>10⁻⁹</td>
<td>nano</td>
<td>n</td>
</tr>
</tbody>
</table>

### Some useful conversions

<table>
<thead>
<tr>
<th>Dose</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sv = 100rem</td>
<td>1 µCi = 37 kBq</td>
</tr>
<tr>
<td>50 mSv = 5 rem</td>
<td>1 mCi = 37 MBq</td>
</tr>
<tr>
<td>200 µSv = 20 mrem</td>
<td>1 Ci = 37 GBq</td>
</tr>
<tr>
<td>7.5 µSv.h⁻¹ = 0.75 mrem.h⁻¹</td>
<td>1 kBq = 27 nCi</td>
</tr>
<tr>
<td></td>
<td>1 MBq = 27 µCi</td>
</tr>
<tr>
<td></td>
<td>1 GBq = 27 mCi</td>
</tr>
</tbody>
</table>
1. FIRE INVOLVING SOURCES OF IONISING RADIATIONS

Proceed as per the instructions in the ‘Fire Action Notice’ for your School/Unit but remember to tell all parties concerned that radiation is involved.

The possibility of Fire Brigade personnel and University Staff becoming contaminated should be kept in mind. This may involve the setting-up of a contamination zone for men and their equipment, so that a radiation check can be made before they leave the zone.

2. INJURY INVOLVING ACTUAL OR POSSIBLE CONTAMINATION FROM RADIOACTIVE MATERIALS
   (a) Serious injury

Treatment of the patient takes priority over all decontamination procedures. Request the attendance of an ambulance, emphasising to the ambulance control that the casualty involved has been exposed to radioactive contamination. A competent person with knowledge of the type and extent of the radiation hazard should accompany the casualty to hospital. The Casualty Department should also be given forewarning that a potential radioactive contaminated victim is en route to the hospital.
   (b) Minor injury

Provide first aid - then proceed as in 3 below.

3. ACTUAL OR SUSPECTED EXPOSURE TO X-RAYS

Switch off the X-ray generator and lock off the power supply to ensure other members of staff/students cannot use the generator until it has been inspected. Post an appropriate notice warning other members of staff that there is a fault with the generator.

The person exposed to the X-rays should be taken to Hospital as the X-rays may cause serious burns. A competent person with knowledge of the equipment including details of the length of exposure to X-rays and also the operating voltage and current should accompany the casualty to hospital.

4. PERSONAL DECONTAMINATION PROCEDURES

For all personal decontamination, the possible need to seek medical advice should be borne in mind.

For contamination of the skin e.g. arms, hands etc., the first step is to wash the affected area with soap and water as normal. If the contamination persists, it should be washed and scrubbed gently, using a soft brush, with a deep cleansing soft soap or liquid soap e.g. ‘Clearasil’ or ‘Dermactyl’. Care must be taken not to break the skin.

If serious injury, cuts and wounds are associated with the contamination, these should be irrigated and first-aid measures taken before dealing with the contamination. Body openings such as eyes, ears, nose and mouth should always be decontaminated first. Decontamination of any ‘hot spots’ on other parts of the body should be dealt with next. Care should be taken to ensure that washings do not contaminate other areas.

Emergency showers are rarely the best solution for dealing with a contaminated person as this can spread the contamination. For hand, arm and head contamination, it is better to use a hand wash basin and for legs a foot bath

5. REPORTING ACCIDENTS AND INCIDENTS INVOLVING SOURCES OF IONISING RADIATIONS

In the event of any accident or incident involving the use of any source of ionising radiation, the following people must be contacted immediately after the above action has been completed:

   (i) The University Radiation Protection Adviser (URPA);
   (ii) The DRPS; and
   (iii) The University Safety Adviser.

In any emergency, steps must always be taken to minimise the doses received from sources of penetrating radiations and also to avoid the spread of contamination from open sources of radioactive materials.