UCC

Colaiste na hOllscoile Corcaigh

University College Cork

CODE OF PRACTICE

FOR THE PROTECTION OF PERSONS

AGAINST IONISING RADIATION IN

UNIVERSITY COLLEGE CORK

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***FOR APPROVAL BY*:** **The Radiation Protection Committee, University College, Cork, 2020.**

CODE OF PRACTICE

FOR THE

PROTECTION OF PERSONS AGAINST IONISING RADIATIONS

IN

UNIVERSITY COLLEGE, CORK.

RADIATION PROTECTION COMMITTEE, UNIVERSITY COLLEGE, CORK.

2020.

RADIATION PROTECTION OFFICER:

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Note: The above list is correct as of November 2020, but Departmental Supervisors do change from time to time. To get an up-to-date list at any time, please contact the Radiation Protection Officer, Prof. A. Ruth.

CONTENTS

SECTION 1

SCOPE OF THE CODE

1.1 Establishments

The Code applies to all research establishments and teaching laboratories within University College, Cork, in which **ionising radiations** are used or where radioactive substances are present. Since governance at UCC refers to a variety of different research and teaching entities, the term "Department" in this document is used synonymously for either "Department", "School", Centre", "Unit", "Institute" or any other relevant research or teaching entity concerned by the Code or Practice. The term "radiation" in this code of practice refers to **ionising radiation** only.

1.2 Persons

The Code applies to all persons within University College, Cork who may be exposed to ionising radiations arising within University College, Cork.

1.3 Hazards

The provisions of the Code relate to hazards arising from:

(i) any radioactive substance, whether sealed or unsealed;

(ii) any apparatus which emits ionising radiations, including apparatus in which charged particles are accelerated by a voltage of not less than 30 kilovolts.

1.4 Compliance

This Code of Practice complies with the Provisions of S.I. No. 30 of 2019 (Radiological Protection Act, 1991 (Ionising Radiation) Regulation 2019 and S.I. No. 256 of 2018 (European Union (Basic Safety Standards for Medical Protection against Dangers arising from Medical Exposure to Ionising Radiation) Regulations 2018. UCC receives a radiation licence from the Environmental Protection Agency – Office for Radiological Protection and Environmental Monitoring (**EPA-ORM**). In 2022 the EPA published a new set of guidelines "Guidance for undertakings on the application of the Ionising Radiation Regulations (IRR19) June 2022". A comprehensive set of rules and regulations can be found in Schedule 1 of the UCC radiation licence available from the Radiation Protection Office. In order to stay compliant with the licence conditions, a brief summary of checks has been provided in **Appendix C** (note: this check list is not fully comprehensive and gives merely an overview over the most important issues). UCC is also registered with and regulated by the Health Information and Quality

Authority (HIQA) concerning medical exposures of patient in Cork University Hospital (Installations Dental School and Hospital and School of Medicine).

SECTION 2

RESPONSIBILITY FOR THE ORGANISATION AND ADMINISTRATION OF RADIATION PROTECTION IN UNIVERSITY COLLEGE, CORK

2.1 Ultimate responsibility

The ultimate responsibility for protective measures in University College, Cork lies with the Governing Body (GB). This body is responsible for the protection of all persons in the College who may be exposed to ionising radiations arising within the college. To assist in the discharge of this duty, an administrative organisation exists as outlined in the remainder of this section.

2.2 Radiation Protection Management Structure and Governance

The administrative organisation for the use of **ionising radiation** essentially consists of the University Management Team (UMT), Radiation Protection Committee (RPC), Radiation Protection Office, Dental School and Hospital RPC, Centre for Research of Vascular Biology RPC, Departmental Radiation Supervisors, and Departmental Heads.

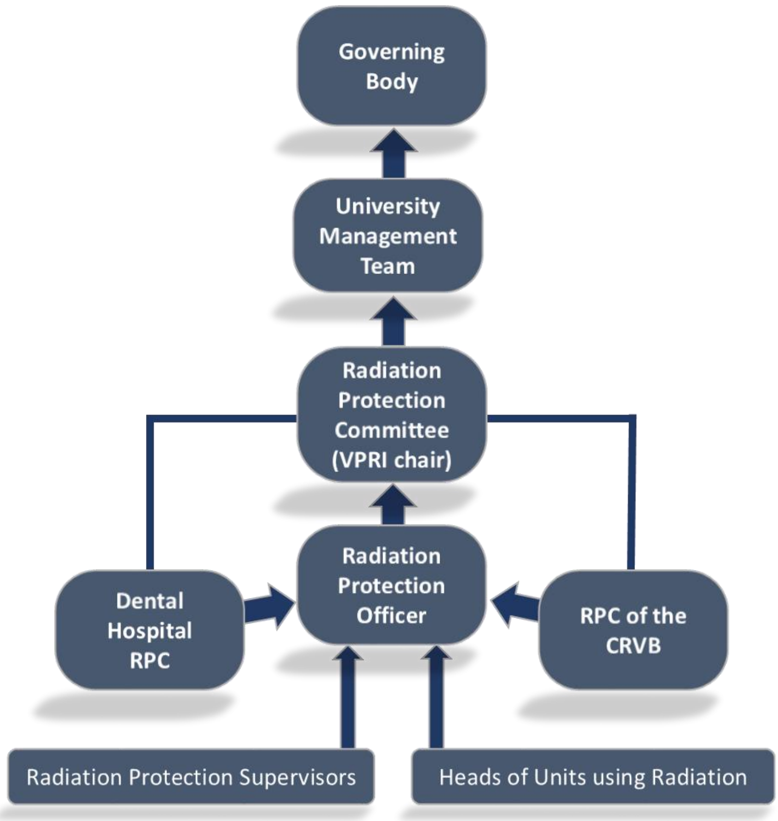

Figure 1. Radiation Protection Management Structure at UCC. VPRI: Vice President for Research and Innovation. CRVB: Centre for Research of Vascular Biology. RPC: Radiation Protection Committee.

2.2.1 RADIATION PROTECTION COMMITTEE

The Radiation Protection Committee was set up by the University Management Team (UMT) as an authoritative Committee to deal with safety matters in the College concerning ionizing radiation. The specific terms of reference are as follows:

(a) To advise the University on questions of ionizing radiation safety policy, to draw attention to its legal obligations relating to the use of ionizing radiation, and to send forward to the University Management Team recommendations for such action as is thought necessary to ensure that reasonable steps are being taken to protect staff, students, and authorised visitors from unlawful exposure to radiation;

(b) To oversee the implementation of radiation safety policy and to inform and advise the University Management Team of specific radiation hazards within the University through annual reporting;

(c) To receive reports/minutes from the Radiation Protection Officer, and appropriate sub-committees;

(d) To ensure that Conditions of the UCC Licence and the provisions of this Code, and any local rules which may from time to time be in force, are adhered to.

At present the Committee is in the process of being reformed after some role changes:

The committee has a standing agenda including: personnel dosimetry report results, the quality assurance programme(s), risk assessments, servicing of X-ray and ionizing radiation units, licence review concerning source acquisition and disposals, incidence reports.

DENTAL HOSPITAL - RADIATION PROTECTION COMMITTEE (RPC)

The Dental Hospital Radiation Protection Committee is a sub-committee of the Radiation Protection Committee. At present the members of the Committee are:

Prof Andy Ruth (Radiation Protection Officer) – Chairman
Dr Christine McCreary (Head of Dental School and Hospital)
Mr John Upton (UCC Radiation Protection Adviser)
Ms Margaret O'Brien (Senior Radiographer, Dental School & Hospital)
Ms Siobhan Lynch (Hospital and School Manager)
Dr Caitriona Ahern (Oral Radiologist)
Ms Mary Daly (Rheumatology, School of Medicine)

CENTRE FOR RESEARCH OF VASCULAR BIOLOGY – RPC

The CRVB Radiation Protection Committee is a sub-committee of the Radiation Protection Committee. At present the members of the Committee are:

Prof Andy Ruth (Radiation Protection Officer) – Chairman
Prof Noel Caplice (Head of Centre for Research of Vascular Biology - CRVB)
Ms Sharon Babington (CRVB)

Mr John Upton (Radiation Protection Adviser for UCC)

Mr Kieran McManamon (Safety Manager, CRVB)

Note: Activities of this committee are temporarily suspended because radiation related work at CRVB has been paused since Summer 2019.

2.2.2 THE RADIATION PROTECTION OFFICER

The Radiation Protection Officer (RPO) acts as executive officer of the Radiation Protection Committee. The RPO reports to the Vice President for Research & Innovation in relation to this role.

(i) The primary duty of the Radiation Protection Officer is, with the Radiation Protection Committee and in cooperation with the Departmental Radiation Supervisors and Heads of relevant Units, to ensure that the procedures outlined in this *Code of Practice* and the conditions of the *UCC Licence* are adhered to.

(ii) He/she is responsible for the monitoring of records covering dosimetric supervision of persons in UCC who may be exposed to ionising radiations.

(iii) He/she is responsible for monitoring the purchase and disposal of radioactive substances and sources of ionising radiations.

(iv) The Radiation Protection Officer is also responsible for maintaining liaison with relevant outside bodies, e.g. The EPA – Office of Radiological Protection (EPA-ORP).

2.2.3 DEPARTMENTAL RADIATION SUPERVISORS

Though the Head of each Department carries the ultimate responsibility for safety in his/her own Department, the daily exercise of that function may be delegated to a Departmental Radiation Supervisor. The duties and responsibilities of the Departmental Radiation Supervisors are:

(i) To supervise Radiation Protection in the Department by ensuring that the provisions of this Code and the Conditions of the College Licence are adhered to, and to provide the Departmental link with the Radiation Protection Officer and hence with the Radiation Protection Committee;

(ii) To ensure that all persons within the Department who are exposed to ionising radiation are instructed as to hazards and precautions, and made aware of their individual responsibilities; this includes a clear protocol on authorisation to access/use sources or licensable items;

(iii) To keep a register of the purchase, use and disposal of all sealed and unsealed sources and to make available copies of all records to the Radiation Protection Officer;

(iv) To perform an inventory of all licensable items in the Department and report it formally to the Radiation Protection Officer on an annual basis;

(v) Through the Radiation Protection Officer, to arrange as necessary for medical supervision of designated persons;

(vi) To arrange personal monitoring for designated persons, and for film badges/TLDs to be examined by a qualified laboratory, to record details of doses and to forward the information to the Radiation Protection Officer;

(vii) To identify and mark supervised areas in the Department.

<u>NOTE</u>: 'Supervised Areas' shall be ascribed to areas where annual exposures might approach the limits set out in Table 1.

The doors of 'supervised area' rooms must be marked with the standard radiation symbol. A notice giving instructions on emergency procedures must be displayed in the room.

(vii) To have ready access to radiation monitors and to ensure that appropriate monitoring is carried out in the Department;

(viii) To arrange, through the Radiation Protection Officer, for the regular calibration of monitors;

(ix) To implement the rules governing the conduct of radiation work (Section 3) in the Department.

(x) To take charge of emergency procedures in the event of an accident or emergency (also see UCC Risk Management Action Cards).

2.2.4 HEADS OF DEPARTMENTS (RESPONSIBILITIES)

The ultimate responsibility for Radiation Safety in a Department lies with the Head of the Department. It is the duty of the Head of a Department to appoint, in consultation with the Radiation Protection Officer, a Departmental Radiation Supervisor and to ensure that the closest liaison exists between himself/herself and his/her Departmental Radiation Supervisor. It is also his/her duty to advise the Radiation Protection Officer when any change of equipment, usage, or environment occurs which may affect Radiation Safety in his/her Department.

SECTION 3

RULES GOVERNING THE CONDUCT OF RADIATION WORK IN UNIVERSITY COLLEGE, CORK.

3.1 Registration procedures

- All work involving exposure to ionising radiations must be notified to the Radiation Protection Officer. This procedure comprises registration of the personnel involved, the radioactive substances or equipment used, and the laboratory if unsealed radioactive substances are concerned (see 3.1.1).
- If, after inspection by the Radiation Protection officer, the precautions are considered to be unsatisfactory, work may not commence until changes prescribed by the Radiation Protection Officer have been effected.
- The College Licence issued by the Radiological Protection Institute of Ireland sets out the quantities of radioactive substances which the College may keep, the permitted discharges into the external environment and methods for the disposal of waste.
- The Radiation Protection Officer must maintain records dealing with the aforementioned, for the College. **It is, therefore, essential that every Department compiles at the end of each term a complete list of all radioactive substances that have entered or left the Department since the previous report. An annual account covering the previous year must be sent to the Radiation Protection Officer every January.**

3.1.1 Registration of Personnel

Unless specifically exempted, all persons who will be engaged on registered work in the context of ionizing radiation must register individually with the Radiation Protection Office and must sign a statement (see **Appendix B**) that they agree to abide by the rules set out in this Code and in Schedule 1 of the current UCC licence. This involves the taking of a video course on radiation protection (Protection from ionising radiation [DVD] / Sheffield University Radiation Protection Service, N 363.17 PROT) available in the Boole library or from the RPO.

Persons under the age of 16 are not permitted to carry out work involving exposure to ionising radiation.

3.1.2 Registration of Work

Registration is required for work involving possible exposure to ionising radiation from any of the following items subject to EPA/ORP licensing:

(i) sealed or unsealed radioactive substances where the quantities/concentrations involved exceed in total the exemption values set out in column 2 and column 3 of Table B of S.I. 30 of 2019.

(ii) equipment producing useful beams of x-rays (e.g. for x-ray crystallography) with a dose rate exceeding 1 $\mu Sv\ hr^{-1}$ at a distance of 0.1 m from any accessible surface of the apparatus;

(iii) standard laboratory equipment (e.g. high-voltage units, cathode-ray oscilloscopes) operating at potentials exceeding 30 kV; see also (b) below;

(iv) experimental apparatus producing non-useful x-rays (e.g. image converters) operating at potentials above 30 kV.

Registration is not required for the following:

(a) equipment such as cathode-ray oscilloscopes, television picture monitors and image intensifiers operating at potentials not exceeding 30 kV when used with the maker's case-work intact;

(b) apparatus described under item (iii) above, when the Radiation Protection Officer is satisfied that the dose rate does not exceed 1 $\mu Sv\ hr^{-1}$ at a distance of 0.1 m from any accessible surface of the apparatus

3.1.3 Registration of Laboratories

Work with unsealed radioactive substances is permitted only in certain laboratories. These will normally be registered laboratories which have been examined by the Radiation Protection Officer. In cases where there are strong reasons for carrying out work in general laboratories the Radiation Protection Officer may issue a joint certificate covering the work and the laboratory. The nature of the work, the radioactive substances used, the finish and equipment of the laboratory and the experience of the personnel concerned will all be taken into consideration in granting permission. Greater restrictions will be placed on work carried out under these conditions, than on work carried out in laboratories especially fitted out for work with ionising radiation.

3.2 Radiation Warning Signs

A sign denoting the presence of a radiation source and an indication of the nature of the source must be fixed at every entrance to laboratories or areas in which registered work is carried out.

3.3 Protection of Personnel

Although the nature of the work carried out in College to date has not required it, persons engaged on registered work may be asked to undergo medical examinations as recommended by the Radiation Protection Officer. They should also wear dose measuring devices if appropriate to the work being carried out.

3.3.1 Maximum Permissible Dose Levels

The limit on effective dose for a **member of the public is 1 mSv in a period of 12 months**.

An "**exposed worker**" is a person, working for an employer, who is subject to an exposure incurred at work from practices or work activities exceeding the dose level equal to the dose limits for members of the public (see also Regulation 39 in Statutory Instrument No. 30 of 2019): The limit on effective dose for an **exposed worker** is 20 mSv in a period of 12 months. Exposed workers are subdivided into category B exposed worker with an exposure of more than 1 mSv but less than 6 mSv per annum, and category A workers who are liable to receive an effective dose greater than 6 mSv. The annual limit on effective dose for students or apprentices between 16 and 18 years, working with sources of ionizing radiation is equal to the limit for Category B workers of 6 mSv, as set out in Regulation 40 of S.I. 30 of 2019.

Departmental Radiation Supervisors (DRS) must ensure that the licensed items are controlled in such a manner as to optimize work conditions and consequently to keep exposures as low as reasonably achievable.

If any worker receives a dose, in any 16 week period, equal to or greater than the values listed below (Table 1), the DRS must investigate the work practice involved and notify and send a report to the College Radiation Protection Officer. The Radiation Protection Officer will inform the EPA/ORP.

TABLE 1

Effective dose	**2 mSv**
Equivalent dose to lens of eye	**15 mSv**
Equivalent dose to skin and extremities (hands, forearms, feet, ankles)	**50 mSv**

Work practices must be arranged to ensure that non-occupationally exposed personnel do not receive annual doses that exceed:

(a) In the case of persons employed by the licensee (non-exposed workers): **0.3 mSv**

3.3.2 Medical Treatment in Case of an Accidents

Medical attention should be promptly sought from the Accident and Emergency Services at Cork University Hospital following any accident involving suspected significant exposure to radiation, or ingestion, or inhalation of a radioactive substance. Monitoring must also be carried out on workers present at the scene of any incident or accident involving the spillage of any significant quantity of radio-iodine (see also *section 3.13*)

3.3.3 Personal Monitoring and Dosimetry Programmes

Personal dosimetry may be required for individuals who are likely to be subject to annual occupational doses exceeding the annual dose limits for members of the public (i.e. for designated exposed workers), or for apprentices/students who work routinely with licensed items, subject to a risk assessment performed by the RPO or the RPA. The basic personal dose meter is the thermoluminescent badge which must be worn on the trunk, preferably on the lapel or waistband and inside any protective clothing. Additional personal dosimeters may be worn on the wrists or other parts of the body to monitor peripheral dose, if these are liable to be exposed appreciably. Radiation survey meters should also be carried as an additional precaution if high dose rates are probable. Personal dose badges are issued for a period determined by the dosimetry programme, which is to be organized through the Departmental Radiation Supervisors if deemed necessary. Depending on the dosimetry programme dose badges must be returned promptly at the end of the issue period. Departmental Radiation Supervisors are to forward the corresponding dosimetry reports to the Radiation Protection Office annually (i.e. twice during the term of the UCC licence).

Presently the following UCC entities run dosimetry programmes:

UCC Entity	Person looking after dose records	Provider	Frequency of badge return
Dental Hospital	M. O'Brien	Landauer Europe	2 months
CRVB	J. Choi	Landauer Europe	paused
Physics Dept.	A. Ruth	Public Health England	3 months
Biochemistry Dept.	S. Barry	Public Health England	3 months
Tyndall Nat. Inst.	B. O'Driscoll	Public Health England	3 months

Approved providers of dosimetry services can be found at:
https://www.epa.ie/radiation/regulation/dosimetry/

Eye-Dosimetry:

Where a school/dept./unit/centre has an eye dose monitoring programme in place, it is strongly recommended, that a log book should be maintained to accurately record for each case; the date, operating personnel, screening times, kV and mA ranges, and Dose Area Product (if measured), so that a more accurate correlation can be established between workload and recorded eye dose.

3.3.4 Degree of Supervision in Relation to Types of Work

Dosimetric supervision shall be carried out on all persons regularly engaged on the following types of work:

(i) X-ray crystallography and work with other equipment producing X-rays;
(ii) irradiation facilities (e.g. large gamma-emitting sources);
(iii) unsealed radioactive substances in single batch quantities greater than one-third of the maximum permissible annual intake in drinking water for continuous exposure.

Persons carrying out work in the following categories will not normally be required to register or to carry dose-measuring devices, but the work itself must be registered.

(i) work with electron microscopes or electron (as distinct from X-ray) diffraction apparatus, provided the Radiation Protection Officer is satisfied that the dose to personnel is likely to be less than 0.5 mSv in a year;
(ii) Undergraduate experiments with sealed sources of radioactive substances in which it is impossible for any student to receive more than 0.5 mSv in one year. Heads of Departments, however, may well consider the use of dose-measuring devices an essential part of the training;
(iii) undergraduate experiments involving quantities of unsealed radioactive substances not exceeding one-tenth of the acceptable limit for ingestion in one year by an occupational worker based on the International Commission on Radiological Protection (ICRP) maximum permissible concentration in drinking water for continuous exposure and a daily water intake of 2.2 litres). Typical quantities are e.g. 6 MBq of ^{131}I and 0.6 MBq of ^{32}P. If more than one type of radioactive material is used, then the permissible quantities of each will be calculated on a pro-rata basis. This 'concession' may also be applied to postgraduate work, if it is of short duration;
(iv) cleaning or maintenance in areas where registration work is carried out.

3.4 Hazards of Ionising Radiations

A distinction can be drawn between external radiation hazards and contamination hazards. In general, there is an external radiation exposure risk from any device in which electrons or heavy particles are accelerated and from sealed or unsealed radioactive substances. Unsealed radioactive substances are also a potential contamination hazard.

3.4.1 External Radiations

Vacuum tubes in which electrons are accelerated through potentials greater than 5 kV may be hazardous due to the emission of X-rays, but the current and the construction of the equipment will obviously influence the degree of exposure risk. Where electron beams of a few microamps are accelerated up to about 10 to 15 kV, glass vacuum tubes usually have sufficiently thick walls to absorb almost all of the X-radiation; this might not apply, however, in a device in which beams of many milliamps are produced. Thin-window tubes (e.g. image intensifiers) may be hazardous because the escaping electrons may cause serious skin burns or eye damage. Most standard equipment, such as cathode ray oscilloscopes or television picture monitors, operating even up to about 20 kV is safe, since the case-work provides additional shielding and flat-faced cathtode-ray tubes have relatively thick walls. Electron Microscopes are not normally regarded as generators of X-rays, but, since they operate at potentials in the range 50 to 100 kV, due regard must be paid to the possibility of X-rays being emitted in unexpected directions. If the casing around the gun is thin, appreciable doses may be recorded in this vicinity.

The radiation from most devices producing X-rays ceases as soon as the machine is switched off, though the same may not be true for particle accelerators. On the other hand there is no way of preventing the emission of radiation from radioactive substances. Normally it is only in the case of heavy particle accelerators, or of materials exposed to neutrons, that the target and irradiated material themselves may become radioactive. Radiation from radioactive substances may be of three main types, alpha particles, beta particles and gamma rays. Alpha particles are not normally considered to be an external radiation hazard, since they can be stopped very easily and are unable to penetrate more than the outer layers of the skin. Beta particles, on the other hand, can cause serious skin burns, while gamma rays are generally of an alpha emitter or high energy gamma emitter with beryllium or other light elements.
Bremsstrahlung, which arises from absorption of beta radiation, can become significant in the case of a pure beta emitter of strength greater than 100 MBq.

3.4.2 Contamination

Radioactive substances sealed in a metal, glass or plastic container constitute an external radiation hazard only, but an entirely different state of affairs exists if they are unsealed, when they will almost invariably give rise to a contamination hazard. Here the main risk arises from these substances entering the body by ingestion, inhalation or through intact or broken skin, thereby giving rise to a very high local dose. The quantity of a radioactive substance constituting an appreciable internal contamination hazard is considerably less than that necessary to give a significant external radiation exposure, since in the former case body tissues are irradiated at extremely close range. Alpha emitters are a major problem since in general they cause a much greater amount of biological damage per unit of absorbed dose than do beta/gamma emitters. As a rough guide, strict precautions against external radiation should be taken when handling activities of gamma emitters greater than 37 MBq (=1 mCi) or at close range to a pure beta emitter. Contamination, however, may present serious problems at levels around 0.037 MBq (=1 μCi); with many substances this may amount to microgram quantities. The following examples may be useful:

- the gamma dose-rate at 1 cm from 37 MBq of ^{60}Co is 154 mSv/hr
- the dose-rate from 37 MBq of most beta emitters at a distance of 3 mm is about 3 Sv/hr.
- the maximum permissible body burden (i.e. held in body) of ^{226}Ra is 3.7 kBq (=0.1 μCi) (which corresponds to about one-tenth of a microgram).

It is clearly vital that contamination of the working area should be kept to the absolute minimum. It should also be noted that contamination at levels which are far below those which constitute a biological hazard can completely invalidate the results of experimental work.

The level of radioactive contamination on any surface should not exceed the following values (averaged over 100 cm^2):

TABLE 2

	Beta/Gamma Emitters Bq/cm^2	**Alpha emitters Bq/cm^2**
In supervised areas	**3.7**	**0.37**
In public areas	**0.37**	**0.037**

A surface with an activity level greater than the above values must be decontaminated. In the case of skin, decontamination procedures shall be immediately carried out if any level of radioactive contamination is deemed to have occurred.

3.4.3 Control of Radiation and Contamination Hazards

The basic principles of external radiation control can be stated simply as ***distance***, ***time*** and ***shielding***. Radiation follows the inverse square law,

$$D_1 r_1^2 = D_2 r_2^2,$$

where D_1 is the dose rate at distance r_1 from the source, and D_2 is the dose rate at distance r_2 from the source. Therefore distance is a powerful method for reducing the dose received. Restriction of the working time will also reduce the total dose received. Shielding is the third method which can be applied; as a working example, it can be assumed that the effectiveness of a shielding material is roughly in proportion to its density. For example 10 cm of concrete is approximately equivalent to 2 cm of lead. **Cleanliness and tidiness in working methods are vital for the control of contamination. Impervious and easily cleaned surfaces for workbenches, floors and walls are essential. The avoidance of ingestion and inhalation of radioactive materials is of paramount importance. For this reason, eating, drinking and smoking are forbidden in radiation laboratories in the College. Protective clothing and rubber gloves should be worn at all times when unsealed materials are handled. Operations liable to cause dust or spray raise particular problems because of the ensuing inhalation risk.** Further details of methods of reducing these risks are to be found in Section 3.7 and 3.8.

3.5 X-ray Equipment

All X-ray Units must be operated in accordance with the manufacturer's instructions and under the control of a competent person. The Radiation Protection Officer must be satisfied as to the credentials (experience etc.) of the competent person.

Persons undergoing instruction may only have access to, or use the unit, under the direct supervision of the competent person. Monthly checks and annual overhauls must be carried out by a qualified expert and a copy of the service reports must be kept by the Departmental Radiation Supervisor.

All persons working with X-ray equipment must wear a film badge on the upper half of the trunk. During all potentially hazardous operations, such as adjustment to Guinier and precession cameras, realignment or similar physical alterations, and during servicing, additional monitoring devices must be worn on or near the hands; these may consist of film badges on the wrists or thermoluminescent dose meters on the fingers. It is recognised that there are occasions when adjustments must be made with shielding removed; in these cases extra care must be exercised and such operations should only be carried out by experienced workers. In no circumstances may the collimation be adjusted by eye when the tube is running.

Signs which are clearly visible at all times must be fixed to every set showing (i) when

the beam is on and (ii) when the beam shutter is open or closed. Both signs should be near the tube, with duplicates elsewhere if necessary. As far as possible, they should be arranged to fail safe and operating rules should be drawn up for each type of equipment, taking into consideration the nature of the warning devices. Wherever practical, the equipment should be positioned so that if a shutter is open the primary beam is directed away from areas occupied by other workers, unless adequate shielding is interposed. X-ray equipment, other than that for crystallographic examination, should as far as possible be sited in a protective enclosure to which no person has access when the tube is running. A sign bearing the radiation symbol must be displayed at the entrance to any room containing X-ray equipment. Areas where the dose rate exceeds 2.5uSv/hr while the tube is running should also be delineated.

All licenced items shall be checked for correct operation and shall be serviced and maintained at least every 12 months or more frequently, depending on use, by suitably qualified and competent persons in accordance with the manufacturer's instructions or best practice. All services and maintenance activities must be documented by the end-user and kept on file.

Quality Assurance (QA):

A QA programme for each piece of X-ray equipment shall be carried out by the respective users in accordance with the manufacturers' instructions. The Departmental Radiation Supervisors are responsible for the implementation of appropriate logs and checklists, depending on the frequency of use of the equipment and the level of risk involved. Where there are no manufacturer's instructions available concerning QA checks, a checklist should be established similar to the one in Appendix A. The form in Appendix A serves as a general template and can be edited as necessary for different types of equipment. The recommended (general) frequency of checks/testing should be monthly depending on usage. QA programmes must be documented rigorously and will be audited at appropriate intervals by the RPO.

Licensed items taken out of use and put into storage shall be stored in a secure location. A visual check of these items, or where a prior agreement has been made with the EPA/ORP a check on the on-going security arrangements, shall be carried out at monthly intervals. A record shall be kept of these checks.

3.5.1 The Dental School and Hospital

The radiological activities pertaining to the X-ray units in the Dental School and Hospital at Cork University Hospital are governed by the Code of Practice for Radiological Protection in Dentistry as issued by the EPA/ORP in 2019. See:
https://www.epa.ie/pubs/reports/radiation/EPA-Ionising-Radiation-Dentistry.pdf
A quality assurance programme for the dental X-ray units has been established by the former

Radiation Protection Advisor (Mr Michael Sheehy) and is continued by Mr John Upton as of November 2016, who ensures the maintenance and clear documentation of the programme.

3.6 Radiation Risk Assessments

Prior to commencing any new work practice involving a source of ionising radiation it is important that a realistic assessment of the radiation risks is carried out. This assessment will provide the necessary information for the drafting of good radiation protection and safety procedures. It will also identify areas where special protective measures should be implemented to reduce exposure to radiation. A risk assessment should enable the end-user of radiation to identify the actions to be taken to ensure that the radiation exposure of all persons is kept as low as reasonably achievable. A radiation risk assessment should take into account all the risks, both real and potential, of exposures to workers and members of the public and should be done in accordance with the Guidance Notes on Radiation Risk Assessment by the EPA/ORP (2016): https://www.epa.ie/pubs/advice/radiation/Guidance_radiation_risk_assessmentJun2016.pdf
At UCC Radiation Risk Assessments must be performed regularly by the end-users for all licensable items. The risk assessments must be documented and reviewed within the validity of the licence and immediately where circumstances arise in which the end-user has reason to believe that the Risk Assessment is no longer appropriate.

3.7 Classification of Radioactive Isotopes

The amount of unsealed radioactive material which can reasonably be handled in a single batch in a laboratory depends on a number of factors of which the most important are:

(i) the ease with which contamination can be controlled in the laboratory;
(ii) the external radiation level;
(iii) the radiotoxicity of the substance.

The control of contamination risks depends largely on the internal fittings and finish of the laboratory, while the radiotoxicity is assessed from a consideration of such factors as the biological half-life of the material, the nature and energy of the radiation emitted, and the critical organ concerned.

Table 3 is derived from Technical Reports Series No. 15 – ‘A Basic Toxicity Classification of Radionuclides’, IAEA Vienna (1963), and classifies the radionuclides according to relative radiotoxicity per unit activity

TABLE 3

Class 1 (High Toxicity) Radionuclides

In the list ‘m’ means the metastable state.

^{210}Pb, ^{201}Po, ^{223}Ra, ^{226}Ra, ^{228}Ra, ^{227}Ac, ^{227}Th, ^{228}Th, ^{230}Th, ^{231}Pa, ^{230}U, ^{232}U, ^{233}U, ^{234}U, ^{237}Np, ^{238}Pu, ^{230}Pu, ^{240}Pu, ^{241}Pu, ^{242}Pu, ^{241}Am, ^{243}Am, ^{242}Cm, ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{265}Cm, ^{249}Cf, ^{250}Cf, ^{252}Cf.

Class 2 (Medium Toxicity) Upper Sub-Group A

^{22}Na, ^{36}Cl, ^{45}Ca, ^{46}Sc, ^{54}Mn, ^{56}Co, ^{60}Co, ^{68}Ge, ^{89}Sr, ^{90}Sr, ^{91}Y, ^{95}Zr, ^{105}Ru, ^{110m}Ag, ^{115m}Cd, ^{114m}In, ^{124}Sb, ^{125}Sb, ^{127m}Te, ^{129m}Te, ^{124}I, ^{125}I, ^{126}I, ^{133}I, ^{134}Cs, ^{137}Cs, ^{140}Ba ^{144}Ce, ^{152}Eu (half-life 13 years), ^{154}Eu, ^{160}Tb, ^{170}Tm, ^{181}Hf, ^{182}Ta, ^{192}Ir, ^{204}Tl, ^{212}Pb, ^{207}Bi, ^{210}Bi, ^{211}At, ^{224}Ra, ^{228}Ac, ^{234}Th, ^{230}Pa, ^{236}U, ^{249}Bk.

Class 3 (Medium Toxicity) Lower Sub-Group B

^{7}Be, ^{14}C, ^{18}F, ^{24}Na, ^{31}Si, ^{32}P, ^{35}S, ^{38}Cl, ^{41}A, ^{42}K, ^{43}K, ^{47}Ca, ^{47}Sc, ^{48}Sc, ^{48}V, ^{51}Cr, ^{52}Mn, ^{56}Mn, ^{52}Fe, ^{55}Fe, ^{59}Fe, ^{56}Co, ^{58}Co, ^{63}Ni, ^{65}Ni, ^{64}Cu, ^{65}Zn, ^{67}Ga, ^{69m}Zn, ^{72}Ga, ^{73}As, ^{74}As, ^{76}As, ^{77}As, ^{75}Se, ^{82}Br, ^{85m}Kr, ^{87}Kr, ^{81}Rb, ^{86}Rb, ^{85}Sr, ^{91}Sr, ^{92}Sr, ^{87}Y, ^{90}Y, ^{92}Y, ^{93}Y, ^{97}Zr, ^{93m}Nb, ^{95}Nb, ^{99}Mo, ^{96}Tc, ^{97m}Tc, ^{97}Tc, ^{99}Tc, ^{97}Ru, ^{103}Ru, ^{104}Ru, ^{105}Rh, ^{103}Pd, ^{109}Pd, ^{105}Ag, ^{111}Ag, ^{109}Cd, ^{115}Cd, ^{115m}In, ^{113}Sn, ^{125}Sn, ^{122}Sb, ^{125m}Te, ^{127}Te, ^{129}Te ^{131m}Te, ^{132}Te, ^{123}I, ^{130}I, ^{132}I, ^{134}I, ^{135}I, ^{135}Xe, ^{131}Cs, ^{136}Cs, ^{139}Cs, ^{131}Ba, ^{140}Ba, ^{141}Ce, ^{143}Ce, ^{142}Pr, ^{143}Pr, ^{147}Nd, ^{149}Nd, ^{147}Pm, ^{149}Pm, ^{151}Sm, ^{153}Sm, ^{152}Eu (Half-life 9.2 hrs.), ^{155}Eu, ^{153}Gd, ^{159}Gd, ^{165}Dy, ^{166}Dy, ^{166}Ho, ^{169}Er, ^{171}Er, ^{171}Tm, ^{175}Yb, ^{177}Lu, ^{181}W, ^{185}W, ^{187}W, ^{183}Re, ^{186}Re, ^{188}Re, ^{185}Os, ^{191}Os, ^{193}Os, ^{190}Ir, ^{194}Ir, ^{191}Pt, ^{197}Pt, ^{196}Au, ^{199}Au, ^{197}Hg, ^{197m}Hg, ^{203}Hg, ^{200}Tl, ^{201}Tl, ^{202}Tl, ^{203}Pb, ^{206}Bi, ^{212}Bi, ^{220}Rn, ^{222}Rn, ^{231}Th, ^{233}Pa, ^{239}Np.

Class 4 (Low Toxicity)

^{3}H, ^{11}C, ^{13}N, ^{15}O, ^{37}A, ^{58m}Co, ^{59}Ni, ^{68}Ga, ^{69}Zn, ^{71}Ge, ^{85}Kr, ^{87}Rb, ^{35m}Sr, ^{87m}Sr, ^{91m}Y, ^{93}Zr, ^{97}Nb, ^{96m}Tc, ^{99m}Tc, ^{103m}Rh, ^{113m}In, ^{129}I, ^{131m}Xe, ^{134m}Cs, ^{135}Cs, ^{144}Nd, ^{147}Sm, ^{187}Re, ^{191m}Os, ^{193m}Pt, ^{197m}Pt, ^{232}Th, Th-Nat, ^{235}U, ^{238}U, U-Nat, U-Dep, U-Enr.

3.8 Grading of laboratories

The following specifications are intended as a guide in assessing the necessary structural alterations to existing laboratories or in designing new laboratories for radiochemical work with unsealed substances. In general special provision should be made for receipt and storage of substances, preparation of stock solutions, chemical work and counting. The layout should be such that there is a progressive reduction in activity from the place of storage through the laboratories to the counting room, and should be arranged to minimise the distance over which radioactive substances are carried. Steps or stairs between rooms are undesirable, owing to the risk of stumbling and thus spilling of the active material. The detailed design should aim at providing an area which can be readily kept in a very clean condition. Further information on design and equipment may be obtained from the Radiation Protection Officer, who should be consulted at an early stage in planning.

Where the work involves using only very small amounts of radioactive material the Radiation Protection Committee may give permission for it to be carried out under conditions which do not fulfil the requirements for a Grade C laboratory (see section 3.7.1). In such cases, the work and the laboratory will be assessed jointly and will be graded – 'S'. **In these circumstances, restrictions will be placed on the radioactive isotopes handled, the quantities used, the experimental methods and also the personnel carrying out the work.**

3.8.1 Grade C Laboratory

A high degree of cleanliness is essential, and fittings and finish should be chosen with this in view. Working space should be allocated on a generous scale compared with normal laboratory standards. Office accommodation must be provided separately.

The floor should be sealed, made waterproof and arranged to fall, in places, away from sources of contamination (e.g. sinks and under edges of benches). Joins to vertical surfaces should be covered. Good quality linoleum has been used for many years, but it requires continuous waxing and polishing to be satisfactory and it is difficult to seal joints adequately. Modern plastic floor coverings based on PVC have the advantage of requiring less maintenance and can be welded to present a continuous impervious surface. Care must be taken, however, to ensure that the PVC content is at least 50%. The acid and solvent- resistance of such material is quite good and can be slightly improved by polishing with plastic emulsion polish.

Walls and ceiling should be smooth and reasonably free of electrical conduit, water and gas pipes, etc. They should be finished with a high gloss paint. **Unpainted woodwork or stonework and perforated acoustic tiled ceilings should be avoided.** Radiators should be of flush pattern and should be arranged to permit easy cleaning. If two radiators are fitted close together to increase the heating area, they should be sufficiently apart to permit cleaning of both sides of each.

Wooden benches and cupboards may be used, but they must be painted with a light-coloured gloss paint. Chemically resistant finishes such as chlorinated rubber paints or epoxide resins are preferable. Bench tops must have a waterproof chemically resistant covering. Melamine plastics may be suitable but if they are scratched or abraded they tend to trap contamination. Rigid PVC coatings might also be considered. Self adhesive PVC coverings are undesirable for working surfaces, since they are attacked by many organic solvents, but are suitable for shelf coverings.

Stainless steel has been widely used for sinks, and is recommended; glazed porcelain is satisfactory, but it should be realised that it may be difficult to ensure continued freedom from cracks in the glaze which could lead to serious contamination problems. **There must be no possibility of leakage between the top of the sink and the adjacent bench. A small sink in the centre of a bench is therefore undesirable and stainless steel sinks with integral drainers are recommended.** All plumbing should be continuous. Troughs and open-pattern traps lead to possible overflows. Polythene is a suitable material, since it is highly resistant to chemical attack, is not readily contaminated, and is easy to dismantle if screw couplings are carefully arranged. These must, however, be leakproof. Hand-operated taps are undesirable; those operated by elbow, foot or knee are preferable.

There must be at least one fume cupboard in the laboratory. All interior woodwork must be painted with a chemically resistant (e.g. chlorinated rubber) paint. The working surface should normally be stainless steel, mild steel painted with a chemically resistant paint, melamine or linoleum. Toughened or safety glass must always be used for the window; ordinary plate glass is to be avoided. **While it is preferable that fume cupboard exhaust air should be carried in independent ducting to the top of the building, it is often permissible in a Grade C laboratory to discharge into normal ducting provided there is no possibility of blowing back into other fume cupboards.** The practice of fitting separate fans to each cupboard, blowing into a single main duct, does not meet this requirement. All services in the fume cupboard (e.g. electricity, gas, water) should be controlled from outside the cupboard, although it is preferable for the service outlets themselves to be within the cupboard.

A wash-hand basin should be provided, preferably immediately inside the laboratory. A rack should be available near the door for laboratory coats. It is useful also to have a rack for rubber gloves at a convenient point within the laboratory.

Some form of shielded storage should be provided. Protection should be such that the dose-rate at any point 5 cm from the outside wall does not exceed 2.5 μSv/hr when the store contains 370 MBq of a hard gamma emitter (e.g. ^{60}Co). It is difficult to specify exact thickness of shielding, since the size and shape will have some influence, but as a guide it may be assumed that about 10 cm of lead or 50 cm of concrete will be required. Simple remote handling equipment may be needed for handling and opening radioactive isotope containers. **At least one contamination monitor fitted with detectors appropriate to the work must be available.**

3.8.2 Some Quantitative Considerations

Utilising the classification given in Table 3 (Section 3.6), a table setting out the amount of unsealed radioactive materials which may be handled in a Grade C laboratory has been drawn up (Table 4).

TABLE 4

Class of Isotope	C - Grade Laboratory
I	0.37 MBq max
II	37.0 MBq max
III	3700 MBq max
IV	37×10^4 MBq max

The above quantities, which refer to normal chemical operations are subject to modification depending on the contamination risk associated with the particular work. Thus storage presents less hazard, while dusty operations increase the hazard due to the probability of inhalation.

A table of modifying factors is given below (Table 5):

TABLE 5

Procedure	**Factor**
Storage	× 100
Simple wet operations	× 10
Normal Chemical operations	× 1
Complex wet operations with risk of spills	× 0.1
Simple dry operations	× 0.1
Dry and dusty operations	× 0.01
Use of special 'biochemicals'*	× 0.001

* Labelled organic material of special biological importance may present a considerably greater hazard than normal. For example, ^{3}H- or ^{14}C-labelled thymidine is not metabolized but is retained intact by the body.

3.9 Techniques for Handling Sealed and Unsealed Radioactive Substances

3.9.1 Sealed Sources

A sealed source may be defined as a preparation of radioactive material in solid, liquid or gas phase, permanently sealed in a container such that, under normal circumstances, no leakage can take place. There is no contamination hazard from such a source unless the casing is fractured. For example, a capsule of aluminium or steel containing ^{60}Co in metallic form is unlikely to suffer damage if it is dropped; a source of this nature may safely be handled in any laboratory provided that the relevant precautions are taken against external radiation.

The same degree of safety does not necessarily apply to a liquid or a gaseous material, particularly when sealed in glass. **Unless otherwise decided by the Radiation Protection Officer, such sources may be used only in areas of the standard required for handling one-hundredth of the quantity of the same radioactive material when unsealed.**

The relevant requirements regarding X-ray equipment apply to sealed preparations of radioactive isotopes. However, since emission from radioactive material cannot be switched off, as can an X-ray tube, the following additional precautions should be observed: When not in use, the sealed source must be placed in a shielding container or place of storage such that the level of radiation leaking from the container is as low as possible. On the surface of the container it must not exceed **0.5 μSv hr^{-1}**. The container must bear the radiation symbol and an indication of the contents. Sealed sources are sometimes used in temporary installations (e.g. for testing dose measuring devices or for radiography of castings); special precautions must be taken to ensure that excessive dose-rates do not occur in accessible areas when the source is in use or during transit to and from the place of storage. A notice bearing the radiation symbol, together with the word 'Radiation' must be displayed outside the room in which a sealed source is used. In addition, the level of radiation must be specified if this is liable to exceed **2.5 μSv/hr** at any readily accessible point in the area during the normal operations.

3.9.2 Unsealed Radioactive Substances

All work with unsealed radioactive substances should be segregated from other work and, where possible, carried out in a laboratory reserved for this work alone. Where work involves the use of widely different levels of activity, separate rooms are preferred. Counting apparatus should normally be situated in a separate room. **The standard of cleanliness in a laboratory used for radioactive work must be much higher than normal. Supervisors are strongly advised to remove from radioactive work any person who is not scrupulously clean and tidy in himself and his/her work.** The untidy and careless worker is a danger not only to himself but to everyone in the laboratory. Signs bearing the radiation symbol, together with the word 'Radiation' and 'Contamination' where appropriate, must be displayed on the doors of all laboratories in which radioactive work is carried out. Protective clothing must be worn at all times in the laboratory and must be reserved for this purpose alone. Due to the risk of contaminating other work, this rule applies even at very low levels of activity.

Rubber gloves should be worn for all work with unsealed radioactive substances. The surgical technique should always be used when putting on or removing gloves, to avoid contaminating the hands and the inside surfaces of the gloves. Gloves must always be washed and monitored before removal. Suitable surgical-type rubber gloves should be available.

Eating, drinking, smoking or the application of cosmetics must not take place in the laboratory; no food, drink, cups, saucers, etc. may be brought into the laboratory. Pipettes must be syringe or bulb-operated, and flexible polythene wash-bottles are recommended. Glass blowing should be avoided in the laboratory; where such work is essential, blowing by mouth is not permissible. **All reagents, tools and, where possible, apparatus used in the active area should be clearly labelled (e.g. with yellow paint). These materials should not normally be removed from the active area.** If it is essential, however, to take any equipment out of the active areas, then this should be done only after the item has been rigorously monitored and found to be free from contamination. It should be remembered that an item which may be virtually free from contamination for work in one laboratory might still possess sufficient radioactivity to affect the results of another worker employed on very low background work.

All operations involving the production of vapour, spray, dust or radioactive gas, whether necessarily or accidentally, should be carried out in a good fume cupboard or in a glove box.

Electrical heating is preferable to gas in a laboratory handling radioactive substances. The preferred method of evaporation is from above, by means of an infra-red lamp, since this reduces the risk of splashing and spraying. **To avoid the spread of contamination in the event of a breakage or spill, all work, should be carried out in double containers or over large trays (e.g. stainless steel or enamel); such trays should be lined with absorbent paper to restrict the spread of liquid.**

All radioactive preparations must be clearly marked with details of the chemical compound, radioactive isotope, activity and date. Gummed labels should not be used; self-adhesive labels, bearing the radiation symbol should be available. **A waste bin for solid active materials (e.g. filters papers) should be provided in the laboratory.** The foot operated plastic type, with removable polythene bucket, has been found convenient. **A marker container should be provided for liquid waste of higher specific activity.**

Wherever possible, a preliminary experiment should be carried out with inactive materials so that any difficulties in handling the active samples may be foreseen. Adequate shielding and remote handling facilities should be provided; distance is the best method for reducing radiation dose, and the use of simple remote handling devices (e.g. for opening isotope containers) should be regarded as routine. Shielding of beta emitters need not involve more than a sheet of thick perspex, but gamma shielding should consist of interlocking lead bricks, with lead-glass windows for observation. It is difficult to lay down a level of activity above which shielding is essential since it depends on the material and the type of work, but its use should be considered when handling quantities in excess of 1.85 MBq. The protection of the eyes from radiation is most important, due to the risk of inducing cataract. While work with natural uranium and thorium does not normally present a serious hazard, care should be taken to avoid inhaling dust containing these materials, or air which has been standing over them in an enclosed volume.

It is essential that, on leaving the laboratory, every worker should wash his/her hands thoroughly, preferably also scrubbing gently with a nailbrush, especially around the nails. Hands should then be monitored to ensure that no contamination is present. These procedures should be followed rigorously before meals and before leaving the laboratory at the end of the day's work.

It is strongly advised that manipulative work with radioactive substances should be carried out only during normal working hours, when full emergency facilities are available. The counting of samples of low activity is excluded from this recommendation. Cleaning or similar work in possibly contaminated areas should be carried out under the supervision of the Departmental Radiation Supervisor.

Repairs to sinks and waste pipes should be carried out only after the Departmental Radiation Supervisor has verified that there is no hazard involved.

3.10 Storage of Radioactive Substances

Radioactive substances must always be used and stored in conditions that do not present a hazard to other persons in the vicinity and are reasonably secure against theft or unauthorised tampering. Licensed items taken out of use and put into storage shall be stored in a secure location, locked with highly restricted access such as the UCC Radiation Store (contact the RPO for advice). Radioactive sources put into storage shall be adequately shielded. A visual check of these items, or where a prior agreement has been made with the EPA/ORP a check on the on-going security arrangements, shall be carried out at monthly intervals. A record shall be kept of these checks.

All radioactive substances must be clearly identified, segregated from non-radioactive substances and securely and safely stored so that a dose rate of 0.5 μSv/hr must not be exceeded within the working area, and that part of the store which contains the active substances must be locked off.

It is not necessary however to remove all substances to a store every night. Common sense will decide whether or not to remove every item to the store every night. Where the radioactive substance is likely to evolve a radioactive gas or vapour the store must have adequate mechanical ventilation to the outside air. The fan must have operated for at least two minutes before any person enters the store.

When unsealed preparations of radioactive substances are stored, the following procedures should be adopted: Active residues at tracer level may be stored in glass vessels with polythene, rubber or cork stoppers; glass or screw-on stoppers should not be used.

Because radiation may induce decomposition of water, it may be necessary to use vented containers for storage; as a guide it can be assumed that chemically stable solutions containing about 185 MBq of alpha activity or 370 MBq of beta activity normally produce about 1 ml per month of gas, at NTP. Old bottles of radioactive liquors should be opened only in a fume hood.

Particular care should be taken with thermally unstable solutions containing radioactive substances (e.g. nitric acid or other oxidising solutions containing traces of organic material, peroxides, chlorates, etc.), which should always be stored in vented containers; in addition acidic or alkaline waste should be neutralised.

3.10.1 Radiation Store

The Physics Department holds low activity teaching and calibration sources for student and teacher training and other educational purposes in the **UCC Radiation Store**. Access to the Radiation Store is under the strict control of the Departmental Radiation Supervisor. The Radiation Store is a proprietary structure with thick concrete block walls and only one access door – a heavy duty steel structure. The approach to the store is guarded by an intruder alarm and CCTV camera. UCC Security checks on the store nightly; a clear emergency procedure is in place.

3.11 Transport of Radioactive Substances

Custody and use of the licensed items is restricted to the departmental premises of the College as listed in the College Licence.

Transport of licensed items outside College premises is limited to that associated with importation, unless special permission is obtained from the EPA-ORP.

Transport of licensed items outside the Department for which they have been ordered and into which they have been received must not be done without due caution and prior notification of the Radiation Protection Officer. Shielding, packaging and transport of radioactive substances shall be in accordance with the current version of IAEA Regulations for the Safe Transport of Radioactive Materials.

3.12 Acquisition and Disposal of Radioactive Sources/Materials

3.12.1 Acquisition of radioactive sources / materials (sealed or unsealed)

The Radiation Protection Officer is to be advised and consulted prior to the acquisition of a new licensable source or material. Prior to acquisition a risk assessment must be performed by the end-user and forwarded to the RPO. The local rules and procedures must be amended accordingly. The end-user of radioactive sources and materials must have an appropriate disposal route identified before the acquisition of radioactive sources/materials. For sealed sources a take-back agreement with the supplier has to be in place.
Shipments of sources/materials within the EU are governed by the Euratom Directive 1493/93. The regulation requires that all transfers of radioactive sources within the EU are controlled and documented. A licensee who intends to purchase a sealed source from another Member State of the European Union must first complete a standard declaration document, known as the 1493 form (http://www.epa.ie/pubs/forms/radiation/RPII_Shipment_Sealed_Sources_Form.pdf). The licensee is then required to submit this form to the EPA/ORP for approval and stamping. Once authorisation has been received from the EPA/ORP, the form should then be forwarded to the supplier. This procedure is carried out through the Radiation Protection Office.

3.12.2 Disposal of Radioactive Waste

It is the function of the Radiation Protection Committee to specify arrangements for the safe disposal of any radioactive waste that may arise. Guidelines as to the safe disposal of certain radioactive isotopes are outlined in the following:

Discharge must not take place without the approval of the Radiation Protection Officer.

Sealed radioactive sources may only be disposed of by exportation to the original supplier or a successor, unless otherwise authorised by the EPA-ORP.

Except in the case of excreta from patients, waste containing unsealed radioactive substances shall not be disposed of unless,

(i) **for the total quantity of waste to be disposed of per day, the sums of the fractions of the activities or concentrations for each radionuclide present divided by the respective values given in Columns 2 and 3 of Table B of SI No. 30 of 2019 are both less than or equal to 1 (see Table 6), and**

(ii) **the method of disposal of the waste does not result in the further concentration of the radioactivity contained therein to values greater than those specified in Column 3 of Table B of SI No. 30 of 2019. (e.g. in the residual ash from the**

incineration of solid waste) (see Table 6), and

(iii) in liquid form, it is readily soluble or dispersible in water.

Prior to disposal, solid active waste shall be retained in safe and secure storage in heavy duty polythene bags in a designated area. The radiation level shall be low enough (based on a risk assessment for potentially involved individuals) so that the accumulative dose rate per year does not exceed 1 mSv (limit for members of the public). Special storage arrangements shall be made, subject to the approval of the Radiation Protection Officer, if the accumulative dose equivalent per annum is likely to exceed the public limit. The wastes shall be stored until such time as the radioactivity has decayed to background levels. **All labels indicating that the material was radioactive shall then be removed and the material disposed of with normal waste.**

It is important not to indiscriminately classify all solid waste from the radioactive laboratory as active waste. Where it is obvious that some waste is uncontaminated, as evidenced by the contamination monitor, this material should be disposed of as ordinary garbage. Otherwise the volume of solid waste that must be put into storage grows at an unnecessarily rapid pace.

TABLE 6

Table B of S.I. No 30 of 2019

Total activity values for exemption (column 3) and exemption values for the activity concentration in moderate amounts of any type of material (column 1 or 2):

Element Name	**Radio-nuclide**	**Activity**	**Activity Concentration**
		[Bq]	**[kBq kg^{-1}]**
Tritium-3	H-3	10^9	10^6
Beryllium-7	Be-7	10^7	10^3
Carbon-14	C-14	10^7	10^4
Oxygen-15	O-15	10^9	10^2
Fluorine-18	F-18	10^6	10
Sodium-22	Na-22	10^6	10
Sodium-24	Na-24	10^5	10
Silicon-31	Si-31	10^6	10^3
Phosphorous-32	P-32	10^5	10^3
Phosphorous-33	P-33	10^8	10^5
Sulphur-35	S-35	10^8	10^5
Chlorine-36	Cl-36	10^6	10^4
Chlorine-38	Cl-38	10^5	10
Argon-37	Ar-37	10^8	10^6
Argon-41	Ar-41	10^9	10^2
Potassium-40 [a]	K-40 [a]	10^6	10^2
Potassium-42	K-42	10^6	10^2
Potassium-43	K-43	10^6	10
Calcium-45	Ca-45	10^7	10^4
Calcium-47	Ca-47	10^6	10
Scandium-46	Sc-46	10^6	10
Scandium-47	Sc-47	10^6	10^2
Scandium-48	Sc-48	10^5	10
Vanadium-48	V-48	10^5	10
Chromium-51	Cr-51	10^7	10^3
Iron-52	Mn-51	10^5	10
Iron-55	Mn-52	10^5	10
Iron-59	Mn-52m	10^5	10
Manganese-51	Mn-53	10^9	10^4
Manganese-52	Mn-54	10^6	10

Manganese-52m	Mn-56	10^5	10
Manganese-53	Fe-52	10^6	10
Manganese-54	Fe-55	10^6	10^4
Manganese-56	Fe-59	10^6	10
Cobalt-55	Co-55	10^6	10
Cobalt-56	Co-56	10^5	10
Cobalt-57	Co-57	10^6	10^2
Cobalt-58	Co-58	10^6	10
Cobalt-58m	Co-58m	10^7	10^4
Cobalt-60	Co-60	10^5	10
Cobalt-60m	Co-60m	10^6	10^3
Cobalt-61	Co-61	10^6	10^2
Cobalt-62m	Co-62m	10^5	10
Nickel-59	Ni-59	10^8	10^4
Nickel-63	Ni-63	10^8	10^5
Nickel-65	Ni-65	10^6	10
Copper-64	Cu-64	10^6	10^2
Zinc-65	Zn-65	10^6	10
Zinc-69	Zn-69	10^6	10^4
Zinc-69m	Zn-69m	10^6	10^2
Gallium-72	Ga-72	10^5	10
Germanium-71	Ge-71	10^8	10^4
Arsenic-73	As-73	10^7	10^3
Arsenic-74	As-74	10^6	10
Arsenic-76	As-76	10^5	10^2
Arsenic-77	As-77	10^6	10^3
Selenium-75	Se-75	10^6	10^2
Bromine-82	Br-82	10^6	10
Krypton-74	Kr-74	10^9	10^2
Krypton-76	Kr-76	10^9	10^2
Krypton-77	Kr-77	10^9	10^2
Krypton-79	Kr-79	10^5	10^3
Krypton-81	Kr-81	10^7	10^4
Krypton-83m	Kr-83m	10^{12}	10^5
Krypton-85	Kr-85	10^4	10^5
Krypton-85m	Kr-85m	10^{10}	10^3
Krypton-87	Kr-87	10^9	10^2
Krypton-88	Kr-88	10^9	10^2

Rubidium-86	Rb-86	10^5	10^2
Strontium-85	Sr-85	10^6	10^2
Strontium-85m	Sr-85m	10^7	10^2
Strontium-87m	Sr-87m	10^6	10^2
Strontium-89	Sr-89	10^6	10^3
Strontium-90+	Sr-90 [b]	10^4	10^2
Strontium-91	Sr-91	10^5	10
Strontium-92	Sr-92	10^6	10
Yttrium-90	Y-90	10^5	10^3
Yttrium-91	Y-91	10^6	10^3
Yttrium-91m	Y-91m	10^6	10^2
Yttrium-92	Y-92	10^5	10^2
Yttrium-93	Y-93	10^5	10^2
Zirconium-93+	Zr-93 [b]	10^7	10^3
Zirconium-95	Zr-95	10^6	10
Zirconium-97+	Zr-97 [b]	10^5	10
Niobium-93m	Nb-93m	10^7	10^4
Niobium-94	Nb-94	10^6	10
Niobium-95	Nb-95	10^6	10
Niobium-97	Nb-97	10^6	10
Niobium-98	Nb-98	10^5	10
Molybdenum-90	Mo-90	10^6	10
Molybdenum-93	Mo-93	10^8	10^3
Molybdenum-99	Mo-99	10^6	10^2
Molybdenum-101	Mo-101	10^6	10
Technetium-96	Tc-96	10^6	10
Technetium-96m	Tc-96m	10^7	10^3
Technetium-97	Tc-97	10^8	10^3
Technetium-97m	Tc-97m	10^7	10^3
Technetium-99	Tc-99	10^7	10^4
Technetium-99m	Tc-99m	10^7	10^2
Ruthenium-97	Ru-97	10^7	10^2
Ruthenium-103	Ru-103	10^6	10^2
Ruthenium-105	Ru-105	10^6	10
Ruthenium-106+	Ru-106 [b]	10^5	10^2
Rhodium-103m	Rh-103m	10^8	10^4
Rhodium-105	Rh-105	10^7	10^2
Palladium-103	Pd-103	10^8	10^3

Palladium-109	Pd-109	10^6	10^3
Silver-105	Ag-105	10^6	10^2
Silver-108m+	Ag-108m	10^6	10
Silver-110m	Ag-110m	10^6	10
Silver-111	Ag-111	10^6	10^3
Cadmium-109	Cd-109	10^6	10^4
Cadmium-115	Cd-115	10^6	10^2
Cadmium-115m	Cd-115m	10^6	10^3
Indium-111	In-111	10^6	10^2
Indium-113m	In-113m	10^6	10^2
Indium-114m	In-114m	10^6	10^2
Indium-115m	In-115m	10^6	10^2
Tin-113	Sn-113	10^7	10^3
Tin-125	Sn-125	10^5	10^2
Antimony-122	Sb-122	10^4	10^2
Antimony-124	Sb-124	10^6	10
Antimony-125	Sb-125	10^6	10^2
Tellurium-123m	Te-123m	10^7	10^2
Tellurium-125m	Te-125m	10^7	10^3
Tellurium-127	Te-127	10^6	10^3
Telurium-127m	Te-127m	10^7	10^3
Tellurium-129	Te-129	10^6	10^2
Tellurium-129m	Te-129m	10^6	10^3
Tellurium-131	Te-131	10^5	10^2
Tellurium-131m	Te-131m	10^6	10
Tellurium-132	Te-132	10^7	10^2
Tellurium-133	Te-133	10^5	10
Tellurium-133m	Te-133m	10^5	10
Tellurium-134	Te-134	10^6	10
Iodine-123	I-123	10^7	10^2
Iodine-125	I-125	10^6	10^3
Iodine-126	I-126	10^6	10^2
Iodine-129	I-129	10^5	10^2
Iodine-130	I-130	10^6	10
Iodine-131	I-131	10^6	10^2
Iodine-132	I-132	10^5	10
Iodine-133	I-133	10^6	10
Iodine-134	I-134	10^5	10

Iodine-135	I-135	10^6	10
Xenon-131m	Xe-131m	10^4	10^4
Xenon-133	Xe-133	10^4	10^3
Xenon-135	Xe-135	10^{10}	10^3
Caesium-129	Cs-129	10^5	10^2
Caesium-131	Cs-131	10^6	10^3
Caesium-132	Cs-132	10^5	10
Caesim-134m	Cs-134m	10^5	10^3
Caesium-134	Cs-134	10^4	10
Caesium-135	Cs-135	10^7	10^4
Caseium-136	Cs-136	10^5	10
Caesium-137 [b]	Cs-137 [b]	10^4	10
Caseium-138	Cs-138	10^4	10
Barium-131	Ba-131	10^6	10^2
Barium-140 [b]	Ba-140 [b]	10^5	10
Lanthanum-140	La-140	10^5	10
Cerium-139	Ce-139	10^6	10^2
Cerium-141	Ce-141	10^7	10^2
Cerium-143	Ce-143	10^6	10^2
Cerium-144 [b]	Ce-144 [b]	10^5	10^2
Praseodymium-142	Pr-142	10^5	10^2
Praseodymium-143	Pr-143	10^6	10^4
Neodymium-147	Nd-147	10^6	10^2
Neodymium-149	Nd-149	10^6	10^2
Promethium-147	Pm-147	10^7	10^4
Promethium-149	Pm-149	10^6	10^3
Samarium-151	Sm-151	10^8	10^4
Samarium-153	Sm-153	10^6	10^2
Europium-152	Eu-152	10^6	10
Europium-152m	Eu-152m	10^6	10^2
Europium-154	Eu-154	10^6	10
Europium-155	Eu-155	10^7	10^2
Gadolinium-153	Gd-153	10^7	10^2
Gadolinium-159	Gd-159	10^6	10^3
Terbium-160	Tb-160	10^6	10
Dysprosium-165	Dy-165	10^6	10^2
Dysprosium-166	Dy-166	10^6	10^3
Holmium-166	Ho-166	10^5	10^3

Erbium-169	Er-169	10^7	10^4
Erbium-171	Er-171	10^6	10^2
Thulium-170	Tm-170	10^6	10^3
Thulium-171	Tm-171	10^8	10^4
Ytterbium-175	Yb-175	10^7	10^3
Lutecium-177	Lu-177	10^7	10^8
Hafnium-181	Hf-181	10^1	10^6
Tantalum-182	Ta-182	10^4	10
Tungsten-181	W-181	10^7	10^3
Tungsten-185	W-185	10^7	10^4
Tungsten-187	W-187	10^6	10^2
Rhenium-186	Re-186	10^6	10^3
Rhenium-188	Re-188	10^5	10^2
Osmium-185	Os-185	10^6	10
Osmium-191	Os-191	10^7	10^2
Osmium-191m	Os-191m	10^7	10^3
Osmium-193	Os-193	10^6	10^2
Iridium-190	Ir-190	10^6	10
Iridium-192	Ir-192	10^4	10
Iridium-194	Ir-194	10^5	10^2
Platinum-191	Pt-191	10^6	10^2
Platinum-193m	Pt-193m	10^7	10^3
Platinum-197	Pt-197	10^6	10^3
Platinium-197m	Pt-197m	10^6	10^2
Gold-198	Au-198	10^6	10^2
Gold-199	Au-199	10^6	10^2
Mercury-197	Hg-197	10^7	10^2
Mercury-197m	Hg-197m	10^6	10^2
Mercury-203	Hg-203	10^5	10^2
Thallium-200	Tl-200	10^6	10
Thallium-201	Tl-201	10^6	10^2
Thallium-202	Tl-202	10^6	10^2
Thallium-204	Tl-204	10^4	10^4
Lead-203	Pb-203	10^6	10^2
Lead-210 [b]	Pb-210 [b]	10^4	10
Lead-212 [b]	Pb-212 [b]	10^5	10
Bismuth-206	Bi-206	10^5	10
Bismuth-207	Bi-207	10^6	10

Bismuth-210	Bi-210	10^6	10^3
Bismuth-212 [b]	Bi-212 [b]	10^5	10
Polonium-203	Po-203	10^6	10
Polonium-205	Po-205	10^6	10
Polonium-207	Po-207	10^6	10
Polonium-210	Po-210	10^4	10
Astatine-211	At-211	10^7	10^3
Radon-220 [b]	Rn-220 [b]	10^7	10^4
Radon-222 [b]	Rn-222 [b]	10^8	10
Radium-223 [b]	Ra-223 [b]	10^5	10^2
Radium-224 [b]	Ra-224 [b]	10^5	10
Radium-225	Ra-225	10^5	10^2
Radium-226 [b]	Ra-226 [b]	10^4	10
Radium-227	Ra-227	10^6	10^2
Radium-228 [b]	Ra-228 [b]	10^5	10
Actinium-228	Ac-228	10^6	10
Thorium-226 [b]	Th-226 [b]	10^7	10^3
Thorium-227	Th-227	10^4	10
Thorium-228 [b]	Th-228 [b]	10^4	1
Thorium-229 [b]	Th-229 [b]	10^3	1
Thorium-230	Th-230	10^4	1
Thorium-231	Th-231	10^7	10^3
Thorium-234 [b]	Th-234 [b]	10^5	10^3
Protactinium-230	Pa-230	10^6	10
Protactinium-231	Pa-231	10^3	1
Protactinium-233	Pa-233	10^7	10^2
Uranium-230	U-230	10^5	10
Uranium-231	U-231	10^7	10^2
Uranium 232 [b]	U-232 [b]	10^3	1
Uranium-233	U-233	10^4	10
Uranium-234	U-234	10^4	10
Uranium-235 [b]	U-235 [b]	10^4	10
Uranium-236	U-236	10^4	10
Uranium-237	U-237	10^6	10^2
Uranium-238 [b]	U-238 [b]	10^4	10
Uranium-239	U-239	10^6	10^2
Uranium-240	U-240	10^7	10^3
Uranium-240 [b]	U-240 [b]	10^6	10

Neptunium-237 [b]	Np-237 [b]	10^3	1
Neptunium-239	Np-239	10^7	10^2
Neptunium-240	Np-240	10^6	10
Plutonium-234	Pu-234	10^7	10^2
Plutonium-235	Pu-235	10^7	10^2
Plutonium-236	Pu-236	10^4	10
Plutonium-237	Pu-237	10^7	10^3
Plutonium-238	Pu-238	10^4	1
Plutonium-239	Pu-239	10^4	1
Plutonium-240	Pu-240	10^3	1
Plutonium-241	Pu-241	10^5	10^2
Plutonium-242	Pu-242	10^4	1
Plutonium-243	Pu-243	10^7	10^3
Plutonium-244	Pu-244	10^4	1
Americium-241	Am-241	10^4	1
Americum-242	Am-242	10^6	10^3
Americum-242m [b]	Am-242m [b]	10^4	1
Americum-243 [b]	Am-243 [b]	10^3	1
Curium-242	Cm-242	10^5	10^2
Curium-243	Cm-243	10^4	1
Curium-244	Cm-244	10^4	10
Curium-245	Cm-245	10^3	1
Curium-246	Cm-246	10^3	1
Curium-247	Cm-247	10^4	1
Curium-248	Cm-248	10^3	1
Berkelium-249	Bk-249	10^6	10^3
Californium-246	Cf-246	10^6	10^3
Californium-248	Cf-248	10^4	10
Californium-250	Cf-250	10^4	10
Californium-251	Cf-251	10^3	1
Calfornium-252	Cf-252	10^4	10
Calfornium-253	Cf-253	10^5	10^2
Californium-254	Cf-254	10^3	1
Einsteinium-253	Es-253	10^5	10^2
Einsteinium-254	Es-254	10^4	10
Einsteinium-254m	Es-254m	10^6	10^2
Fermium-254	Fm-254	10^7	10^4
Fermium-255	Fm-255	10^6	10^3

[a] Potassium salts in quantities less than 1 000 kg are exempted.

[b] Parent radionuclides, and their progeny whose dose contributions are taken into account in the dose calculation (thus requiring only the exemption level of the parent radionuclide to be considered), are listed in the following:

Parent radionuclide	**Progeny**
Sr-90	Y-90
Zr-93	Nb-93 m
Zr-97	Nb-97
Ru-106	Rh-106
Ag-108 m	Ag-108
Cs-137	Ba-137 m
Ba-140	La-140
Ce-144	Pr-144
Pb-210	Bi-210, Po-210
Pb-212	Bi-212, Tl-208 (0.36), Po-212 (0.64)
Bi-212	Tl-208 (0.36), Po-212 (0.64)
Rn-220	Po-216
Rn-222	Po-218, Pb-214, Bi-214, Po-214
Ra-223	Rn-219, Po-215, Pb-211, Bi-211, Tl-207
Ra-224	Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Ra-226	Rn-222, Po-218, Pb-214, Bi-214, Po-214, Pb-210, Bi-210, Po-210
Ra-228	Ac-228
Th-226	Ra-222, Rn-218, Po-214
Th-228	Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
Th-229	Ra-225, Ac-225, Fr-221, At-217, Bi-213, Po-213, Pb-209
Th-234	Pa-234 m
U-230	Th-226, Ra-222, Rn-218, Po-214
U-232	Th-228, Ra-224, Rn-220, Po-216, Pb-212, Bi-212, Tl-208 (0.36), Po-212 (0.64)
U-235	Th-231
U-238	Th-234, Pa-234 m
U-240	Np-240 m
Np237	Pa-233
Am-242 m	Am-242
Am-243	Np-239

3.13 Monitoring

The success of the control of hazards from radioactive substances or other sources of ionising radiation is assessed by monitoring. Several different types of instrument are required since no single instrument is suitable for all the tasks involved.

Monitoring can be divided into,

(i) personal;
(ii) environmental;
(ii) surface contamination;
(iv) air;
(v) effluent.

These methods are now examined individually.

3.13.1 Personal Monitoring and Dosimetry

The purpose of personal monitoring is to assess the dose received by the individual. The main concern is with the whole-body dose from external radiation, but doses to particular areas such as the fingers or eyes may also be important. The doses to internal organs from radioactive substances that have entered the body are difficult to assess and special methods are necessary. Whole-body external doses are usually measured by a thermoluminescent badge which should be carried on the upper part of the trunk, generally on the lapel. Although it is often assumed that it records the whole-body dose, this is true only if the person is in a uniform radiation field. This is rarely the case, in particular, work close to sources of small dimensions or with devices producing narrow beams of radiation (e.g. X-ray crystallography machines) involves exposure to very non-uniform fields. In these cases, there is no simple method of obtaining a better estimate of the whole-body dose, but it is then very important to measure the intense local doses. Further detectors on the wrist or the finger tips may be useful.

Each badge is numbered and is for use by one person only. It is essential that badges be returned promptly at the end of the issue period.

Detectors issued to individuals must be carried on the person. They must not be used to check the dose in a fixed position (e.g. at a bench); special detectors should be used for this purpose. Detectors are not issued to persons working with radioisotopes emitting radiation which is too weak to penetrate the cover of the badge. These include some alpha emitters having no associated significant gamma radiation and low energy beta emitters such as ^{3}H, ^{14}C and ^{35}S.

3.13.2 Environmental Monitoring

The purpose of environmental monitoring is to find the areas in which appreciable dose-rates exist so that appropriate measures, such as provision of shielding or restriction of working time, may be taken to reduce the dose to personnel. It is, however, no substitute for personal monitoring.

The instrument used is the dose-rate meter, which usually incorporates an ionisation chamber. One model, however, uses a Geiger counter, around which compensating filters are arranged to make the response more nearly independent of the energy of the incident radiation. It should be clearly recognised that if the whole volume of an ionisation chamber is not in the beam of radiation, the instrument will underestimate the dose rate by a factor approximately equal to the ratio between the chamber volume and the fraction of it transversed by the beam. Extensive monitoring should be carried out during and immediately following the installation and testing of new equipment or following any alteration in experimental arrangements. With equipment producing X-rays, once the pattern of radiation has been established subsequent surveys can be less detailed. Where sealed or unsealed radioactive substance are handled, surveys should in general be frequent since the substances are normally moved fairly often, thus changing the distribution of radiation in the area.

Particular problems may arise with X-ray crystallography machines, where the primary beam and beams or sheets of scattered radiation are generally very small in dimensions. Photographic methods may be useful in such cases to detect the presence and extent of the beam. Monitoring of this type of apparatus should be carried out with great care whenever the experimental conditions are changed in any way, however trivial these changes may appear to be. High energy machines may present similar problems, complicated by the much wider energy spectrum and different types of particles. Electron microscopes and electron diffraction (as distinct from X-ray diffraction) apparatus generally present fewer problems. A thorough initial survey when the equipment is installed is usually sufficient, additional shielding being added if necessary in those places where the dose rate is high.

3.13.3 Monitoring for Surface Contamination

Regular contamination monitoring is required only in areas where unsealed radioactive substances are handled. Sealed sources that are in use, however, should be checked at regular intervals, at least once every 2 years, and whenever there is a suspicion of leakage, e.g. after damage or suspected damage to source container. In addition, all regions around neutron sources should be checked before handling.

The most common type of instrument used is a counting rate meter, to which a variety of probes may be attached. The main unit incorporates the high voltage supply for the detector together with a loudspeaker or attachments for headphones. Head units vary considerably, but are normally connected to the main unit by about 1 meter of flexible cable. The most commonly used pattern is based on a glass Geiger counter with a wall thickness of about 10 mg/cm^2. This is adequate for most work with beta-gamma emitters since high-energy beta particles (e.g. from ^{32}P) can penetrate walls. It is necessary, however, to use a thinner window for many beta emitters, particularly those emitting low-energy particles, such as ^{14}C and ^{35}S; here an end-window Geiger counter is normally used, the window being of mica, about 2 mg/cm^2 in thickness. It should be noted that there is no satisfactory simple method of checking for tritium surface contamination using inexpensive portable equipment. A wipe test (as described below) followed by counting in a liquid scintillation counter is the most convenient way to check for tritium surface contamination.

Alpha probes are often scintillation counters. They are rather delicate since the light-tight window is extremely thin and is therefore very liable to damage.

It should be remembered that both alpha particles and low-energy beta particles have very limited ranges in air, so the detector must be held very close to but not actually touching the surface under investigation.

Another point worth noting is the value of wipe or smear testing, when monitoring for contamination in the presence of a high background (e.g. checking a sealed source for leakage). In this the surface is rubbed with absorbent material such as a filter paper or paper tissue, which is then presented to the counter for measurement in the area of reasonably low background. It is normally assumed that about 10% of the removable contamination is transferred to the paper and that levels may be averaged over 100 sq. cm. for floors, ceilings and walls, or 300 sq. cm. for other surfaces; for parts of the body integration over an area of 100 sq. cm. or a whole hand is permissible.

The normal type of contamination monitor can be used for checking hands and clothing for contamination.

3.13.4 Monitoring for Airborne Contamination

Airborne contamination can be one of the major risks in radiochemical laboratories. If any dust or spray-producing operations involving radioactive substances are carried out, some form of air monitoring should be regarded as routine. The most common method used is to draw a known volume of air (generally seven hundred litres) through a filter, which is then checked in conventional counting apparatus. If such a sample is to be representative of the air breathed by the worker, it is essential that it should be drawn from near the face. While large samplers strategically sited, can be useful, the small personal sampler is greatly to be preferred. Care must be taken in interpreting air monitoring measurements. In the first place an air sampler does not normally measure contamination due to gases, since it is effectively a particle collector; it is, however, a useful method for checking the levels of radon or thoron in air, since the decay products of these gases are solids. They in their turn may lead to serious errors of interpretation, since they are present naturally in air. A sample taken from normal, uncontaminated air will generally give appreciable alpha and beta counting rates at a level which is frequently sufficient to mask true contamination from other material, even at maximum permissible level. The half-life of the activity is, however, only of the order of half an hour, so if measurement of the sample filter is deferred for a few hours, the natural activity will have decayed sufficiently to permit assessment of contamination other than that due to high-toxicity alpha emitters, for which a longer delay is normally necessary.

3.14 Accidents and Emergency Procedures

3.14.1 Definition of a Reportable Accident

Any accident, however minor, in which it is suspected that a person may have been exposed to radiation.

Any accident in which a person, or his clothing, may have been significantly contaminated; or any incident following which there is a possibility of radioactive substances entering the body (e.g. through a cut or open wound, by breathing or through the mouth).

Any fire or explosion which results in damage to a room or its contents where sealed or unsealed radioactive substances are handled.

3.14.2 Reporting

Spillage of unsealed radioactive substances must be reported to the Departmental Radiation Supervisor. Any other incident defined above must be reported immediately to the Departmental Radiation Supervisor or his/her stand-in who will take charge of the emergency procedures. In case where the ingestion of radioactive substances is suspected it is important that the earliest possible notification to the Supervisory Medical Officer should be made.

The Departmental Radiation Supervisor must send a full report on any accident or emergency to the Radiation Protection Officer.

The Departmental Radiation Supervisor must inform the Radiation Protection Officer of damage to, leakage from, or loss/theft of the licensed items. The Regulatory Service of the Radiological Protection Institute of Ireland shall also be notified of an incident/accident involving a licensed item as soon as possible and at the latest within 24 hours. The EPA/ORP may be contacted at 3 Clonskeagh Square, Clonskeagh Road, Dublin 14, telephone 01-2697766 or fax number 01-2697437. A duty officer is on call outside normal working hours. The numbers are available on the answering machine.

Radiological incidents that require reporting to the EPA/ORP are defined in the "Guidelines for reporting radiological incidents to the Radiological Protection Institute of Ireland" (2016). The reporting must be done in accordance with these guidelines. See:
https://www.epa.ie/pubs/advice/radiation/RPII_Guide_Report_Incidents_03.pdf

3.14.3 Immediate Measure on the Site

During the time it takes for expert assistance to reach the site any obvious injury should be treated immediately, taking care to avoid undue spread of contamination if this is suspected. Care should be taken by those first on the scene of an accident involving personal injury (particularly a fracture) not to compound the injury by unnecessary movement of the victim. Decontamination should also be started as soon as possible. Contaminated clothing should be removed and the following procedure followed, where applicable:

Eyes: Irrigate with saline solution (0.9% common salt solution); if this is not immediately available, use distilled or tap water. The standard plastic wash-bottle is a convenient applicator.
Hands: Wash with soap and water, scrubbing lightly with a soft nailbrush. If this fails, to remove the contamination, repeat with EDTA soap. As a last resort, immerse the hands in a saturated potassium permanganate solution, allow to dry and remove stain with 5% sodium bisulphite solution.

Skin and other than hands: Rub the area gently with a cotton wool pad soaked in 'Cetavlon'. Do not scrub the skin sufficiently to produce abrasions.

Mouth: Wash out several times with hydrogen peroxide solution (1 tablespoon of 10 volume solution to a tumbler of water).

Contaminated wounds: Wash under a fast-running tap and encourage bleeding; if the wound is on the face, take care not to contaminate the eyes, mouth or nostrils. Finally, wash the wound with soap and water, apply a gentle antiseptic and the a first aid dressing.

Decontamination should be continued until monitoring shows that the contamination has been reduced to an acceptable level, unless there is a risk of contamination entering the blood stream due to abrasion or breaking of the skin.

3.14.4 Fire and Explosion

Fire-fighting takes precedence over the control of contamination, but all reasonable efforts should be made to minimise the spread of contamination, particularly at the clearing up stage.

Where safe to do so, portable sources should be removed from areas in immediate danger, and X-ray equipment should be powered down.

The Station Officers of the local Fire Brigade Station are aware of the hazards and will take particular care in those areas marked with the approved radiation fire sign. Informing the local fire authorities annually of the locations and hazards associated with all licensed radioactive sources is a condition of the UCC license. Planned changes of the locations of radiation equipment and/or sources must be brought to attention of the RPO prior to the move.

Emergency services contact details:

Reception Centre / Security Main Campus	ext. 3111 or 2266
General Emergency	999 or 112
Mercy Hospital Urgent Care Centre	(021) 4926900
	(021) 4271971
Accidents & Emergency Dept	(021) 4920200
Fire Brigade (Anglesea Street)	(021) 4966333
Garda (Anglesea Street)	(021) 4522000

APPENDIX A:

University College Cork

X-RAY SAFETY CHECKS

Date	X-ray on warning light[1]	Emergency stop [2]	Wiring/Cables[3]	Mains-on light[4]	Door/Enclosure Interlock[5]	Key Control[6]	[7]	[7]	Comments	Signed

[1] Check that the x-ray on warning light on the scanner is illuminating during exposure, and extinguishes following exposure.
[2] Check the operation of the emergency stop button.
[3] Check that all mains and other connectors are properly seated and that the insulation on all cables is undamaged.
[4] Check the operation of the mains power indicator light.
[5] Check that x-rays not generated or that the shutter is closed while the door or enclosure interlock is opened.
[6] Check that the scanner will only operate where the key is in place.
[7] Additional monthly checks as recommended by the manufacturer or as required under additional licence conditions.

APPENDIX B:

REGISTRATION OF PERSONNEL FORM

FOR

WORKERS USING IONISING RADIATIONS

AT

UNIVERSITY COLLEGE CORK

Date of registration:
Name of new personnel dealing with ionising radiation:
Department/School/Unit/Centre:
Email & Phone:

The above name person will be working with, *(brief details of type of work, activities involved etc.)*

…….

…….

…….

This is to certify that *(name)* ……………………………has received instructions in the handling and usage of radioactive materials/sources of ionising radiation and/or the safe handling of x-ray equipment. The instructions must include the taking of a generic video course on Radiation Protection (Protection from ionising radiation [DVD] / Sheffield University Radiation Protection Service N 363.17 PROT) available in the Boole library.

I have read and agree to abide by the regulations relating to the use of ionising radiations in the College (see UCC Code of Practice and schedule 1 of the current licence).

Workers Signature: …………………………………………………………………. Date:……………..……

Departmental Radiation Supervisor: ………………………………………………………… Date:……………..……..

A copy of this form must be sent to the College Radiation Protection Office.

APPENDIX C:

UCC Annual EPA-Licensed Items Check List

It is the responsibility of the licensee (Head of Unit and Departmental Radiation Supervisor(s)) to ensure that the practice in work with ionising radiation is in compliance with all EPA licence conditions and relevant legislation. Some of the compliance issues which regularly arise during EPA Inspections of practices are listed below and should be checked at least on an annual basis.

CHECKS RELEVANT TO ALL LICENSED ITEMS	
The current EPA licence is on public display in the department and all radioactive sources and X-ray equipment are listed in schedule 2 for use or custody as appropriate.	
All faults or incidents involving licenced equipment or sources have been reported to the RPO and documented.	
The proposed acquisition or disposal of any radioactive sources or irradiating apparatus has been communicated to the RPO, the EPA has been appropriately notified, and the licence appropriately amended.	
Security arrangements have been reviewed to ensure that they are adequate to prevent loss, theft, or unauthorised access to a licensed item. All licensed items carry a legible warning sign indicating the radiation hazard (e.g. X-ray or Radioactive Source) and that access is restricted to authorised/trained persons.	
A radiation risk assessment relating to all licensed equipment has been performed or revised during the issue period of the licence (or where new equipment/sources are acquired) and forwarded to the RPO.	
Standard Operating Procedures relating to the use of licensed items have been updated to take account of any additional controls or recommendations in the most recent risk assessment.	
Appropriate training has been documented for all persons authorised to operate licensed equipment or to use sources (including newly appointed persons), including evidence that the radiation safety procedures have been read and signed.	
Records of monthly visual checks are available for licensed equipment or sources in storage. All such equipment carries a warning that it is not to be removed without authorisation by the RPO.	
Any radiation detectors used in radiation safety checks have been sent for calibration within the past 12 months.	
CHECKS RELEVANT TO X-RAY EQUIPMENT	
Annual maintenance by recognized external suppliers or service agents (including appropriate radiation leakage checks) has been carried out and records are available.	
The Monthly Radiation Safety Check List is up to date	
Radiation Safety Check Lists and maintenance records have been forwarded to the RPO for review within the past 12 months.	
CHECKS RELEVANT TO RADIOACTIVE SOURCES	
All sealed sources have been wipe/leak tested within the past 2 years and records are available.	
A monthly visual check list to confirm the presence of all sources is up to date and records have been forwarded to the RPO within 12 months.	
A take back agreement has been arranged with the suppliers of all sources, and an attempt has been made to return or dispose of any disused sources or orphan sources in custody.	

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X-Spect Medical Physics Services

UCC Radiation Protection Officer
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