RADIATION SAFETY MANUAL

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UNIVERSITÉ Concordia UNIVERSITY

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i. Scope and Purpose

Ionizing Radiation emitted from Nuclear Substances and Radiation Devices is an essential tool in both research and teaching activities of universities. Since Ionizing Radiation is potentially hazardous, both from radio-toxicity and external exposure, strict regulations have been developed in the form of legislation and institutional policies to protect employees, students, research subjects and the general public from unnecessary or potentially harmful levels of Radiation exposure.

This Radiation Safety Manual (the "Manual") applies to all persons working with and in the vicinity of Nuclear Substances and Radiation Devices at Concordia University (the "University") and should be read in conjunction with the *Radiation Safety Policy* (VPS-46). In the event of a discrepancy between this Manual and the Radiation Safety Policy, the latter shall prevail. Please take note that this Manual will be reviewed on a regular basis and may be modified as circumstances require. Any documents referred to in this document reflect the most up-to-date versions of those documents.

All persons working with Nuclear Substances or Radiation Devices at the University **must** comply with all rules and procedures detailed in this Manual. The purpose of this Manual is to describe the University's requirements for routine activities and emergency situations in order to ensure maximum safety in areas in which Nuclear Substances and Radiation Devices are used. This Manual does not deal with issues related to the use of non-Ionizing Radiation.

The rules and procedures described in this Manual are also intended to ensure full compliance with the terms and conditions of licences issued by the Canadian Nuclear Safety Commission ("CNSC"), and other regulatory agencies. The Nuclear Substance and Radiation Device Licence ("NSRDL") for Consolidated Uses of Nuclear Substances ("CL") is issued by the CNSC and authorizes the University to issue internal permits to those working with Ionizing Radiation under conditions defined in this Manual. Human research studies may be carried out under the Human Research Studies Licence ("HRSL"). The CNSC guidelines for human research will always be met, unless exceptional circumstances satisfy the Human Research Ethics Committee. This Manual deals with issues of authority and responsibility, management of radioactive materials and facilities, radiation protection and emergency procedures. In addition to sections specifically dealing with rules and procedures, the Manual includes a number of appendices providing theoretical, technical and practical information related to the rules and their specific application in the particular context of this University and its compliance with legislative requirements.

Each Internal Radiation Permit Holder ("IRPH") and persons authorized under an HRSL are issued a copy of this Manual, which must be read and *retained* for future reference in the principle location in which the work is being carried out. These persons are responsible for communicating the information contained in this Manual to their laboratory personnel and ensuring the full compliance with its provisions by all such personnel. Copies of the Manual are provided to Faculty Deans, Department Chairs and Centre Directors if work with Radiation occurs in areas for which they are responsible. Service Area Directors who are directly or indirectly involved in laboratories with a potential Radiation hazard will also receive a copy of the Manual for distribution to appropriate individuals reporting to them.

ii. Abbreviations

- ALARA – As Low as Reasonably Achievable
- ALI – Annual Limit of Intake
- AMPs – Administrative Monetary Penalties
- Bq – Becquerel
- CCÉR - Comité Centrale d'éthique de la recherche (CCÉR)
- Ci – Curie
- CL- Consolidated Uses of Nuclear Substances Licence
- CNSC – Canadian Nuclear Safety Commission
- CPM – Counts Per Minute
- CT – Computed Tomography
- DCF – Dose Conversion Factor
- DEXA – Dual Energy X-Ray Absorptiometry
- EH&S – Environmental Health & Safety
- EQ – Exemption Quantity
- GM – Geiger-Muller
- Gy – Gray
- HRSL – Human Research Studies Licence
- IRP – Internal Radiation Permit
- IRPH – Internal Radiation Permit Holder
- MeV – Mega Electron-Volts
- MSSS – Ministre de Santé et Service Sociaux
- NEW – Nuclear Energy Worker
- NSCA – *Nuclear Safety and Control Act* (1997, c.9)
- NSRDL- Nuclear Substance and Radiation Device Licence
- OSLD – Optically Stimulated Luminescent Dosimeter
- QF – Quality Factor
- PET – Positron Emission Tomography
- RBE – Relative Biological Effectiveness
- REM – Roentgen Equivalent Man
- RSO – Radiation Safety Officer
- RSO-CL – Radiation Safety Officer responsible for the Consolidated Uses of Nuclear Substances Licence
- RSO-NM - Radiation Safety Officer responsible for the Human Research Studies Licence
- SI – Système International
- SPECT – Single Photon Emission Computerized Tomography
- Sv – Sievert
- TDG – Transportation of Dangerous Goods
- TLD – Thermoluminescent Dosimeter
- URSC – University Radiation Safety Committee

iii. Glossary of Terms / Definitions

Absorbed Dose
The amount of energy deposited in any substance by Ionizing Radiation per unit mass of the substance, expressed numerically in rads or Grays.

1 Rad = 0.01 Joule/kg (100 ergs/g) 1 Gy = 1 Joule/kg.

Absorption
The process whereby Radiation is stopped or reduced in intensity as it passes through matter.

Activity
The rate of disintegration (transformation) or Decay of radioactive material per unit time. The units of Activity are the Becquerel (Bq) and the Curie (Ci).

ALARA (As Low As Reasonably Achievable)
A philosophy inherent in any program of Radiation safety intended to reduce exposure, whether internal or external, to a minimum. It is necessary to make every reasonable effort to maintain exposures to Ionizing Radiation as far below the Dose limits as practical, consistent with the purpose for which the licensed activity is undertaken taking into account the state of technology, the economics of improvements in relation to benefits to public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

ALI (Annual Limit on Intake)
The derived limit for the amount of radioactive material taken into the body of an adult by inhalation or ingestion in a year, which will result in a committed Effective Dose of 20 mSv for Nuclear Energy Workers. Refer to Appendix III – Regulatory Quantities for Radioisotopes.

Alpha Particle
Refer to the definition of Radiation.

Alternate RSO
Concordia University holds two licenses from the CNSC. A NSRDL and a HRSL and each license has a different RSO identified as the primary RSO. That RSO also serves as alternate RSO for the other license. *See also RSO Responsible definitions.*

Authorized Worker
An authorized worker is a person indicated on an Internal Radiation Permit that is authorized to possess, handle, prepare for disposal, and otherwise use, the indicated nuclear substances in the indicated locations and for the indicated purposes as specified on the Internal Radiation Permit. *See also* ***Responsible User.***

Background Radiation
Refers to Radiation from cosmic sources, naturally occurring radioactive materials and global fallout from the testing of nuclear explosive devices and reactor effluents.

Basic-Level Laboratory
A room is classified as "Basic-Level" for the use of unsealed Nuclear Substances when more than one (1) Exemption Quantity (EQ) is handled and where the largest quantity (in Bq) of a substance handled by any Responsible User does not exceed five (5) times its corresponding ALI (in Bq).

Becquerel (Bq)
The international unit (SI) of radioactive Decay equal to 1 disintegration per second.
37 billion (3.7×10^{10}) Bq = 1 Ci.
Refer to Appendix II – Conversion Table for Radiation Units.

Beta Particle
Refer to the definition of Radiation.

CCER
Comité central d'éthique de la recherche du ministre de la Santé et des Services sociaux. Provincial ethics review board appointed by the ministre de la Santé et des Services sociaux.

Committed Dose
In respect to a Dose of Radiation, it is that Dose received by an organ or tissue from a Nuclear Substance after the substance is taken into the body of a person eighteen (18) years old or older or during the period beginning at intake and ending at age seventy (70).

Contamination
Undesired radioactive material that is deposited on the surface or inside structures, areas, objects or people.

Computed Tomography (CT)
Computer defined three-dimensional (3-D) image reconstruction. A medical imaging method employing a computer defined three-dimensional (3-D) image reconstruction of the inside of an object from a large series of two-dimensional X-Ray images taken around a single axis of rotation.

Curie (Ci)
The older unit used to describe the intensity of radioactivity in a sample of material. The Ci is equal to 37 billion (3.7×10^{10}) disintegrations per second, which is approximately the Activity of one (1) gram of radium. Refer to Appendix II – Conversion Table for Radiation Units.

Decay
The decrease in the amount of any radioactive material with the passage of time due to the spontaneous emission from the atomic nuclei of either Alpha or Beta particles, often accompanied by gamma Radiation.

Decommissioning
The process of closing down a facility followed by reducing residual radioactivity to a level that permits the release of said facility for unrestricted use.

Decontamination
The reduction or removal of contaminating radioactive material from a structure, area, object or person.

Decontamination may be accomplished by:

(1) treating the surface to remove or decrease the Contamination
(2) letting the material stand so that the radioactivity is decreased as a result of natural radioactive Decay, or
(3) covering the Contamination to shield or attenuate the Radiation emitted.

Device
Any piece of equipment designed to use a sealed source(s) with the sealed source(s) installed and for which the CNSC has issued a Device Certification.

Dual Energy X-Ray Absorptiometry (DEXA)
Method used to measure bone mineral density using two X-Ray beams with differing energy levels.

Dose
Refers to the Absorbed Dose, given in Rad or Gy units, and represents the energy absorbed from that Radiation per unit weight.

Dose Conversion Factor (DCF)
The committed Effective Dose in Sv, per unit Activity in Bq, delivered by a given radionuclide of a given form. It is related to the ALI (DCF = 0.02 Sv/ALI).

Dosimeter
A small portable device for measuring and recording the total accumulated personal Dose of Ionizing Radiation during the time it is worn or carried by an individual.

Effective Dose
The sum of products, in Sv or Rem units, obtained by multiplying the Equivalent Dose of Radiation received by, and committed by, each organ or tissue by the weighting factor of that item. This is used when various tissues of differing sensitivities are irradiated.

Equivalent Dose
The product, in Sv or Rem units, obtained by multiplying the Absorbed Dose of Radiation (Gy or Rad) of a certain type by the weighting factor (RBE or QF) of that particular type of Radiation. RBE or QF is a measure of the relative impact that different types of Radiation have on humans.

Excepted Packages
Contain radioactive material, instruments or articles in limited quantities, as specified in IAEA's current *Regulations for Safe Transport of Radioactive Materials*, or are empty packages that have contained radioactive material.

Exemption Quantity (EQ)
Refers to the maximum amount of a radioactive material that can be possessed without a licence (see Appendix III: Regulatory Quantities for Radioisotopes). EQ also refers to any combined quantity of at least two radioactive

Nuclear Substances in which the sum of the quotients obtained by dividing the quantity of each substance by its corresponding EQ is equal to one (1).

Extremities
The hands, forearms, elbows, feet, knees, legs below the knee, and ankles (permissible Radiation exposures in these regions are generally greater than to the whole body because they contain less blood-forming tissues and have smaller volumes for energy Absorption).

Gamma Rays
Refer to the definition of Radiation.

Geiger-Müller Counter
Most commonly used Radiation detection and measuring instrument that consists of an inert gas-filled tube containing electrodes between which there is an electric voltage but no current flowing. When Ionizing Radiation passes through the tube, a short intense pulse of current moves from the negative electrode to the positive electrode and is measured or counted. The number of pulses per second is proportional to the intensity of the Radiation field.

Gray (Gy)
The Système International (SI) unit of Radiation Dose expressed in terms of absorbed energy per unit mass of tissue. The Gy is the unit of Absorbed Dose and replaces the Rad. (1 Gy = 1 Joule/Kg=100 Rad). Refer to Appendix II – Conversion Table for Radiation Units.

Half-life
The physical or radioactive Half-life is the time required for the Activity of a given radioisotope to Decay to one-half of its initial value. In evaluating the effects of radioactive substances deposited in humans, biological Half-life also needs to be considered:

The Biological Half-life is the time required for a biological system, such as that of a human, to eliminate, by natural processes, half the amount of a substance (such as radioactive material) internally deposited by excretion, egestion, exhalation and perspiration.

The Effective Half-life is the time required for the radioactivity from a given amount of radioactive substances deposited in the tissues or organs to diminish by 50% as a result of the combined action of radioactive Decay and loss of the material by biological elimination.

Half-Value Layer
Thickness of material which reduces X or Gamma Ray intensity by 50%; tenth-value layer reduces intensity to 10%.

Human Research Studies Investigator
An individual authorized under the NSRDL for human research studies who is the principal investigator (PI) of a research project and is responsible for securing all necessary approvals for protocols and overseeing compliance with all regulations related to procedures involving use of Radiation and/or radioisotopes in human research subjects.

Human Research Studies Participant
An individual who has provided consent to participate in a research study which involves the use of Nuclear Substances. This may include healthy volunteers or those with no pre-existing medical conditions related to the study and who will not derive a personal health benefit from the research. Other Human Research Studies Participants could be recruited among patients with existing medical conditions relevant to the research protocol of interest.

Inactive Status
An Internal Radiation Permit Holder (IRPH) may request that their Internal Radiation Permit (IRP) be considered Inactive. When a laboratory has opted for Inactive status, certain conditions must be satisfied. All radioisotopes are removed from the laboratory, including radiation waste and stored samples, and the laboratory is effectively decommissioned. The IRPH retains the internal radiation permit, appropriate radiation warning signage, and a liaison with the radiation safety program. All persons listed on the internal radiation permit must maintain their training compliance during Inactive Status.

Intermediate-Level Laboratory
A room is classified as "Intermediate-Level" for use of unsealed Nuclear Substances when more than 5 EQ is handled and where the largest quantity (in Bq) of a substance handled by any Responsible User does not exceed fifty (50) times its corresponding ALI (in Bq).

Internal Radiation Permit (IRP)
An IRP is issued by the University Radiation Safety Committee to a Concordia University Faculty or Staff member, that allows for the acquisition, use, and preparation for disposal, of nuclear substances in compliance with the CNSC issued license to Concordia University.

Internal Radiation Permit Holder (IRPH)
The Faculty or Staff member that is indicated on an IRP, that is authorized to acquire, use, and prepare for disposal, specific nuclear substances, in specific authorized spaces, and for specific authorized purposes. In addition, the IRPH may have Authorized Workers to which they may delegate some of these responsibilities. *See also Responsible User.*

Ionizing Radiation
Refers to Alpha particles, Beta particles, Gamma Rays, X-Rays, neutrons, high-speed electrons, high-energy protons and other particles capable of producing ion pairs.

Minimal Risk
As defined by the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*, research presenting minimal risk to participants is defined as research in which the probability and magnitude of possible harms implied by participation in the research is no greater than those encountered by participants in those aspects of their everyday life that relate to the research.

Non-Ionizing Radiation
Refers to all electromagnetic Radiation with wavelength greater than 1nm including radio waves, microwaves as well as visible, infrared or ultraviolet light.

Non-Stochastic Effects
The health effects, the severity of which varies with the Dose and for which a threshold is believed to exist.

Nuclear Energy Worker (NEW)
A person who is required, in the course of one's business or occupation in connection with a Nuclear Substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability of receiving a Dose of Radiation that is greater than the prescribed limit for the general public.

Nuclear Medicine Facility Manager
The person designated to supervise personnel and activities in Nuclear Medicine Rooms under the authority of a CNSC NSRDL for human research studies.

Nuclear Medicine Room
A room where unsealed Nuclear Substances are prepared or administered to a person, or where imaging is performed.

Nuclear Medicine Specialist
A person who has been granted permission from the College of Physicians and Surgeons (*Collège des médecins*) to read and interpret nuclear medicine studies.

Nuclear Substance
Refers to the following:

(a) deuterium, thorium, uranium or an element with an atomic number greater than ninety two (92);
(b) a derivative or compound of deuterium, thorium, uranium or of an element with an atomic number greater than ninety two (92);
(c) a radioactive nuclide;
(d) a substance that is prescribed as being capable of releasing nuclear energy or as being required for the production or use of nuclear energy;
(e) a radioactive by-product of the development, production, or use of nuclear energy.

Nuclear Substance Laboratory
Any laboratory in which Nuclear Substances are used (also known as a "radioisotope laboratory").

Nuclear Substance and Radiation Device Licence (NSRDL)
A licence issued by CNSC for Consolidated Uses of Nuclear Substance (CL) (non-human) or Human Research Studies (HRSL).

Positron Emission Tomography (PET)
An imaging procedure that detects Gamma Rays that are produced through annihilation of positrons emitted from incorporated radionuclides.

Rad
A unit of Absorbed Dose, which is the amount of energy from any type of Ionizing Radiation deposited in any

medium. A Dose of one (1) Rad corresponds to the Absorption of one hundred (100) ergs per gram of absorbing tissue (100 Rad = 1 Gy). Refer to Appendix II – Conversion Table for Radiation Units.

Radiation

The emission by a Nuclear Substance, or the generation using a Nuclear Substance, or electronic device of an atomic or subatomic particle or electromagnetic wave with sufficient energy for ionization.

Alpha particle

A positively charged nuclear particle identical to the nucleus of a helium atom. It consists of two protons and two neutrons and is ejected at high speed from the nucleus of an atom during certain radioactive transformations.

Very thin absorbing materials can stop Alpha particles, e.g., a few sheets of paper or 0.5 mm of aluminum foil. Since Alpha particles travel only short distances in the air and are absorbed by the outer layer of the skin (dead tissue), Alpha Radiation is not considered an external exposure hazard but is extremely damaging internally.

Beta particle

A positively or negatively charged electron emitted from a nucleus during radioactive Decay. A negatively charged Beta particle is identical to an electron. A positively charged Beta particle is called a positron. Large amounts of Beta Radiation may cause skin burns and Beta emitters are harmful if absorbed by tissues. Although Beta particles have a greater penetration in any absorber than Alpha particles, they may be stopped by thin absorbing materials, e.g., 25 mm of wood or 10 mm of Lucite. Positrons annihilate releasing 0.51 MeV gamma photons and, for Shielding purposes, are treated as Gamma Radiation.

Gamma Radiation (Gamma Rays)

High energy, short wavelength, electromagnetic radiation emitted from the nucleus. It frequently accompanies Alpha and Beta particle emissions. Gamma Rays are very penetrating and are best attenuated or shielded by dense materials such as lead.

X-Radiation (X-Ray)

Is produced when electrons change orbits within an atom, or electrons from an external source decelerate through interaction with matter. As with Gamma Rays, X-Rays are very penetrating and are best attenuated or shielded by dense materials such as lead.

Radiation-Controlled Area

A laboratory or room operating under an IRP or CNSC licence containing Nuclear Substances or Radiation Devices or any area in which a Radiation Field may result from a licensed activity.

Radiation Device

Refers to:

(a) a Device containing more than the EQ of a Nuclear Substance and that enables the Nuclear Substance to be used for its Radiation properties, and
(b) a Device that contains a radium luminous compound.

Radiation-Emitting Device

Refers to a machine capable of generating high-energy charged particles or electromagnetic Radiation.

Radiation Field
An area surrounding an open source or Radiation-Emitting Device yielding an exposure Dose rate above Background Radiation.

Radiation Safety Officer (RSO)
A professional with formal university-level education in a relevant discipline and approved by the CNSC who reports directly to the Applicant Authority on matters of radiation safety.

Radiation Safety Officer (RSO) responsible for the Consolidated Uses of Nuclear Substance and Radiation Device Licence (RSO-CL)
Reports to the Director, EH&S, and the Applicant Authority on matters of radiation safety, and assumes all responsibilities of the RSO in accordance with the regulations of the CNSC for the University's Consolidated Uses of Nuclear Substance and Radiation Device Licence (CL), including the day-to-day administration and control of the University radiation safety program. This individual may also be referred to as the Radiation Safety Officer (Consolidated Licence) or the RSO Responsible when not making reference to any particular license. This individual also serves as the Alternate RSO for the Human Research Studies License.

Radiation Safety Officer (RSO) responsible for the Human Research Studies Licence (RSO-NM)
Reports to the Associate Director, Bio-Imaging, PERFORM Centre, and the Applicant Authority on matters of radiation safety, and assumes all responsibilities of the RSO in accordance with the regulations of the CNSC for the University's Human Research Studies Licence (HRSL) including the day to day administration of the HRSL radiation safety program. This individual may also be referred to as the Radiation Safety Officer (HRSL) or the RSO Responsible when not making reference to any particular license. This individual also serves as the Alternate RSO for the Consolidated Uses of Nuclear Substance and Radiation Device License.

Radiation Survey Meter
An instrument that is capable of measuring Radiation Dose rates.

Radionuclide
An unstable isotope of an element that decays or disintegrates spontaneously, emitting Radiation.
Also known as a radioisotope.

Responsible User

Includes
(a) IRPHs,
(b) Authorized Workers,
(c) Human Research Studies Investigators,
(d) Nuclear Medicine Facility Managers who are authorized to use radioisotopes, Radiation Devices and Radiation-Emitting Devices under approved procedures and in designated facilities, and
(e) All persons who are responsible for ensuring compliance and safety of those working with this equipment and/or in these facilities under their supervision.

Roentgen
A unit of air exposure Dose applicable only to X- or Gamma Radiation. It is the amount of Gamma or X-Rays producing ions with a charge of 0.000258 Coulombs/Kg of air under standard conditions.

Roentgen Equivalent Man (Rem)
A standard unit that measures the effects of Ionizing Radiation on humans. It is derived by multiplying the Radiation Dose (Rads) by the quality factor (QF) or the relative biological effectiveness (RBE) for various types of Radiation. (1 Rem = 10 mSv). Refer to Appendix II – Conversion Table for Radiation Units.

Scintillation Counter
A device for counting atomic particles or photons by means of tiny flashes of light (fluorescence) that are produced when they interact with certain solid crystals or liquid organic fluors.

Sealed Source
A radioactive Nuclear Substance in a sealed capsule or under a cover to which the substance is bonded, where the capsule or cover is strong enough to prevent contact with, or the dispersal of, the substance under the conditions for which the cover or capsule is designed.

Shielding
A method of Radiation protection. A shield is a body of material positioned to prevent or reduce the passage of Radiation. The effectiveness of Shielding is determined by the interaction between the incident Radiation and the absorbing medium. X- and Gamma Radiation require lead/steel Shielding and not all Radiation can be absorbed. Beta Radiation is best attenuated in low atomic number materials and can be completely absorbed.

Sievert (Sv)
The Système International (SI) unit for Dose equivalent equal to 1 Gy (1 Joule/Kg) multiplied by QF or RBE to compensate for differential biological effects of different kinds of Radiation.
1 Sv = 100 Rem. Refer to Appendix II – Conversion Table for Radiation Units.

Single-Photon Emission Computed Tomography (SPECT)
An imaging procedure that detects gamma photons emitted from injected or ingested Radionuclides.

Specific Activity
The Activity (Ci or Bq) per unit mass expressed per unit weight or per mole of compound.

Stochastic Effects
Health effects that occur randomly and for which the probability of occurrence, rather than its severity, is proportional to the Dose and for which there is no threshold. Heredity effects and cancer incidence are examples of stochastic responses to Radiation exposure.

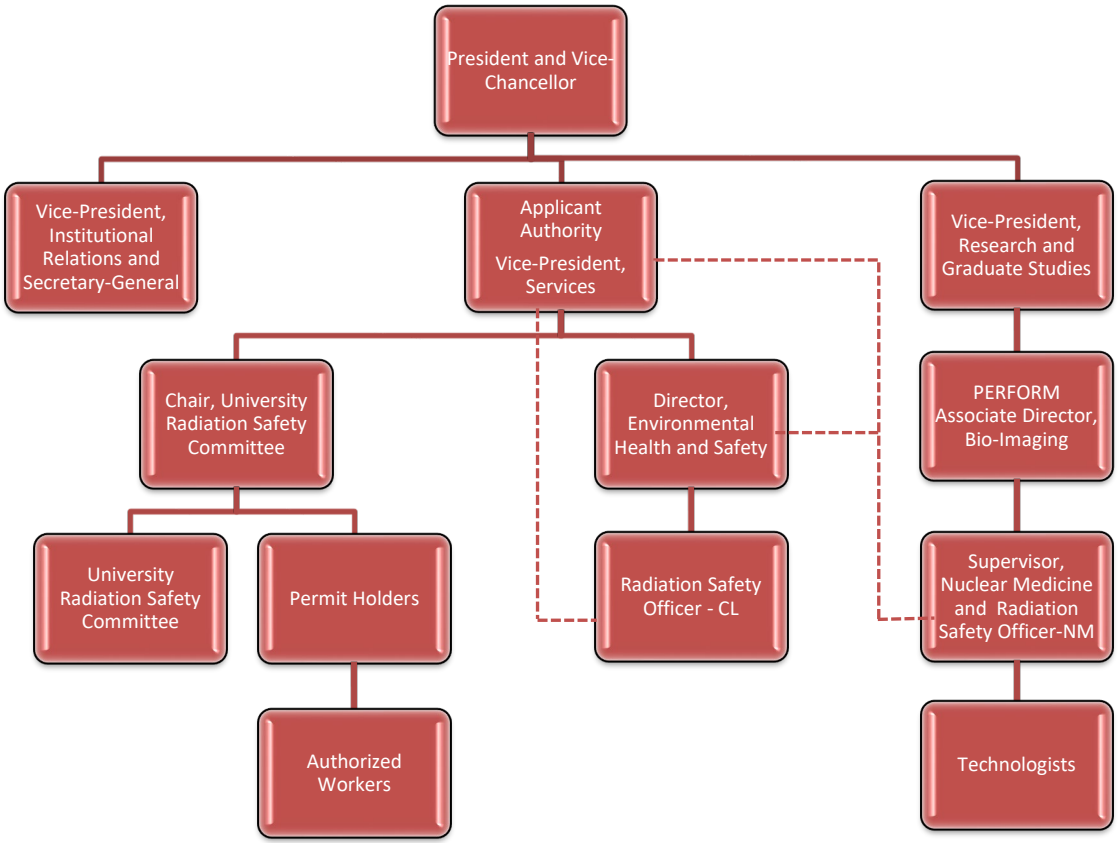
Thermoluminescent Dosimeter (TLD)
A small portable device (such as a ring-badge or pocket Dosimeter) used to determine Dose by measuring the amount of visible light emitted by controlled heating of a crystal (normally lithium fluoride) in the detector following exposure to Ionizing Radiation.

Unsealed Source
Nuclear Substance which may be a liquid, gas or solid other than a Sealed Source.

Weighting Factor
In reference to an organ or tissue, is the proportion of the risk of Stochastic Effects resulting from irradiation of that organ or tissue to the total risk of Stochastic Effects when the whole body is irradiated uniformly.

X-Radiation
Refer to the definition of Radiation.

iv. Concordia University Administrative Structure



Note: All responsible users in the radiation safety program will have direct access to the RSO Responsible.

1. University Radiation Safety Committee (URSC)

1.1 The Vice-President, Services and Sustainability (Applicant Authority) has authorized the URSC to establish policies concerning the usage of Radiation from sources such as Nuclear Substances and Radiation Devices, on behalf of the University. Such policies shall be enforced through the activities of the Chair of the URSC and the Radiation Safety Officer ("RSO") per the terms of the University's *Radiation Safety Policy* (VPS-46).

1.2 The URSC shall consist of:

- a Chair;
- the RSO-CL;
- the RSO-NM;
- the Director of Environmental Health & Safety (EH&S);
- a representative from the Office of Research;
- one (1) member from each Department of the University in which Nuclear Substances or Radiation Devices are used and at least one (1) member from each campus;
- in deliberations involving human research subjects, a Nuclear Medicine specialist, radiologist and/or health physicist.

All members of the URSC shall be appointed by the Vice-President, Services and Sustainability on the basis of theoretical or practical expertise or a stake in radiation safety matters. The Director of EH&S, the representative from the Office of Research and the RSO-CL and RSO-NM will be *ex-officio* members of the URSC.

The URSC:

1.3 Advises the Vice-President, Services and Sustainability (Applicant Authority) regarding policies on radiation safety, particularly with respect to handling, storage, and disposal of Nuclear Substances, the operation of Radiation Devices, working conditions, and of the need for additional resources to establish, maintain or improve radiation protection programs or to fulfill compliance requirements.

1.4 Establishes and oversees general radiation protection and safety training programs and all radiation safety matters on behalf of the University.

1.5 Advises the RSO-CL regarding approval of IRP applications, laboratory designation for the handling or storage of Nuclear Substances, the operation of a Radiation Device, action for non-compliance with all government and University regulations and/or policies pertaining to radiation.

1.6 Advises the RSO-NM regarding approval of protocols for use of radioisotopes or radiation in humans, action for non-compliance with government and University regulations and/or policies pertaining to radiation.

1.7 Advises its Chair regarding disciplinary action for non-compliance with government and University

regulations and/or policies pertaining to radiation.

1.8 Reviews proposed uses of Nuclear Substances and Radiation Devices and their proposed locations of use to ensure full compliance with University procedures and governmental regulatory requirements.

1.9 Approves the establishment or relocation of Basic-Level Laboratories, Intermediate-Level Laboratories and Nuclear Medicine Rooms.

1.10 Approves annual reports presented by the RSO-CL on the use of Nuclear Substances authorized under the CL and by the RSO-NM on the use of Nuclear Substances authorized under the HRSL for submission to the CNSC.

1.11 Reviews:

- the effectiveness of the radiation safety programs and procedures to assure that radiation exposures comply with regulatory limits outlined in both the NSCA and *Nuclear Substances and Radiation Devices Regulations* (SOR/2000-207) and, whenever necessary, adhere to the ALARA principle, social and economic factors taken into account.
- results of internal inspections of facilities, premises, equipment and work practices that assess whether Nuclear Substances and Radiation Devices are used in compliance with internal and external regulations regarding licensed activities;
- annual summaries of the occupational radiation exposures received by all those on dosimetry service;
- reports concerning any incidents or unusual occurrences on University premises that involved radiation;
- standard operating procedures for use of external radiation or radioisotopes in human research subjects;
- calibration and certification records, as required, by approved standard operating procedures.

1.12 Recommends corrective measures or improvements:

- when review or assessment identifies deficiencies in a proposal, program, practice, procedure, equipment, record or report;
- to prevent recurrences of any incidents that exposed persons to unnecessary radiation, or to prevent recurrence of any other unusual incidents.

1.13 Maintains written records of activities, decisions, advice and recommendations concerning radiation safety, including details of meetings and reviews of data, reports, programs, procedures, circumstances, incidents or unusual occurrences.

1.14 Meeting Frequency

The URSC shall meet no less than three (3) times per year. The timing of such meetings shall be established by the Chair. Special meetings may be called at any time by the Chair or upon request by EH&S, the RSO-CL or the RSO-NM. The manner and conduct of the meetings of the URSC shall be determined by the Chair and may be held in person, by telephone conference or by email, as appropriate in the circumstances.

2. The Chair of the URSC

2.1 Where necessary, advises the Applicant Authority concerning communications with appropriate federal, provincial and municipal departments and agencies, on behalf of the University, with respect to activities involving Nuclear Substances and Radiation Devices.

2.2 Convenes regular meetings of the URSC.

2.3 Reviews CNSC annual compliance reports, licence applications and renewal licence applications (CL and HRSL) as required, ensuring continuous authorization(s) to possess and use Nuclear Substances and Radiation Devices.

2.4 Authorizes the closing of facilities or restricts access to rooms in which Nuclear Substances are in use if a hazard is deemed to be excessive by the RSO Responsible or the URSC.

2.5 In cases where RSO enforcement concerning IRPH non-compliance results in temporary suspension of the IRP, purchases under the IRP will only be allowed under the direct control of the Chair of the URSC.

2.6 Assumes responsibilities of the RSO-CL and RSO-NM, for absences of less than four (4) weeks, when both the RSO-CL and RSO-NM are absent from the University.

3. The Radiation Safety Officer (RSO)

3.1 The RSO is a professional with formal university-level education in a relevant discipline and with appropriate Radiation Safety Officer Training. The RSO will maintain a minimum 5 year recurrent RSO Refresher training as recommended by the CNSC.

The Radiation Safety Officer Training should be provided by an external agency and include the following relevant topics:

Structure of matter;
Radiation and radioactivity;
Radiation quantities and units;
Radiation detection, instrumentation and dosimetry;
Biological and health effects of exposure to radiation;
Radiation protection principles and practices, including contamination control;
Nuclear gauges and their applications (as necessary);
Workplace radiation safety program: organization and administration;
Emergency procedures;
Employee training programs;
Transport of radioactive materials;
Workplace inspections and audits;
Regulatory agencies and standard-setting organizations;
Licensing of nuclear substances and radiation devices;
Key sections of the Nuclear Safety and Control Act and the following Regulations:
General Nuclear Safety and Control Regulations
Radiation Protection Regulations
Class II Nuclear Facilities and Prescribed Equipment Regulations (as necessary)
Nuclear Substance and Radiation Devices Regulations
Packaging and Transport of Nuclear Substances Regulations

The RSO provides the day-to-day administration and control of the radiation safety program on behalf of the University, which includes Radiation Safety Training and compliance with CNSC regulations, the University's Radiation Safety Policy (VPS-46) and the present Manual.

3.2 Concordia University Radiation Safety Officers

Concordia University appoints two (2) RSOs:

a. an RSO responsible for the Consolidated Use of Nuclear Substances Licence (RSO-CL); and
b. an RSO responsible for the Human Research Studies License (RSO-NM)

3.2.1 RSO - CL

Reports to the Director, EH&S and assumes all responsibilities of the RSO in accordance with the regulations of the CNSC for the University's CL. This individual is referred to as the Radiation Safety

Officer (Consolidated Licence) or the RSO Responsible when not making reference to any particular license. The RSO-CL works in partnership with the RSO-NM, communicating regularly to ensure compliance with CNSC regulations, the University's Radiation Safety Policy (VPS-46) and the University's Radiation Safety Manual.

RSO-CL has direct access to the Applicant Authority (Vice-President, Services and Sustainability) and is required to notify the Applicant Authority immediately of any violations of University radiation safety policies or procedures that pose immediate or significant risk or danger to the safety or health of faculty, staff, students or public; involves the release or potential release to the environment of reportable quantities of radiation; or places the University's CL in jeopardy.

3.2.2 RSO - NM

Reports to the Associate Director, Bio-Imaging, PERFORM Centre and assumes all responsibilities of the RSO in accordance with the regulations of the CNSC for the University's HRSL. This individual is referred to as the Radiation Safety Officer (Human Research Studies License) or the RSO Responsible when not making reference to any particular license. The RSO-NM work in partnership with the RSO-CL, communicating regularly to ensure compliance with CNSC regulations, the University's Radiation Safety Policy (VPS-46) and the University's Radiation Safety Manual.

The RSO-NM has direct access to the Applicant Authority (Vice-President, Services and Sustainability) and is required to notify the Applicant Authority immediately of any violations of University radiation safety policies or procedures that pose immediate or significant risk or danger to the safety or health of faculty, staff, students or public; involves the release or potential release to the environment of reportable quantities of radiation; or places the University's HRSL in jeopardy.

3.3 Radiation Safety Reporting Structure

3.3.1 The RSO-CL reports to the Director, Environmental Health & Safety

3.3.2 The RSO-NM reports to the Associate Director, Bio-Imaging, PERFORM Centre

3.3.3 Both the RSO-CL and RSO-NM reports directly to the Vice-President, Service and Sustainability (Applicant Authority) in situations whereby violations of University radiation safety policies or procedures that pose immediate or significant risk or danger to the safety or health of faculty, staff, students or public; involves the release or potential release to the environment of reportable quantities of radiation; or places the University's licences in jeopardy.

3.4 Authority of the Radiation Safety Officers

The RSOs have the authority to suspend all or any operations involving Nuclear Substances or Radiation Devices in the cases where they judge an immediate or significant threat to health, safety, or the environment.

3.5 General Responsibilities of the RSO

General responsibilities of RSOs for their respective licences and assigned areas are:

3.5.1 Advises and consults the Chair of URSC regarding issues related to the University's use of Nuclear Substances and Radiation Devices so as to ensure that all such use is carried out in compliance with CNSC regulations, University policies and the conditions of the licences. Maintains records of URSC meetings.

3.5.2 Notifies the Vice-President, Services and Sustainability (Applicant Authority), Chair of the URSC and the Director, EH&S, immediately of any violations of University radiation safety policies or procedures that pose immediate or significant risk or danger to the safety or health of faculty, staff, students or the public; that involve the release or potential release to the environment of reportable quantities of radiation; or that place the University's licences in jeopardy.

In the aforementioned situations:

i. the RSO-CL is also required to advise the RSO-NM

ii. the RSO-NM is also required to advise the RSO-CL; the Associate Director, Bio-Imaging, PERFORM Centre

3.5.3 Ensures that records and reports that are required of the University by legislation and by the conditions of the NSRDL are prepared, maintained or submitted as required; these include:

- Names of all persons involved in the use or handling of Nuclear Substances and Radiation Devices;
- Names of persons who have completed radiation safety related training;
- Storage locations of Nuclear Substances;
- External dosimetry and internal bioassay results;
- Details of incidents involving Nuclear Substances or Radiation Devices;
- Records of purchase(s) of radioisotopes;
- Transfers of radioactive material;
- Removable and fixed contamination monitoring results;
- Surveys of radiation fields in radiation-controlled areas and adjoining public areas;
- Waste disposal records for Nuclear Substances;
- Transport documents;
- List of radiation detection equipment and calibration dates;
- Leak-test results for Sealed Sources;
- Inspections, measurements, acceptance tests and all servicing records performed on any Radiation Device. These records will be retained as per the Concordia Radiation Safety Record Retention Schedule (see Appendix XVI), and

- Any other documents required by CNSC regulations and/or any other federal, provincial or municipal agencies and any University policy.

3.5.4 Notifies the CNSC ninety (90) days prior to the disposal of any records pertaining to the University's licence.

3.5.5 Provides IRP application form, safety warning signs, information bulletins and guidelines for those requiring such material.

3.5.6 Maintains up to date copies of all relevant regulations, guidelines and contingency plans in the event of an emergency.

3.5.7 Notifies Responsible Users and, if necessary, University Department/Unit Heads of actions required to correct any deficiencies identified in the inspections.

3.5.8 Submits a request to the CNSC to amend the license prior to any activities occurring that are not specified in the license.

3.5.9 Revises procedures and designates facility design to ensure that the University's operations, equipment and facilities remain in compliance with regulatory requirements.

3.5.10 Reviews and authorizes the purchase, transfer, disposal or use of Nuclear Substances and Radiation Devices.

3.5.11 Assesses the qualifications and competence of persons who apply to use or handle Nuclear Substances or operate Radiation Devices to determine whether they can do so safely and in compliance with relevant legislation and licences.

3.5.12 Posts, in a readily visible location within each licensed area:

- signage corresponding to the classification of the area,
- radiation signage;
- emergency contact information, and
- emergency procedures.

3.5.13 Maintains a complete and up-to-date list of all designated areas, rooms and enclosures within which Radiation Devices are located and those where more than one EQ of a Nuclear Substance is used or stored.

3.5.14 Supervises the decontamination of Radiation-Controlled Area, as required.

3.5.15 Certifies decommissioned Radiation-Controlled Areas.

3.5.16 Develops, implements and maintains administrative controls and/or procedures to ensure radiation safety and compliance.

3.5.17 Ensures that any individual (faculty, staff and students) who are required to work with radiation have received appropriate radiation safety-related training.

3.5.18 Makes certain that persons who may be exposed to radiation in the course of their duties (such as cleaners, security staff, secretaries, shippers and receivers), and equipment operators receive appropriate training in radiation safety.

3.5.19 Designs and implements, in accordance with regulatory requirements, appropriate personnel monitoring and bioassay programs to measure external and internal exposures to radiation.

3.5.20 Ensures that all persons who use or handle Nuclear Substances and Radiation Devices follow approved procedures in order to prevent occupational exposures to radiation that exceed regulatory limits or, when applicable, violate the ALARA principle of dose limitation.

3.5.21 Monitors the occupational radiation exposures received by persons working with Nuclear Substances and Radiation Devices by reviewing, at least quarterly, their records of exposure; maintains personnel monitoring service and health physics records for all such personnel.

3.5.22 Recommends to the URSC measures to reduce the exposures when the above review of records indicates exposures are unnecessarily high.

3.5.23 In the event of overexposures, unintended exposures, and exposures of the public to radiation, as well as accidents involving Nuclear Substances and Radiation Devices, the RSO will:

- Immediately informs the CNSC, the Chair of the URSC and the Director, EH&S overexposures, unintended exposures, and exposures of the public to radiation, and of accidents involving Nuclear Substances or Radiation Device
    - the RSO-CL is also required to advise the RSO-NM
    - the RSO-NM is also required to advise the RSO-CL; the Associate Director, Bio-Imaging, PERFORM Centre
- Investigates all overexposures, unintended exposures, and exposures of the public to radiation, and of accidents involving Nuclear Substances or Radiation Device
- Submits investigation reports to the URSC. Investigation reports will include corrective actions to mitigate the consequences of the incident and to prevent reoccurrence.

- If required, submits in writing, within 21 days, an incident report to the CNSC concerning the event (refer to CNSC Reportable Events Guide*, see Appendix XVI)*

3.5.24 Notifies the CNSC immediately and submits a written report to the CNSC within twenty one (21) days after the day in which the RSO Responsible becomes aware of the following incidences:

- A Nuclear Substance or a Radiation Device is lost or stolen;
- A Radiation Device is damaged to an extent that could impair its normal use;
- A Sealed Source is separated from the Radiation Device when the latter is not being serviced;
- An exposure device has a radiation dose rate of more than 2 mSv per hour on any part of its surface when the Sealed Source assembly is in the Shielded position;
- A Sealed Source fails to return to the Shielded position inside the Radiation Device;
- There is a spill of an unsealed radioactive Nuclear Substance, set out in Column 1 of Schedule 1 of the *Nuclear Substances and Radiation Devices Regulations* SOR/2000-207, which has produced in excess of one hundred (100) times the activity, set out in Column 3 of Schedule 1 of the *Nuclear Substances and Radiation Devices Regulations* SOR/2000-207; and
- There is a spill of an unsealed radioactive Nuclear Substance, which is not set out in Column 1 of Schedule 1 of the *Nuclear Substances and Radiation Devices Regulations* SOR/2000-207,
- Any item indicated in section 29 of the *General Nuclear Safety and Control Regulation* SOR/2000-202
- Any item indicated in section 35 of the *Packaging and Transport of Nuclear Substances Regulations, 2015* SOR/2015-145
- Any item indicated on CNSC Reportable Events Guide (*See Appendix XVI)*.

The written report referred to in this Section shall include a complete description of the incident, including the location and circumstances of the incident, details of the Nuclear Substances and/or Radiation Devices involved, and of any actions taken or proposed action plan to correct the situation and to prevent a recurrence.

3.5.25 Assesses the adequacy of survey programs for measuring or managing Radiation Fields and radioactive contamination associated with licensed activities, such as during the handling, storage and disposal of Nuclear Substances or the operation of Radiation Devices.

3.5.26 Every six (6) months, inspects Radiation-Controlled Areas to ensure compliance with CNSC regulations, the University's Radiation Safety Policy and Radiation Safety Manual using

a. 815 Type II Inspection Worksheet (CNSC),
b. 875 Type II Inspection Worksheet (CNSC), or
c. Radiation Safety Inspection Form (RSO)

as deemed appropriate by the RSO (refer to Appendix XVI). Inspection reports are provided to the IRPH or Nuclear Medicine Facility Manager.

3.5.27 Ensures that Sealed Sources are leak-tested in accordance with University's procedures, Appendix AA of REGDOC 1.6.1 and regulatory requirements. If leakage of 200 Bq or more is detected, the RSO Responsible immediately notifies the CNSC. The RSO responsible must notify EHS and ensure that the use of the Source and Radiation Device are discontinued.

3.5.28 Prepares annual reports in accordance with conditions contained in the licences issued to the University by the CNSC.

3.5.29 Coordinates, or participates in, emergency responses to incidents involving Nuclear Substances and Radiation Devices; the RSO Responsible maintains adequate supplies of disposal materials, protective clothing, decontamination materials, warning signs, and a portable survey meter or contamination meter for emergency use.

3.5.30 Ensures that the Director of Security and the Director of EH&S are informed and appropriate signs posted in emergency situations in which a Radiation-Controlled Area has been closed.

3.5.31 Authorizes the disposal of radioactive materials in accordance with legislation, the respective CNSC licence conditions, and the relevant University's policies and procedures making certain that any radioactive materials requiring transport outside the University are packaged in accordance with transport regulations.

3.5.32 The RSO-CL and RSO-NM will maintain open communication in order to ensure uniform application of the University`s *Radiation Safety Policy* (VPS-46), this Manual and relevant procedures.

3.6 Specific Responsibilities of the RSO-CL:

3.6.1 Is the primary contact with the CNSC and other appropriate government agencies at the federal, provincial and municipal level, on behalf of the University and, shall assume responsibility for the compliance of all persons under the terms of Concordia University's NSRDL-CL, the NSCA and its associated *Regulations*.

3.6.2 Ensures that records and reports that are required of the University by legislation and by the conditions of the CL are prepared, maintained or submitted as required; these include:

- locations of designated Radiation Controlled Areas;
- inventory of Nuclear Substances in the University's possession, excluding those under the HRSL.

3.6.3 Annually and when required, evaluates the University's acquisitions and holdings of Nuclear Substances under the CL and makes arrangements for the disposal of materials no longer required. This is done in an effort to minimize the amount of materials and the number of locations where nuclear substances are used and stored.

3.6.4 Prepares and submits all CNSC annual compliance reports, licence applications and renewal licence applications for the CL as required, ensuring continuous authorization(s) to possess and use Nuclear Substances and Radiation Devices.

3.6.5 Notifies the URSC regarding approval of IRP applications, laboratory designation for the handling or storage of Nuclear Substances, the operation of a Radiation Device, action for non-compliance with all government and University regulations and/or policies pertaining to radiation

3.6.6 Makes requests to the CNSC for the establishment or relocation of Intermediate-Level Labs and for the decommissioning of inactive facilities or Radiation Devices.

3.6.7 Submits to CNSC, for their approval, plans for the construction or renovation of Intermediate-Level and/or a High-Level Radiation Laboratory.

3.6.8 Administers the issuance, use, maintenance, calibration, and location of radiation monitoring devices and equipment within the University, with the exception of those radiation monitoring devices and equipment under the HRSL.

3.6.9 Notifies the CNSC, in writing and within fifteen (15) days of changes to the identity and job-description(s) of the RSO-CL, the RSO-NM or the Applicant Authority (Vice-President, Services and Sustainability).

3.6.10 Replaces the RSO-NM when the RSO-NM is absent from the University.

3.7 Specific responsibilities of the RSO-NM:

3.7.1 Is the primary contact with the CNSC and other appropriate government agencies at the federal, provincial and municipal level, on behalf of the University and, shall assume responsibility for the compliance of all persons under the terms of Concordia University's NSRDL-HRSL, the NSCA and its associated *Regulations*.

3.7.2 Ensures that records and reports that are required of the University by legislation and by the conditions of the HRSL are prepared, maintained or submitted as required and are available to EH&S; these include:

- locations of designated Radiation Controlled Areas;
- inventory of Nuclear Substances under the HRSL; and
- records pertaining to the use of radiopharmaceuticals in humans.

3.7.3 Annually and when required, evaluates the University's acquisitions and holdings of Nuclear Substances under the HRSL and makes arrangements for the disposal of materials no longer required. This is done in an effort to minimize the amount of materials and the number of locations where radioisotopes are used and stored.

3.7.4 Prepares and submits all CNSC annual compliance reports, licence applications and renewal licence applications for the HRSL as required, ensuring continuous authorization(s) to possess and use Nuclear Substances and Radiation Devices.

3.7.5 Makes requests to the CNSC for the establishment or relocation of Nuclear Medicine Rooms and for the decommissioning of inactive facilities and Radiation Devices.

3.7.6 Submits to the CNSC, for their approval, plans for the construction or renovation of Nuclear Medicine Rooms and Intermediate or High level Radiation Laboratories.

3.7.7 Notifies the URSC regarding approval of protocols for use of radioisotopes or radiation in humans, action for non-compliance with government and University regulations and/or policies pertaining to radiation.

3.7.8 Administers the issuance, use, maintenance, calibration, and location of radiation monitoring devices and equipment in those areas covered by the HRSL.

3.7.9 Prepares annual reports in accordance with conditions contained in the HRSL.

3.7.10 Notifies the CNSC, EH&S and the RSO-CL, in writing and within fifteen (15) days of changes to the identity and job description(s) of the RSO-NM, the RSO-CL, or the Applicant Authority (Vice-President, Services and Sustainability).

3.7.11 Informs EH&S, the Associate Director, Bio-Imaging, RSO-CL and Chair, URSC immediately of any issues of non-compliance, more specifically incidents involving theft or loss of Nuclear Substances or Radiation Devices, abnormal radiation exposures or radiation doses not permitted in human studies.

3.7.12 Replaces the RSO-CL when the RSO-CL is absent from the University.

4. Internal Licensing and Authorization Conditions

4.1 The CNSC, the federal regulatory body governing usage of Nuclear Substances and Radiation Devices, issues the University's NSRDL for Consolidated Uses of Nuclear Substances (CL), and for Human Research Studies (HRSL).

4.2 The URSC approves IRPs for Responsible Users under the terms and conditions of the CL for Consolidated uses of Nuclear Substances and authorizes the RSO to issue such IRPs. These IRPs specify guidelines and restrictions on the radioisotope possession limits, specific uses and approved locations, as well as personnel authorized to work with such material or operate approved Radiation Devices.

4.3 An IRP will normally be issued for a maximum period of two (2) years. The IRP may become *inactive* at any time at the request of the IRPH, and may be renewed as an *inactive* permit only once (see Internal Management of Radiation Permits, *appendix XVI*). The CNSC licences are generally issued for a period of five (5) years.

4.4 Approval of IRPs is conditional upon successful completion of the radiation safety related training by both the IRPH and their research personnel (as listed on the IRP application). IRP status and compliance conditions are set according to the document entitled Internal Management of Radiation Permits (*see appendix XVI*).

4.5 Work with radiopharmaceuticals in a nuclear medicine facility is conditional upon successful completion of the radiation safety related training and approved standard operating procedures for human research studies.

4.6 Administration of radioisotopes and radiopharmaceuticals or exposure of external radiation to humans is subject to further requirements such as membership in an appropriate professional order (i.e., *Collège des médecins* or *Ordre des technologues en imagerie médicale et en radio-oncologie: OTIMRO)* and requires approval from the University Human Research Ethics Committee.

4.7 Any amendment(s) to the specifications of the IRP involving personnel, use, quantity, location, or significant changes in procedures described on the original IRP application must be made, in writing, to the RSO-CL.

4.8 Any transfer of a Nuclear Substance or Radiation Device requires the authorization of the RSO-CL or RSO-NM, as appropriate.

4.9 An up-to-date logbook must be maintained for all Nuclear Substances and operation of Radiation Devices outlined in the IRP or licensed for use in the nuclear medicine facilities.

4.10 Nuclear Medicine Facility Managers are also required to keep consent forms and other documents in accordance with applicable regulations.

4.11 Human Research Studies Investigators are required to keep consent forms and other documents in accordance with applicable regulations, and may retain confidential records regarding research on human subjects involving nuclear medicine procedures.

4.12 The following are integral records that must be maintained in the logbook:

- a valid copy of the IRP for those authorized under the CL;
- names of all Authorized Workers involved in the handling of Nuclear Substances and Radiation Devices;
- names and job categories of persons designated as Nuclear Energy Workers (NEWs);
- an up-to-date inventory of all Nuclear Substances which includes their location;
- records of radioactive materials purchased or transferred;
- transport documents;
- list of radiation-detection equipment;
- any daily direct monitoring results;
- wipe-test results;
- leak-test certificates carried out on Sealed Sources;
- copies of all waste-disposal forms;
- Transportation of Dangerous Goods (TDG) Class 7 certificates for the users handling packages of Nuclear Substances;
- incident reports;
- decommissioning results;
- any other pertinent documents required by CNSC regulations.

The above documents must be retained for a period of time dictated according to CNSC regulations (refer to CNSC Document Retention Schedule, see Appendix XVI).

4.13 The logbook, as well as a copy of this Manual and any SOPs, must be readily accessible to all Authorized Workers in the area as well as to the RSOs.

4.14 No IRPH shall possess more than the maximum quantity of radioisotopes specified by the appropriate CNSC licence, URSC guidelines or their IRP. Authorized quantities in the nuclear medicine facility are specified by the HRSL.

4.15 A copy of the CL, IRP, CNSC laboratory classification and emergency procedures must be posted in a readily visible location in each laboratory where radioisotopes are or will be used or stored as well as in rooms with Radiation Devices.

4.16 The following will be posted in the Basic, Intermediate or High-Level Laboratories and Waste Rooms under either license:

- A copy of the appropriate CNSC license;
- A copy of the IRP if applicable;
- CNSC Laboratory Classification poster which include
    - Laboratory safety guidelines;
- Emergency procedures which include
    - 24 hr emergency number
    - RSO information

4.17 The following will be posted at the main point of access of the Nuclear Medicine Facility (Room PC S1.119):

- A copy of the HRSL; and
- Emergency procedures which include
    - 24 hr emergency number
    - RSO information

4.18 The following will be posted at the entrance (boundary) of all nuclear medicine rooms:

- The radiation warning symbol; and
- The words “RAYONNEMENT-DANGER-RADIATION”
- CNSC Nuclear Medicine poster which include
    - Laboratory safety guidelines;
- 24 hour emergency number
- RSO information

4.19 A copy of the appropriate CNSC license will be posted at the entrance to each building referenced in the license, as well as the main university address at each campus.

4.20 CNSC Approval for Special Projects

Any use of unsealed Nuclear Substances that are in a quantity of more than ten thousand (10,000) times any exemption quantity are considered special projects and require written authorization by the CNSC. If any activities will be engaged in whereby these quantities will be exceeded, the RSO Responsible must be contacted so that the necessary CNSC authorization can be obtained prior to the issuance of an IRP. (Refer to Application for Special Project, *See Appendix XVI)*

5. Radiation Safety Related Training

Radiation safety related training is provided by EH&S and is a critical component of the University's radiation safety program. Before working in or entering an area where Nuclear Substances or Radiation Devices are located, faculty, staff and students must be appropriately trained. Radiation safety related training completed at other institutions may be accepted when the level of knowledge is deemed satisfactory upon evaluation by the RSO-CL; if deemed unsatisfactory, the appropriate training will be required. Training documents are retained by EH&S as per the CNSC Document Retention Schedule (Appendix XVI).

Training certificates are provided to all participants who successfully complete the training exam. Certificates are valid for a period of three (3) years, after which time refresher training is required. As per CNSC regulations and the University`s policy, all faculty, staff and students who work with or in the vicinity of Nuclear Substances or Radiation Devices must be trained in safe radiation work practices and procedures.

5.1 Radiation Safety Training (for open source users)

Radiation Safety Training must be given prior to the use of radiation materials or equipment. All new IRPH, Authorized Workers or those who need to be added to an IRP relating to work with open sources of radiation must attend this Radiation Safety Training and must successfully complete the training exam. Successful candidates are permitted to work with Nuclear Substances or Radiation Devices without direct supervision.

Topics covered during Radiation Safety Training include, but are not limited to:

- Basics of radiation (What is a radioisotope? What is Ionizing Radiation?);
- Biological effects of radiation (How radiation interacts with cells, radiation doses, effective dose limits, ionizing radiation health effects);
- Canadian Regulation: Nuclear Safety & Control Act, Regulations & the Canadian Nuclear Safety Commission;
- University radiation policies & procedures;
- Responsibilities of Internal Radiation Permit Holders and Authorized Workers;
- Safe work procedures;
- Contamination monitoring & decontamination procedures;
- Waste disposal; and
- Emergency procedures.

5.2 Radiation Safety – Laboratory Tool Pack (for open source users)

This is a required training for all new open source users. It is designed as a supplement to the full radiation safety training listed above. In addition to practical aspects of the radiation safety program and the tracking tools used in the program, the training includes:

- Radionuclide Data Sheets
- Log book - introduction to radioisotope tracking
- Radioactive package receiving and unpacking
- Packaging disposal

- Radioisotope storage
- Radioisotope waste
- Wipe test procedures
- How GM Counters work
  - Effectiveness of different probes
  - Survey meter versus contamination meter
  - Meter/Probe efficiency and how/when meter can be used
  - When/how the meter readings can be recorded
- Decontamination procedures
- Emergency procedures (tabletop only)

5.3 Radiation Safety for Sealed Sources and X-Ray Emitting Devices

This is a training targeted to sealed source and radiation device users that do not work with open sources. This includes persons working with x-ray emitting devices, with or without a sealed source contained therein.

Topics covered include, but are not limited to:

- Basics of radiation (beta, gamma, x-ray);
- Biological effects of radiation (How radiation interacts with cells, radiation doses, effective dose limits, ionizing radiation health effects);
- Canadian Regulation: Nuclear Safety & Control Act, Regulations & the CNSC, (including Health Canada and Safety Code 35);
- University radiation policies & procedures;
- Responsibilities of Internal Radiation Permit Holders and Authorized Workers;
- Safe work procedures;
- Leak test requirements;
- Sealed source and x-ray device disposal; and
- Emergency procedures.

5.4 Radiation Safety Refresher Training

Refresher training is required every three years to remain in compliance with conditions for the safe handling or nuclear substances and radiation devices. The refresher training recaps the basics of radiation, biological effects and safe work practices but focuses on recent changes in the radiation safety program, the regulations, and rules of operation.

Topics include but are not limited to:

- Compliance requirements,
- regulations,
- policies,
- the radiation safety manual
- and the CNSC license conditions.

5.5 Radiation Safety Awareness Training

Auxiliary personnel, such as clerical, distribution, custodial, maintenance and security staff, who work in areas where radiation is used, must attend Laboratory Safety Awareness Training for Auxiliary Staff.

Topics covered in Laboratory Safety Awareness Training for Auxiliary Staff include, but are not limited to:

- Description of the type of nuclear substances and radiation devices found at the University;
- Radiation signage;
- Safe work practices; and
- Emergency procedures.

5.6 Transportation of Dangerous Goods Training – Class 7 Radioactive Materials

Any individual involved in packaging, sending or receiving shipments of Nuclear Substances must be trained in the relevant requirements of Transport Canada's *Transportation of Dangerous Goods (TDG) Regulations* and must possess a valid TDG certificate. This training is valid for a period of three (3) years, after which time refresher training is required. This training will be provided by an external certified provider or the RSO Responsible.

Topics covered during *Transportation of Dangerous Goods Training – Class 7: Radioactive Materials* include, but are not limited to:

- TDG background;
- Class 7 shipments;
- Responsibilities;
- Receiving & opening radioactive shipment procedure;
- Packing & shipping procedure;
- Identification of Exempted Packages and Type A radioactive packages, labels and placards and
- Reporting requirements.

6. Responsible Users - Roles & Responsibilities

The following requirements apply to all Responsible Users.

Failure of Responsible Users to comply with the rules and regulations set forth throughout this Manual will lead to the implementation of the Radiation Safety Enforcement Policy. The RSOs have the authority to suspend all or any operations involving Nuclear Substances or Radiation Devices in the cases where they judge an immediate or significant threat to health, safety, the environment, or cases that may be judged to place the university license in jeopardy. Similarly, all Responsible Users may communicate directly with the RSO Responsible for any concerns, especially those related to Regulation, Health, Safety, Security and the Environment.

A Responsible User must:

6.1 Ensure that all persons involved with the handling of Nuclear Substances or operating Radiation Devices under their supervision, or in facilities under their jurisdiction, fully comply with all federal, provincial and municipal legislation, the relevant procedures and policies contained in this Manual, CNSC license conditions and IRP conditions, as well as any directives from the RSO Responsible and/or the URSC. Any changes from the approved procedures appearing in the IRP must be incorporated into an amendment request or new IRP application for subsequent URSC approval prior to the implementation of the change(s).

6.2 Possess knowledge of the potential Radiation hazards inherent to a proposed activity and understands the risks associated with the possession, use and shipment of all radioactive materials and/or operation of Radiation Devices.

6.3 Make certain that all Authorized Workers under their supervision are properly trained, supervised and made aware of potential risks, safety procedures and the proper operation of monitoring or Radiation Devices to prevent unintended exposure to themselves and others and/or contamination of the work areas or environment.

6.4 Assure instruction of Authorized Workers, and especially female Authorized Workers, of the risks associated with radioactive materials or radiation exposure during pregnancy.

6.5 Possess an appropriate and operational Radiation Survey Meter and/or contamination meter; Radiation Survey Meters must be calibrated annually; all monitoring equipment used for contamination checks must be verified every twelve (12) months using a NIST-certified source or by a company or organization approved by the CNSC.

6.6 Maintain an up-to-date inventory with knowledge of the various forms (physical and chemical) and quantities of Nuclear Substances that are present in work areas listed on the IRP. Keeps current records of the ordering, inventory and waste of radioactive materials in their possession including their use in research, waste disposal, transfer and storage.

6.7 Post warnings and restrict entry to areas with potential Ionizing Radiation hazards; label equipment and areas used for radioactive work and take appropriate security measures to prevent unauthorized access to Nuclear Substances or Radiation Devices.

6.8 Provide the RSO Responsible with twenty-four (24) hour contact information of individuals able to respond to emergency situations.

6.9 Notify the RSO Responsible of any personnel changes, including the intent to add or remove students and employees to the IRP, also including change of location where radioactive materials may be used or stored.

6.10 Inform the RSO Responsible of the designation of a responsible individual to oversee work involving Nuclear Substances and Radiation Devices during short absences, and of a stand-in Principal Investigator during absences greater than forty-five (45) days.

7. Compliance & Enforcement

Concordia University assumes responsibility of ensuring that any use of Nuclear Substances and Radiation Devices will be used in strict compliance with the NSCA and associated regulations, and the conditions of the University's licences as issued by the CNSC. Notwithstanding, Responsible Users are required to adhere to all radiation safety legislation and CNSC guidelines, as well as Concordia's radiation safety policy, the Manual and procedures, including any conditions specified on their IRP.

7.1 Radiation Safety Enforcement

As per the responsibilities of the RSO, outlined in Section 3, the RSOs will monitor and conduct inspections of areas to which an IRP has been issued and of the work practices of Responsible Users in order to ensure compliance with all applicable radiation safety legislation and guidelines, the conditions of the University's licences and with Concordia's radiation safety policy, manual and procedures, including any conditions specified on Internal Radiation Permits. All individuals working in areas associated with an Internal Radiation Permit are required to carry out their work in a manner that is compliant. Oversight of compliance is a shared responsibility between IRPH and Administrative Head of the centre/department where the IRPH is held.

7.1.1 Radiation Safety Enforcement Policy

The Radiation Safety Enforcement Policy allows for the internal verification and enforcement of all applicable radiation safety legislation and guidelines, the conditions of the University's licences and with Concordia's radiation safety policy, manual and procedures, including any conditions specified on the Internal Radiation Permits. A progressive scale of enforcement has been adopted based on the level of risk and degree of repetition of incidents related to non-compliance.

7.1.2 Non-Compliance

Non-compliance is when a Responsible User fails or refuses to comply with radiation safety legislation and guidelines, the conditions of the University's CNSC licences and with the radiation safety policy, manual and procedures, including IRP conditions, and that requires corrective actions.

Examples of non-compliance include, but are not limited to:

- use or storage of food or drink in radiation controlled areas
- contamination above license criteria
- inadequate monitoring program
- lack or inadequate training
- unauthorized possession of radioactive materials
- incomplete records
- inadequate security for nuclear substances
- security breaches

- non-participation in required bioassay programs
- inadequate and/or unsafe work practices (Dosimeter, gloves, safety glasses, etc.)
- inadequate and/or unsafe storage
- inadequate/inappropriate posting of required warning signs or labels
- inappropriate preparation/segregation/identification of radioactive waste
- inadequate inventory records
- non-removal of expired permits and forms
- inadequate/incorrect posting (IRP, CNSC posters)

7.1.3 Levels of Enforcement

LEVEL A: IMMEDIATE HIGH RISK

The RSO will take immediate action when there is an immediate or perceived high risk to health, safety, the environment or security, or places the University's CNSC licences in jeopardy.

On behalf of the Vice-President, Services and Sustainability (Applicant Authority), the RSO has the authority to temporarily stop any activities considered to be in violation of University procedures or CNSC regulations and to suspend the use of Nuclear Substances and Radiation Devices. The IRPH, the Chief Administrative Officer-PERFORM, the PI, the Director of EHS, the appropriate Dean, the Vice-President, Services and Sustainability (Applicant Authority) and/or the Vice-President, Research and Graduate Studies will be informed directly of any such action.

LEVEL B: NON-COMPLIANCE

Step 1: Non-compliance with radiation safety requirements is observed by the RSO or reported to the RSO and subsequently investigated and confirmed by the RSO. The RSO may provide a verbal warning to the IRPH or an inspection report is sent to the IRPH outlining required corrective actions. A deadline for completing the corrective actions will be issued and the IRPH must advise the RSO of the completion of the corrective actions within the stated deadline.

Step 2: If the IRPH has not completed the corrective actions and advised the RSO by the set deadline or if a repeat non-compliance is observed within one year, a Notice of Non-Compliance is sent to the IRPH. The Chair of the IRPH's Department or equivalent and the Chair of the URSC will be copied. The Notice of Non-Compliance will outline the required corrective actions and associated deadlines for the corrective actions. The IRPH must advise the RSO of the completion of the corrective actions within the stated deadline.

Step 3: If the IRPH has not completed the corrective actions and advised the RSO by the set deadline or if the non-compliance is observed for a third time within one year, the RSO advises the Chair of the URSC and Vice-President, Services and Sustainability (Applicant Authority). The matter will be referred to the URSC and Vice-President, Services and Sustainability (Applicant Authority) for determination of appropriate course of action, including sanctions. Possible sanctions include: suspension of purchasing privileges, suspension of IRP, confiscation of Nuclear Substances or

Radiation Devices and revocation of IRP. The RSO may temporarily suspend the IRP or require that all further work and purchases under the IRP only be allowed under the direct control of the Chair of the URSC.

Any issues of non-compliance recurring in a period greater than one year will not be considered in further actions, provided that they are adequately addressed prior to the set deadlines.

The RSO and Chair of the URSC reserve the right to bypass any of the steps or levels in the enforcement policy if a serious violation occurs.

The IRPH may appeal, in writing, any sanctions or the revocation of their IRP to the URSC and Vice-President, Services and Sustainability (Applicant Authority).

7.2 Canadian Nuclear Safety Commission

CNSC inspectors verify through on-site inspections, the University's compliance with all applicable NSCA legislation, CNSC guidelines, conditions indicated on the University's licenses, and compliance with documents indicated in the license Appendix: License Documents. This applies to Concordia's radiation safety manual, and by extension, to policy, procedures and any other documents referenced by the Manual. CNSC inspections ensure that the above regulations and conditions are being met by Concordia University and its Responsible Users.

The CNSC's compliance verification and enforcement program includes a number of tools, including written warnings, requests under subsection 12(2) of the General Nuclear Safety and Control Regulations, orders, increased regulatory scrutiny, licensing action, administrative monetary penalties and decertification.

The CNSC has the authority to withdraw Concordia University Licenses if violations are observed and this would affect all IRPH and Human Research Studies Investigators under Concordia's University's Licenses. CNSC authority extends to issuing Administrative Monetary Penalties to either individuals (Responsible Users) or the University (licensee).

7.3 Administrative Monetary Penalties

Administrative Monetary Penalties are monetary penalties imposed by the CNSC, without court involvement, for the violation of a regulatory requirement. They can be applied against any individual or corporation subject to the NSCA.

AMPs provide the CNSC with a broader range of options for responding to non-compliance. The first and most commonly used action is regular discussions with licensees. If this fails to resolve the issue, other actions will be taken based on the situation. Notwithstanding, the CNSC will continue to consider prosecution for actions that are considered offences under the NSCA.

The CNSC will apply its practice for public disclosure as per other regulatory actions: information about each AMP will be published to the CNSC's Web site soon after the Notice of Violation has been issued. If contested within 30 days of receiving the Notice of Violation, the result of the reviews will also be posted on the CNSC's Web site.

7.3.1 Issuing AMPs

AMPs can be issued to any individual or the University for non-compliance with regulatory requirements. Non-compliance is defined as a CNSC regulatory requirement that has not been met. A non-compliance becomes a violation if it is listed in the schedule to the AMP Regulations and the CNSC selects AMPs as the appropriate enforcement option. Only the non-compliance listed as violations in the AMPs regulations may be subject to monetary penalties. Each AMP will be issued in the form of a Notice of Violation from the CNSC along with the invoice for payment and instructions on how to request a review.

An individual could receive an AMP for:

- any violation of section 17, "Obligations of Workers", of the General Nuclear Safety and Control Regulations
- any violation of section 31 "Obligations of Operators" of the Nuclear Substances and Radiation Devices Regulations

Section 44 of the NSCA establishes maximum and minimum penalty amounts for individuals and corporations. The maximum penalty for a single violation by an individual will be $25,000. The maximum penalty for a single violation by a corporation will be $100,000. These amounts will be applied per violation. A violation committed or continued on more than one day may be considered as a separate violation (NSCA, s. 65.07). Any additional daily penalties will be calculated accordingly.

8. Facilities Designated For Radioactive Materials Usage

8.1 The classification of radioisotope laboratories and rooms is dependent upon the nature of the radioisotope(s), EQ and ALI quantities of unsealed radioactive material handled at any single time within the facility. The design for an Intermediate-Level, High-Level, Containment-Level Laboratory, or Nuclear Medicine Room must be approved in writing by the CNSC prior to its use. These rooms are designated Radiation Controlled Areas.

8.2 All usage of greater than one (1) EQ of an unsealed Nuclear Substance at a single time must be carried out in a designated laboratory, room or area as defined below. EQs of radioisotopes in use at the University are defined in Appendix III– Regulatory Quantities for Radioisotopes and are specific to each radioisotope due to differing radiotoxicity.

a) Basic-Level Laboratory: the quantity of a radioisotope used in a single procedure on an open bench does not exceed five (5) ALI.
b) Intermediate-Level Laboratory: the quantity of a radioisotope used in a single procedure on an open bench does not exceed fifty (50) ALI. This classification of rooms requires specific approval from the CNSC.
c) High-Level Laboratory: the quantity of radioisotope used in a single procedure on an open bench does not exceed five hundred (500) ALI. This classification of rooms requires specific approval from the CNSC.
d) Containment-Level Laboratory: the quantity of a radioisotope used in a single procedure on an open bench exceeds five hundred (500) ALI. This classification of rooms requires specific approval from the CNSC.
e) Nuclear Medicine Room(s): A room where unsealed Nuclear Substances are prepared for or administered to a person, or where imaging is performed. This classification requires specific approval from the CNSC.

8.3 Any facility with adequate ventilation, finishing and fixtures, plumbing, storage, shielding and security conforming to requirements of *CNSC REGDOC 2.5.6 Design of Rooms Where Nuclear substances are Handled* which will supersede the *CNSC regulatory document* (GD-52, *Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms*) concerning the design and construction of Basic, Intermediate and High-Level Laboratories and Nuclear Medicine Rooms may be used. All such areas must be identified in licence applications and permits, appropriately labelled with Radiation warning signs and maintained in accordance with CNSC regulatory documents and guides indicated in this Manual. A Design Assessment Form (GD-52) must be completed for any new construction or major renovation (such as demolishing walls, changes to existing shielding, or installing new fume hoods) and submitted to the CNSC for review prior to starting renovations or new construction.

8.4 An appropriate CNSC radioisotope safety poster (see Appendix XVI) corresponding to the classification of Radiation Controlled Areas must be kept posted in a readily visible location. The same is applicable to an emergency procedures card (the Card) (see Appendix XVI). The information on the Card must include the name and phone number(s) of contact persons to be called in case of an emergency.

8.5 Access to nuclear substances in Basic Level laboratories will be restricted to Responsible Users. The IRPH may authorize other individuals to access the Basic Level laboratory provided access to Nuclear Substances is prohibited, and Nuclear Substances remain locked and secured at all times.

8.6 Access to Intermediate, High-Level, Containment-Level Laboratories and Nuclear Medicine Rooms will be restricted to Responsible Users only, as indicated on the IRP.

8.7 To ensure that individuals are aware, prior to entering any Radiation-Controlled Areas containing more than one hundred (100) EQ and/or if there is a reasonable probability that a person will be exposed to an Effective Dose rate greater than 2.5 µSv/h, appropriate signs bearing the radiation warning symbol and the words "**RADIATION – DANGER – RAYONNEMENT**" must be visibly posted at each boundary and every point of access.

8.8 A radioactive waste holding area must be available in all labs designated for radioactive materials use. Only University approved radioactive waste containers can be used for the collection and storage of radioactive waste. Radioactive waste containers are available from the RSO Responsible and EH&S. The designated and clearly identified area for waste within the lab must be provided with second containment to control a spill and appropriate shielding.

8.9 A radioactive materials storage area must be available in all labs designated for radioactive materials use. Stored radioactive substances must only be accessible to authorized individuals who are listed on IRP. Nuclear Substances must be in locked storage areas when unattended.

8.10 Radiation Devices must only be accessible only to Responsible Users.

8.11 Areas containing Nuclear Substances and Radiation Devices must be locked at all times. Options include the following:

- Access Doors to be locked
- Fridges and freezers to be locked
- Storage spaces to be locked

8.12 The Dose-rate at any occupied location, outside the storage area, resulting from the Nuclear Substance(s) or Radiation Device(s) in storage will be measured or estimated by the RSO and may not exceed 2.5 µSv/h. Appropriate measures must also be taken to ensure that Dose-limits to Responsible Users in the area are not exceeded. The measured or estimated dose rate must be updated annually, or when there are changes to the storage configuration, the storage unit construction, inventory, changes in the distances of the occupied location and changes in the occupancy of adjacent areas. The RSO Responsible must maintain a record of the dose rate measurement or estimation.

8.13 Any surface should be decontaminated as close to Background Radiation levels as possible. The IRPH or Human Research Studies Investigator or Nuclear Medicine Facility Manager must ensure that, for Nuclear Substances listed on their permits or licences, the contamination limits are not surpassed.

8.14 Prior to Decommissioning (see section 21), the RSO Responsible must certify that: (i) non-fixed contamination conforms to the prescribed limits specified in Section 15.2 , (ii) all radioisotopes and Radiation Devices have been appropriately transferred to licensed facilities, and (iii) all radiation warning signs have been removed. The release of an area with any fixed contamination to general use must be approved by the CNSC.

8.15 Radiation levels in designated Radiation Controlled Areas and in adjacent areas will be monitored regularly for contamination and appropriate action taken if contamination exceeds prescribed limits.

9. Worker Classification & Exposure Control

9.1 Classifying Workers

9.1.1 Authorized Worker

An authorized worker is a person indicated on an Internal Radiation Permit that is authorized to possess, handle, prepare for disposal, and otherwise use, the indicated nuclear substances in the indicated locations and for the indicated purposes as specified on the Internal Radiation Permit.

9.1.2 Nuclear Energy Worker

An Authorized Worker will be classified as a Nuclear Energy Worker (NEW) if it has been determined that there is a reasonable probability that the Effective Dose to his or her whole body may exceed the prescribed limit for the general public in a one-year dosimetry period; see Section 9.3.

A NEW will be informed in writing by the RSO Responsible, with a document entitled Notification of Nuclear Energy Worker (NEW) Status (See Appendix XVI) of the following:

- that he or she is a NEW;
- of the risks associated with Radiation to which the NEW may be exposed in the course of his or her work, including the risks associated with the exposure of embryos and foetuses to Radiation;
- of risks associated with breastfeeding;
- of the applicable Effective Dose limits and Equivalent Dose limits; and
- of the NEW's reported Radiation Dose levels.

9.1.3 Each female NEW will be informed in writing of the rights and obligations of a pregnant NEW and of the applicable Effective Dose limits prescribed under the legislation; See Section 9.3.

9.2 ALARA (As Low As Reasonably Achievable)

The University is committed to implementing and enforcing a radiation protection program of the highest quality.

Integral to this program is the notion that each Responsible User is responsible for keeping all radiation exposures to themselves and others ALARA, social and economic factors being taken into account. This program is implemented through management control over work practices, personnel qualification and training, control of occupational and public exposure to radiation and planning for unusual situations.

9.2.1 There are three (3) basic practices for reducing exposures to radiation and radioactive materials ALARA:

Time:	Reduce the amount of time spent near a source of Radiation.
Distance:	Stay as far away from the source as possible. Radiation exposure decreases rapidly as you move away from the source.
Shielding:	Surround the source with Shielding. Appropriate Shielding reduces radiation exposure.

9.2.2 To minimize Radiation exposures to personnel, users must observe the policies and procedures described in this Manual and on the CNSC safety posters and immediately inform their supervisor when unsafe conditions are known or suspected to exist.

9.3 Control of Internal and External Exposures

9.3.1 Unless excluded from the program by virtue of a written risk assessment completed by the RSO-Responsible, all those working with radioisotopes emitting Beta particles (except 3-H), or Gamma Radiation are required to wear dosimeter (TLD or OSLD) badges. See Appendix XVI for Dosimeter Use and Care Guide. Dosimeters are also required for those working routinely in these areas even though they may not be directly handling Nuclear Substances or operating Radiation Devices. Extremity badges (ring-Dosimeters) will be required for those handling containers with more than 37 MBq ^{32}P, 740 MBq ^{99m}TC, 370 MBq ^{18}F, in single operations.

9.3.2 Personal Radiation monitoring devices (TLD, OSLD or ring badges) are provided by the RSO Responsible or department technical officers when required.

9.3.3 Bioassay services are referred by the RSO Responsible to a certified external service provider when required.

9.3.4 For purposes related to the administration of the NSCA and NSRD regulations, the University collects personal information, as defined in Quebec's *Loi sur l'accès aux documents des organismes publics et sur la protection des renseignements personnels, L.R.Q., c-A-2.1* that may be required to be disclosed to the CNSC, another government department or a dosimetry service.

Every Responsible User and NEW shall provide the following information:

- given names, surname and any previous surname;
- Social Insurance Number;
- sex;
- date, province and country of birth; and
- Dose-record for the current one-year and five-year dosimetry periods from *any previous employment.*

9.3.5 Users must wear only their personally assigned badges and assure the return of such badges at the end of the monitoring period or upon termination of their work. Loss of, or damage to, any badge must be reported to the RSO Responsible immediately. Dosimeters must not leave University premises without the explicit written authorization of the RSO Responsible. (See Dosimeter Use and Care Guide, Appendix XVI)

9.3.6 Failure of personnel to use dosimeters or other required monitoring devices as a licence condition, as specified in the IRP or at the request of the RSO Responsible will be reported to their supervisors and the Chair of the URSC. Such failure may result in disciplinary action.

9.3.7 A survey meter or a contamination meter shall be accessible at all times in areas where Nuclear Substances are used or stored, and shall be appropriate for the detection of the radiation used. Refer to Survey and Contamination Meter Guidelines (see Appendix XVI).

9.3.8 Instruments used for measuring exposure rates shall be calibrated once a year. Instruments used for determining the amount of radioactivity present in samples or surfaces shall be verified at least once a year. Pre-operation checks to be performed prior to use. Refer to Survey and Contamination Meter Guidelines (see Appendix XVI).

9.3.9 Calibrations shall be performed by individuals who meet the specified CNSC requirements and using sources, procedures in accordance with appendix Z of REGDOC-1.6.1 and record keeping that assure compliance with federal regulations and licence conditions.

9.3.10 The RSO Responsible will annually verify that Radiation Controlled Areas are checked for radiation levels and airborne or surface contamination according to standardized procedures approved by the URSC.

9.3.11 The Effective Dose for NEW shall not exceed those limits outlined in the following table:

Person	**Period**	**Effective Dose Limits (mSv)**
NEW, including a pregnant NEW	One-year dosimetry period	50
	Five-year dosimetry period	100
Pregnant NEW	Balance of pregnancy	4
A person who is not a NEW	One calendar year	1

Radiation Protection Regulations (SOR/2000-203), sec. 13

9.3.12 The Equivalent Dose received by and committed to an organ or tissue shall not exceed those limits outlined in the following table:

Organ or Tissue	**Person**	**Period**	**Equivalent Dose Limits (mSv)**
Lens of an eye	(a) NEW	One-year dosimetry period	50
	(b) Any other person	One calendar year	15
Skin	(a) NEW	One-year dosimetry period	500
	(b) Any other person	One calendar year	50
Hands and feet	(a) NEW	One-year dosimetry period	500
	(b) Any other person	One calendar year	50

Radiation Protection Regulations (SOR/2000-203), sec. 14

Please Note: When the skin is unevenly irradiated, the Equivalent Dose received by the skin is the average Equivalent Dose over the 1 cm² area that received the highest Equivalent Dose.

9.3.13 Breath and urine bioassay analysis procedures will be available for those using large amounts of ^{14}C or tritium (>5 ALIs) or in any situation in which inhalation or ingestion is suspected by the RSO Responsible. Urine analysis or external whole-body counting will be made available if accidental ingestion of radioisotopes is suspected. Responsible Users must refer to Bioassay Program Guide, see Appendix XVI.

9.3.14 All NEW will be notified in writing by the RSO Responsible of their dose at least once per year. Any NEW receiving whole-body Effective Dose exceeding 3 mSv in a one-year dosimetry period will be notified immediately in writing by the RSO Responsible. The RSO Responsible will investigate all reported exposures in any quarter (three months) exceeding 1 mSv for NEWs and 0.2 mSv for all others. The RSO responsible will investigate all reported extremity exposures (hands) exceeding 30 mSv in a dosimetry reporting period for NEWs and 3 mSv for all others.

9.3.15 All exposures resulting in doses of radiation received by, and committed to, a person, organ or tissue exceeding the regulatory limit will require the following actions in accordance with the *CNSC Radiation Protection Regulations* (SOR/2000-203):

- the CNSC, the Chair of the URSC, the immediate supervisor and the individual involved will be immediately notified by the RSO Responsible;
- the individual involved will be required to cease any work likely to add to the dose;
- an investigation will be conducted to determine the magnitude of the dose, establish the causes of the exposure and take any action required to prevent the occurrence of a similar incident.
- a written report showing the results of the investigation will be sent to the CNSC within twenty-one (21) days after becoming aware that the dose limit has been exceeded.

9.3.16 Complete dosimetry records will be maintained by the RSO Responsible who, if necessary, will inform all individuals receiving any reported exposure. Upon written request, the RSO Responsible will advise individuals of their annual exposure to radiation.

9.4 Pregnant Responsible Users

9.4.1 Female Responsible Users are strongly encouraged to disclose all suspected or known pregnancies to their immediate supervisor to whom she reports, in confidence and at the earliest possible date.

9.4.2 Every NEW who becomes aware that she is pregnant is strongly encouraged to inform, in writing, their immediate supervisor who shall notify the RSO Responsible within twenty-four (24) hours.

9.4.3 On being informed by a Responsible User, including NEW that she is pregnant or breastfeeding, the licensee shall, in order to comply with Section 11 of the *CNSC Radiation Protection Regulations* (SOR/2000-203), make any accommodation that will not occasion costs or business inconvenience

constituting undue hardship to the licensee. In cooperation with the Responsible User's immediate supervisor, there shall be a prompt review of her schedule and work assignment to ensure that prenatal radiation exposures are kept as low as reasonably possible.

9.4.4 Under certain conditions, if the reduction of radiation exposures to the lowest level possible is not feasible, the pregnant Responsible User shall be strongly encouraged to consider termination of any further work with radiation.

9.4.5 All female Responsible Users shall be made aware of the above by the RSO Responsible prior to use of Nuclear Substances or Radiation Devices.

10 Handling of Radioactive Materials

10.1 Purchasing Radioactive Materials for Basic, Intermediate or High-Level Laboratory Use

10.1.1 Prior to the purchase of radioactive materials, IRPHs will ensure that the amount ordered will not increase their on-hand quantity beyond the total amount allowed by their IRP.

10.1.2 All purchase requisitions for radioactive materials require:
- the signature of the IRPH;
- the internal permit number;
- the amount, activity and chemical form and physical state of the radioisotope being ordered as well as the total quantity of said radioisotope currently in the IRPH's possession;
- the signature of the RSO Responsible; in his/her absence, the signature of the Alternate RSO or Chair of the URSC.

10.1.3 Copies of all completed purchase orders as well as the packing slips of the relevant shipments for radioactive materials must be sent to the RSO Responsible by the IRPH.

10.2 Purchasing Radioactive Materials for Human Research Studies

10.2.1 Prior to the purchase of radioactive materials for human research studies, the Human Research Studies Investigator or Nuclear Medicine Facility Manager will ensure that the amount ordered will not increase their on-hand quantity beyond the total amount allowed by the licence.

10.2.2 Requisitions for a standing order or any special order for radioactive materials require:
- the HRSL number
- the amount, activity, chemical form and physical state
- the total quantity of that radioisotope currently in possession
- the signature of the RSO-NM or in his/her absence, the alternate RSO or Chair of the URSC

10.2.3 Copies of all completed purchase orders as well as the packing slips of the relevant shipments for radioactive materials must be maintained by the RSO-NM and be available to EH&S and the CNSC.

10.3 Transport of Dangerous Goods

10.3.1 In keeping with the ALARA principle of Dose limitation, controls must be in place to protect personnel from exposure to Radiation and radioactive materials. These controls include proper packaging and transportation labels and must be applied as indicated in the following regulations:

Transportation of Dangerous Goods Regulations (TDG)
CNSC Packaging and Transport of Nuclear Substances Regulations, 2015 (SOR/2015-145)
The current publication of the IAEA Regulations for the Safe Transport of Radioactive Material.
Please refer to the TDG-7 Guide to Radioactive Packages (see Appendix XVI)

10.4 Receiving and Distribution within the University

10.4.1 Shipments of radioactive material for use in Basic or Intermediate-Level Laboratories shall not be forwarded in the usual manner by the University's Distribution Services to the purchaser or his/her Department. Immediately upon receipt of radioactive material, the University's Distribution Services must contact the purchaser or his/her laboratory personnel to collect the package(s). In cases where these individuals are unavailable, Distribution Services shall contact the RSO-Responsible who will ensure appropriate and secure temporary storage.

10.4.2 Radiopharmaceuticals for use in human subjects will be delivered directly by the supplier to the nuclear medicine facility via a previously approved route. The RSO-NM or a person with a Class TDG-7 certificate will be responsible for the reception. The RSO-NM or a NEW will be responsible for proper storage and opening of the package in accordance with the procedures described in this Section.

10.4.3 Outside of normal operating hours a designated qualified person (normally the Responsible User with a Class TDG-7 certificate) must be available to inspect and take charge of any radioactive material received at the University. In cases where these individuals are not available, no package will be accepted.

10.4.4 Only those holding a Class 7 TDG certificate are authorized to handle radioactive shipments. It is recommended that each IRPH select, when possible, two (2) qualified Responsible Users to be responsible for the pick-up of such shipments.

10.4.5 A specifically designed container is made available and must be used for the transport of radioactive materials, within the University, so as to provide shielding, increase the distance between the transporter and the package, to minimize radiation exposure and contain any leakage. Only approved routes as posted may be used to transport the radioactive materials to the authorized location.

10.4.6 Disposable gloves, a lab coat and a Dosimeter must be worn while handling the package. Eye protection should also be worn.

10.4.7 The labels and Transport Index (TI) shall be verified by the person responsible for transporting the package to its final destination. If measured values are greater than the TI indicated, the RSO Responsible must be contacted immediately before moving such materials.

10.4.8 The Responsible User, prior to taking charge of the package shall inspect the external surfaces of the package for damage and check for Contamination using the appropriate monitoring method (see section 15. Contamination Monitoring, and the Survey and Contamination Meter Guidelines), and contamination must be below 4 Bq/cm^2 averaged over an area of 300 cm^2 of any part of the surface. If there is contamination, the RSO Responsible must be notified immediately.

10.5 Inspection of Shipments

10.5.1 All external packaging inspections shall be conducted in the receiving area prior to transport to the Radiation Controlled Area. All internal package inspections shall be conducted in the Radiation Controlled Area.

10.5.2 External Packaging examined in receiving area- Immediately contact the RSO Responsible concerning any anomalies such as damaged packages, radiation levels in excess of the package labelling, incorrect Transport Index (TI), signs of contamination, leakage and/or shipment discrepancies.

10.5.3 If the material is volatile (iodine, tritium, radioactive gases, etc.), the package must be placed in a designated radioisotope fume hood upon arrival in the designated area.

10.5.4 Internal Packaging examined in Radiation Controlled Area- the Responsible User must remove the packing slip, open the outer package and verify that there is no discoloration of the packing materials, broken seals, and loss of liquid or damaged contents. If there is damage, the RSO Responsible must be notified immediately.

10.5.5 The responsible user will remove the inner package and wipe-test the inner package and the container. If there is contamination above the public areas limit indicated in section 15.2, monitor all areas having come into contact with the package and decontaminate as necessary (refer to section on Decontamination).

10.5.6 Confirm that the contents (Activity, isotope, chemical form and quantity) are consistent with what was ordered. Record on the Radioisotope Inventory Form (see Appendix XVI) all details regarding the radioisotope including Activity, date received along with any anomalies.

10.5.7 If the shipping carton is found to be free of contamination, remove the packing materials and remove or deface all radiation symbols. Then dispose as regular non-radioactive waste.

10.5.8 For nuclear medicine re-usable containers, contamination tests shall be performed and documented according to internal procedures (Refer to Nuclear Medicine Facility PERFORM Operating Document, see Appendix XVI).

10.6 Off-Campus Shipments

Contact the RSO Responsible prior to making arrangements for any radioactive shipment to be sent outside of the University. The RSO will ensure the radioactive package is prepared and shipped in conformance with Transportation of Dangerous Goods Regulations and with Packaging and Transport of Nuclear Substances Regulations.

11. Unsealed Nuclear Substance Procedures

The following safe work practices must be respected when working with unsealed nuclear substances:

11.1 Radioactive Work Areas

The Radioactive Work Areas are those areas within a Radiation Controlled Area that are designated for the handling of Unsealed Nuclear Substances. The following must be respected at all times:

11.1.1 The Radioactive Work Areas must be made as small as possible in order to minimize the potential for contamination while still allowing sufficient room to carry out procedures. These areas (benches, fume hoods and sinks) must be clearly defined and delimited by yellow warning tape displaying the standard radiation warning symbol.

11.1.2 A suitably verified Contamination meter and/or calibrated Radiation Survey Meter must be available for use before starting any procedure involving radioisotopes or Radiation Devices (Refer to Survey and Contamination Meter Guidelines).

11.1.3 Bench areas that are in low-traffic zones shall be chosen. Bench areas next to the fume hood shall be used if part of a procedure incorporates the use of a fume hood.

11.1.4 If possible, only one sink, located in or near radioactive work area(s) and delimited with Radiation warning tape, will be selected for radioactive work usage, for the cleaning of contaminated labware, and may not be used by the Responsible User for disposal of aqueous radioactive waste.

11.1.5 Any equipment, such as water-baths, centrifuges, incubators, micropipettes and glassware, used in experiments requiring radioisotopes in excess of the Exemption Quantity (see Appendix III, Regulatory Quantities for Radioisotopes) shall be located within the radioactive area, and be labeled with radiation warning tape displaying the Radiation Warning Sign when used for this purpose. It is recommended that all such equipment be dedicated solely for radioactive work. All such equipment must be verified after each experiment with a contamination or survey meter, and included in wipe test locations. The Radiation Warning Sign must be removed from this equipment when not in use.

11.1.6 Any equipment involved in the radiation program and used with less than one (1) Exemption Quantity of a radioisotope may be permanently labelled ‘Equipment Dedicated to the Radiation Program’ without the Radiation Warning Sign. This sign does not have to be removed when equipment is not in use. See the Radiation Program Labelling Guide, Appendix XVI.

11.1.7 All radioactive materials, instruments and storage containers must be properly labelled and identified with radiation warning tape.

11.1.8 Radioactive work areas and waste trays shall be covered with appropriate absorbent bench covering, the absorbent side facing up. Replacement frequency of the covering must reflect the use of radioisotopes or whenever monitoring indicates contamination. For example, daily usage requires

that the bench covering be changed at least once a week.

11.1.9 Unsealed radioisotopes must be stored in a locked refrigerator, freezer or cabinet clearly labelled with a Radiation warning sign. The storage area shall be cleaned and at a minimum, wipe-tested on a monthly basis. In order to minimize the degradation of the radio-chemicals, it is recommended to aliquot and/or dilute the stock solution into smaller volumes, which are then shielded and stored.

11.1.10 Secured storage areas dedicated for unsealed radioisotopes that are maintained with restricted access and not accessed or in use for long periods should be wipe-tested twice per year.

11.1.11 IRPs that are INACTIVE as defined in the document entitled Internal Management of Radiation Permits (*see appendix XVI*) are excused from performing the workplace monitoring.

11.2 Working with Unsealed Radioisotopes

11.2.1 It is strictly forbidden to eat, drink, store food, smoke or apply cosmetics in any area where radioactive materials are used, handled, transferred or stored. Food/beverages must not be kept in refrigerators used to store radioactive materials nor prepared on lab benches or in/on laboratory equipment.

11.2.2 Appropriate clothing, such as closed-toe shoes and long pants, shall be worn. Loose hair must be tied back.

11.2.3 Buttoned-up lab coats or protective clothing must be worn whenever handling unsealed radioactive sources and must be routinely monitored for contamination. Lab coats are not to be worn in coffee lounges, cafeterias, classrooms, public areas or when consuming food/beverages. Notify the RSO Responsible if a lab coat or protective clothing is found to be contaminated.

11.2.4 Protective gloves (two pairs recommended) shall be worn whenever operations are performed that may result in hand contamination. Gloves must be removed before leaving the immediate radioactive area and may not be used to handle instruments outside that work area. Upon completing the work, users shall remove their gloves and monitor their hands for contamination. If contamination is found follow appropriate personnel decontamination procedures (See Appendix X, Emergency and Spill Procedures). It is recommended that hands be washed before exiting the lab regardless of whether any work was performed with radioactive material.

11.2.5 The hands, lab coat, clothing, shoes, and the entire body must be monitored for radioactive contamination before leaving the Radiation Controlled Area.

11.2.6 Safety glasses or goggles shall be worn when working with high-energy Beta emitters (unsealed ^{32}P, ^{18}F) and appropriate low atomic number shielding shall be used for Beta radiation.

11.2.7 Unless working with ^{3}H or deemed 'not required' based on a written risk assessment performed by the RSO-Responsible, all personnel must wear dosimeter badges or pocket ionization chambers when working with radioisotopes in Radiation Controlled Areas. Other personnel monitoring equipment should be worn as appropriate. Extremity badges will be required by those handling more than 37 MBq (1 mCi) of ^{32}P in a single procedure and recommended for NEWs handling quantities of radiopharmaceuticals exceeding 1.0 ALI.

11.2.8 Bioassay samples may be required for ^{3}H and ^{14}C users and thyroid monitoring for ^{125}I and ^{131}I users. Refer to Bioassay Program Guide, Appendix XVI.

11.2.9 Procedures involving Nuclear Substances must be used only in Radiation Controlled Areas (CNSC licence and authorized by internal permits), in accordance with the ALARA principle, minimizing all exposures by judicious consideration of time, distance and shielding.

11.2.10 Mouth pipetting is strictly prohibited; pipetting devices must be used at all times.

11.2.11 All work involving liquids, which may not be completely absorbed by the bench area cover, shall be performed in suitable trays so as to contain spills.

11.2.12 Work involving radioactive materials must be carried out, as much as possible, in a properly operating radiation fume hood. Sashes shall be kept lowered on fume hoods when they are not in use. Any work that may give rise to airborne contamination must be performed only in a radiation fume hood and not on an open bench.

11.2.13 Stock solutions of radionuclides must not be left near general working areas. Quantities required should be extracted and the remaining stock should be immediately returned to the storage area with the appropriate shielding.

11.2.14 Radioactive material must be stored in locked cabinets or refrigerators to prevent the possibility of unauthorized access.

11.2.15 When unoccupied, the lab door must be kept locked to prevent the possibility of unauthorized access.

11.2.16 When appropriate, use remote handling devices such as tongs or shielding materials to reduce exposure to extremities.

11.2.17 At the end of each week in which unsealed radioisotopes are used, designated test-sites shall be inspected, surveyed, wipe-tested and cleaned as needed. Records of survey and/or wipe-tests will be maintained in a radiation logbook in each laboratory in which radioactive material is used. Decontamination shall be undertaken immediately if levels exceed those outlined in Section 15.2.

11.2.18 In addition to weekly monitoring, at the conclusion of an experiment involving unsealed radioisotopes, designated test-sites shall be inspected, surveyed, wipe-tested and cleaned as needed. Records of survey and/or wipe-tests will be maintained in a radiation logbook in each laboratory in

which radioactive material is used. Decontamination shall be undertaken immediately if levels exceed those outlined in Section 15.2.

11.2.19 Any glassware or other equipment used with radioactive materials must be properly decontaminated at the end of its use and checked for contamination.

11.2.20 Equipment, containers or objects formerly used for radioactive work must be surveyed for surface contamination and decontaminated, if necessary. Equipment to be tasked for use outside the radiation program must be decommissioned according to section 21, Decommissioning. All radiation warning labels must be removed prior to the release of equipment, containers, or objects for non-radioactive usage.

11.2.21 Personnel shall not work alone after normal working hours when performing hazardous operations involving Radiation.

11.2.22 In the event of accidents involving spills, airborne release of radioactivity or personnel contamination refer to Appendix X – Emergency and Spill Procedures.

11.2.23 It is the responsibility of the Responsible User to ensure that all required postings remains visible in the radiation controlled area. These include but may not be limited to, (1) the Emergency Card, (2) the Internal Radiation Permit, (3) the CNSC Lab Classification Poster.

11.2.24 Responsible Users must maintain up-to-date information on the Emergency Card, including the name and phone number(s) of contact persons to be called by the RSO in case of an emergency.

11.3 Use of Unsealed Radioisotopes in Undergraduate Laboratories

The following additional precautions shall be observed and stringently applied when using unsealed nuclear substances in University undergraduate laboratories:

11.3.1 The number of different laboratories in which unsealed radioactive material is used, for teaching purposes, will be kept to a minimum and all such laboratories must be identified to the RSO-CL.

11.3.2 The locations within teaching laboratories where unsealed radioactive material is handled will be kept as small as possible without compromising the experiment.

11.3.3 Quantities of radioisotopes utilized should be held at as low as reasonably possible and in no case should more than one-tenth of the limits for basic laboratories (see Section 8.2) be used in any undergraduate laboratory at one time.

11.3.4 Experimental protocols must be reviewed and approved by the RSO-CL.

11.3.5 Laboratory instructors, technicians, teaching assistants and demonstrators must be adequately trained in radiation safety procedures and regulations as determined by the RSO-CL.

11.3.6 Students will be explicitly informed of general radiation protection guidelines as well as directives when working with unsealed radioisotopes (see Section 11.2 above).

11.3.7 Students will be made aware of the physical, chemical, biological and radiological properties of the radioisotopes in use.

11.3.8 Students must have knowledge of appropriate accident and emergency procedures as well as be made aware of the location of all first-aid kits, eye-wash stations, fire alarms, fire blankets, fire extinguishers and fire exits in the laboratory.

11.3.9 Responsible behaviour in the laboratory is required of students at all times. Persons behaving irresponsibly will be required to leave.

11.3.10 Students, laboratory instructors, technicians, teaching assistants and demonstrators may take only essential personal items into the laboratory.

11.3.11 Students shall be instructed on the correct handling and usage procedures for the unsealed radioactive sources.

11.3.12 Students using radioactive materials must be under direct supervision at all times.

11.3.13 Sufficient disposable gloves, pipetting devices, disposable syringes, labelling tape, plastic bags and waste containers (radioactive dry-waste pails and liquid-waste containers with absorbent) will be provided for safe execution of experiments. Glassware and instruments specific for radioisotope usage and separated from general use will also be made available.

11.3.14 Students, laboratory instructors, technicians, teaching assistants and demonstrators must thoroughly wash their hands with liquid hand-soap prior to leaving the lab.

11.3.15 Laboratory instructors, technicians, teaching assistants and demonstrators must have appropriate radiation contamination meters available to monitor hands and lab coats of all students before they leave the lab.

11.3.16 The laboratory radioactive areas shall be thoroughly monitored for contamination by the laboratory staff. All radioactive material shall be removed for disposal and/or storage, as appropriate, before other students are admitted to the laboratory.

12. Sealed Radioactive Sources Procedures

12.1 All Sealed Sources are to be listed on IRPs or in the Sealed Source register in the nuclear medicine facility.

12.2 All Sealed Sources must be secured to prevent unauthorized removal.

12.3 Storage containers must be appropriately labelled.

12.4 Sealed Sources shall not be opened under any circumstances. No person at the university is permitted to attempt to perform the repair, restoration and cleaning of Sealed Sources.

12.5 If damage is discovered, it is imperative that the use of the Sealed Source and the Radiation Device in which the source is located be discontinued The RSO Responsible must be contacted immediately. The RSO Responsible shall inform the CNSC of such damage without delay and secure or properly store the sealed source or instrument to prevent contamination or exposures.

12.6 Leak-Testing

12.6.1 If a Sealed Source contains more than 50 MBq of a Nuclear Substance, a leak test must be conducted on the Sealed Source at designated intervals as per Leak Test Procedures, see Appendix XVI.

12.6.2 Leak tests must be conducted using instruments and procedures that certify the detection of a leakage of 200 Bq or less for that specific nuclear substance.

12.6.3 Leak-testing procedures must conform to CNSC requirements as indicated in Appendix AA of REGDOC 1.6.1.

12.6.4 Leak-testing will also be carried out as per recommended procedures outlined in the manufacturer's operating manual.

12.6.5 Responsible Users who decide to use the services of an approved agency to collect and measure wipe samples must ensure leak tests are conducted in compliance with CNSC requirements.

12.6.6 Responsible Users who choose to carry out the leak-tests themselves must notify the RSO Responsible; they must follow the approved sampling and measuring procedures as delineated in Leak Test Procedures (see Appendix XVI), the manufacturer's instructions, or any other pertinent documentation.

12.6.7 A copy of the procedure used and the results obtained must be sent to the RSO Responsible.

12.6.8 Sealed Source leak-testing records are to be kept in the logbook for a minimum of three (3) years (see CNSC Document Retention Schedule, Appendix XVI).

12.6.9 If leak-testing of a Sealed Source produces results of more than 200 Bq of activity, the results must

be immediately reported to the CNSC. The RSO responsible will ensure the affected Sealed Source or the device containing the sealed source is secured and taken out of service immediately.

12.6.10 Any acquired Sealed Source (purchased, transferred, borrowed, etc.) shall be tested for contamination and/or leakage, unless a certificate is available indicating that a leak test has been carried out in the last six (6) months.

13. Radiation Devices Procedures

13.1 All Radiation Devices that are in use in University facilities, such as the ones in the following table, must be registered with the RSO Responsible.

Radiation Device	Nuclear Substance(s) contained
Gas Chromatograph	^{63}Ni
Liquid Scintillation Counter	^{133}Ba ^{14}C ^{152}Eu ^{226}Ra ^{137}Cs
Mössbauer Spectrometer	^{151}Sm ^{119}Sn ^{57}Co
PET/CT SPECT/CT	^{68}Ge
XRF	^{241}Am ^{55} Fe ^{109}Cd

Please note: Radiation Devices do not necessarily contain all the Nuclear Substances listed.

13.2 Prior to any changes in the status of these devices, such as an acquisition, transfer, change of location or disposal, written authorization by the RSO Responsible will be required.

13.3 No modifications or alterations to the Radiation Device or its shielding are permitted.

13.4 A list of individuals authorized to use the Radiation Device, the operation manual as well as safety instructions shall be placed in a visible location close to the Radiation Device.

13.5 Device operators must be trained and familiarized with the proper techniques of use by the IRPH, Human Research Studies Investigator or Nuclear Medicine Facility Manager.

13.6 An operations log providing the history of use should be maintained for each Device.

13.7 A legible sign indicating the name and/or job title and the telephone number of a person who can be contacted twenty four (24) hours a day and, who can initiate the accident response procedures, must be posted in a readily visible location in or near each room, area or enclosure where the radiation devices are stored.

13.8 Each entrance or access point to the storage area of a Sealed Source and its associated Radiation Device shall remain locked at all times.

13.9 The Source holder must be labelled with the standard radiation warning symbol.

13.10 Each instrument will be posted with an identification sticker designating the radiation source information. The following must be included:

- the radiation warning symbol;
- radioisotope(s) present;
- Activity of radioisotope(s) at time of purchase;
- date of purchase;
- name of Responsible User.

13.11 When in storage, Radiation Devices must be accessible only to authorized personnel.

13.12 The Dose rate at any occupied location outside the storage area, room or enclosure resulting from the Devices in storage must not exceed 2.5 µSv/hr.

13.13 All servicing records for Radiation Devices must be retained for a period of three (3) years from the expiry date of the licence that authorizes the use of the particular Radiation Device.

14. Radiation-Emitting Devices Procedures

Radiation-Emitting Devices, including but not limited to the X-Ray equipment, and DEXA units, are not regulate by the NSCA or the CNSC, refer to *Concordia University`s Guidelines and Procedures for Radiation-Emitting Devices*.

15. Contamination Monitoring

15.1 Unsealed Sources

15.1.1 Laboratories using Unsealed Sources of radioisotopes are required to monitor the workplace for Contamination weekly using a method appropriate for the isotopes used and the activities being performed; When no activities are being performed involving Unsealed Sources, workplace monitoring is required to be completed monthly. Laboratories that request their status to be changed to INACTIVE must satisfy certain conditions, but may then be excused from monitoring their workplace. For details on the INACTIVE Status, refer to the definition and the document entitled Internal Management of Radiation Permits, *see Appendix XVI*.

15.1.2 Although Contamination assessment can be carried out by either of the two methods described below, it is recommended to use one in conjunction with the other (Refer to Survey and Contamination Meter Guidelines).

15.1.3 Direct Check

The Direct Check method involves using a portable Radiation Contamination meter in areas with low Background Radiation to measure fixed and non-fixed Radiation. This method is suitable only for high-energy Beta particles and Gamma Ray emitters and will be used only for known isotope detector efficiencies (DE):

- Model Ludlum 44-9: 5% for ^{14}C, 32% for ^{32}P (refer to Ludlum 44-9 Data Sheet, Appendix XVI)
- Model Fluke ASM-990 (993- GM and internal pancake detector): 8% for ^{241}Am, 5% for ^{14}C, 24% for ^{137}Cs (refer to Fluke ASM 990 Data Sheet, Appendix XVI)

The Direct Check Method is carried out in the subsequent manner:

a) select an appropriate survey instrument (calibrated within the twelve (12) months preceding its use);
b) for Beta particle counting, the end-window covering must be removed;
c) hold the probe approximately 3 mm (1/8 inch) above the surface; increasing the distance will result in an underestimation or no detection of Activity while decreasing the distance may result in probe Contamination;
d) pass it slowly over the area to be monitored (the sensitivity of detection is inversely proportional to the survey speed);
e) note the contamination areas and the values recorded on the Direct Monitoring Form (see Appendix XVI), and keep the Direct Monitoring Form in the log book (values must be in CPM). If contamination values are greater than allowed for non-fixed contamination (see section 15.2), follow decontamination procedures below. Report as required.

CPM measurements obtained using the Direct Check Method are converted into Bq/cm^2 using the following formula:

net count rate (CPM) *= [counts (CPM) per minute for the test - area] – [background (counts (CPM) per minute for the blank area].*

absolute activity (DPM) *= net count rate (CPM) / GM fractional efficiency*

DPS or Bq *= absolute activity (DPM) / 60 sec*

DPS or Bq / 100 cm^2 (test - area) *= DPS/cm^2 or Bq/cm^2*

Note: The surface of the test area is the surface area of the probe.

15.1.4 Wipe Test

The Wipe-Test method is a systematic collection and counting of wipe samples from surfaces in the work place with measurement of removable Contamination. It is carried out in the subsequent manner:

a) design a workplace Contamination survey plan with a minimum of ten (10) test locations marked. These must include sites where radioisotopes are used as well as unlikely places such as door handles, telephone receivers, pipettes or handles and instrument dials;
b) use one 21-mm micro-fibre filter per location;
c) with forceps, moisten the filter with 70% alcohol;
d) wipe an area of approximately 100 cm^2;
e) place the filter in an appropriately labelled scintillation vial containing scintillation fluid following wiping and shake;
f) it is recommended that vials be stored in the dark for several hours to reduce chemiluminescence;
g) if a single radioisotope was used, appropriate settings and the quench curve for that isotope must be chosen when counting;
h) an open window and no quench correction are used if multiple radioisotopes are in use or if there is Contamination of unknown source;
i) the quantity of Removable contamination ("RC"), in Becquerel per centimetre squared, can be determined using the following formula:

RC (Bq/cm^2) = (N – B) / (Ec x A x F x 60)
F = wipe efficiency (assume 0.1 unless known)
N = Activity detected (counts per minute) from each filter (CPM)
B = Background Radiation counts per minute (same volume of scintillation fluid and an unused filter)
Ec= scintillation counter fractional efficiency (assume 0.5 unless radioisotope is known)
A = area wiped (cm^2)

j) note the contamination areas, record the contamination values in the log book (values must be in CPM), and if any contamination values are greater than allowed for non-fixed contamination

(see section 15.2.), follow decontamination procedures. Report as required.

15.1.5 Imaging Facility

In the imaging facilities, Contamination surveys will be carried out by either of the two methods described above. Wipe filters will be counted in a solid-crystal well-counter calibrated for the Gamma Ray emitters used. See Appendix IV – Liquid Scintillation Counting Procedure for Wipe Testing for conversion of CPM to Bq/cm2.

15.2 Prescribed Limits

15.2.1 IRPHs, Human Research Studies Investigators and Nuclear Medicine Facility Managers must ensure that removable (non-fixed) Contamination on accessible surfaces, in all designated rooms, areas or enclosures where unsealed Nuclear Substances are used does not exceed radioisotope-specific limits outlined on their licence. For purposes of decontamination, see license conditions and see Appendix III– Regulatory Quantities for Radioisotopes and VI– Classification of Radionuclide for the classification of Nuclear Substances and regulatory limits.

15.2.2 Criteria for non-fixed (loose) Contamination

The following table contains the criteria for non-fixed contamination in Radiation Controlled Areas and in public areas. The criteria for non-fixed contamination are in Bq/cm^2 and values are averaged over an area not exceeding 100 square centimetres.

Radionuclide Classification*	**Description of Radionuclide**	**Limit – Control Area (Bq / cm^2)†**	**Limit – Public Area (Bq / cm^2)†**
Class A	long lived radionuclides which emit alpha radiation	3	0.3
Class B	long lived radionuclides which emit beta and/or Gamma Radiation	30	3
Class C	short lived radionuclides which emit beta and/or Gamma Radiation	300	30

**See Appendix VI – Classification of Radionuclides*

†See Appendix IV- Liquid Scintillation Counting Procedure for Wipe Testing for the conversion of CPM to Bq/cm^2.

If the monitoring values are above the Contamination criteria, Decontamination of the area must be repeated (see Section 16. Decontamination and Appendix X, Emergency and Spill Procedures) until the values are equal to or below the Contamination criteria.

15.2.3 Criteria for fixed Contamination

As a CNSC License condition, fixed contamination is not allowed to be maintained at Concordia University. If the survey indicates values above the contamination criteria, decontamination of the area must be repeated until the values are equal to or below the contamination criteria. In the event this cannot be met, the RSO Responsible must be advised. The RSO Responsible will advise the CNSC and with consultation, either appropriate tamper-proof fixed shielding will be installed or physical components removed until the criteria are met (e.g. bench top removed). If these solutions are not possible, the space will remain unavailable and unusable until the criteria are met.

16 Decontamination

16.1 The possibility that floors, equipment, work or storage areas, people or areas outside the Radiation Controlled Areas may become contaminated is always present. However, most contamination is often relatively easy to clean. Detailed decontamination procedures are available in Appendix X, Emergency and Spill Procedures. The following are decontaminants that can be utilized for this purpose.

a) Foam Spray: There are a variety of foam sprays that are specifically designed for the removal of radioactive contamination. These are quite effective and easy to use. The contaminated area is covered with foam, allowed to sit for a few minutes and wiped with a dry paper towel which is disposed of as radioactive waste.

b) Liquid Detergent: Scrubbing and wiping using a diluted (with water) form of concentrated detergent will result in the rapid removal of the contamination.

16.2 If decontamination is resistant to the above-mentioned methods, the Responsible User must:

- Inform the RSO Responsible immediately.
- The contaminated area must be clearly identified and other area personnel advised to avoid contamination
- In accordance with the ALARA principle, the Responsible User should minimize the time and maximize the distance from the contamination, but is required to stay in the general area until the RSO Responsible responds.
- The RSO Responsible will find an alternate method that takes into account the location, surface, radioisotope and its chemical form.

16.3 Contamination in a nuclear medicine facility: The radioisotopes used are usually diluted in saline solution and therefore can be removed with detergent. In the case of contamination with short-lived radioisotopes (half-lives less than 12 hours, e.g. ^{18}F) it may be preferable to identify the contaminated area or equipment, isolate or shield it and let the radioisotope decay to avoid personal exposure during decontamination.

17 Radioactive Waste Disposal Procedures

The University provides facilities and management services for the disposal of sealed and unsealed radioactive waste, which includes aqueous radioactive solutions, liquid scintillation counting fluid in vials and solid materials contaminated with radioactive material. All waste disposal methods are costly and time-consuming so it is imperative that Responsible Users procure and use only as much radioactive material as required for their experiments or studies, thus minimizing the amount of waste produced.

Waste management in the nuclear medicine facility will be under the control of the RSO-NM. Short-lived radioactive waste will be stored for Decay in appropriate shielded containers within the nuclear medicine facility. All syringes will be stored in shielded sharps containers. After the required Decay period (see 17.18 & 17.19), all radioactive warning signs will be removed or defaced and waste will be disposed of as regular waste or bio-hazardous (sharps) waste.

17.1 The RSO-CL will establish a system of radioactive waste collection in all designated radioisotope laboratories.

17.2 Under no circumstances is any radioactive material to be released to the fume hood exhaust, sink drain or regular garbage expressly for disposal purposes. Notwithstanding, the NSCA allows for the disposal of unsealed Nuclear Substances in the municipal garbage, sewer systems or atmosphere provided they do not exceed limits specified in Appendix III– Regulatory Quantities for Radioisotopes, and are indicated on the university license conditions. These limits are intended to cover only occasional inadvertent releases of very low activity material (e.g., glassware washing). Limits apply to each building location specified on the license, and not to specific Radiation Controlled Areas or IRPs.

17.3 Only solid waste may be transported for disposal. Liquid (except scintillation vials) and gas wastes must be solidified (absorbed/adsorbed) before disposal.

17.4 Special containers exclusively used for radioactive waste and having:

- the interior lined with a clear polyethylene bag; and
- the standard Radiation warning symbol of "**RAYONNEMENT – DANGER – RADIATION**" prominently displayed on the lid and side will be made available to each laboratory designated for radioactive materials usage.

17.5 The following radioactive waste containers are available from the RSO-CL or RSO-NM:

- 20-L pails for radioactive dry-waste;
- 20-L pails for liquid scintillation vials;
- 4.5-L containers with absorber material are available for radioactive liquids.

For other special radioactive waste containers contact the RSO-CL or RSO-NM. A Radioactive Waste Container Request Form (see Appendix XVI) should be filled out for such requests.

17.6 Radioactive waste containers shall not be emptied by normal cleaning personnel.

17.7 Radioactive waste must never be placed in non-radioactive waste containers and non-radioactive material must not be placed in radioactive waste containers. For disposal of ordinary non-radioactive waste in designated labs, regular garbage containers may be used, which will be collected by Custodial Services.

17.8 All radioactive waste products will be minimized and the volume of materials designated as "radioactive" kept to an absolute minimum during storage or handling procedures (particularly in the case of liquid waste).

17.9 Care must be taken when disposing of radioactive liquid so as not to contaminate the outside of the container.

17.10 All dry radioactive waste, including contaminated materials, will be collected in appropriately labelled containers lined with a clear polyethylene bag.

17.11 All liquid radioactive waste will be collected in specially provided liquid waste containers (4.5 L) with absorbent material for disposal.

17.12 Liquid scintillation vials containing radioactive material must be collected separately from the dry and liquid radioactive waste. These will be tightly capped and placed in special 20-L dry waste pails.

17.13 All waste containers are to be kept closed and shielded at all times.

17.14 A record of all radioactive waste must be maintained using a Radioactive Waste Disposal Form (see Appendix XVI) and placed in the logbook.

17.15 A properly completed disposal services tag (see Appendix XI– Radioactive Waste Disposal Tag) must be completed by laboratory personnel or a nuclear medicine technologist, and attached to each container of radioactive waste to be collected before the scheduled removal. No radioactive waste container will be collected without the tag being fully completed.

17.16 A Radioactive Waste Disposal Form (see Appendix XVI) must be filled out on an on-going basis as waste is added to the container. A copy of this form must be sent to the RSO Responsible before a disposal pickup. Each container, pail or drum is marked with a unique identification number which must be used on the Radioactive Waste Disposal Form when providing details on Radionuclides, their chemical forms, approximate Activity, and category of the waste found inside. The name of the Responsible User, signature, and date are also required.

17.17 Radioactive waste is collected by EH&S upon request. All radioactive waste is kept in a temporary radioactive waste holding facility managed by the RSO Responsible until adequately Decayed or removed by a licensed carrier.

17.18 Decaying of Radioactive Waste

The following radioisotopes are currently targeted for delay and decay:
- Phosphorus 32
- Sulphur 35
- Technetium 99m
- Fluorine 18

IRPHs using these radioisotopes must segregate their waste according to the radioisotope and physical state, as follows:
- Radioisotopes cannot be mixed: **One isotope per container.**
- Solid waste and liquid waste cannot be mixed.

The RSO Responsible will calculate the date that the waste will be below the exemption quantity and/or is no longer radioactive as per license conditions (minimum of 10 half-lives). The RSO Responsible will remove or deface all radiation warning signs prior to disposing.

17.19 The RSO Responsible will measure and document the activity of all radioactive waste. Any radioactive waste released into the municipal garbage system must always respect the disposal limits specified in the relevant licence.

17.20 Radioactive waste (solid or liquid) which does not qualify for decay must be disposed of off–site.

17.21 Sealed Sources acquired for experimental procedures or sealed sources extracted from Radiation Devices must be disposed of off-site.

17.22 All off-site disposal shall be coordinated by the RSO Responsible and completed through a suitable disposal facility that accepts low level radioactive waste for burial, in accordance with federal regulations and that meets environmental protection and pollution prevention standards.

18. Research Involving Animals

The RSO Responsible must be notified when radioactive materials are to be used in research involving animals. The IRP must clearly indicate that such research has been authorized by the University Animal Research Ethics Committee.

18.1 Any animals and their husbandry materials containing measurable radioactive materials shall be maintained in licensed research labs and not returned to Animal Care Facilities.

18.2 Disposable husbandry materials are recommended when animals have been injected with radioactive material.

18.3 Metabolism, excretion and egestion of Radionuclides in exhaled gases and vapours, urine and feces or blood from experimental animals must be anticipated and appropriate precautions taken to prevent contamination or unwarranted release of radioactivity.

18.4 Special arrangements must be made for monitoring animal cages and other animal room equipment. Thorough decontamination to a level of 3 to 0.3 Bq/cm^2 (see Section 15.2) is required before returning husbandry materials to the equipment pool for general use in Animal Care Facilities.

18.5 Transfer of radioactive materials and contaminated animals from the animal room or laboratory is not permitted through public areas.

18.6 In the event of spills or accidental release of airborne radioactivity or Contamination of personnel, consult Appendix X – Emergency and Spill Procedures.

18.7 Dead animals, which have been administered radioactive materials, must be sealed in double polyethylene bags and disposed as per Section 17 – Radioactive Waste Disposal Procedures. These animals shall be held in a bio-hazardous waste freezer until waste collection.

19. Research Involving Human Participants

All research involving exposure of human research participants to measurable Equivalent Effective Doses require full ethical, scientific and radiation safety review as described below:

19.1 All research involving human participants, including research in which participants are exposed to radiation, and research that involves injecting Radionuclides into human participants, must be reviewed and approved by a duly constituted Research Ethics Board in accordance with the University's policies and all applicable laws and regulations before initiation.

19.2 All research that implies greater than Minimal Risk to human participants, that involves exposing them to radiation, or that involves injecting Radionuclides into them must be reviewed for scientific merit, either through a competitive external peer review process, or an internal peer review process established for that purpose before initiation.

19.3 All research related to injecting Radionuclides into human participants or exposing them to Radiation must be reviewed by the URSC to ensure compliance with the radiation protection guidelines below and the radiation safety manual before initiation.

19.4 All procedures involving the preparation and administration of Radionuclides and testing of participants will be carried out in a licensed nuclear medicine facility under the terms and conditions of the CNSC HRSL and directed by a qualified medical practitioner (member of *Collège des médecins du Québec*).

19.5 All protocols involving external Radiation exposure or the administration of radioisotopes will strive to minimize Radiation exposures to human participants in accordance with ALARA principles (see Section 9.2) taking into consideration the following:

- in order to avoid repeating nuclear medicine and radiological procedures, previous results of such examinations will be made available to the supervising medical practitioner;
- the decision to carry out a nuclear medicine or radiological examination must include all pertinent information to justify such procedures;
- measures to reduce the Dose (ALARA principle) must be put in place by optimizing the injection Activity and any delay between the injections and imaging time;
- no unsealed radioisotope will be administered to a pregnant participant or a child less than eighteen (18) years of age nor should such individuals be exposed to X-Radiation.

19.6 The maximum combined committed Effective Dose received for research purposes from injected radioisotopes in combination with radiological procedures (e.g. CT scans) will not exceed 50 mSv for any participant in a twelve (12) month period (as per Canada's Food and Drug Act amendment, SOR/2012-129).

19.7 All administration of unsealed radioisotope by injection, inhalation or ingestion as well as any radiological examination, will be carried out by certified health professionals such as a technologist member of the *Ordre des technologues en imagerie médicale et en radio-oncologie du Québec* (OTIMRO or *Certified Medical Radiation Technologists* (CMRT).

19.8 Preparation and injection of radiopharmaceuticals will comply with the following requirements:

- disposable protective gloves should be worn during the preparation and during the injection of the radioactive materials;
- lab coats or protective clothing must be worn at all times when working with radioactive materials;
- used syringes or needles containing residues of radioactive material must be separated from other radioactive waste and put in dedicated sharps radioactive containers;
- all areas where radiopharmaceuticals are handled shall be monitored daily for Contamination;
- eating and drinking is prohibited within the nuclear medicine facility.

19.9 A designated waiting area and dedicated washroom will be made available for individuals receiving unsealed radioisotopes.

19.10 Detailed records of all procedures carried out on human participants will be maintained by the responsible medical professional and shall be made available to the RSO-NM, EH&S and the CNSC to ensure that participant Effective Doses received at the University facility do not exceed specified limits.

20. Facilities Operations and External Services

20.1 Repairs to sinks, plumbing, fume hoods and exhaust systems of laboratories or rooms regularly using radioisotopes are not to be undertaken until a Radiation survey has been conducted by the person responsible for the lab or Nuclear Medicine Room accompanied by the RSO Responsible to ensure that repairs can be made in complete safety. Contamination test results must be sent to the RSO Responsible.

20.2 Cleanliness of laboratory benches and equipment is the responsibility of authorized laboratory personnel and staff members of the Nuclear Medicine facilities. Good housekeeping and good laboratory practices are required for the safety of those who may be required to access these areas. Clear labelling of potential hazards must be adequate to instruct visitors regarding potential Radiation exposure or Contamination.

20.3 University Custodial Services may only clean floors (not benches) of laboratories and Nuclear Medicine Rooms using radioisotopes and only with written authorization from the RSO Responsible. This activity will only be conducted under the direct supervision of a Responsible User or the RSO.

20.4 All radioactive waste containers must be labelled to prevent removal of radioactive waste with regular garbage collection.

21. Decommissioning

CNSC regulations state that facilities designated as Radiation-Controlled Areas must be decontaminated and Decommissioned when they are permanently closed or are to be used for a more general purpose. Decommissioning refers to the complete removal of radioactive material and/or Contamination from a room previously designated as a radioactive materials laboratory. The laboratory must be left in a condition that is safe for the next occupant. This process includes removing radioactive Contamination from equipment and structures that are to be re-used, dismantling equipment and disposing of all radioactive materials.

21.1 No Radiation-Controlled Area shall be abandoned without proper Decommissioning.

21.2 The Responsible User shall notify the RSO Responsible as soon as possible that he or she will vacate, close down or transfer a laboratory to another location in the University. This will facilitate the clearance of the laboratory so that proper procedures may be followed ensuring that the schedule of the facility is met and that radioactive waste disposal costs are kept to a minimum.

21.3 It is the responsibility of the RSO Responsible to decommission any laboratory or Nuclear Medicine Room that will no longer be used for radioactive materials and to determine that these areas are free of radioactive Contamination, allowing use as a general (non-radioactive) laboratory.

21.4 Decommissioning entails ensuring that:

- all laboratory surfaces are free of hazardous Contamination. These include lab benches, storage compartments and cabinets, drawers, floors, sinks and areas underneath telephones and door handles;
- all fume hoods must be free of Contamination. This includes the removal of all radioactive waste containers;
- all refrigerators and freezers must be emptied and decontaminated.

Decommissioning also entails the removal of all signs, postings, radioactive warning tape, and the performance of final wipe test surveys that ensure that all equipment and surfaces are free of Contamination.

21.5 Any equipment that was used in the manipulation or handling of radioactive material must be decontaminated to levels allowed by CNSC regulations.

21.6 Once all radioactive materials have been removed, a Contamination survey must be performed to ensure that the areas are free of Contamination as per the criteria indicated in Section 15.2 (Refer to Survey and Contamination Meter Guidelines).

21.7 The release of any area containing fixed Contamination must be submitted to the CNSC for approval.

21.8 All Decommissioning records must be kept with the RSO Responsible for future inspections by the CNSC. All Decommissioning must be accompanied by a Decommissioning Document that is signed by the Responsible User and the RSO-Responsible.

21.9 The Responsible User is accountable for the lab or room until final Decommissioning and removal of the radioactive warning signs is authorized by the RSO Responsible.

Appendix I – Introduction to Radiation

1. Atomic Structure

All elements are composed of atoms, which consist of a central nucleus composed of relatively massive positively charged protons and uncharged neutrons. In a neutral atom, the core is surrounded by a number of orbital electrons equal to the number of protons.

The number of protons within the nucleus defines the atomic number, designated by the symbol Z. In an electrically neutral atom, Z also indicates the normal number of electrons within the atom. The number of protons plus neutrons in the nucleus is termed the mass number, designated by the symbol A.

The atomic number of an atom designates its specific elemental or chemical identity. For example, an atom with a Z of 1 is hydrogen, an atom with a Z of 2 is helium, and an atom with a Z of 3 is lithium. A given species of nucleus characterized by a particular atomic number and mass number is called a nuclide. A specific nuclide is represented by its chemical symbol with the mass number in superscript, e.g., ^{3}H, ^{14}C, ^{125}I or H-3, C-14, I-125. Nuclides with the same number of protons (i.e., the same Z) but different number of neutrons (e.g. different A) are called isotopes of that particular element. Isotopes of elements have, for most practical purposes, identical chemical properties.

2. Radioactive Decay &Half-life

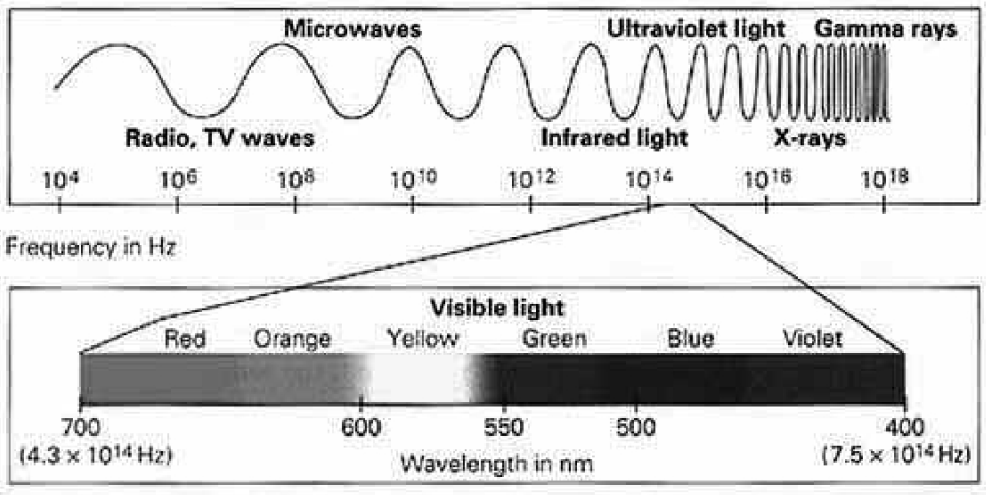
Depending upon the ratio of neutrons to protons within its nucleus, an isotope of a particular element may be stable or unstable. Nuclides, which undergo radioactive Decay, are called radioisotopes or Radionuclides. Over time the nuclei of unstable isotopes spontaneously disintegrate, or transform, in a process known as radioactive Decay. As part of this process, various types of Ionizing Radiation may be emitted from the nucleus and/or its surrounding electrons. Depending on how the nucleus loses this excess energy, either a lower energy atom of the same form results or a completely different nucleus and atom is formed. A given radioisotope decays through a specific transformation or specific transformations. The types of emissions, along with the energy of emissions that result from the radioactive Decay are unique to that isotope. Any material, which contains measurable amounts of one or more radioisotopes, is considered a radioactive material. Each radioisotope decays at its own unique rate, which cannot be altered. A useful measure of this rate is the Half-life of the isotope, i.e., the time required for half of available Radionuclides to Decay.

3. Radiation

Radiation is energy transmitted through space in the form of energetic particles or electromagnetic waves. When an atom undergoes radioactive Decay, it emits one or more forms of Ionizing Radiation. Ionizing Radiation is defined as Radiation with sufficient energy to remove orbital electrons from the atoms with which it interacts. It can consist of high speed subatomic particles ejected from the nucleus or electromagnetic Radiation (e.g. photons) emitted by either the nucleus or orbital electrons.

Examples of **Ionizing Radiation** include:

- Alpha particles;
- Beta particles;
- Gamma Rays;
- X-Rays.
- Neutrons;



Non-Ionizing Radiation is not energetic enough to ionize atoms. Examples include:

- Microwaves;
- TV waves;
- Visible light;
- Ultraviolet light.
- Radio waves;

4. Types of Ionizing Radiation

A. Alpha Radiation

Certain Radionuclides of high atomic mass (e.g. ^{226}Ra, ^{238}U; atoms with nuclei rich in neutrons) Decay by the emission of Alpha particles. These Alpha particles are tightly bound units of 2 neutrons and 2 protons each (^{4}He nucleus). Emission of an Alpha particle from the nucleus results in a decrease of two units of atomic number (Z) and four units of mass number (A). Alpha particles are emitted with discrete energies characteristic of the particular transformation from which they originate. In other words, all Alpha particles from a particular Radionuclide transformation will have identical energies. Because of their double charge and relatively slow velocity, Alpha particles have a high specific ionization and relatively short range in matter (a few centimetres in air and only fractions of a millimetre in tissue).

B. Beta Radiation

A nucleus with a slightly unstable ratio of neutrons to protons may Decay through the emission of a high speed electron (positively or negatively charged) called a Beta particle. This results in a net change of one unit of atomic number (Z). The Beta particles emitted by a specific Radionuclide range in energy from near 0 up to a maximum value (normally MeV) characteristic of the particular transformation. Beta particles have a much lower specific ionization than Alpha particles and, generally, a greater range. For example, the relatively energetic Beta particles from ^{32}P have a maximum range of 7 meters in air and 8 millimetres in tissue. The low energy Beta particles from ^{3}H, on the other hand, are stopped by only 6 millimetres of air or 6 micrometers of tissue.

Positron

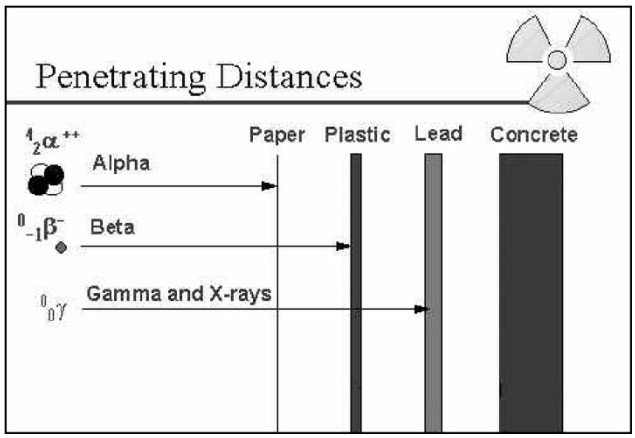
Positively charged Beta particles interact with orbital electrons through annihilation in which two 0.51 MeV gamma photons are produced and Radionuclides which emit positrons must be treated as gamma sources.

C. Gamma and X-Radiation

A nucleus, which is in an excited state, may emit one or more photons (e.g. particles of electromagnetic Radiation) of discrete energies. The emission of these Gamma Rays does not alter the number of protons or neutrons in the nucleus but instead has the effect of changing the nucleus from a higher to a lower energy state. Gamma Ray emission frequently follows Beta particle Decay, Alpha particle Decay, and other nuclear Decay processes.

X-Rays are also part of the electromagnetic spectrum and are distinguished from Gamma Rays only by their source (e.g. orbital electrons rather than the nucleus). X-Rays are emitted with discrete energies by electrons as they shift orbits following certain types of nuclear Decay processes. A continuous energy spectrum of X-Rays called bremsstrahlung may also be emitted by charged particles (e.g. Beta particles) as they decelerate near atomic nuclei.

Gamma and X-Rays are referred to as indirectly Ionizing Radiation since, having no charge; they do not directly apply impulses to orbital electrons as do Alpha and Beta particles. They instead proceed through matter until there is a chance interaction with a particle. If the particle is an electron, it may receive enough energy to be ionized whereupon it causes further ionization by direct interactions with other electrons. As a result, indirectly Ionizing Radiation (e.g. Gamma X-Rays) can cause the liberation of directly ionizing particles (e.g. electrons) deep inside a medium. Because these neutral Radiations undergo only chance encounters with matter, they do not have finite ranges, but rather are attenuated in an exponential manner. In other words, a given Gamma Ray has a definite probability of passing through any medium of any depth.


Penetrating Distances
Paper
Plastic
Lead
Concrete
Alpha
Beta
Gamma and X-rays

Appendix II – Conversion Table for Radiation Units

RAD		GRAY
100 millirad (mrad)	=	1 milligray (mGy)
1 millirad (mrad)	=	10 micrograys (µGy)
100 microrad (µrad)	=	1 microgray (µGy)
1 microrad (µrad)	=	10 nanograys (nGy)
100 nanorad (nrad)	=	1 nanogray (nGy)
REM		**SIEVERT**
100 milliRem (mRem)	=	1 millisievert (mSv)
1 milliRem (mRem)	=	10 microsievert (µSv)
100 microRem (µRem)	=	1 microsievert (µSv)
1 microRem (µRem)	=	10 nanosievert (nSv)
100 nanoRem (nRem)	=	1 nanosievert (nSv)
CURIE		**BECQUEREL**
1 millicurie (mCi)	=	37 Megabecquerels (MBq)
1 microcurie (µCi)	=	37 Kilobecquerels (KBq)
1 nanocurie (nCi)	=	37 Becquerels (Bq)
27 millicurie (mCi)	=	1 Gigabecquerels (Gbq)
27 microcurie (µCi)	=	1 Megabecquerels (MBq)
27 nanocurie (nCi)	=	1 Kilobecquerels (KBq)
27 picocuries (pCi)	=	1 Becquerel (Bq)

Appendix III – Regulatory Quantities for Radioisotopes

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm²	Wipes (Public Area) Bq/cm²	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m³
Ag-110m	A	1 MBq	2.7 MBq	7.1 MBq	13.5 MBq	135 MBq	1.35 GBq	3	0.3	0.01	0.1	
Am-241	A	10 kBq	740 Bq	100 kBq	3.7 kBq	37 kBq	370 kBq	3	0.3	0.0037	10	
Ar-41*	C	1 GBq	45 kBq	N/A	225 kBq	2.25 MBq	22.5 MBq	300	30	N/A	N/A	0.037
Au-198	B	1 MBq	18 MBq	20 MBq	90 MBq	900 MBq	9 GBq	30	3	0.1	100	
Ba-133	B	1 MBq	11 MBq	20 MBq	55 MBq	550 MBq	5.5 GBq	30	3	0.037	1	
Bi-210	A	1 MBq	330 kBq	15 MBq	1.65 MBq	16.5 MBq	165 MBq	3	0.3	0.037		
Br-82	B	1 MBq	23 MBq	37 MBq	115 MBq	1.15 GBq	11.5 GBq	30	3	0.1	0.1	
C-11	C	1 MBq	9.1 GBq	830 MBq	45.5 GBq	455 GBq	4.55 TBq	300	30	0.01		
C-14	C	10 MBq	1 GBq	34 MBq	170 MBq	1.7 GBq	17 GBq	300	30	3.7	10,000	
Ca-45	C	10 MBq	8.7 MBq	26 MBq	43.5 MBq	435 MBq	4.35 GBq	300	30	0.37	1,000	
Ca-47	B	1 MBq	9.5 MBq	13 MBq	47.5 MBq	475 MBq	4.75 GBq	30	3	0.01	100	
Cd-109	C	1 MBq	2.1 MBq	10 MBq	10.5 MBq	105 MBq	1.05 GBq	300	30	0.37	10	
Ce-139	B	1 MBq	14 MBq	77 MBq	70 MBq	700 MBq	7 GBq	30	3	0.1	1	
Ce-141	C	10 MBq	6.5 MBq	28 MBq	32.5 MBq	325 MBq	3.25 GBq	300	30	0.037	10	
Ce-143	B	1 MBq	20 MBq	18 MBq	100 MBq	1 GBq	10 GBq	30	3	0.1	1	

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
Cl-36	C	1 MBq	3.9 MBq	22 MBq	19.5 MBq	195 MBq	1.95 GBq	300	30	0.37	10,000	
Co-56	A	100 kBq	4.1 MBq	8 MBq	20.5 MBq	205 MBq	2.05 GBq	3	0.3	0.01		
Co-57	C	1 MBq	33 MBq	95 MBq	165 MBq	1.65 GBq	16.5 GBq	300	30	0.37	1,000	
Co-58	B	1 MBq	12 MBq	27 MBq	60 MBq	600 MBq	6 GBq	30	3	0.37	100	
Co-60	A	100 kBq	1.2 MBq	5.9 MBq	6 MBq	60 MBq	600 MBq	3	0.3	0.01	0.1	
Cr-51	C	10 MBq	560 MBq	530 MBq	2.65 GBq	26.5 GBq	265 GBq	300	30	3.7	100	
Cs-134	A	10 MBq	2.1 MBq	1.1 MBq	10.5 MBq	105 MBq	1.05 GBq	3	0.3	0.01	0.1	
Cs-137	A	10 MBq	3 MBq	1.5 MBq	15 MBq	150 MBq	1.5 GBq	3	0.3	0.01	1	
Cu-60	C	100 kBq	320 MBq	280 MBq	1.6 GBq	16 GBq	160 GBq	300	30	0.01		
Cu-64	C	1 MBq	130 MBq	170 MBq	650 MBq	6.5 GBq	65 GBq	300	30	0.1	1	
Cu-67	B	1 MBq	34 MBq	59 MBq	170 MBq	1.7 GBq	17 GBq	30	3	0.1		
F-18	C	1 MBq	220 MBq	410 MBq	1.1 GBq	11 GBq	110 GBq	300	30	0.01	0.1	
Fe-55	C	1 MBq	22 MBq	61 MBq	110 MBq	1.1 GBq	11 GBq	300	30	3.7	10,000	
Fe-59	B	1 MBq	6.3 MBq	11 MBq	31.5 MBq	315 MBq	3.15 GBq	30	3	0.01	1	
Fr-169	C	10 MBq	22 MBq	54 MBq	110 MBq	1.1 GBq	11 GBq	300	30	10	10,000	
Ga-67	C	1 MBq	71 MBq	110 MBq	355 MBq	3.55 GBq	35.5 GBq	300	30	0.037	100	

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
Ga-68	C		250 MBq	200 MBq	1 GBq	10 GBq	100 GBq	300	30	0.01		
Ge-68	C	100 kBq	2.5 MBq	15 MBq	12.5 MBq	125 MBq	1.25 GBq	300	30	0.01	0.1	
H-3	C	1 GBq	1 GBq	1 GBq	5 GBq	50 GBq	500 GBq	300	30	37	1,000,000	37
Hg-194	B		1.1 MBq	390 kBq	5.5 MBq	55 MBq	550 MBq	30	3	0.01	10	
Hg-197	C	10 MBq	71 MBq	87 MBq	355 MBq	3.55 GBq	35.5 GBq	300	30	0.1	1,000	
Hg-203	B	100 kBq	11 MBq	37 MBq	55 MBq	550 MBq	5.5 GBq	30	3	0.1	10	
I-123	C	10 MBq	95 MBq	95 MBq	475 MBq	4.75 GBq	47.5 GBq	300	30	3.7	1,000	3
I-124	A		17 MBq	1.5 MBq	85 MBq	850 MBq	8.5 GBq	3	0.3	0.01	10	
I-125	C	1 MBq	1.4 MBq	1.3 MBq	6.5 MBq	65 MBq	650 MBq	300	30	0.037	100	0.03
I-131	C	1 MBq	1 MBq	910 kBq	4.55 MBq	45.5 MBq	455 MBq	300	30	0.037	10	0.175
In-111	C	1 MBq	65 MBq	69 MBq	325 MBq	3.25 GBq	32.5 GBq	300	30	0.037	100	
In-113m	C	1 MBq	630 MBq	710 MBq	3.15 GBq	31.5 GBq	315 GBq	300	30	0.1	1	
In-114	C							300	30			
Ir-192	B	10 kBq	4.1 Mbq	14 MBq	20.5 MBq	205 MBq	2.05 GBq	30	3	0.37	1	
K-42	C	1 MBq	100 MBq	47 MBq	500 MBq	5 GBq	50 GBq	300	30	0.1	1,000	
Kr-79*	B	100 kBq	250 kBq	N/A	1.25 MBq	12.5 MBq	125 MBq	30	3	N/A	N/A	0.37

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
Kr-85*	C	10 kBq	11 MBq	N/A	55 MBq	550 MBq	5.5 GBq	300	30	N/A	N/A	3.7
La-140	B	100 kBq	13 MBq	10 MBq	65 MBq	650 MBq	6.5 GBq	30	3	0.01	0.1	
Lu-177	C	10 MBq	18 MBq	38 MBq	90 MBq	900 MBq	9 GBq	300	30	1	10	
Lu-177m	A		1.7 MBq	12 MBq	8.5 MBq	85 MBq	850 MBq	3	0.3	0.01	0.1	
Mn-52	A	100 kBq	11 MBq	11 MBq	55 MBq	550 MBq	5.5 GBq	3	0.3	0.01		
Mn-52m	C	100 kBq	400 MBq	290 MBq	2 GBq	20 GBq	200 GBq	300	30	0.01		
Mn-54	B	1 MBq	17 MBq	28 MBq	85 MBq	850 MBq	8.5 GBq	30	3	0.01	1	
Mn-56	C	100 kBq	100 MBq	80 MBq	500 MBq	5 GBq	50 GBq	300	30	0.01	0.1	
Mo-99	B	1 MBq	18 MBq	17 MBq	90 MBq	900 MBq	9 GBq	30	3	0.1	100	
N-13	C	1 GBq	15 GBq	1.2 GBq	7.5 GBq	75 GBq	750 GBq	300	30	0.1		
Na-22	A	1 MBq	10 Mbq	6.3 MBq	31.5 MBq	315 MBq	3.15 GBq	3	0.3	0.01	0.1	
Na-24	C	100 kBq	38 MBq	47 MBq	190 MBq	1.9 GBq	19 GBq	300	30	0.01	100	
Nb-95	B	1 MBq	15 MBq	34 MBq	75 MBq	750 MBq	7.5 GBq	30	3	0.01		
Nb-98	C	100 kBq	200 MBq	180 MBq	1 GBq	10 GBq	100 GBq	300	30	0.01		
Ni-63	C	100 MBq	38 MBq	130 MBq	190 MBq	1.9 GBq	19 GBq	300	30	0.1	1,000	
O-15	C	1 GBq	41 GBq	3.7 GBq	205 GBq	2.05 TBq	20.5 TBq	300	30	0.1		

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
P-32	C	100 kBq	6.9 MBq	8.3 MBq	34.5 MBq	345 MBq	3.45 GBq	300	30	0.37	1	
P-33	C	100 MBq	15 MBq	83 MBq	75 MBq	750 MBq	7.5 GBq	300	30	1	10	
Pa-233	B	10 MBq	6.3 MBq	23 MBq	31.5 MBq	315 MBq	3.15 GBq	30	3	0.1		
Pb-210	A	0.01 MBq	18 kBq	29 kBq	90 kBq	900 kBq	9 MBq	3	0.3	0.0037	1	
Pm-147	C	10 MBq	5.7 MBq	77 MBq	28.5 MBq	285 MBq	2.85 GBq	300	30	0.37	10,000	
Po-210	B	0.01 MBq	9.1 kBq	83 kBq	45.5 kBq	455 kBq	4.55 GBq	30	3	0.0037	10	
Pr-144	C		670 MBq	400 MBq	3.35 GBq	33.5 GBq	335 GBq	300	30	0.1		
Pu-238	A	0.01 MBq	670 Bq	87 kBq	3.35 kBq	33.5 kBq	335 kBq	3	0.3	0.001	1	
Pu-239	A	0.01 MBq	630 Bq	80 kBq	3.15 kBq	31.5 kBq	315 kBq	3	0.3	0.001	1	
Pu-240	A	0.001 MBq	630 Bq	80 kBq	3.15 kBq	31.5 kBq	315 kBq	3	0.3	0.001	1	
Pu-241	C	0.1 MBq	34 kBq	4.3 MBq	0.170 MBq	1.7 MBq	17 MBq	300	30	0.1		
Ra-223	B	0.1 MBq	3.5 kBq	100 kBq	17.5 kBq	175 kBq	1.75 MBq	30	3	0.1	1	
Ra-226	A	10 kBq	9.1 kBq	71 kBq	45.5 kBq	0.455 MBq	4.55 MBq	3	0.3	0.0037	1	
Rb-86	B	0.1 MBq	15 MBq	7.1 MBq	75 MBq	750 MBq	7.5 GBq	30	3	0.1	10	
Re-186	B	1 MBq	17 MBq	13 MBq	85 MBq	850 MBq	8.5 GBq	30	3	1	10	
Re-188	B	0.1 MBq	27 MBq	14 MBq	135 MBq	1.35 GBq	13.5 GBq	30	3	0.1		

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
Ru-103	B	1 MBq	9.1 MBq	27 MBq	45.5 MBq	455 MBq	4.55 GBq	30	3	0.037		
Ru-106	B	0.1 MBq	570 kBq	2.9 MBq	2.85 MBq	28.5 MBq	285 MBq	30	3	0.037		
S-35	C	100 MBq	18 MBq	26 MBq	90 MBq	900 MBq	9 GBq	300	30	0.37	1,000	
Sb-122	B	0.01 MBq	17 MBq	12 MBq	85 MBq	850 MBq	8.5 GBq	30	3	0.1		
Sb-124	A	1 MBq	4.3 MBq	8 MBq	21.5 MBq	215 MBq	2.15 GBq	3	0.3	0.37	0.1	
Sc-46	A	1 MBq	4.2 MBq	13 MBq	21 MBq	210 MBq	2.1 GBq	3	0.3	0.1	0.1	
Se-75	B	1 MBq	12 MBq	7.7 MBq	60 MBq	600 MBq	6 GBq	30	3	0.1	1	
Sm-153	B	1 MBq	29 MBq	27 MBq	145 MBq	1.45 GBq	14.5 GBq	30	3	0.1	10	
Sn-113	C	10 MBq	11 MBq	27 MBq	55 MBq	550 MBq	5.5 GBq	300	30	1		
Sr-85	B	1 MBq	31 MBq	36 MBq	155 MBq	1.55 GBq	15.5 GBq	30	3	0.1	1	0.175
Sr-89	C	1 MBq	3.6 MBq	7.7 MBq	18 MBq	180 MBq	1.8 GBq	300	30	0.37	1,000	
Sr-90	B	10 kBq	260 kBq	710 kBq	1.3 MBq	13 MBq	130 MBq	30	3	0.0037	1	
Tc-99	C	10 MBq	6.3 MBq	26 MBq	31.5 MBq	315 MBq	3.15 GBq	300	30	0.37	10,000	
Tc-99m	C	10 MBq	690 MBq	910 MBq	3.45 GBq	34.5 GBq	345 GBq	300	30	3.7	1,000	
Te-127	C	1 MBq	110 MBq	120 MBq	550 MBq	5.5 GBq	55 GBq	300	30	1		
Th-228	A	10 kBq	630 Bq	290 kBq	3.15 kBq	31.5 kBq	315 kBq	3	0.3	0.001	100	

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
Th-230	A	10 kBq	710 Bq	95 kBq	3.55 kBq	35.5 kBq	355 kBq	3	0.3	0.001	100	
Th-232	A	10 kBq	690 Bq	91 kBq	3.45 kBq	34.5 kBq	345 kBq	3	0.3	0.001	1	
Tl-201	C	1 MBq	260 MBq	21 MBq	105 MBq	1.05 GBq	10.5 GBq	300	30	0.037	100	
Tl-204	C	10 kBq	32 MBq	15 MBq	160 MBq	1.6 GBq	1.6 GBq	300	30	0.37	100	
U Natural	A	1 kBq	3.2 kBq	410 kBq	16 kBq	160 kBq	1600 kBq	3	0.3	0.01	1.4 kg	
U-234	A	10 kBq	2.9 kBq	410 kBq	14.5 kBq	145 kBq	1450 kBq	3	0.3	0.01		
U-235	A	10 kBq	3.3 kBq	430 kBq	16.5 kBq	165 kBq	1650 kBq	3	0.3	0.01		
U-238	A	10 kBq	3.5 kBq	450 kBq	17.5 kBq	175 kBq	1750 kBq	3	0.3	0.01		
V-48	A	100 kBq	7.4 MBq	10 MBq	37 MBq	370 MBq	3.7 GBq	3	0.3	0.01		
V-49	C		770 MBq	1.1 GBq	3.85 GBq	38.5 GBq	385 GBq	300	30	10		
Xe-127*	B		250 kBq	N/A	125 MBq	12.5 MBq	125 MBq	30	3	N/A	N/A	
Xe-133*	C	10 kBq	2 MBq		3.35 MBq	33.5 MBq	335 MBq	300	30	N/A	N/A	3.7
Y-88	A		6.1 MBq	15 MBq	15.5 MBq	155 MBq	1.55 GBq	3	0.3	0.01	0.1	
Y-90	B	100 kBq	12 MBq	7.4 MBq	60 MBq	600 MBq	6 GBq	3	3	0.37	10,000	
Yb-169	B	10 MBq	8.3 MBq	28 MBq	41.5 MBq	415 MBq	4.15 GBq	30	3	0.1	1	
Zn-65	A	1 MBq	7.1 MBq	5.1 MBq	35.5 MBq	355 MBq	3.55 GBq	3	0.3	0.01	1	

Radionuclide	Classification	EQ / Exemption Quantity	ALI Estimate (Inhalation)	ALI Estimate (Ingestion)	Basic Level </= 5 ALI	Intermediate Level </= 50 ALI	High Level </= 500 ALI	Wipes (Controlled Area) Bq/cm^2	Wipes (Public Area) Bq/cm^2	Municipal Waste MBq/kg	Sewer MBq/yr	Air kBq/m^3
Zr-89	A		27 MBq	25 MBq	135 MBq	1.35 GBq	13.5 GBq	3	0.3	0.01		
Zr-95	B	1 MBq	4.8 MBq	23 MBq	24 MBq	240 MBq	2.4 GBq	30	3	0.01		

Note: * Concentration, in Bq/m^3, that results in a dose of 20 mSv if one is exposed to this concentration for 2,000 hours.
Note: EQ for radiation devices containing sealed sources is 10x unsealed limits.

Table reproduced from CNSC REGDOC-1.6.1, appendix R.

Appendix IV – Liquid Scintillation Counting Procedure for Wipe Testing

Since wipe-test samples may contain very low levels of radioactivity approaching Background Radiation the following procedures will improve counting accuracy. Filter samples should be placed in 20-ml glasses or plastic vials (mini vials are not suitable) already containing at least 5 ml of scintillation cocktail fluid.

Samples should be mixed for at least five (5) minutes so as to improve the mixing of material on the filter with the scintillation fluid. This will improve counting and reduce chemiluminescence. Storing vials in the dark will reduce phosphorescence.

Place the vials in a counting rack and position the rack in the sample compartment. Lower the compartment cover to reduce interference due to phosphorescence from the fluorescent lighting.

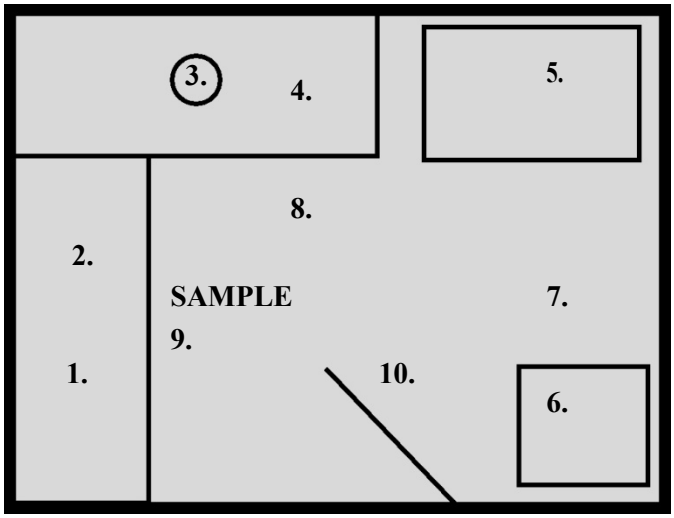
Scintillation Counters should have one dedicated user file for wipe-test counting. If the radioisotope in use is known, optimize the counter window setting and use standard quench correction procedures. If more than one radioisotope is in use, one full energy (full spectrum) window and two or more lower energy spectrum windows should be set to cover anticipated energy ranges which will help identify any contaminant.

If significant chemiluminescence is obscuring the true count rate, samples can be re-counted at a later time by using an alternate scintillation fluid. Wipe-testing counts will be taken from a full-spectrum channel and counts from other channels provide spectral information regarding the possible identification of the radioisotope(s) being detected.

Since radioactive Decay is a random process (counts follow Poisson distribution), the standard deviation of the count is estimated by taking the square root of the total counts. For example, a sample counted for one minute giving 25 counts is actually 25 ± 5 CPM (± 20 %). As wipe-test counts approach Background Radiation, longer counting times are required to obtain reasonably accurate counts. Remember 10 000 counts have a 1% error. For example, a 100-cm^2 wipe-test count of 850 CPM assuming 50% count efficiency (E= 0.5) and 10% wipe efficiency (F = 0.1) with a Background Radiation of 50 CPM would yield approximately 3 Bq/cm^2 which is the limit for all areas for a class A radioisotopes and for packaging prior to disposal of Class B radioisotopes.

The storage area shall be cleaned and wipe-tested on a monthly basis. Storage areas used for unsealed radioisotopes that are not in use for long periods should be wipe-tested twice per year.

Appendix V – Contamination Monitoring Results Log



Room/Lab:			**Action Level: 90 CPM (if exceeded decontaminate, recount and report)**	
Date:		**Checked by:**		
#	**Site Wiped**	**Initial Count**	**Recount After Decontamination**	**Notes**
0	**Background Radiation**			
1	**Lab Bench Top**			
2	**Lab Bench Top**			
3	**Centrifuge**			
4	**Sink**			
5	**Work Desk**			
6	**Refrigerator Shelves**			
7	**Floor – Refrigerator**			
8	**Floor – Sink**			
9	**Floor - Bench**			
10	**Etc.**			

Appendix VI – Classification of Radionuclide

The following table is taken Appendix Y from the October 2015 version of the CNSC REGDOC-1.6.1 Licence Application Guide, Nuclear Substances and Radiation Devices, and 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 (3) classes—Class A, Class B, or Class C—on the basis of common radiological characteristics. Please see the Appendix in the University License.

CLASS A: 3 Bq/cm2 controlled, 0.3 Bq/cm2 public

Ag-110m	Am-241	Bi-210	Co-56	Co-60	Cs-134	Cs-137
I-124	Lu-177m	Mn-52	Na-22	Pb-210	Pu-238	Pu-239
Pu-240	Ra-226	Sb-124	Sc-46	Ta-182	Th-228	Th-230
Th-232	U-naturel	U-234	U-235	U-238	V-48	Y-88
Zn-65	Zr-89	All Alpha particle emitters and their daughter isotopes				

CLASS B: 30 Bq/cm2 controlled, 3 Bq/cm2 public

As-74	Au-198	Ba-133	Br-82	Ca-47	Ce-139	Ce-143
Co-58	Cu-67	Fe-59	Ga-72	Gd-153	Hg-194	Hg-203
Ir-192	Kr-79	La-140	Mn-54	Mo-99	Nb-95	Pa-233
Po-210	Ra-223	Rb-84	Rb-86	Re-186	Re-188	Ru-103
Ru-106	Sb-122	Se-75	Sm-153	Sr-85	Sr-90	Xe-127
Y-86	Y-90	Yb-169	Zr-95			

CLASS C: 300 Bq/cm2 controlled, 30 Bq/cm2 public

Ar-41	Au-195m	C-11	C-14	Ca-45	Cd-109	Ce-141
Ce-144	Cl-36	Co-57	Cr-51	Cu-60	Cu-64	Er-169
F-18	Fe-55	Ga-67	Ga-68	Ge-68	H-3	I-123
I-125	I-131	In-111	In-113m	In-114m	In-114	K-42
Kr-81m	Kr-85	Lu-177	Mn-52m	Mn-56	N-13	Na-24
Nb-98	Ni-63	O-15	P-32	P-33	Pm-147	Pr-144
Pu-241	S-35	Sn-113	Sn-123	Sr-89	Tc-99	Tc-99m
Te-127	Tl-201	Tl-204	V-49	W-188	Xe-188	

Appendix VII – Radioactive Packages

Anyone internal to the University shipping Nuclear Substances to any external licensed location is subject to the *Transportation of Dangerous Goods Regulations* (TDG) *and the CNSC Packaging and Transport of Nuclear Substances Regulations, 2015* (SOR/2015-145).The latter regulations are based on the current International Atomic Energy Agency's *Regulations for the Safe Transport of Radioactive Material,* which provides standards for ensuring a high level of safety for people, property and the environment against Radiation and other hazards associated with the transport of Nuclear Substances.

All Nuclear Substances are transported in packages that are selected based on the nature, form, and quantity or Activity of the substance and according to the content limits for packages specified in Section IV of the current IAEA *Regulations for the Safe Transport of Radioactive Material*. All packages must meet the applicable performance standards referred to in Section VI of the current IAEA *Regulations for the Safe Transport of Radioactive Material*. Packages are to be categorized and labelled based on the Radiation level at both the surface and at one (1) metre from the package.

Based on these criteria Nuclear Substances shall be transported in one of the following types of packages:

(i) non-certified packages, which are designed for the transport of low risk-level radioactive material having little or no impact on health and safety and include both Excepted Packages and Type A packages (as defined by the current IAEA *Regulations for the Safe Transport of Radioactive Material)*;

(ii) certified packages, which are designated for the transport of high risk-level radioactive material having an impact on health and safety.

For each package of Nuclear Substances, the United Nations (UN) number and proper shipping name must be determined. Packages other than Excepted Packages are categorized, marked and labelled on opposite sides of the package to identify the contents and Activity level. In the case of Excepted Packages, only the UN number is required and the Radiation level at any point on its external surface shall not exceed 5µSv/h. The word "**radioactive**" must be visible upon opening the package.

In preparing a package for transport or while transporting it, both consignor and carrier must ensure that the package is labeled to reflect the Radiation level on any part of the package's external surface (see below for Labels for Radioactive Packages). The labels also must include the contents (name of the Radionuclide), the Activity (maximum Activity of the radioactive contents during transport in Bq) and the transport index (maximum Radiation level in mSv/h at a distance of one (1) meter from the external surface of the package). The label must conform to the models specified below.

TYPE	DESCRIPTION	SYMBOL
Category I (Radioactive White)	Displays the black Radiation trefoil and the Roman numeral I, which shall be colored red, on a white background and indicates that the Radiation level does not exceed 5 µSv/h at any location on the external surface of the package.	 Category I - White
Category II (Yellow II)	Displays the black Radiation trefoil with the Roman numeral II, which shall be colored red, on a background where the top half is yellow and the bottom half, white. The Category II labels indicate that the Radiation level on any part of the package's external surface does not exceed 500 µSv.	 Category II - Yellow
Category III (Yellow III)	Displays the black Radiation trefoil with the Roman numeral III, which shall be colored red, on a background where the top half is yellow and the bottom half, white. The Category III labels indicate that the Radiation level on any part of the package's external surface does not exceed 2 mSv/h.	 Category III - Yellow

Appendix VIII – Organ or Tissue Weighting Factors

	Organ or Tissue	Weighting Factor
1	Gonads (testes or ovaries)	0.08
2	Red bone marrow	0.12
3	Colon	0.12
4	Lung	0.12
5	Stomach	0.12
6	Bladder	0.04
7	Breast	0.12
8	Liver	0.04
9	Esophagus	0.04
10	Thyroid gland	0.04
11	Skin[1]	0.01
12	Bone surfaces	0.01
13	Brain	0.01
14	Salivary Glands	0.01
15	All organs and tissues not listed in Items 1 to 12 (Remainder organs and tissues) collectively, namely the adrenal glands, extra-thoracic region, gall bladder, heart, kidneys, oral mucosa, pancreas, small intestine, spleen, thymus and prostate or uterus/cervix[2,3]	0.12
16	Whole body	1.00

[1] *The Weighting Factor for skin applies only when the skin of the whole body is exposed.*

[2] *The weighting factor for the remainder organsand tissues applies to the arithmetic mean dose of the 13 remainder organs and tissues.*

[3] *Hands, feet and the lens of an eye have no Weighting Factor.*

As Taken from Schedule 1 of the *Radiation Protection Regulations SOR/2000-203*

Appendix IX – Relative Radiotoxicity per Unit Activity

Very High Toxicity			
Actinium-227	Curium-243	Plutonium-240	Radium-228
Americium-241	Curium-244	Plutonium-241	Thorium-227
Americium-243	Curium-246	Plutonium-242	Thorium-228
Californium-249	Lead-210	Plutonium-210	Thorium-230
Californium-250	Neptunium-237	Protactinium-213	Uranium-230
Californium-252	Plutonium-238	Radium-223	Uranium-232
Curium-242	Plutonium-239	Radium-226	Uranium-233

High Toxicity			
Actinium-228	Cesium-137	Iridium-192	Tellurium-127m
Antimony-124	Chlorine-36	Lead-212	Tellurium-129m
Anitmony-125	Cobalt-56	Manganese-54	Terbium-160
Astatine-211	Cobalt-60	Protactinium-230	Thallium-204
Barium-140	Europium-152	Radium-224	Thallium-203
Berkelium-249	Europium-154	Ruthenium-106	Thulium-170
Bismuth-207	Hafnium-181	Scandium-46	Uranium-236
Bismuth-210	Indium-114m	Silver-110m	Yttrium-91
Cadmium-115m	Iodine-124	Sodium-22	Zirconium-95
Calcium-45	Iodine-126	Strontium-89	
Cerium-144	Iodine-131	Strontium-90	
Cesium-134	Iodine-133	Tantalum-182	

Moderate Toxicity			
Antimony-122	Cesium-131	Gadolinium-159	
Argon-41	Cesium-136	Gallium-72	Lutetium-177
Arsenic-73	Chlorine-38	Gold-196	Manganese-52
Aresenic-74	Chromium-51	Gold-198	Manganese-56
Aresenic-76	Cobalt-57	Gold-199	Mercury-197
Aresenic-77	Cobalt-58	Holmium-166	Mercury-197m
Barium-131	Copper-64	Indium-114m	Mercury-203
Beryllium-7	Dysprosium-165	Iodine-125	Molybdenum-99
Bismuth-206	Dysprosium-166	Iodine-130	Neodymium-147
Bismuth-212	Erbium-165	Iodine-132	Neodymium-149
Cadmium-109	Erbium-169	Iodine-134	Neptunium-239
Cadmium-115	Erbium-171	Iodine-135	Nickel-63
Moderate Toxicity (Continued)			
Calcium-47	Europium-152m	Iridium-190	Nickel-65
Carbon-14	Europium-155	Iridium-194	Niobium-93m
Cerium-141	Fluorine-18	Iron-52	Niobium-95
Cerium-143	Gadolinium-153	Lanthanum-140	Osmium-185

Osmium-191	Rhenium-183	Strontium-24	Thulium-171
Osmium-193	Rhenium-186	Strontium-85	Tin-113
Palladium-103	Rhenium-188	Strontium-91	Tin-125
Palladium-109	Rhodium-105	Sulfur-35	Tungsten-181
Phophorus-32	Rubidium-86	Technetium-96	Tungsten-185
Platinum-191	Ruthenium-97	Technetium-97	Tungsten-187
Platinum-193	Ruthenium-103	Technetium-97m	Vanadium-48
Platinum-197	Ruthenium-105	Technetium-99	Xenon-135
Potassium-42	Samanum-151	Tellurium-125m	Yttrium-90
Potassium-43	Samanum-153	Tellurium-127	Yttrium-92
Praseodymium-142	Scandium-47	Tellurium-129	Yttrium-93
Praseodymium-143	Scandium-48	Tellurium-131m	Yttrium-175
Promethium-147	Selenium-75	Tellurium-132	Zinc-65
Promethium-149	Silicon-31	Thallium-200	Zinc-69m
Protcatinium-233	Silver-105	Thallium-201	Zirconium-97
Radon-220	Silver-111	Thallium-202	
Radon-222	Sodium-24	Thorium-231	

Slight Toxicity		
Argon-37	Osmium-191m	Thorium-232
Cesium-134m	Oxygen-15	Natural Thorium
Cesium-135	Platinum-193m	Uranium-235
Cobalt-58m	Platinum-197m	Uranium-238
Germanium-71	Rhenium-187	Natural Uranium
Hydrogen-3	Rhodium-103m	Xenon-131m
Indium-113m	Rubidium-87	Xenon-133
Iodine-129	Samarium-147	Yttrium-91m
Krypton-85	Strontium-85m	Zinc-69
Nickel-59	Technetium-96m	Zirconium-93
Niobium-97	Technetium-99m	

Appendix X – Emergency and Spill Procedures

GENERAL

The risk of certain incidents, such as accidental spills or release of airborne radioactive material (e.g., vapours, gases. aerosols, dust) occurring while working with Nuclear Substances is always present. In such cases, the risk of accidental exposure is higher.

Accidental exposure includes:

- for example, Contamination of the environment, a person's skin or clothing by Nuclear Substances, following a spill of radioactive liquid;
- intake of radioactive material by absorption, ingestion, inhalation, injection or through a cut or wound;
- exposure to external sources of X or Gamma Radiation from Radiation Devices, Radiation-Emitting Devices or Radionuclides.

Anyone who knows or suspects that they, or anyone else, has been involved in any abnormal situation as described above, shall immediately report this to the Responsible User and to the RSO Responsible.

The RSO Responsible will:

a) assist in emergency procedures, including Decontamination where necessary;
b) estimate the Radiation Dose(s) received by the person (s) involved. This may necessitate the immediate read-out of personnel dosimeter and/or the provision of special bioassay procedures for the individual (s) concerned;
c) advise on the necessity, or otherwise, of medical examination and arrange such examination, if appropriate; investigate the incident with a view of determining its cause and advising on remedial measures to prevent a recurrence;
d) in co-operation with the IRPH, Human Research Studies Investigator, or Nuclear Medicine Facility Manager, prepare a full report to ensure adequate documentation;
e) if required, submit a report to the CNSC.

1. External exposure (not involving Contamination)

The most difficult step is to recognize that an abnormal situation has occurred. For example, X-Ray equipment has failed to switch off or a Sealed Source is exposed or improperly shielded. It is therefore important that users become familiar with the normal appearance and operation of the Sources, Radiation Devices and/or Radiation-Emitting Devices with which they are working, especially if the Devices or Sources are capable of delivering a high Dose rate.

Once an accidental external exposure has been recognized, proceed as follows:

a) immediately perform all necessary actions to prevent further exposure. For example, withdraw the exposed part of the body from the beam, switch off the X-Ray beam, shield the radioactive source, etc. In some circumstances, the exposed person cannot perform these actions on their own and must first call for assistance;
b) report the incident to the Responsible User, the RSO Responsible and EH&S;
c) the RSO Responsible will make a preliminary estimate of the Radiation Dose(s) received by the exposed person(s). At this stage, it is better~~,~~ to overestimate rather than underestimate. A more definitive Dose estimate is usually made later, when the Dosimeter reading for the exposed person is obtained.

2. Accidents involving radioactive Contamination

If an incident does take place, it must be classified in one (1) of two (2) ways:

- Minor Incident
- Major Incident

The appropriate measures must be taken.

2.1 A Minor Incident usually involves spills or airborne release of less than 1 EQ of a radioisotope. The Responsible User(s) involved are aware of proper Decontamination methods and are able to do so within a short period of time and without risk of exposure or spreading the Contamination to the surrounding area or themselves. If a Minor Incident occurs, the following measures must be taken:

a) immediately inform persons in the area that a spill (airborne release) has occurred. Keep them away from the contaminated area;
b) estimate the Activity involved and the nature of the contamination;
c) confine the spill and prepare to decontaminate;
d) cover the spill with absorbent material to prevent the spread of the contamination and personnel exposures;
e) survey hands, shoes, clothing and lab equipment for the presence of contamination;

f) wearing two (2) pairs of disposable gloves and a lab coat, clean up the spill using Decontamination foam spray or liquid detergent for surfaces. If this product is not available, regular cleaning spray and absorbent paper (wet spill) or dampened absorbent paper (dry spill) may be used. Work from the outside of the spill toward the centre (to avoid spreading the Contamination) and transfer to a radioactive waste container. All cleaning materials (sponges, brushes, rags etc.) must be wrapped with adequate amounts of absorbent paper and be disposed of as dry radioactive waste. If there is a problem cleaning up a spill, call the RSO Responsible immediately;
g) decontaminate using the procedures in Section 16, Decontamination;
h) wipe-test or survey for residual contamination, as appropriate. Repeat decontamination as necessary until contamination levels are within the limits. Surface contamination limits should be as outlined in Section 15.2;
i) record all spill details and contamination monitoring results. Adjust inventory and waste records appropriately;
j) report the spill and clean up to the Responsible User, the RSO Responsible and EH&S. The RSO Responsible will verify if actions taken were appropriate and see if corrective actions could be taken to avoid the recurrence of a similar incident.

2.2 A Major Incident may involve spills of more than 1 EQ of a radioisotope, highly radiotoxic radioisotopes, large areas of contamination including those extending outside of Radiation Controlled Areas, contamination of personnel (skin or clothing) or the release of airborne radioactive material. If a Major Incident occurs, the following measures must be taken:

a) immediately inform persons in the area that a major incident has occurred. The area must be cleared. Persons not involved in the spill must leave the area immediately. The movement of all personnel who may be contaminated must be limited until they have been monitored;
b) if possible, attempt to minimize the spreading of radioactive material by using absorbent paper. Do not attempt to clean it up yourself;
c) close off and secure the spill area to prevent entry. Post warning signs;
d) monitor, with a suitable detector, any persons suspected of being contaminated and, if appropriate, proceed with the personnel Decontamination measures described below;
e) estimate the Activity involved and the nature of the Contamination;
f) monitor the area with a suitable detector and estimate the total exposure expected for the personnel involved in the Decontamination measures; this is not a simple procedure and it must be performed by trained personnel only;
g) if the Decontamination procedures are not expected to lead to a significant exposure for the personnel (for example, less than 1 mSv) and if no airborne Contamination is expected, proceed as described in Minor Incident above. Otherwise proceed as described in accidents involving radioactive dusts, fumes or gases;
h) notify University Security who will contact the RSO Responsible immediately. Provide Security with the following information:

For Security

- your name;
- location of the incident (building, room number);
- nature of the emergency;
- any injuries (type and degree of seriousness).

For the RSO Responsible (RSO-CL or RSO-NM)

- radioisotope involved;
- amount of radioactivity;
- chemical form of the released material(s) or other hazardous chemicals involved;
- location of incident (building, room number);
- persons contaminated or exposed;
- any injuries (type and degree of seriousness);
- presence or absence of airborne radioactivity;
- steps taken so far;
- your name and the name of the Responsible User or Human Research Studies Investigator or Nuclear Medicine Facility Manager;
- telephone number where you can be reached.

3. Personnel Decontamination procedures

The following procedures apply for the Decontamination of personnel:

a) if skin, clothing or shoes might be contaminated, it is preferable to remain in the room, as far as possible from the immediate area of Contamination and call for assistance. This way the spread of the Contamination to other rooms is prevented;
b) estimate the Activity involved, the nature of the Contamination and the affected area;
c) if the spill is on clothing, the article of clothing must be removed at once and left on the premises in a plastic bag or other closed container;
d) if skin Contamination has occurred, begin Decontamination by gently flushing the affected area with non-abrasive soap and lukewarm water rinsing downwards~~,~~ towards the Extremities. Take care not to injure the skin, as it would provide a direct pathway for radioactive Contamination into the body. Decontamination foam spray can be used as an alternative;
e) if whole-body Contamination is involved, proceed to the nearest emergency shower only after local Contamination is thoroughly cleansed. Dry swabs must be used to clean any cuts, abrasions, or open wounds observed;
f) all incidents involving abnormal exposure and/or Contamination must be reported to the RSO Responsible, either at the time or as soon as possible afterwards. If immediate assistance is needed contact University Security and advise that an incident has occurred involving radiation. Security will contact the RSO while the affected individual continues decontamination procedures;
g) If the estimated skin contamination is to an ***extremity*** and greater than 50 mSv for a NEW or greater than 5 mSv for a Non-NEW, then the RSO Responsible is required to report the incident to the CNSC as per the DNSR Article 'CNSC Expectations for Licensee Response During Skin Contamination Events' (see Appendix XVI).

4. Response to the release of airborne radioactive material

a) if possible, stop the release of radioactive material (powder, gas, vapour, smoke) from the source into the environment;
b) evacuate personnel from affected area, to the closest available laboratory designated for radioisotope usage, for monitoring and possible Decontamination;
c) close doors and air outlets leading to other areas. Leave fume hood exhaust system running. Contact the RSO immediately and advise University Security as per Emergency Procedures Card (see Appendix XVI) and request that they immediately notify the RSO Responsible, take appropriate action for ventilation control, and coordinate evacuation, if required;
d) close and lock doors leading to the contaminated area and post appropriate warning signs;
e) monitor all persons who may have been exposed to external Radiation, have surface Contamination, and/or have inhaled or ingested Radionuclides;
f) perform simple Decontamination; obtain medical assistance promptly, if required;
g) follow the procedure outlined for Major Incidents;
h) any incident involving spills or releases of airborne radioactive material must be reported as follows:

For Security

- your name;
- location of the incident (building, room number);
- nature of the emergency (Specify Radiation involved);
- any injuries (type and degree of seriousness).

For the RSO Responsible (RSO-CL or RSO-NM)

- radioisotope involved;
- amount of radioactivity;
- chemical form of the released material(s) or other hazardous chemicals involved;
- location of incident (building, room number);
- persons contaminated or exposed;
- any injuries (type and degree of seriousness);
- presence or absence of airborne radioactivity;
- steps taken so far;
- your name and the name of the Responsible User or Human Research Studies Investigator or Nuclear Medicine Facility Manager;
- telephone number where you can be reached.

5. Theft or Loss of Radioactive Material

The radiation safety emergency procedures listed here shall be followed, in the event of theft, suspected theft or other loss of radioactive material:

For the CL:

a) immediately report any theft or loss to the IRPH and the RSO-CL, including the amount of material that may be missing;
b) per the University's *Security Policy* (VPS-20), all thefts must be reported to the Security Department; and
c) any theft or loss of radioactive material shall be reported immediately to the CNSC by the RSO-CL and incident report filed within 21 days of becoming aware of the incident.

For the HSRL:

a) immediately report any theft or loss to the Nuclear Medicine Facility Manager and the RSO-NM, including the amount of material that may be missing;
b) per the University's *Security Policy* (VPS-20), all thefts must be reported to the Security Department; and
c) any theft or loss of radioactive material shall be reported immediately to the CNSC and EH&S by the RSO-NM; and the RSO-NM submits to the CNSC an incident report within twenty one (21) days of becoming aware of the incident.

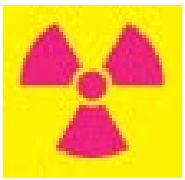
6. Fires in the proximity of radioactive materials

It is imperative that the emergency instructions applicable to the building concerned are exactly followed. It is essential to report the location of radioactive sources to the firefighting teams and to estimate any additional risk, which these sources may present. The RSO Responsible will survey the premises at the end of the emergency and, before authorizing access to the premises, will ensure that there is no significant risk of Radiation exposure.

Appendix XI – Radioactive Waste Disposal Tag

CONCORDIA UNIVERSITY
UNIVERSITÉ CONCORDIA

CONTAINER NUMBER



PERMIT HOLDER: _____
PERMIT #: _____
ROOM #: _____
WEIGHT: _____

ISOTOPE	ACTIVITY	DATE

Appendix XII – ^{32}P: Potential Hazards and Safe Working Procedures

A. Physical Characteristics

^{32}P decays to ^{32}S with the emission of Beta particles that have a maximum energy of 1.7 MeV. The Half-life is 14.3 days. The most energetic particles have a range of about 6 meters (20 feet) in air. In contrast, the range in water, plastic and in soft tissue is about 7 to 8 mm (1/3 inch). It takes about 3 mm of glass to stop the most energetic particles. Most test tubes and centrifuge tubes do not have the necessary thickness. Although ^{32}P emissions are totally absorbed by 0.7 mm lead or about twice that thickness of steel, neither should be used to hold ^{32}P samples since bombarding high atomic number materials with energetic electrons gives rise to X-Radiation which in turn can be difficult to attenuate with Shielding materials. It is therefore important to shield tubes with Lucite (plastic) and to work behind a Plexiglas or Lucite shield to absorb the Beta particles.

B. Radiation Doses

Doses of Ionizing Radiation are normally expressed in either of two units, Rem (100 erg/g) or Sv (1 J/kg), which reflect the amount of energy deposited per unit weight of tissue and weighted for biological effectiveness. To give some sense of magnitude to the following potential Dose estimate from ^{32}P you should realize that the average population Dose is 0.1 to 0.2 Rem (1-2 mSv/y). A NEW may not receive more than 50mSv per year. The exposure limit is 1 mSv for all others, whole body and 50 mSv for hands. An acute exposure to 100 Rem or 1 Sv will have significant short-term biological effects on tissues. Aside from the Dose-proportional increase in cancer, risk to exposed cells and tissues, such Doses are beyond the threshold for most Non-Stochastic Effects (cell killing, cataract induction).

^{32}P is slightly more hazardous than other common Beta particle emitting radioisotopes (e.g. ^{14}C or ^{35}S) from the point of view of ingestion or inhalation (internal hazard). It is, however, substantially more hazardous from the point of view of external exposure, particularly with respect to hands and eyes because of its greater range in both air and tissues (and the greater Shielding requirement). One should still regard ingestion and/or inhalation as serious concerns. The maximum intake (ALI) for a NEW (amount of radioisotope that would give 20mSv lifetime exposure) is only 8 MBq. Only one percent of the body burden is excreted from soft tissue per day and the rate is much less from bone.

The Radiation Field (Gy/h) from an open (unshielded), 1 mCi (37 MBq) source of ^{32}P is substantial. At 0.1 cm the Dose rate is 290 Gy/h to the surface of the closest skin; at 1 cm it is 0.29 Gy/h; at 10 cm it is 0.029 Gy/h and at 100 cm it is 0.03 cGy/h. Most radioisotopes are contained in some small volume of solvent and the assumptions about decreases in Dose rate (inverse square law) are not valid. In most cases, intensity decreases inversely with distance and not as the square of the distance giving higher Doses than predicted by the ‘inverse square law’.

Direct handling of ^{32}P contained in small volumes of liquid can lead to very substantial Doses to the skin and underlying tissues of the hands. It is estimated that the Dose to the surface of the hands

from a tube with 1-mm glass (2-3-mm plastic) wall thickness could be 150 Gy/h. From a 2-mm glass wall thickness (4-5-mm plastic) the Dose rate decreases to about 8 Gy/h. In both cases, even short-term handling can lead to significant exposure to hands. Your limit of exposure is 20 mSv/y (<10mGy) to the hands or eyes and consequently that exposure could be exceeded in seconds to minutes if handling of ^{32}P in a disposable plastic tube. Any procedure involving such quantities should be carried out with special consideration for ensuring adequate plastic Shielding.

Extremity monitors (ring badges) must be worn when handling more than 37 MBq of ^{32}P in a single tube or a single procedure. Safety glasses should always be worn when working with ^{32}P.

Working with protective gloves is essential for all who work with radioisotopes. Skin Contamination can lead to skin burns. Doses are very large to tissues near the contaminated skin. Even 1 μCi spread over 1 cm^2 of skin gives 5.4 cGy/h to about 2 cm^2 area to a depth of 1 cm.

C. Monitoring ^{32}P

Personal dosimeters readily measure the general Radiation Dose to skin, eyes, and hands. Ring badges may be needed to monitor hands if handling small volume open/partially shielded sources. G-M tube portable monitors detect ^{32}P with fairly high efficiency (10 - 20% at 1 cm). A handy conversion from contamination meter count rate to Dose is the following:

0.1 µCi on the skin surface (< 1 cm²) will give approximately 20,000 CPM measured at 1 cm. This corresponds to a Dose rate of 0.2 cGy/h. One cGy corresponds to about 100,000 CPM. Remember that Beta particle Radiation Doses are highly localized and one cannot receive major whole-body-exposures. On the other hand, however, Dosimeters worn on lab coats may not detect accurately exposures to hands or eyes.

Monitoring of Activity in low-level waste for disposal via non-compacted wet garbage presents some problems with respect to determining Activity. It is forbidden to discard more than 0.37 MBq/y via regular garbage. The EQ of ^{32}P is 0.01 MBq. The average count rate at the surface of the bag should not exceed 100 CPM. All other waste should be stored in a shielded 1-cm Lucite or painted hardwood container until the Activity decays to an acceptable level. Such waste must be in special labeled waste containers not to be collected by cleaning staff. If the waste cannot be safely accommodated in the laboratory, please contact the RSO Responsible to make arrangements to have waste transferred to a designated storage area for Decay purposes.

Items with higher levels of ^{32}P (tubes, gels, scintillation vials, etc.) should be placed in radioactive waste containers (plastic pails lined with clear plastic bags).

D. Alternatives to ^{32}P

While ^{32}P remains one of the most commonly used radioisotope in Molecular Biology and Biochemistry experiments, there are alternatives. One of the most obvious is the use of ^{33}P, which is only slightly more expensive (but has a significant longer Half-life). Specific Activities are necessarily somewhat lower; however, hazards are much reduced and are comparable to those associated with ^{14}C and ^{35}S. One significant advantage is the greater resolution possible with this lower energy emitter when used in sequencing gels or blotting procedures. In addition, it is possible to order and handle larger quantities of this radioisotope in a regular, Basic-Level Laboratory. The possession limit (for a Basic-Level Laboratory) for ^{33}P is 400 MBq compared to 40 MBq for ^{32}P.

Appendix XIII – Transfer of Personnel and Radioisotopes among Licensed Laboratories

Occasionally, the situation may arise in which an IRPH wishes to transfer radioisotopes from colleagues in other laboratories. Such transfers are allowed by the CNSC, internal radioisotope conditions and University policy provided that the individual receiving the radioisotope has a permit authorizing the possession and/or handling of the item in question. The radioisotope must be used in a licensed location, the Activity must not exceed the possession limit of the IRP held by the individual receiving the radioactive material and the RSO-CL must be informed, in writing, in advance, of such transfer. All transfers must be carried out in accordance with transportation of dangerous goods provision and CNSC *Nuclear Substances and Radiation Devices Regulations* (SOR/2000-207) and recorded in the logbooks of both permit holders involved. A Radioisotope Transfer Document must be completed (see Appendix XVI). Under no circumstances may one transfer radioactive materials to non-licensed facilities or to laboratories not licensed for that particular radioisotope. No movement of radioactive materials into, or out of, University facilities may take place without the formal approval of the RSO Responsible. The University must be able to provide accurate inventories of all radioactive materials in emergency situations or upon request by the CNSC.

There are some situations in which students and/or research staff may work in laboratories other than those for which their supervisor is responsible. It is absolutely essential that all individuals working with radioactive materials in any laboratory or any communal facility be listed on the permit(s) of the individual(s) responsible for those areas. Any work carried out with radioisotopes must be in accordance with the limits of maximum Activities for specified radioisotopes in designated areas as stated on the permit under which the individual is working. No individual may work with radioactive materials unless he or she has received training and is listed on the permit of the person responsible for the laboratory in which the work takes place. Individuals may be listed on more than one permit and authorized locations may also be listed on more than one permit.

Transfer Procedure:

1. IRPHs to contact RSO Responsible to request transfer.
2. RSO validates if the transfer is permitted:
    a. Internal Transfer: RSO to verify and amend IRPs as necessary.
    b. Transfer from another Licensee (IN):
        i. For a radiation device or sealed source, RSO to request excerpt of previous year's ACR from the other licensee indicating the reported radiation device or sealed source;
        ii. RSO to verify and request amendment of CNSC licence as necessary;
        iii. RSO to verify and amend IRP as necessary.
    c. Transfer to another Licensee (OUT):
        i. RSO to request copy of CNSC licence of external organisation;

ii. For a radiation device or sealed source, RSO to provide excerpt of previous year's ACR to the other licensee indicating the reported radiation device or sealed source;

iii. RSO to verify and amend CNSC Licence as necessary;

iv. RSO to verify and amend IRP as necessary.

3. RSO to complete Transfer Document with appropriate signatures, in triplicate (RSO copy, Transferee copy, Transferor copy) at the time of transfer.
4. Transfer is completed internally by RSO and/or responsible users.
5. Transfer is completed with external organisation (IN or OUT) in accordance with PTNSR, TDGR, and IAEA.
6. RSO to update inventory.

Note 1: For transfers involving a radiation device, the transferor shall provide the transferee with the instructions referred to in the radiation device certificate for dealing with accidents, including fires and spills.

Note 2: For transfers involving a sealed source or nuclear substance used as shielding, the transferor shall provide the transferee with a record of the most recent leak test conducted.

Appendix XIV –Radiation Warning Symbol

All radiation warning signs must contain the Radiation Warning Symbol and wording as indicated below.

As well, the following must be respected:

- It must be shown in contrasting colours, black on a yellow background or magenta on a yellow background
- It must be clearly visible and identifiable from a distance of 1 metre
- No text can be printed over the Radiation Warning Symbol

RADIATION – DANGER – RAYONNEMENT

Appendix XV – Additional References

The following documents are available from the CNSC website and may be consulted for more information.

1. Nuclear Safety and Control Act
2. Canadian Nuclear Safety Commission Rules of Procedure
3. General Nuclear Safety and Control Regulations
4. Radiation Protection Regulations
5. Radiation Safety in Educational, Medical and Research Institutions
6. Nuclear Substances and Radiation Devices Regulations
7. Packaging and Transport of Nuclear Substances Regulations
8. Radioisotope Safety: Spill Procedures
9. Receiving Radioactive Packages
10. Radioisotope Safety: Basic Laboratories
11. Radioisotope Safety: Intermediate Laboratories
12. Design Guide for Basic and Intermediate Level Radioisotope Laboratories
13. Guidelines for Research on Human Subjects using Radionuclides (GMA-5)

The following documents available from Health Canada can be consulted for more information.

1. *Safety Code 35: Safety Procedures for the Installation Use and Control of X-Ray Equipment in Large Medical Radiological Facilities.*
2. *Safety Code 32: Safety Requirements and Guidance for Analytical X-Ray Equipment.*

The following web sites are available for additional information.

Canadian Nuclear Safety Commission (CNSC)	www.nuclearsafety.gc.ca
Health Canada	www.hc-sc.gc.ca
The Canadian Radiation Protection Association	www.crpa-acrp.ca
International Atomic Energy Agency (IAEA)	www.iaea.org
Radiation Safety Institute of Canada	www.radiationsafety.ca
Table of Nuclides (Dept. of Advanced Technology, Brookhaven National Laboratory)	www.nndc.bnl.gov/nds
Canadian Legal Information Institute (CanLII)	https://www.canlii.org/en/index.html
Department of Justice (Canada)	http://laws.justice.gc.ca/eng

Appendix XVI – List of Forms

The following forms and documents are available from the RSO Responsible or the EH&S website.

- Application for Internal Radiation Permit
- Application to Add a New Radioisotope User to an Existing Permit
- Application for Special Project
- Radioisotope Inventory Form
- Direct Monitoring Form
- Radioactive Waste Container Request Form
- Radioactive Waste Disposal Form
- Notification of Nuclear Energy Worker (NEW) Status
- Declaration of Pregnancy by Nuclear Energy Workers
- Radioisotope Transfer Document

Additional documents:

- Emergency Procedures Card
- CNSC Radioisotope Safety Poster
- CNSC Reportable Events Guide
- CNSC Document Retention Schedule
- Internal Management of Radiation Permits
- Dosimeter Use and Care Guide
- Survey and Contamination Meter Guidelines
- Leak Test Procedures
- Bioassay Program Guide
- TDG-7 Guide to Radioactive Packages
- Nuclear Medicine Facility PERFORM Operating Document
- Radiation Program Labelling Guide
- Ludlum 44-9 Data Sheet
- Fluke ASM 990 Data Sheet
- CNSC Expectations for Licensee Response During Skin Contamination Events
- Radiation Safety Inspection Form (RSO)
- 815 Type II Inspection Worksheet (CNSC)
- 875 Type II Inspection Worksheet (CNSC)
- *Concordia University`s Guidelines and Procedures for Radiation-Emitting Devices*

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