RADIATION SAFETY

POLICY

AND

PROCEDURES

University Radiation Safety Committee
and
The Department of Environmental Health and Safety

January 2004

UNIVERSITY RADIATION SAFETY COMMITTEE
as at July 1, 2007

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Ms. Susan Marlin	Office of Research Services	ex-officio
Mr. J.E.D. (John) Bullock	Environmental Health & Safety	ex-officio (URSO)
Mr. Dan Langham	Environmental Health & Safety	ex-officio (Director EH&S)
Ms. Anne Browne	Physical Plant Services	ex-officio (Director PPS)
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Dr. H. F. (Gus) Shurvell	Chemistry	June 30, 2008
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POLICY

1. Radiation Safety Policy

The Principal of Queen's University has appointed the University Radiation Safety Committee (hereafter referred to as the Committee) to carry the advisory responsibility for the overall operation of the University Radiation Safety Program. The details are included in the Terms of Reference of the Committee. It is the policy of Queen's University that all activities involving ionizing radiation or radiation emitting devices be conducted so as to keep hazards from radiation to a minimum. Persons involved in these activities are expected to comply fully with the Canadian Nuclear Safety Act and all its regulations, with the Occupational Health and Safety Act and its regulations regarding X-ray sources, lasers and sound.

2. Scope

The Radiation Safety Policy and Procedures will apply to all activities which utilize radioisotopes and radiation emitting devices including

(1) University teaching programs and University research projects

(2) research involving the use of University facilities

(3) research funded by other agencies through the University

(4) any other projects that the Committee deems are within the jurisdiction of the Committee.

3. Authority and Responsibilities of the University Radiation Safety Committee

3.1 Authority

The Committee has authority from the Principal to recommend

(1) the procedures for the authorization and control of the use of radioisotopes and radiation producing devices at the University in compliance with the Canadian Nuclear Safety Act, the consolidated or individual licences issued by the Canadian Nuclear Safety Commission (CNSC) and the Regulation Respecting X-ray Safety made under the Occupational Health and Safety Act.

(2) the suspension, when necessary, of the use of any radioisotope or radiation producing devices at the University, regardless of the source of authorization.

3.2 Responsibilities

The Committee is responsible for

(1) developing University policy with respect to the safe use of radioactive materials and techniques capable of producing hazardous emissions, including: X-rays, lasers and electromagnetic radiations, such as microwave and other potentially hazardous emissions such as ultrasound

(2) advising the University, its faculties, departments, cross-appointees and researchers of the Committee's policy and of the special requirements relating to research and transport of the above materials and devices

(3) making recommendations to the University, through the Vice-Principal (Operations and Finance), concerning the actions to be taken on specific aspects of radiation matters as they arise

(4) advising the development of appropriate procedures for the handling of emergency situations relating to radiation within the University

(5) providing at appropriate intervals to the University and to external agencies, as required, reports on

    i) situations and activities involving radiation

    ii) all radiation incidents and accidents that require reports on safety aspects

(6) acting as a resource body for the University and its staff to provide

    i) dissemination of up-to-date information regarding current AECB and other government regulations concerned with licencing, containment facilities, training procedures and other related matters as they arise

    ii) arrangement for providing monitoring facilities, through the office of Environmental Health and Safety, for both personnel and equipment

    iii) a library resource

    iv) instructional services in radiation safety technology

    v) relevant planning advice for new construction and modification of University buildings

(7) providing liaison with the Radiation Committees of the Hospitals, Royal Military College and other local institutions regarding items of mutual concern.

4. Authority and Responsibilities of University Radiation Safety Officer

4.1 Authority

1. The University Radiation Safety Officer (URSO) works under the advice of and reports to the Chair of the Radiation Safety Committee and the Director of Environmental Health and Safety on all matters pertaining to radiation safety. The URSO is to assume control in any emergency involving radiation hazards and to take such actions as may be necessary to ensure the safety of personnel, property, and equipment, and report these actions at the earliest possible time to the Chair of the Radiation Safety Committee. The URSO has the authority to shut down, temporarily, any process or laboratory that he or she considers to be in violation of University policy or CNSC regulations.

2. The URSO has the authority to enter research areas to conduct tests required for monitoring safe handling and disposal of radiation sources.

3. The URSO is required to report to the Radiation Safety Committee or to its Executive, at the discretion of the Chair, on his or her activities, including advice given and actions taken or recommended.

4.2 Responsibilities

The URSO is responsible for

1. administering the policy of the University and its Radiation Safety Programme and acting as liaison with the CNSC and other regulatory agencies.

2. advising the Radiation Safety Committee on new and proposed Federal and Provincial legislation or items which may affect the use of radiation on campus.

3. preparing renewal applications to the CNSC and preparing any other application as required bt the CNSC.

4. preparing the annual reports to the CNSC and preparing any other reports as required by the CNSC.

5. serving as the Radiation Safety Committee representative when plans are being formulated for new radiation laboratory facilities or alterations to existing laboratories.

6. providing at appropriate intervals to the University and to external agencies, as required, reports on
   i. situations and activities involving radiation;
   ii. all radiation incidents and accidents that require reports on safety aspects.

7. Notifying the CNSC of any condition listed in the Department of Environmental Health and Safety's *SOP-Radiation 04 Notification to CNSC*.

8. Develop and implement administrative controls or procedures to ensure radiation safety and compliance with regulatory requirements.

9. supervising the technical and support staff of Environmental Health and Safety in the matter of radiation safety activities.

10. distributing documents outlining policies and procedures which detail the acquisition and handling, control and disposal of radioactive materials.

11. reviewing all applications for Radioisotope Users' Permits. The URSO will approve all Permits unless they are of an unusual or complex nature. These permits applications will be submitted, with recommendations, to the Radiation Safety Committee for consideration.

12. maintaining files on all activities involving radioactive materials and sources of hazardous radiation. These files include lists of designated laboratories, permits, permit approved isotopes with limits and users.

13. providing and supervising educational programmes on radiation safety for University personnel

14. reviewing orders for the purchase of radioactive materials and other radiation sources and ensuring that they are in compliance with the CNSC licence and University policies.

15. ensuring that personnel who accept radioisotopes from public carriers are trained as per Queen’s University Policy SOP-CHEM-02 *Transportation of Dangerous Goods Procedures*.

16. maintaining a campus-wide inventory, including the Waste Transfer Station, of radioactive materials by permit. This will be updated regularly by checking purchase orders and disposal records for radioactive material and by cross-reference with inventories held by users, as necessary.

17. supervising a radioactive waste collection and disposal service in accordance with established procedures. This will include assuming responsibility for the proper handling of any radioactive substance which cannot be identified as the responsibility of another individual or Department.

18. administering the Health Canada personnel dosimeter service and maintaining all necessary records

19. inspecting and surveying laboratories and other workplaces where radioisotopes, or any other radiation emitting devices are used.

20. ordering and supervising decontamination procedures when radiation accidents are reported.

5. University Permits

Permits for the use of radioisotopes and radiation emitting devices will be issued by the Committee to qualified persons under the Consolidated University Licence granted by

CNSC. These permits do not permit experiments directly involving human subjects where more than an exemption quantity is used **and** unless specifically authorized.

6. Responsibilities of the Permit Holders and Delegation of Responsibility

6.1 Permit holders must have experience in the handling of radiation emitting sources and materials. Each permit holder is responsible for

1) ensuring that the conditions stated in the radioisotope permit are fulfilled

2) arranging for adequate facilities, equipment, instruments, supervision and instruction in compliance with the University's radiation protection policies. The normal sources of financing research support, both inside and outside the University, should be solicited

3) establishing a laboratory procedure to ensure that when working with an open source

   i) survey measurements have established that external radiation and contamination levels are within permissible limits

   ii) radiation sources are properly labelled and stored

   iii) experiments that will be in progress after normal working hours will be properly attended

   iv) each laboratory is secured against unauthorized access

4) reporting all radiation incidents to the URSO in accordance with Radiation Committee Policy and Procedures (see Appendix 14)

5) instructing all workers, prior to employment in radiation laboratories, to make them aware of the potential hazards of radiation, including genetic effects and ensure that all workers have completed the University Radiation Safety Course.

6) maintaining an inventory of radioactive materials used in his or her research projects, and ensuring that the possession limits are not exceeded

7) keeping records of the disposal of radioactive material

8) ensuring that all persons wear appropriate protective equipment, radiation monitoring badges and/or pocket dosimeters as required

9) allowing only authorized persons to enter rooms that are specified as restricted areas

10) ensuring that the URSO has an up-to-date listing of all radioisotope users authorized by the permit

11) posting of warning signs and labels as required by the Canadian Nuclear Safety Commission Regulations and the Radiation Committee Policy and Procedures.

6.2 Delegation of Responsibilities by Permit Holders

Every application for a permit requires the applicant to name the persons who will be using the radioactive materials, the authorized users. There may be circumstances where the permit holder is not listed as an authorized user or else is absent from the laboratory for a prolonged time. In both these circumstances, the responsibilities of the permit holder, as set out above, must be delegated. Permission of the Radiation Safety Committee must be obtained before the responsibilities can be delegated and the Head of the Department must agree to the proposed delegation.

Some responsibilities of a permit holder may be delegated to any qualified person who is an employee. These responsibilities are of an administrative nature and include items 6-11 in the list of responsibilities of a permit holder. Items 1-5 from the list of responsibilities require financial and professional decisions from an employee who can be held accountable. In most circumstances, this could only be a permit holder who works as an authorized user in a laboratory or a technically qualified employee as defined below.

The Radiation Safety Committee will follow the general policy outlined below to reach a decision concerning the delegation of responsibilities by a permit holder. Each request will be considered on its own merits and a final decision will be made only after taking extenuating circumstances into account.

All responsibilities of a permit holder may be delegated to a technically qualified employee of the University who also holds either a letter of appointment from the Principal or is an employee who would qualify as an "Internal Applicant" as defined by Human Resources. In many circumstances, these conditions would exclude technicians and assistants paid from research grants or contracts. Graduate and undergraduate students are also excluded.

7. Responsibilities of Radioisotope Workers

Each individual who uses radioactive material is responsible for complying with the Radiation Committee Policy and Procedures, and with those established for the permit holder's radioisotope permit.

8. Users of X-ray Equipment

Users of X-ray equipment are responsible for complying with the University Radiation Committee's Policy and Procedures, the Occupational Health and Safety Act, its Regulations and also the owner's instructions regarding the use of the X-ray producing equipment.

RADIATION SAFETY

PROCEDURES

9. Obtaining a Permit

9.1 New Permits

(1) Complete in full the form "Application for a Radioisotope User's Permit" (Appendix 8) and forward the form to the URSO. The application form is also available at http://www.safety.queensu.ca/safety/radiation/forms/radpermitapp.pdf A permit is not required to use the SLOWPOKE-2 facilities at R.M.C. However radioactive material generated by the facility may not be brought back to the University unless the user has a valid Radioisotope User's Permit.

(2) The applications will be reviewed by the URSO.

(3) If approved by the URSO/Committee, a permit will be issued, signed by the University Radiation Safety Officer.

(4) One copy of the approved permit will be forwarded to the applicant and another copy will be filed by the Department of Environmental Health and Safety.

NOTE: Strict adherence to the conditions of approval for each and every permit is mandatory. Failure to comply can result in suspension or cancellation of individual permits and may also seriously jeopardize the continuance of the University's consolidated licence.

9.2 Amendments to Permits

(1) Amendments may be obtained by e-mailing or writing the URSO. Major amendments may require the approval of the Radiation Safety Committee

9.3 Renewal of Permits

(1) Each permit has an expiry date to be specified on the permit.

(2) Not less than four weeks before this date, the URSO will send a renewal package to each permit holder. The permit holder shall forward a completed "Application for a Radioisotope Permit Renewal" to the Department of Environmental Health and Safety. This form must also be signed by the department head.

(3) Renewal without major amendments may be granted by the URSO.

(4) Renewal with major amendments will be referred for approval to the Committee.

10. Purchasing Radioisotopes

10.1 In order to prevent delays and to keep the ordering as simple as possible, while at the same time maintaining a system of control which the CNSC demands, investigators are requested to place their orders in the following manner.

10.2 Place orders through the Financial Services Web Site. Permit number must be included under section "**Additional Information**". Ensure that **06** Radioisotopes is selected under "**Commodity Numbers**".

10.3 Suppliers will be asked to deliver directly to the investigator's department and to forward invoices to the Purchasing Department. Arrangements for payment will be made directly between the purchaser and the Purchasing Department.

11. Record Keeping

In broad terms any records involving the purchase, handling or disposal of isotope that are generated or produced should be kept on file.

Records may not be disposed of until permission has been received from the URSO. The URSO must give the CNSC a 90-day notice prior to disposal of prescribed records.

11.1 Inventory

Inventory records must be kept. One record is required for every vial of isotope ordered. Forms must be filled out upon receipt of product. A copy of the purchase order, packing slips, Transport of Dangerous Goods documents and any other documents associated with the order must be attached to the inventory form. (See Appendix 11 for a copy of the standard Inventory Form).

11.2 Flow Sheets

The one instrument that links the entire record-keeping process is the flow sheet. Beginning with the amount of product used and ending with an accurate record of the waste(s) produced. A flow sheet must be developed and kept for each and every procedure that is to be carried out in the laboratory. In most cases the protocol will have to be investigated only one time on a step-wise basis so that the flow sheet can provide a record of the movement of isotopic activity through the procedure. Direct measurements (printouts must be kept) should be made of the activity of all side and end products and must be detailed in writing. Where appropriate, manufacturers specifications for percentage of incorporation may be used, however, direct measurements are generally more accurate.

11.3 Waste Logs

Waste logs must be kept to detail all wastes disposed of via the sewer or Environmental Health and Safety. Separate logs should be made for individual bags of waste. Information contained in the waste log should be cross-referenced with information from the flow sheet. Logs must be sufficiently detailed so that the activity of the contents of any given bag of waste can be accurately demonstrated.

12. Disposal of Radioisotopes (see Appendices 9 and 13)

12.1 Radioactive material is the responsibility of the holder of the permit while it is in his or her possession. The methods for radioactive waste disposal will be outlined specifically on the permit. All radioactive waste is disposed of via the Department of Environmental Health and Safety.

12.2 Wastes shall be handled as follows:

(1) radioisotopes with short half-lives must be stored until they can be disposed of as in 12.3 and Appendix 13;

(2) other radioisotopes must be safely stored until they are disposed of by an approved method. Environmental Health & Safety has a limited storage space. Please ask the URSO to arrange for the use of this storage space.

12.3 Disposal of waste

(1) Laboratory personnel will package dry waste and/or scintillation solvent in such a way to prevent contamination to handlers and will ensure that the activity measured at surface is less than 0.1 mSv/hr gamma or 1 mSv/hr beta (1 mSv=100 mrem).

(2) Fill out the approved disposal tag (yellow) and attach one to each package.

12.4 When radioactive wastes that cannot be dealt with by methods outlined in 12.3 occur, the permit holder is responsible for ensuring that wastes which may be hazardous apart from their radioactivity can be disposed of safely and in accordance with any regulation governing the disposal of such substances. The presence of these wastes should be brought to the attention of the URSO. All waste material should be packaged carefully for disposal and should not present a hazard to anybody who may handle the containers (e.g. articles such as broken glass and used syringes must not be able to puncture the package).

12.5 Dry solid wastes originating in the laboratory consist of a wide variety of combustible and non-combustible materials. All solid waste must be disposed of through the Department of Environmental Health & Safety.

12.6 Aqueous radioactive waste must be stored in a separate secure container.

12.7 Flammable Liquid Radioactive Wastes

By far the greatest proportion of flammable liquid radioactive wastes produced on campus are liquid scintillation solvents. Although the radiation health hazard from these solvents is minimal they do present other hazards common to organic solvents. Scintillation liquid shall be disposed of according to Appendix 13.

12.8 Animal Carcasses

Animal carcasses containing radioisotopes may be disposed of as:

(1) non-radioactive carcasses, provided that the activity per kg. of body weight is less than one scheduled quantity as shown in Appendix 2. After appropriate labelling as radioactive carcasses, the animals containing radioisotopes may be taken from the secure place and disposed of through the normal system;

(2) carcasses containing short-lived radioisotopes shall be placed in sealed plastic bags and stored in a refrigerated secure place in the laboratory until the levels of activity permit disposal as non-radioactive carcasses;

(3) carcasses containing radioisotopes with longer half-lives at levels greater than one scheduled quantity per kilogram are to be stored in a refrigerated secure place until arrangements can be made with the URSO for their disposal.

12.9 All permit holders will keep up-to-date records of the purchases, uses, storage, and disposal of all radioactive material used in their laboratories. (see section 11 for details).

13. Contamination Control (see Appendix 12)

All laboratories must be monitored weekly for removable surface contamination when open source radioisotopes are in use. A written record of results will be maintained by the permit holder. Monitoring systems will include either direct methods or indirect methods or both.

13.1 Sealed Sources (see Appendix 15)

Sealed sources shall be tested as required by our licence for leaks or following any incident that could result in source damage. The URSO will ensure that all applicable Nuclear Substances and Radiation Devices Section 18 leak test requirements are be complied with. Leak testing will be conducted by the Department of Environmental Health and Safety. Records of tests will be kept, and any incident or leak will be reported to the URSO.

14. Decontamination of Work Areas and Equipment

It is self-evident that good working habits and good housekeeping will prevent most contamination incidents and circumvent the need for decontamination. For example, disposable absorbent bench coverings and working on trays will limit the spread of contamination. When decontamination is required, the procedures detailed in Appendix 14 should be used.

15. Personal Decontamination

The URSO must be informed of all cases of personal contamination immediately. If a person is suspected of being contaminated, locate the contaminated area with a survey meter, if possible. If external contamination is present and the skin is not broken, flush copiously with water and then wash the area with a mild nonabrasive detergent or soap such as Ivory. Work the lather into the contaminated area by rubbing gently for about 3 minutes and then rinse thoroughly with lukewarm water. Repeat the procedure twice if necessary. If the skin is broken in the contaminated area, swab the area with wet swabs taking care not to spread the activity over the body or into the wound.

16. General Rules for Working with Radioisotopes

(For specific radioisotopes - see Appendix 4)

To reduce the possibility of accidental ingestion of radioisotopes the following rules must be observed by all personnel.

(1) There will be no smoking, eating or storage of food in any area containing radioactive material.

(2) There will be no mouth pipetting of solutions containing radioactive material.

(3) Whenever practical, the user should perform a trial experiment using stable or low activity material to establish the adequacy of the procedures and equipment.

(4) Prior to performing an operation on a source of radioactive material, radiation levels will be measured. Handling tongs or a suitable remote handling device must be used for handling any source or container which emits, at contact, a dose rate in excess of 10 uSv/hr (1 mrem/hr).

(5) When performing operations that might produce airborne contamination (e.g. boiling, evaporating, sanding or grinding), work shall be carried out in a fume hood.

(6) A glove box should be used for work involving dry radioactive powdered material.

(7) When hand or clothing contamination is possible, protective gloves and clothing shall be worn.

(8) After handling unsealed radioactive material, hands shall be washed before leaving the laboratory and clothes, shoes and hands should be monitored for contamination.

(9) Whenever possible, work with radioactive material shall be carried out using trays lined with disposable absorbent material.

(10) Objects and equipment used in work with radioactive material shall not be used for other purposes and shall be surveyed for contamination prior to removal from the laboratory.

17. Personal Dosimetry

Everyone working with radioisotopes must be registered as an authorized user with the URSO. Where appropriate, thermoluminescent dosimeter badges shall be worn. These badges are issued and processed by the Radiation Protection Branch of Health Canada. The URSO will assist in obtaining these badges. Thermoluminescent dosimeters do not monitor low energy beta emission isotopes (e.g. ^{3}H, ^{14}C or ^{45}Ca). Workers using such isotopes may be required to submit biological samples.

18. Laboratory Decommissioning (See Appendix 19)

Before a Permit Holder leaves the University, moves their laboratory, or wishes to cancel their internal permit their laboratories must be decommissioned as per Environmental Health and Safety Policy SOP-LAB-04 (Laboratory Decommissioning). Please refer to Appendix 19 for contamination control criteria.

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APPENDICES

MEASUREMENT UNITS CONVERSION TABLE

Système International (SI) Units

* 1 Bq = 1 disintegration/second

The curie (Ci) is replaced by the becquerel (Bq)*

1	kilocurie (kCi)	=	37	terabecquerels (TBq)
1	curie (Ci)	=	37	gigabecquerels (GBq)
1	millicurie (mCi)	=	37	megabecquerels (MBq)
1	microcurie (µCi)	=	37	kilobecquerels (kBq)
1	nanocurie (nCi)	=	37	becquerels (Bq)

The becquerel (Bq)* replaces the curie (Ci)

1	terabecquerel (TBq)	=	27	curies (Ci)
1	gigabecquerel (GBq)	=	27	millicuries (mCi)
1	megabecquerel (MBq)	=	27	microcuries (µCi)
1	kilobecquerel (kBq)	=	27	nanocuries (nCi)
1	becquerel (Bq)	=	27	picocuries (pCi)

The rem (rem) is replaced by the sievert (Sv)

1	kilorem (krem)	=	10	sieverts (Sv)
1	rem (rem)	=	10	millisieverts (mSv)
1	millirem (mrem)	=	10	microsieverts (µSv)
1	microrem (µrem)	=	10	nanosieverts (nSv)

The sievert (Sv) replaces the rem (rem)

1	sievert (Sv)	=	100	rems (rem)
1	millisievert (mSv)	=	100	millirems (mrem)
1	microsievert (µSv)	=	100	microrems (µrem)
1	nanosievert (nSv)	=	100	nanorems (nrem)

The rad (rad) is replaced by the gray (Gy)

1	kilorad (krad)	=	10	grays (Gy)
1	rad (rad)	=	10	milligrays (mGy)
1	millirad (mrad)	=	10	micrograys (µGy)
1	microrad (µrad)	=	10	nanograys (Gy)

The gray (Gy) replaces the rad (rad)

1	gray (Gy)	=	100	rads (rad)
1	milligray (mGy)	=	100	millirads (mrad)
1	microgray (µGy)	=	100	microrads (µrad)
1	nanogray (Gy)	=	100	nanorads (nrad)

EXEMPTION QUANTITIES

ISOTOPE	Bq	uCi	ISOTOPE	Bq	uCi
Americium 241	1×10^{3}	2.7×10^{-2}	Dysprosium 159	1×10^{6}	2.7×10
Americium 243	1×10^{3}	2.7×10^{-2}	Erbium 169	1×10^{6}	2.7×10
Antimony 124	1×10^{4}	2.7×10^{-1}	Erbium 171	1×10^{4}	2.7×10^{-1}
Antimony 125	1×10^{5}	2.7	Fluorine 18	1×10^{4}	2.7×10^{-1}
Arsenic 73	1×10^{5}	2.7	Gadolinium 153	1×10^{4}	2.7×10^{-1}
Arsenic 74	1×10^{4}	2.7×10^{-1}	Gallium 67	1×10^{6}	2.7×10
Arsenic 76	1×10^{4}	2.7×10^{-1}	Gallium 68	1×10^{4}	2.7×10^{-1}
Barium 131	1×10^{5}	2.7	Germanium 68	1×10^{4}	2.7×10^{-1}
Barium 133	1×10^{5}	2.7	Gold 195	1×10^{5}	2.7
Barium 140	1×10^{4}	2.7×10^{-1}	Gold 198	1×10^{4}	2.7×10^{-1}
Beryllium 7	1×10^{6}	2.7×10	Hydrogen 3	1×10^{9}	2.7×10^{4}
Bismuth 206	1×10^{5}	2.7	Indium 111	1×10^{5}	2.7
Bismuth 207	1×10^{5}	2.7	Indium 113 m	1×10^{5}	2.7
Bismuth 210	1×10^{4}	2.7×10^{-1}	Indium 115	1×10^{5}	2.7
Bromine 82	1×10^{5}	2.7	Iodine 123	1×10^{7}	2.7×10^{2}
Cadmium 107	1×10^{7}	2.7×10^{2}	Iodine 125	1×10^{6}	2.7×10
Cadmium 109	1×10^{6}	2.7×10	Iodine 129	1×10^{6}	2.7×10
Cadmium 113 m	1×10^{4}	2.7×10^{-1}	Iodine 131	1×10^{4}	2.7×10^{-1}
Cadmium 115	1×10^{4}	2.7×10^{-1}	Iridium 192	1×10^{4}	2.7×10^{-1}
Cadmium 115 m	1×10^{4}	2.7×10^{-1}	Iron 52	1×10^{4}	2.7×10^{-1}
Calcium 45	1×10^{6}	2.7×10	Iron 55	1×10^{6}	2.7×10
Calcium 47	1×10^{4}	2.7×10^{-1}	Iron 59	1×10^{5}	2.7
Carbon 11	1×10^{5}	2.7	Krypton 77	1×10^{10}	2.7×10^{5}
Carbon 14	1×10^{8}	2.7×10^{3}	Krypton 85	1×10^{11}	2.7×10^{6}
Cerium 139	1×10^{6}	2.7×10	Krypton 87	1×10^{10}	2.7×10^{5}
Cerium 141	1×10^{6}	2.7×10	Lead 210	1×10^{4}	2.7×10^{-1}
Cerium 144	1×10^{5}	2.7	Magnesium 28	1×10^{4}	2.7×10^{-1}
Cesium 134	1×10^{5}	2.7	Manganese 52	1×10^{5}	2.7
Cesium 134 m	1×10^{7}	2.7×10^{2}	Manganese 54	1×10^{5}	2.7
Cesium 137	1×10^{4}	2.7×10^{-1}	Mercury 203	1×10^{5}	2.7
Chlorine 36	1×10^{4}	2.7×10^{-1}	Molybdenum 99	1×10^{4}	2.7×10^{-1}
Chlorine 38	1×10^{4}	2.7×10^{-1}	Nickel 59	1×10^{8}	2.7×10^{3}
Chromium 49	1×10^{5}	2.7	Nickel 63	1×10^{7}	2.7×10^{2}
Chromium 51	1×10^{6}	2.7×10	Nickel 65	1×10^{4}	2.7×10^{-1}
Cobalt 56	1×10^{5}	2.7	Niobium 95	1×10^{5}	2.7
Cobalt 57	1×10^{5}	2.7	Nitrogen 13	1×10^{5}	2.7
Cobalt 58	1×10^{5}	2.7	Oxygen 15	1×10^{6}	2.7×10
Cobalt 58 m	1×10^{7}	2.7×10^{2}	Phosphorous 32	1×10^{4}	2.7×10^{-1}
Cobalt 60	1×10^{5}	2.7	Phosphorous 33	1×10^{6}	2.7×10
Copper 60	1×10^{5}	2.7	Polonium 210	1×10^{4}	2.7×10^{-1}
Copper 64	1×10^{5}	2.7	Potassium 42	1×10^{4}	2.7×10^{-1}
Copper 67	1×10^{5}	2.7	Promethium 147	1×10^{7}	2.7×10^{2}

ISOTOPE	Bq	uCi	ISOTOPE	Bq	uCi
Radium 226	1 x 10^4	2.7 x 10^{-1}	Thallium 201	1 x 10^6	2.7 x 10
Rubidium 86	1 x 10^4	2.7 x 10^{-1}	Thallium 204	1 x 10^4	2.7 x 10^{-1}
Samarium 153	1 x 10^4	2.7 x 10^{-1}	Thorium 232	1 x 10^2	2.7 x 10^{-3}
Scandium 46	1 x 10^5	2.7	Tin 113	1 x 10^5	2.7
Scandium 47	1 x 10^5	2.7	Uranium (natural)	1 x 10^4	2.7 x 10^{-1}
Selenium 75	1 x 10^5	2.7	in dispersable form		
Selenium 79	1 x 10^7	2.7 x 10^2	Uranium (natural)	1 x 10^7	2.7 x 10^2
Sodium 22	1 x 10^4	2.7 x 10^{-1}	in non-dispersable form		
Sodium 24	1 x 10^4	2.7 x 10^{-1}	Xenon 123	1 x 10^{11}	2.7 x 10^6
Strontium 85	1 x 10^5	2.7	Xenon 129 m	1 x 10^{11}	2.7 x 10^6
Strontium 87 m	1 x 10^5	2.7	Xenon 133	1 x 10^{11}	2.7 x 10^6
Strontium 89	1 x 10^4	2.7 x 10^{-1}	Xenon 135	1 x 10^{10}	2.7 x 10^5
Strontium 90	1 x 10^4	2.7 x 10^{-1}	Yttrium 90	1 x 10^4	2.7 x 10^{-1}
Sulphur 35	1 x 10^8	2.7 x 10^3	Zinc 65	1 x 10^6	2.7 x 10
Technetium 99	1 x 10^6	2.7 x 10	Zirconium 95	1 x 10^5	2.7
Technetium 99 m	1 x 10^7	2.7 x 10^2			

"Exemption Quantity (EQ)" means

a) in respect of a radioactive nuclear substance set out in column 1 (ISOTOPE), the corresponding quantity set out in column 2 (Bq) of the schedule;

(b) in respect of a radioactive nuclear substance that is not set out in column 1 of the schedule,
   (i) 10 kBq, where the atomic number of the substance is equal to or less than 81,
   (ii) 10 kBq, where the atomic number of the substance is greater than 81 and the substance, or its short-lived radioactive progeny, does not emit alpha radiation, and
   (iii) 500 Bq, where the atomic number of the substance is greater than 81 and the substance or its short-lived radioactive progeny emits alpha radiation; and

(c) in respect of more than one radioactive nuclear substance, any combined quantity of those substances in which the sum of the quotients obtained by dividing the quantity of each substance by its corresponding exemption quantity, as to in paragraphs (a) and (b), is equal to, or greater than one.

LABORATORY CLASSIFICATION

Level of Radioisotope Laboratory	**Permissible Quantity of Radioactivity**
Storage	Stored without manipulation
Basic	Does Not Exceed 5 times corresponding ALI
Intermediate	Does Not Exceed 50 times corresponding ALI
High	Does Not Exceed 500 times corresponding ALI
Containment	Exceeds 500 times corresponding ALI

* See Appendix 17 Annual Limit of Intake (ALI)

GENERAL GUIDELINES AND PRECAUTIONS FOR THE USE OF SPECIFIC RADIOISOTOPES

Low Energy beta-emitters

Low energy beta radiation is blocked readily by the skin or by plastic film or paper. Thus it poses no radiation hazard unless it is ingested and enters body cells where it can exert its effects at very short distances. Dosimeter badges are not needed or required. It is important to take precautions to prevent ingestion or inhalation. Good work habits and frequent wipe checks for surface contamination are essential. Specific problems with individual radioisotopes include:

Tritium - Radiolytic breakdown of labelled compounds is common. The consequent release of either tritium gas or tritiated water vapour can pose a hazard in poorly ventilated areas. Tritiated borohydride is quite unstable and must always be opened and handled inside a fume hood.

Carbon-14 - Most compounds are quite stable and need only to be protected from bacterial breakdown. The common exceptions are bicarbonate and carbonate compounds. These compounds must be stored in a well ventilated area and must always be opened and handled inside a fume hood.

Sulphur-35 - All compounds in common use are stable and need only be protected from bacterial breakdown. Waste should be stored in a well ventilated area and discarded immediately if there is any smell of hydrogen sulphide. When labelling cells in culture with ^{35}S-methionine, (a relatively common biochemical technique), ^{35}S contaminated gases are often produced. Therefore, the culture should be placed in a plastic bag with activated charcoal and the incubator monitored for contamination.

Calcium-45 - All compounds in common use are very stable. Cleaning of contaminated surfaces is difficult and is best accomplished with mild acid (acetic) and chelators.

High Energy Beta-emitters (eg Phosphorous-32, Chlorine-36)

High energy beta radiation (high velocity electrons) penetrates skin readily. Whole body dosimeter badges must be worn. As well, the high velocity electrons displace orbital electrons from molecules and cause the emission of low-energy X-rays called bremsstrahlung. This displacement effect is more efficient in dense materials. Thus it is necessary to shield high energy beta radiation with low density shielding. About 1 cm of plastic or wood is effective shielding for either Phosphorus-32 or Chlorine-36. Substantial irradiation of the hands can occur when these radioisotopes are handled. It is mandatory to wear finger badges if more than 1.35 mCi of Phosphorus-32 is handled and finger badges are recommended if amounts of more than 135 µCi are handled. Good work habits are essential to prevent accidental ingestion. Contamination checks are most conveniently done with a standard survey meter with a common Geiger-Muller detector.

Radioactive Iodine

The two most commonly used radioactive isotopes of iodine are Iodine-125 and Iodine-131. They both emit gamma-radiation and dosimeter badges must be worn. By coincidence the long half-life of 60 days for Iodine-125 is compensated by its very low energy gamma radiation as far as biological effects are concerned and its toxicity is about the same as Iodine-131 which has a short half-life, but a much higher energy gamma radiation. Thus the radiation hazard from Iodine-125 is easily eliminated by only one mm of lead. But if it is ingested the effect upon the thyroid gland, where iodine is concentrated, is the same as the effect of Iodine-131.

It is very important to prevent ingestion or inhalation of radioactive iodine. Accidental ingestion can be prevented by good work habits and by frequent checks for surface contamination. A standard survey meter with a Geiger-Muller detector will detect Iodine-131 but Iodine-125 can be detected only with a special NaI crystal detector. Wipe tests are the easiest way to detect whether surfaces are contaminated with Iodine-125.

Iodine vapourizes readily and can be inhaled when it is in the I_2 state. When iodine is bound to organic molecules or when it is in the reduced ionic state, it does not vapourize. All reactions which are employed to label organic molecules with radioactive iodine require the iodine to be in the volatile I_2 state. <u>Great care must be taken to prevent the escape of radioactive iodine vapours</u> during these reactions. It is mandatory that

i. all reactions be carried out in an approved fume hood (NOTE: All fumehoods in Intermediate laboratories at Queen’s meet this criteria).

ii. all subsequent purification of labelled products be carried out either in alkaline, reducing conditions or be done in a fume hood

iii. double gloves must be worn and the outer pair must be discarded between steps in the procedure.

RADIOTOXICITY OF RADIOISOTOPES*

Table 1

Radiotoxicity of the Individual Radionuclides	Permissible Level of Activity (for Normal Chemical Operations)
Very High	5 MBq (135 µCi)
High	500 MBq (13.5 mCi)
Moderate	** 5 GBq (135 mCi)
Slight	50 GBq (1.35 Ci)

* Radiotoxicity is defined as potential toxicity following ingestion, inhalation and absorption.

** Except for Mo/^{99m}Tc generators and ^{99m}Tc eluate, for which the permissible activity is 100 GBq (3Ci)

Table 2

Relative Radiotoxicity* and Physical
Half Life of some Radioisotopes

1. Very High Radiotoxicity

Actinium 227	(21.2 years)
Americium 241	(458 years)
Americium 243	(7,650 years)
Californium 249	(360 years)
Californium 250	(10 years)
Californium 252	(2.6 years)
Curium 242	(163 days)
Curium 243	(32 years)
Curium 244	(17.6 years)
Curium 245	(9,320 years)
Curium 246	(5,480 years)
Lead 210	(21 years)
Neptunium 237	($2.1x10^6$years)
Plutonium 238	(89 years)
Plutonium 239	($2.4x10^4$years)
Plutonium 240	(6,760 years)
Plutonium 241	(13 years)
Plutonium 242	($3.8x10^5$years)
Polonium 210	(138 days)
Protactinium 231	($3.2x10^4$years)
Radium 223	(11.7 days)
Radium 226	(1,620 years)
Radium 228	(6.7 years)
Thorium 227	(18.2 days)
Thorium 228	(1.9 years)
Thorium 230	($7.6x10^4$years)
Uranium 230	(20.8 days)
Uranium 232	(73.6 years)
Uranium 233	($1.6x10^5$years)
Uranium 234	($2.5x10^5$years)

*Appendix I, "Safety Code; Laboratory Facilities for Handling Radioisotopes" Bulletin RPB-SC-12, Health and Welfare Canada 1976

2. High Radiotoxicity

Actinium 228	(6.1 hours)
Antimony 124	(60 days)
Antimony 125	(2.7 years)
Astatine 211	(7.2 hours)
Barium 140	(12.8 days)
Berkelium 249	(314 days)
Bismuth 207	(30 years)
Bismuth 210	(5.0 days)
Cadmium 115m	(43 days)
Calcium 45	(165 days)
Cerium 144	(285 days)
Cesium 134	(2.1 years)
Cesium 137	(30 years)
Chlorine 36	($3x10^{5}$years)
Cobalt 56	(77 days)
Cobalt 60	(5.3 years)
Europium 152	(13 years)
Europium 154	(16 years)
Hafnium 181	(45 days)
Indium 114m	(50 days)
Iodine 124	(4.2 days)
Iodine 125	(57 days)
Iodine 126	(132.2 days)
Iodine 131	(8.0 days)
Iodine 133	(21 hours)
Iridium 192	(74 days)
Lead 212	(10.6 hours)
Manganese 54	(314 days)
Protactinium 230	(17 days)
Radium 224	(3.6 days)
Ruthenium 106	(1.0 years)
Scandium 46	(84 days)
Silver 110m	(249 days)
Sodium 22	(2.6 years)
Strontium 89	(50 days)
Strontium 90	(28 years)
Tantalum 182	(115 days)
Tellurium 127m	(105 days)
Tellurium 129m	(33 days)
Terbium 160	(73 days)
Thorium 234	(24.1 days)
Thulium 170	(127 days)
Uranium 236	($2.4x10^{7}$ years)
Yttrium 91	(59 days)
Zirconium 95	(65 days)
Thallium 204	(3.8 years)

3. Moderate Radiotoxicity

Antimony 122	(2.8 days)	Iron 59	(45 days)
Argon 41	(1.8 hours)	Krypton 85m	(4.4 hours)
Arsenic 73	(76 days)	Krypton 87	(78 minutes)
Arsenic 74	(18 days)	Lanthanum 140	(40.2 hours)
Arsenic 76	(26.5 hours)	Lead 203	(52 hours)
Arsenic 77	(39 hours)	Lutetium 177	(6.8 days)
Barium 131	(11.6 days)	Manganese 52	(5.7 days)
Beryllium 7	(53 days)	Manganese 56	(2.6 hours)
Bismuth 206	(6.2 days)	Mercury 197m	(24 hours)
Bismuth 212	(60.6 minutes)	Mercury 197	(65 hours)
Cadmium 109	(1.3 years)	Mercury 203	(47 days)
Cadmium 115	(2.3 days)	Molybdenum 99	(66 hours)
Calcium 47	(4.5 days)	Meodymium 147	(11.1 days)
Carbon 14	(5730 years)	Neodymium 149	(1.8 hours)
Gerium 141	(32.5 days)	Neptunium 239	(2.4 days)
Cerium 143	(33 hours)	Nickel 63	(92 years)
Cesium 131	(9.7 days)	Nickel 65	(2.6 hours)
Cesium 136	(13 days)	Niobium 93m	(3.7 years)
Chlorine 38	(37 minutes)	Niobium 95	(35 days)
Chromium 51	(27.8 days)	Osmium 185	(94 days)
Cobalt 57	(267 days)	Osmium 191	(15 hours)
Cobalt 58	(71 days)	Osmium 193	(32 hours)
Copper 64	(12.9 hours)	Palladium 103	(17 days)
Dysprosium 165	(2.3 hours)	Palladium 109	(13.5 hours)
Dysprosium 166	(80 hours)	Phosphorus 32	(14.3 days)
Erbium 169	(9.4 days)	Phosphorus 33	(25.3 days)
Erbium 171	(7.5 hours)	Platinum 191	(3.0 days)
Europium 152m	(9.2 hours)	Platinum 193	(500 years)
Europium 155	(1.7 years)	Platinum 197	(2.0 hours)
Fluorine 18	(111 minutes)	Potassium 42	(12.4 hours)
Gadolinium 153	(200 days)	Potassium 43	(22 hours)
Gadolinium 195	(18 hours)	Praseodymium 142	(19.2 hours)
Gallium 72	(14.1 hours)	Praseodymium 143	(13.7 days)
Gold 196	(6.2 days)	Promethium 147	(2.5 years)
Gold 198	(64.8 hours)	Promethium 149	(53 hours)
Gold 199	(3.15 days)	Protactinium 233	(27.4 days)
Holmium 166	($9x10^4$ years)	Radon 220	(56 seconds)
Indium 115m	(4.4 hours)	Radon 222	(3.8 days)
Iodine 130	(12.5 hours)	Rhenium 183	(70 days)
Iodine 132	(2.3 hours)	Rhenium 186	(90 hours)
Iodine 134	(53 minutes)	Rhenium 188	(17 hours)
Iodine 135	(6.7 hours)	Rhodium 105	(36 hours)
Iridium 190	(12 days)	Rubidium 86	(18.7 days)
Iridium 194	(19 hours)	Ruthenium 97	(2.9 days)
Iron 52	(8.3 hours)	Ruthenium 103	(40 days)
Iron 55	(2.7 years)	Ruthenium 105	(4.4 hours)

3. Moderate Radiotoxicity (cont'd)

Samarium 151	(90 years)	Tellerium 132	(78 hours)
Samarium 153	(46.7 hours)	Thallium 200	(26 hours)
Scandium 47	(3.4 days)	Thallium 201	(73 hours)
Scandium 48	(44 hours)	Thallium 202	(12 days)
Selenium 75	(120 days)	Thorium 231	(25.6 hours)
Silicon 31	(2.6 hours)	Thulium 171	(1.9 years)
Silver 105	(40 days)	Tin 113	(118 days)
Silver 111	(7.5 days)	Tin 125	(9.4 days)
Sodium 24	(15 hours)	Tungsten 181	(130 days)
Strontium 85	(64 days)	Tungsten 185	(74 days)
Strontium 91	(9.7 hours)	Tungsten 187	(24 hours)
Sulfur 35	(87 days)	Vanadium 48	(16.1 days)
Technetium 96	(43 days)	Xenon 135	(9.2 hours)
Technetium 97m	(91 days)	Ytterbium 175	(4.2 days)
Technetium 97	($2.6x10^6$ years)	Yttrium 90	(64.2 hours)
Technetium 99	($2.1x10^5$ years)	Yttrium 92	(3.5 hours)
Tellerium 125m	(58 days)	Yttrium 93	(10.1 hours)
Tellerium 127	(9.3 hours)	Zinc 65	(245 days)
Tellerium 129	(67 minutes)	Zinc 69m	(14 hours)
Tellerium 131m	(1.2 days)	Zirconium 97	(17 hours)

4. Slight Radiotoxicity

Argon 37	(34.3 days)
Cesium 134m	(2.9 hours)
Cesium 135	($2x10^6$ years)
Cobalt 58m	(9 hours)
Germanium 71	(11 days)
Hydrogen 3	(12.3 years)
Indium 113m	(1.7 hours)
Iodine 129	($1.6x10^7$ years)
Krypton 85	(10.4 years)
Nickel 59	($8x10^4$ years)
Niobium 97	(72 minutes)
Osmium 191m	(14 hours)
Oxygen 15	(2 minutes)
Platinum 193m	(4.4 days)
Platinum 197m	(82 minutes)
Rhenium 187	($4x10^{10}$ years)
Rhodium 103m	(57 minutes)
Rubidium 87	($5x10^{10}$ years)
Samarium 147	($1.1x10^{11}$ years)
Strontium 85m	(70 minutes)
Technetium 96m	(52 minutes)
Technetium 99m	(6.0 hours)
Thorium 232	($1.4x10^{10}$ years)
Natural Thorium	
Uranium 235	($7x10^8$ years)
Uranium 238	($4.5x10^9$ years)
Natural Uranium	
Xenon 131m	(12 days)
Xenon 133	(5.3 days)
Yttrium 91m	(50 minutes)
Zinc 69	(55 minutes)

MAXIMUM PERMISSIBLE DOSES OF IONIZING RADIATION

Effective Dose Limits

Person	Period	Effective Dose
Nuclear Energy Worker, including a pregnant NEW	a) 1 year dosimetry period b) 5 year dosimetry period	50 mSv 100 mSv
Pregnant NEW	Balance of the Pregnancy	4 mSv
Non NEW	One Calendar Year	1 mSv

Equivalent Dose Limits

Organ or Tissue	Person	Period	Effective Dose
Lens of an eye	a) NEW b) Non NEW	1 year dosimetry period 1 calendar year	150 mSv 15 mSv
Skin	a) NEW b) Non NEW	1 year dosimetry period 1 calendar year	500 mSv 50 mSv
Hands and Feet	a) NEW b) Non NEW	1 year dosimetry period 1 calendar year	500 mSv 50 mSv

Although The Canadian Nuclear Safety Commission has set extremely conservative limits, precautions should be taken to avoid unnecessary exposures.

Currently all workers at Queen’s University are classified as **Non Nuclear Energy Workers**

MAXIMUM PERMISSIBLE LEVELS FOR RADIOACTIVE CONTAMINATION

(a) on all normally accessible working surfaces in any location where a radioactive prescribed substance is used or stored, non-fixed contamination does not exceed 5 Bq/cm^2 of substances that emit only beta or gamma radiation or 0.5 Bq/cm^2 of substances that emit alpha radiation, averaged over an area not exceeding 100 square centimetres.

(b) on all other surfaces, and prior to decommissioning any location where a radioactive prescribed substance has been used or stored, non-fixed contamination does not exceed 0.5 Bq/cm^2 of substances that emit only beta or gamma radiation or 0.05 Bq/cm^2 of substances that emit alpha radiation, averaged over an area not exceeding 100 square centimetres.

(c) the dose rate due to contamination does not exceed 0.5 µSv/h at 0.5 metre from any surface.

(d) records of all measurements shall be maintained for at least three years.

It is preferable to have no removable contamination present.

APPLICATION FOR A RADIOIOTOPE USER'S PERMIT

Appendix 8

Return Original to: University Radiation Safety Officer
Department of Environmental Health & Safety

Keep Copy

The personal information on this form is collected under the authority of the Royal Charter of 1841, as amended. Personal information collected on this form will be used to generate internal permits and to check against training records. If you have any questions or concerns about the information collected or how it will be used please contact the Environmental Health & Safety Department, Rideau Building, Room 326 by telephone at 613-533-2999

1. Applicant Information

______________________ Principal Investigator

______________________ Position

______________________ Department

______________________ Telephone

______________________ e-Mail

2 List all buildings and rooms where radionuclides will be stored or used. Indicate location of fumehoods

Building	Room	Fumehood

3 Open Source Isotopes Required

Isotope	Form	Possession Limit (uCi)	Annual Limit (uCi)

4 Sealed Source Isotopes Required

Isotope	Activity	Desciption	Manufacturer	Model #	Serial #

5 Radioisotope Users

Surname	First Name	Gender	Position	Staff/Student Number	Queen's Training	
					Radiation	WHMIS

6 Radioisotope Use

Will animals be used? ________

Will culture systems be used? ________

Will there be use on humans? (below exemption quantity of isotope) ________

If Yes attach Ethics Committee Approval

7 Details of Experiment

Supply a short description of experiment involving the above isotpes.
(Attach additional sheets if space is too small. Fully describe any human use)

8 Monitoring Equipment

Type of Detector	Manufacturer	Model No.	Serial No.

9 Project Dates

Project Start Date: ____________________ Project Termination Date : ____________________

I understand that my staff and I must abide by the Canadian Nuclear Safety Act and University regulations . Failure to comply can result in the cancellation of my permit.

____ ________________

Signature - Pricipal Investigator Date:

____ ________________

Signature - Department Head Date:

SETTING UP RADIOISOTOPE LABORATORY

After receiving you permit the following steps must be followed:

Signage

All laboratories listed on your permit must have a copy of the permit posted in a conspicuous place. All doors leading into the laboratory must have a 'Caution Radioactive Area' sign affixed to them. The AECB poster 'Radioisotope Safety Basic Laboratories' or 'Radioisotope Safety Intermediate Laboratories' must be filled in with your Permit number and telephone number and posted in each laboratory. It is highly recommended that this poster be affixed to the door.

All areas where radioisotope work is to be carried out must be so marked with radiation signage. All equipment and storage areas must also have a radiation warning sign affixed to them.

Intermediated labs must be locked when not in use. The 'Intermediate Laboratory Users's Exit Log" (see APPENDIX 16) must be posted.

Equipment

Meters, if required must be obtained. Efficiencies (for the isotopes that will be used in the laboratory) for all meters and scintillation/gamma counters must be obtained.

Training

All authorized radioisotope users must be registered in the next available Radiation Training Course, put on by the Department of Environmental Health and Safety.

Flow Chart

The one instrument that links the entire record-keeping process is the flow sheet. Beginning with the amount of product used and ending with an accurate record of the waste(s) produced. A flow sheet must be developed and kept for each and every procedure that is to be carried out in the laboratory. In most cases the protocol will have to be investigated only one time on a step-wise basis so that the flow sheet can provide a record of the movement of isotopic activity through the procedure. Direct measurements (printouts must be kept) should be made of the activity of all side and end products and must be detailed in writing. Where appropriate, manufacturers specifications for percentage of incorporation may be used, however, direct measurements are generally more accurate.

Inventory Records

Inventory records (see APPENDIX 11) must be set up. One record is required for each vial. Copies of the purchase order (if available), packing slips and any Transportation of Dangerous Goods documents must be attached to the form.

Waste Records

Waste logs must be kept to detail all wastes disposed of via the sewer or E.H.&S. Separate logs should be made for individual bags of waste. Information contained in the waste log should be cross-referenced with information from the flow sheet. Logs must be sufficiently detailed so that the activity of the contents of any given bag of waste can be accurately demonstrated.

Contamination Monitoring Records

Contamination Monitoring Records (see APPENDIX 12) must be set up. Contamination monitoring must be done at least weekly when isotopes are being used. During those periods when there is no isotope use, this inactivity must be so indicated on the forms. Printouts from scintillation/gamma counters must be attached to the Record of Contamination Monitoring.

APPENDIX 10

GUIDELINES FOR HANDLING PACKAGES CONTAINING NUCLEAR SUBSTANCES

The packaging and labelling of nuclear substances is governed by the Canadian Nuclear Safety Commission's *Packaging and Transport of Nuclear Substances (PTNS) Regulations.* Nuclear substances may be shipped in "Excepted Packages", "Type A" or "Type B" packages, "Industrial Packages I, II, III", and packages for "Fissible Materials". The "radioactive" category labels also show radiation dose rates.

On Excepted Packages no external labeling is required, and the safety mark "RADIOACTIVE" must be visible upon opening the package. The radiation level at any point on the surface must not exceed 5 μSv/h. All other packages must be categorized by radiation level and display the corresponding radiation warning labels as follows:

Category I - WHITE
Does not exceed 5 μSv/h at any location on the external surface of the package.

Category II - YELLOW
Does not exceed 500 μSv/h at any location on the external surface of the package and the transport index does not exceed 1.

Category III - YELLOW
Does not exceed 2 mSv/h at any location on the external surface of the package and the transport index does not exceed 10.

The transport index is the maximum level in microsieverts per hour at one metre from the external surface of the package, divided by 10.
Example: 1 μSv/h (0.1 mrem/h) at 1 m equals a TI= 0.1

Upon receipt of a package containing nuclear substances, keep your distance. Examine the package for damage or leakage. If the package is damaged or leaking, contain and isolate itto minimize radiation exposure and contamination, and comply with Section 19 of the Pacaging and Transport of Nuclear Substances Regulations

1. If an appropriate survey monitor is available, monitor the radiation fields around the package. Note any discrepancies.
2. Avoid unnecessary direct contact with unshielded containers.
3. Verify the nuclear substance, the quantity, and other details with the information on the packing slip and with the purchase order. Log the shipment details and any anomalies in the inventory record.
4. Report any anomalies (radiation levels in excess of the package labeling, incorrect transport index, contamination, leakage, short or wrong shipment) to the Radiation Safety Officer.

When opening packages containing unsealed nuclear substances, additional steps should be taken:

5. Wear protective clothing while handling the package.
6. If the material is volatile (unbound iodine, tritium, radioactive gases, etc.) or in a powder form, open the package in a fume hood.
7. Open the outer package and check for possible damage to the contents, broken seals, or discoloration of packing materials. If the contents appear to be damaged, isolate the package to prevent further contamination and notify the Radiation Safety Officer.
8. If no damage is evident, wipe test the inner package or primary container which holds the unsealed nuclear substance. If contamination is detected, monitor all packaging and, if appropriate, all locations in contact with the package, for contamination. Contain the contamination, decontaminate, and dispose in accordance with the conditions of the Nuclear Substances and Radiation Devices licence.

RADIOISOTOPE INVENTORY FORM

Permit Holder ___________________________ Permit Number _____________

Department ______________________________ Room No. _______________

Isotope ________ Purchase Order Number_________

Lot Number __________ Amount Purchased __________

Date dd/mm/yy	Initial of Handler	Amount used (µCi)	Amount Disposed of or Decayed (µCi)	Amount Remaining (µCi)

Please indicate method(s) used for disposal:

CONTAMINATION MEASUREMENT

Introduction

These instructions and procedures provide general guidance for monitoring radioactive contamination, and relating the monitoring results to the CNSC radioisotope licence criteria.

Each CNSC radioisotope licence authorizing the use of open source radioactive material contains a condition which states the regulatory criteria pertaining to radioactive contamination. Our licence condition is as follows:

> Contamination Criteria:
> The licensee shall ensure that for nuclear substances listed in the licence application guide table titled "Classifications of Radionuclides";
> (a) non-fixed contamination in all areas, rooms or enclosures where unsealed nuclear substances are used or stored does not exceed:
> (i) 3 bequerels per square centimetre of for all Class A radionuclides;
> (ii) 30 bequerels per square centimetre of for all Class B radionuclides; or
> (iii) 300 bequerels per square centimetre of for all Class C radionuclides;
> averaged over an area not exceeding 100 square centimetres; and
> (b) non-fixed contamination in all other areas does not exceed:
> (i) 0.3 bequerels per square centimetre of for all Class A radionuclides;
> (ii) 3 bequerels per square centimetre of for all Class B radionuclides; or
> (iii) 30 bequerels per square centimetre of for all Class C radionuclides;
> averaged over an area not exceeding 100 square centimetres.

See Appendix 18 - Classes of Nuclear Substances for a list of isotopes in each class.

Elements of a Contamination Monitoring Program

Method of Measurement

Radioactive contamination may be measured directly or indirectly. Direct measurement means the use of portable radiation detection instruments to detect both fixed and removable contamination. Direct measurement may be used when background radiation levels are negligible compared to licence criteria. Indirect measurement only detects removable contamination by means of wipe tests.

Instrument Selection

The ability of various radiation detection instruments to detect radioisotopes of interest will vary with the instrument and manufacturer. Guidance on the selection of instruments may be obtained from Environmental Health and Safety. For specific information on a particular make or model, contact the manufacturer.

Locations of Measurements

The locations that are to be monitored should be numbered on a plan of the radioisotope work area. These locations should include working surfaces (benches, countertops, fume hoods etc.), storage areas, and non-working surfaces such as floors, instruments, door handles, light switches, sink taps and telephone receivers. Several random locations should also be monitored. Too rigid a set of locations may overlook problem areas.

Instrument Checks and Calibration

Non portable instruments for counting wipes, such as liquid scintillation counters, well-crystal type gamma counters, should be routinely serviced according to the manufacturer's instructions. Keep a record of the service information and dates. A copy of this service information should be kept with your contamination monitoring records. A blank and a standard should be counted and recorded with each set of wipes.

Before monitoring for contamination, portable instruments should be given operational checks as specified by the manufacturer (battery check, response check etc.) and the background radiation level should be measured. Record the operational checks and background measurements on your contamination monitoring records.

Instruments that are not operating within the parameters of the operational checks or which show anomalous background, blank or standard measurements, should not be used until their proper operation can be verified.

Frequency of Monitoring

Contamination monitoring frequencies must conform to the requirements indicated on the appropriate CNSC Laboratory Rules Poster, or in a radioisotope licence condition. It is recommended that wipes be done on the same day each week to ensure that contamination monitoring requirements are met. (NOTE: This day should not be a Monday to avoid statutory holidays.)

Decontamination

Any area that is found to have non-fixed contamination exceeding the regulatory criteria must be cleaned and remonitored. If the area cannot be cleaned to meet the criteria, the contaminated area must be sealed, removed, or shielded until the criteria are met.

Monitoring Records

Contamination monitoring records must be kept for three years or the next CNSC inspection whichever is longer. Approval of the URSO must be obtained prior to destruction. The records must be available for inspection by the CNSC or the University Radiation and Laser Safety Officer. These records must include:

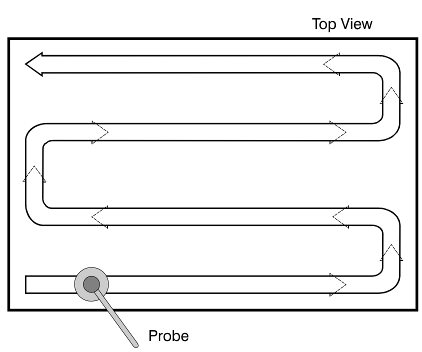
(a) date of measurement
(b) make an model of the instrument
(c) monitoring locations
(d) contamination monitoring results in Bq/cm^2 (before and after decontamination)
(e) results of operational checks and background measurements for portable instruments.
(f) blank and standard measurement results for non-portable instruments.

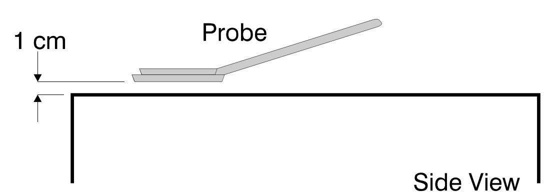
Instrument calibration data must be recorded and updated as necessary.

DIRECT MEASUREMENT OF CONTAMINATION USING PORTABLE METRE

Direct Contamination Survey Technique

- Perform operational checks on the instrument. Record results of checks.
- Select a slow response time (if the metre is so equipped) and measure and record the background count rate.
- Select the response time to a fast response time and commence to survey the surfaces marked on the plan of the working area. Start at the leading edge with the metre or probe 1 cm from the surface. Use a paint brush technique (see diagrams below), this will ensure that the entire surface is surveyed. Please note that the meter is not a 'magic wand', therefore you must survey slowly to give the metre time to respond.
- When an increase in count rate is detected, the surveyor should change ranges (if necessary) and move the meter or probe back and forth over the source at the centre. If it is a point source, the count rate will decrease as the metre or probe moves away from the source. If it is a large area source, the cross survey technique can be used to find its extent. An accurate count rate can now be obtained by slowing down the metre response time and then subtracting the background.
- Clean the area until the instrument measurement is below the licence criteria. A reading in excess of licence criteria after repeated cleaning is an indication of fixed contamination or a high radiation background.
- Record the highest measurement for each area and the final measurement after decontamination.
- If the levels of beta and gamma contamination are high enough, they may cause the metre to go off scale. This would indicate that a dose rate measurement may be required.





DETECTOR EFFICIENCY

The detector efficiency depends upon:

- the type of detector (GM, NaI Scintillation, Proportional)
- the detector size and shape
- the distance from the detector to the radioactive material
- the radioisotope and type of radiation measured (alpha, beta, gamma radiations and their energies)
- the backscatter of radiation toward the detector (the denser the surface, the more scattering)
- the absorption of radiation before it reaches the detector (by air and the detector covering)

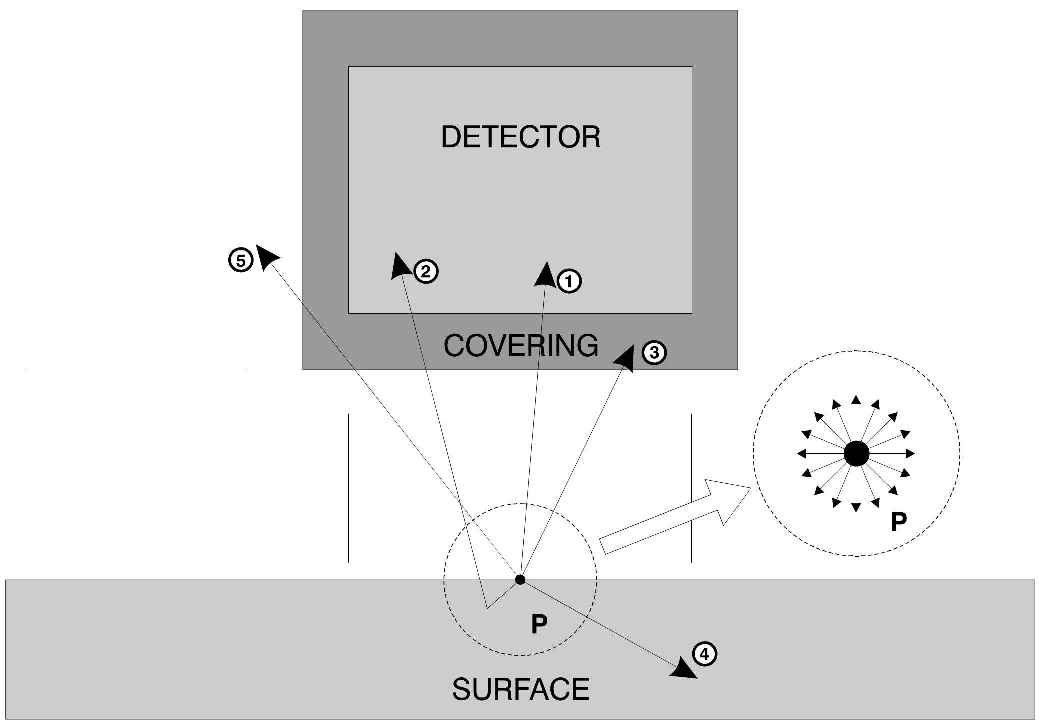
The factors effecting the efficiency are show in the diagram below.

The detector efficiency can be found by:

1. Counting a standard source of known activity with your detector.

$$\text{efficiency} = \frac{\text{(detector count rate-background count rate)}}{\text{known activity of standard source}}$$

2. Asking the manufacturer about the efficiency of the detector for specific radioisotope(s).



1. Some radiation goes directly from the radioactive material **P**, into the detector.
2. Some radiation will backscatter off the surface, into the detector.
3. Some radiation is absorbed by the detector covering.
4. Most radiation doesn't even get detected.
5. If the detector was closer, this radiation would be detected.

INDIRECT MEASUREMENT OF CONTAMINATION WITH WIPES

Indirect Contamination Measurement Technique

- Indirect removable contamination measurements are made by sampling with a wipe and measuring the activity on the wipe.
- Wipe each of the locations shown on the plan of the working area with a filter paper.
- Hold the filter paper with your thumb and forefinger and rub the smear over the surface using light pressure.
- Wipe an area of 100 cm^2 (slightly larger than the palm of your hand).
- Use only one wipe per location.
- If the wipes are counted with a contamination meter, the wipe should be smaller than or equal to the sensitive area of the detector.
- If the wipes are counted in a liquid scintillation counter, the printouts from the counter must be kept with the contamination monitoring records.
- Clean any contaminated area and remonitor.

RELATING MEASUREMENT READINGS TO REGULATORY CRITERIA

Derived Working Level (DWL) for measurements can be calculated as follows:

$$C = \frac{(N-B)}{Ex60xAx(F)}$$

Where:

C	=	Contamination Level (Bq/cm^2)
N	=	Total Counts in Counts per Minute (CPM) measured directly or on the wipe
B	=	Normal Background count rate (in CPM) from the survey instrument or on the blank)
E	=	Instrument efficiency factor (expressed as a decimal, i.e. 26% efficiency E=0.26) for the radioisotope being measured (consult the manufacturer or determine using a radioactive source with a known activity in a counting geometry similar to that used when surveying)
60	=	sec/min
A	=	area wiped (not to exceed 100 cm^2) or area of the detector in cm^2 (for direct measurements)
F	=	collection factor for the wipe (used ONLY when calculating indirect monitoring results)

If F is not determined experimentally, a value of F=.1 (i.e. 10%) shall be used

$$DWL\ (1\ Bq/cm^2) = \frac{(N-B)}{C} = \text{(cpm above background)}$$

CONTAMINATION CONTROL RECORD

PERMIT HOLDER ______________________________ PERMIT # ________

DEPARTMENT ____

ROOM # _________

ISOTOPES USED

3H ______ 14C ______

32P ______ 35S ______

125I ______ 22Na ______

______ ______

______ ______

Make and Model of Detector ____

Date Last Calibrated ______________________________

WIPES OR MONITORING MUST BE TAKEN AT LEAST ONCE A WEEK WHEN RADIOISOTOPES ARE IN USE.

THE RESULTS MUST BE RECORDED ON THE FORM
WEEKS WHEN RADIOISOTOPES ARE NOT IN USE MUST BE INDICATED ON THE FORM

RECORD OF CONTAMINATION CONTROL

Week Starting Background CPM __________ Monitor Date _____________

LOCATION	CPM	Bq/cm^2/100 cm^2	AFTER CLEANUP	COMMENTS
1	_______	_______	_______	
2	_______	_______	_______	
3	_______	_______	_______	
4	_______	_______	_______	
5	_______	_______	_______	
6	_______	_______	_______	
7	_______	_______	_______	

Week Starting Background CPM __________ Monitor Date _____________

LOCATION	CPM	Bq/cm^2/100 cm^2	AFTER CLEANUP	COMMENTS
1	_______	_______	_______	
2	_______	_______	_______	
3	_______	_______	_______	
4	_______	_______	_______	
5	_______	_______	_______	
6	_______	_______	_______	
7	_______	_______	_______	

Week Starting Background CPM __________ Monitor Date _____________

LOCATION	CPM	Bq/cm^2/100 cm^2	AFTER CLEANUP	COMMENTS
1	_______	_______	_______	
2	_______	_______	_______	
3	_______	_______	_______	
4	_______	_______	_______	
5	_______	_______	_______	
6	_______	_______	_______	
7	_______	_______	_______	

Week Starting Background CPM __________ Monitor Date _____________

LOCATION	CPM	Bq/cm^2/100 cm^2	AFTER CLEANUP	COMMENTS
1	_______	_______	_______	
2	_______	_______	_______	
3	_______	_______	_______	
4	_______	_______	_______	
5	_______	_______	_______	
6	_______	_______	_______	
7	_______	_______	_______	

Disposal Procedures - Radioisotopes

DEFACE

- all radioactive warning labels (don't use radioactive warning tape to seal bag).

SEGREGATE

- long-lived isotopes from short-lived isotopes (ie. reduce the bulk of material that needs to be held for long periods to decay).

SEPARATE

- active material from slightly contaminated material (same reasoning as for segregation)
- liquid-filled scintillation vials from all other material (see 2. below)
- lead pigs from any other wastes - wipe test pigs (keep record) and make arrangements through E.H.&S. (ext. 74976) for disposal

LABEL

- fill out tag and attach one per bag (not to be used to seal bag)

You need to identify the isotope and give the activity in microcuries (uCi) (if you have two isotopes, clearly indicate the activity of each), give the date, your permit number and name of the person packaging the material.

Tags can be obtained from Environmental Health & Safety http://www.safety.queensu.ca/supplies.htm

PACKAGING

1. All solid radioactive material, excluding scintillation vials, must be packaged in clear plastic bags as we are required by the Canadian Nuclear Safety Commission to do visual checks to ensure that all radiation warning labels have been defaced.

2. Scintillation vials should be packaged in heavy dark green bags (opaque 6 mil) or other bags as approved by E.H.&S. Users must ensure that bags are not leaking. Individual vials must be securely sealed and separated from all other materials. Tags should indicate activity and be clearly marked as VIALS.

Bags are available from Environmental Health & Safety http://www.safety.queensu.ca/supplies.htm

3. Flammable or organic liquid isotope material must be placed in flammable waste disposal cans as for other flammable wastes. Tags must be attached to indicate isotope(s) and activity. Radioisotopes may be mixed with other materials provided that the materials are compatible. Non-flammable aqueous isotope materials should be treated in the same fashion or placed in other suitable containers provided they are well sealed, do not leak and have been approved by E.H.& S.

SCHEDULING

(1. & 2.) on THURSDAY (3.) on TUESDAY
Materials must be at designated locations before 9:30 AM on day of pickup

PROCEDURES FOR SPILLS OR INGESTION OF RADIOISOTOPES

General Precautions

1. Inform persons in the area that a spill has occurred. Keep them away from the contaminated area.

2. Cover the spill with absorbent material to prevent the spread of contamination.

Minor Spills

Definition: A Minor spill is typically less than 100 exemption quantities of a nuclear substance.

1. Wearing protective clothing (lab coat, or disposable coveralls) and appropriate disposable gloves, clean up the spill using absorbent paper and place it in a plastic bag for transfer to a labelled waste container.

2. Avoid spreading contamination. Work from the outside of the spill towards the centre.

3. Wipe test or survey for residual contamination as appropriate. Repeat decontamination, if necessary, until contamination monitoring results meet the Nuclear Substance and Radiation Devices licence criteria.

4. Check hands, clothing and shoes for contamination.

5. Report the spill and cleanup to the Supervisor.

6. Report the spill and cleanup to the permit holder and the University Radiation Safety Officer.

7. Record spill and cleanup and decontamination monitoring details. Adjust inventory and waste records appropriately.

Major Spills

Definition: A Major Spill involves more than 100 exemption quantities, or contamination of personnel, or release of volatile material.

Major spill procedures should be implemented whenever minor spill procedures would be inadequate.

If an overexposure may have occurred that is in excess of applicable radiation dose limits, the University Radiation Safety Officer shall contact the CNSC within 24 hours of the occurrence (Section 6 of the Radiation Protection Regulations.

1. Clear the area. Persons not involved in the spill should leave the immediate area. Limit the movement of all personnel who may be contaminated until they are monitored.

2. If the spill occurs in a laboratory, leave the fumehood running to minimize the release of

volatile radioactive materials to adjacent rooms and hallways.

3. Close off and secure the spill area to prevent entry. Post warning sign(s).

4. Notify the University Radiation Safety Officer (URSO) and permit holder immediately.

5. The URSO will direct personnel decontamination and will decide about decay or cleanup operations.

6. In general, decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap. Do not scrub skin vigorously.

7. Follow the cleanup procedure for minor spills (if appropriate).

8. Record the names of all personnel involved in the spill. Note the details of any personal contamination.

9. The URSO will arrange for any necessary bioassay measurements.

10. Submit a full report along with a copy of the contamination monitoring results to the URSO

11. The URSO must submit a report to the CNSC.

Sealed Radiation Source Leak Testing Certificate

Queen's University
Environmental Health & Safety
Rideau Building, Room 334
Kingston, ON K7K 6W9

Contact Person: John E. Bullock
Phone: (613) 533-2951
Phone 24 Hours: (613) 533-6111
(Queen's Emergency Report Centre)

CNSC Licence: 07156-1-07.6

Wipe Sampler's Information

Name: ______________________________
Address: ______________________________
____
Phone: ______________________________
Signature: ______________________________

Source Information

Permit #: ______________ Permit Holder: ______________
Building: ______________ Room: ______________
Manufacturer: ______________________________
Serial #: ______________ Model #: ______________
Isotope: ______________ Activity: ______________

VIAL #	CPM	BKGR.	EFF. FACTOR	DPM	<200 Bq	>200 Bq

Wipe Measurement Information
Beckman Liquid Scintillation Counter - Model Number LS6K-LL Serial Number 7065741
Date of Last calibration January 22, 1998

Measured by: ______________________________
Date: ______________ Phone: ______________

Signature: ______________________________

Action to be Taken
Under 150 dpm - results to file
>150 dpm and <200 Bq: **Investigation by URSO**
>200 Bq - **isolate source and inform CNSC.**

APPENDIX 16

USER'S EXIT LOG FOR INTERMEDIATE LEVEL RADIOISOTOPE LABORATORIES

PERMIT HOLDER ________________ BUILDING __________ ROOM # ___

			CONTAMINATION CHECK MARK OK or N/A		
DATE	TIME	NAME	HANDS	LAB COAT	SHOES

Annual Limit on Intake (ALI) For Typical Radionuclides

ISOTOPE	MBq	uCi	ISOTOPE	MBq	uCi
Antimony-124	8	216	Iodine-123	95	2,565
Bromine-82	37	999	Iodine-125	1	27
Cadmium-109	9	243	Iodine-131	1	27
Calcium-45	20	540	Iron-55	100	2,700
Carbon-14	34	918	Iron-59	10	270
Chromium-51	530	14,310	Phosphorous-32	8	216
Chlorine-36	20	540	Phosphorous-33	80	2,160
Cobalt-56	6	162	Radium-226	0.07	1.89
Cobalt-57	95	2,565	Rubidium-86	8.00	216.00
Cobalt-58	27	729	Sodium-22	6	162
Cobalt-60	6	162	Strontium-85	36	972
Fluorine-18	400	10,800	Sulphur-35	26	702
Gallium-67	100	2,700	Technetium-99m	900	24,300
Hydrogen-3	1,000	27,000	Thallium-201	210	5,670
Indium-111	70	1,890			

"ALI" or "annual limit on intake" means the activity, in becquerels, of a radionuclide that will deliver an effective dose of 20 mSv during the 50-year period after the radionuclide is taken into the body of a person 18 years old or older or during the period beginning at intake and ending at age 70 after it is taken into the body of a person less than 18 years old.

Classes of Nuclear Substances

The following tables organizes a number of common nuclear substances, including those for which surface contamination and waste disposal limits are typically incorporated into CNSC licences, into three classes - "Class A", "Class B" or "Class C" - on the basis of common radiological characteristics.

For nuclear substances not listed, please contact the University Radiation Safety Officer.

CLASS	**RADIONUCLIDE**				
CLASS A	All alpha emitters and their daughter isotopes			Na-22	Na-24
	Co-60	Ir-192	Sb-124	Ta-182	Zn-65
CLASS B	As-74	Au-198	Br-82	Co-58	F-18
	Fe-59	Ga-67	Gd-153	Hg-203	I-131
	In-111	In-114m	Nb-95	Rb-84	Rb-86
	Sc-46	Se-75	Sm-153	Sn-113	Sn-123
	Sr-85	Sr-90			
CLASS C	Au-195m	C-14	Ca-45	Cd-109	Ce-144
	Cl-36	Co-57	Cr-51	H-3	I-123
	I-125	Ni-63	P-32	P-33	Re-186
	Re-188	Ru-103	S-35	Sr-89	Tc-99
	Tc-99m	Tl-201	Y-90	Yb-169	

LABORATORY DECOMMISSIONING

Before a Permit Holder leaves the University, moves their laboratory, or wishes to cancel their internal permit their laboratories must be decommissioned as per Environmental Health and Safety Policy SOP-LAB-04 (Laboratory Decommissioning) and CNSC Licence condition 2571.

LC 2571 Decommissioning

The licensee shall ensure that prior to decommissioning any area, room or enclosure where the licensed activity has been conducted;

(a) the non-fixed contamination for nuclear substances listed in the licence application guide table titled "Classification of Radionuclides" does not exceed:
  (i) 0.3 becquerels per square centimetre for all Class A radionuclides;
  (ii) 3 becquerels per square centimetre for all Class B radionuclides; and
  (iii) 30 becquerels per square centimetre for all Class C radionuclides; averaged over an area not exceeding 100 square centimetres;

(b) the release of any area, room or enclosure containing fixed contamination, is approved in writing by the Commission or person authorized by the Commission;

(c) all nuclear substances and radiation devices have been transferred in accordance with the conditions of this licence; and

(d) all radiation warning signs have been removed or defaced.