The University of Western Ontario
Human Resources
Occupational Health and Safety

RADIATION SAFETY MANUAL

Prepared by
Health and Safety Consultant (Nuclear, X-ray, Laser)
Approved by the Radiation Safety Committee

Updated on April 11, 2022
(Rev.1.4.17)

FOREWORD

This manual was prepared with the premise that the success of any program in Radiation Safety for the prevention of exposures and avoidance of accidents, must necessarily rely on the experience, ability, and forethought of the professional user of radio nuclides.

The policies and procedures contained herein are designed to achieve a reasonable and practical standard of safety in compliance with government regulations and codes, while allowing investigators the maximum possible freedom in establishing and implementing their own individual experimental programs.

The manual is intended to provide a ready reference to legislative requirements and procedures, a guide to acceptable methods of practice, and a degree of safety awareness contributory to self- regulation for those who work with nuclear substances.

HUMAN RESOURCES, OCCUPATIONAL HEALTH & SAFETY

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1.1. NUCLEAR SAFETY CONTROL ACT & REGULATIONS

In Canada, there are several government bodies which have jurisdiction over the use of ionizing radiation. The Canadian Nuclear Safety Commission (CNSC) licences the acquisition and use of all nuclear substances and radiation emitting equipment such as nuclear reactors and accelerators. Recommendations from the International Commission on Radiological Protection (ICRP) are also used to formulate the rules and conditions under which radioisotopes or radiation emitting devices are used.

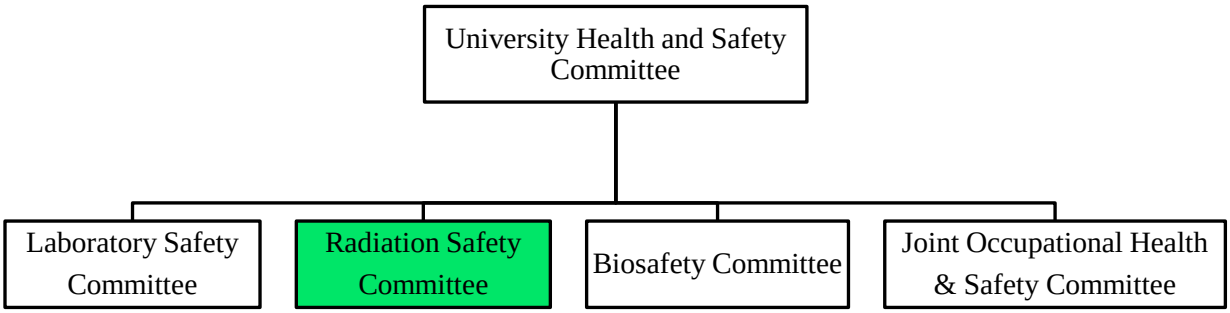
In addition, the Health Protection Branch of Health & Welfare Canada formulates regulations related to the manufacture and functioning of new radiation equipment under the Radiation Emitting Devices Act. Many of the provinces also have their own regulations for the use of radiation emitting equipment (e.g., x-ray emitting equipment).

On March 20, 1997, the federal Nuclear Safety and Control Act were passed by Parliament, replacing the 50-year-old Atomic Energy Control Act. The Act and new Regulations came into force on May 31, 2000. The University of Western Ontario (Western University or Western) is licenced by the CNSC to possess, transfer, import, export, use and store the nuclear substances and the prescribed equipment listed on the Consolidated, Class II Nuclear Facility and Import licences.

1.2. UNIVERSITY HEALTH & SAFETY COMMITTEE

1.2.1. Health and Safety Committees

The University Health & Safety Committee is the senior safety committee of the University. It has the responsibility for reviewing the overall safety performance of the University, for recommending health & safety policy, and for overseeing the activities of any sub-committees reporting to it. This advisory committee reports directly to the President.



1.2.2. Western Safety Policy & Committee Terms of Reference

Western's safety policies, procedures, manuals, forms and Terms of Reference can be found in this link: https://www.uwo.ca/hr/form_doc/health_safety/index.html.

1.3. RADIATION SAFETY PROGRAM

1.3.1. Responsibilities for Radiation Safety

CNSC license applicant(s) must be legal, corporate entities, as the University of Western Ontario (Western). Once licensed, these entities must ensure that they and their activities comply with all license conditions and CNSC Regulations. Western has established a Radiation Safety Program (RSP) to ensure that work with radioactive materials and/or radiation devices are conducted in a manner that protects health and minimizes danger to life, security, and the environment. The RSP at Western is overseen by:

1. **Senior Management** with overall responsibility for regulatory compliance, radiation safety matters, and positive safety culture. A Senior Manager must have adequate authority and resources to ensure effective operations of the Radiation Safety Program.
2. **Health & Safety Consultant (Nuclear, X-ray, Laser)** who is competent and trained in all radiation safety matters to run the day-to-day operations of the Radiation Safety Program. The Health & Safety Consultant is accountable and communicates directly to the Senior Management.
3. **Radiation Safety Committee** which is composed of individuals with expertise or a stake in radiation safety matters. The individuals are approved by Senior Management and act to advise Senior Management and the Health & Safety Consultant on matters of radiation safety.

1.3.2. Senior Management

The Senior Manager (Associate Vice President-Human Resource) has overall corporate responsibility for CNSC regulatory compliance and radiation safety matters. The Senior Manager is responsible to:

1. Submit the application for a radioactive license to the CNSC on behalf of Western, with the required supporting documentation.
2. Ensure the implementation of the Radiation Safety Program, the designation of the Health & Safety Consultant and Radiation Safety Committee.
3. Ensure that essential physical, human and financial resources are provided, as required for the operation of the Radiation Safety Program. The radiation safety program should be funded by monies that are isolated and protected from competing demands.
4. Assure the safety of staff, workers and the public during the conduct of licensed activities, promoting a positive safety culture and encouraging effective communication amongst all levels of workers and managers within the program.
5. Ensure that the Health & Safety Consultant is not assigned competing duties or priorities that might detract significantly from his/her ability to participate in or supervise radiation safety matters.
6. Review the performance of Radiation Safety Program and correct significant deficiencies in the Radiation Safety Program when such deficiencies are detected.
10. Report significant events to the CNSC and other agencies as required by the act, regulations and license conditions. Notify the CNSC any change in the information regarding the Health & Safety Consultant within 15 days after the change occurs.
11. Initiate, undertake or coordinate investigations to determine the cause of significant events, as required to mitigate or to prevent future incidents or effects.

1.3.3. Radiation Safety Committee

The Radiation Safety Committee is a sub-committee of the University Health & Safety Committee. This Committee is composed of individuals with expertise or a stake in ionizing and non-ionizing radiation safety matters. The individuals advise the Senior Management and the University Health & Safety Consultant on matters of all radiation safety including nuclear substances and radiation devices, particle accelerators, X-ray equipment, lasers/laser systems and other non-ionizing radiation sources. This Committee is a requirement of the CNSC regulations.

1.3.3.1. Membership & Appointment

The Radiation Safety Committee will consist of a minimum of eight members with expertise in radiation safety matters. The Committee members are appointed by the Deans of Faculties. Appointment will be a three-year renewable term.

Voting Members

- Vice President, Research and International Relations, Chair or Designate (1)
- Faculty of Science (4)
- Faculty of Medicine and Dentistry (2)
- Faculty of Engineering (1)
- Faculty of Social Science (1)
- Faculty of Health Sciences (1)

Non-Voting Members

- Director, Occupational Health and Safety
- Health & Safety Consultant (Nuclear, X-ray, Laser)
- Facility Safety Consultant
- Associate Director, Facilities Management & Engineering
- A representative from the Division of Facilities Management appointed by the Associate Vice-President of Facilities Management, to advise on matters concerning laboratory design and construction.
- A Departmental Chair from one of the departments in which radioactive materials are in use, to provide advice and present concerns on departmental issues involving the safe use of radioactivity.
- A representative from Society of Graduate Students (SOGS) appointed by the President of SOGS.
- A representative from the Postdoctoral Association (PAW) appointed by the President of PAW.

1.3.3.2. Duties

The Radiation Safety Committee should:

1. Meet three times a year or as required to review the Radiation Safety Program and report recommendations to the University Health and Safety Committee.
2. Advise the Senior Manager and the Health & Safety Consultant on all radiation safety matters, including the safe use of radioactive materials during licensed activities.
3. Review proposed or existing radiation programs and procedures to determine if they assure that radiation exposures will comply with regulatory limits and will be As Low As Reasonably

Achievable (ALARA).

4. Review proposed uses of nuclear substances, and their planned locations of use to determine whether these proposals comply with corporate procedures and regulatory requirements.
5. Assess the adequacy and effectiveness, in terms of the contents and schedules of delivery, of the University's radiation safety training programs.
6. Review the results of internal inspections that are designed to assess whether nuclear substances are used safely in licensed areas.
7. Review annual summaries of the occupational radiation exposures received by permitted workers to assess whether this respect the ALARA principle of dose limitation.
8. Review reports concerning incidents or unusual occurrences at the University that involve nuclear substances.
9. Recommend, to the Health & Safety Consultant and Senior Manager, possible corrective measures or improvements when their review or assessment identifies deficiencies in a proposal, program, practice, procedure, equipment, record or report.
10. Recommend corrective measures or possible improvements to prevent recurrences of any incident that exposes persons to unnecessary radiation.
11. Advise Senior Manager of any need for additional resources to establish, maintain or improve radiation protection program.
12. Maintain written records of their activities, decisions, advice and recommendations concerning radiation safety, including details of meetings and reviews of data, reports, programs, procedures, circumstances, incidents or unusual occurrences.
13. Cancel Internal Permit(s) in situations of non-compliance as recommended by the Health & Safety Consultant.

1.3.4. Health & Safety Consultant (Nuclear, X-Ray, Laser)

The Health & Safety Consultant (Nuclear, X-ray, Laser) is a specialist in all aspects of radiation safety who provides day-to-day administration and control of the radiation safety program on behalf of Western. The Health & Safety Consultant (Nuclear, X-ray, Laser) should:

- Possess both relevant work experience and formal training in radiation safety.
- Understand methods and technology to control use, handling, storage and disposal of nuclear substances and to monitor and control radioactive contamination, radiation fields and radiation exposures.
- Understand pertinent regulatory processes and requirements.

The Health & Safety Consultant (Nuclear, X-ray, Laser) is appointed by and reports directly to Senior Management. To ensure radiation safety and compliance with regulatory requirements on behalf of Senior Management, the Health & Safety Consultant (Nuclear, X-ray, Laser) has the following duties and responsibilities:

1. Communicate with Senior Managers, Radiation Safety Committee, Permit Holders and nuclear substance users on all matters relevant to radiation safety.
2. Act as a signing authority and prepare annual reports in accordance with conditions contained in the license issued to the University by the CNSC. Report to the CNSC any changes to the Radiation Safety Program.

3. Review and authorize requests to purchase or use nuclear substances to ensure that the proposed uses and locations of use comply with relevant legislation, license conditions and the radiation safety program.
4. Assess the proposed use of nuclear substances in laboratories, and designate laboratories for use of nuclear substances.
5. Maintain a record of the status of all designated laboratories that use nuclear substances.
6. Authorize the decommissioning of laboratories in which radioactive use has been terminated.
7. Develop and implement administrative controls or procedures to ensure radiation safety and compliance with regulatory requirements.
8. Assess competencies of persons who apply to use or handle nuclear substances and authorize the use of nuclear substances by these individuals.
9. Designate Nuclear Energy Workers in accordance with CNSC Regulations.
10. Verify that persons who handle nuclear substances or may be exposed to radiation (e.g., secretaries, shippers & receivers, maintenance & service workers) are adequately trained in radiation safety and the institution's radiation safety policies.
11. Authorize the disposal of nuclear substances in accordance with legislation, the CNSC and institutional policies.
12. Assess, in conjunction with the Radiation Safety Committee, the effectiveness of radiation protection programs.
13. Develop and implement programs under the direction of Senior Manager to inspect and critically review the conduct of licensed activities, the adequacy of locations and facilities where nuclear substances are used and stored, and the adequacy of personnel training and safety procedures.
14. Implement remedial actions to correct deficiencies identified upon inspection program referred to in (13) above.
15. Under the direction of Senior Manager initiate revisions to procedures, changes to equipment and facilities, and amendments to the CNSC license(s) to ensure compliance with regulatory requirements.
16. Design and implement appropriate personnel monitoring and bioassay programs to measure exposures to ionizing radiation.
17. Administer or control the issue, use and maintenance of radiation monitoring devices and equipment and the recording of results.
18. Monitor the occupational radiation exposures received by persons by reviewing, at least twice a year, their records of exposure.
19. Where the above reviews of radiation exposure indicate that exposures are unnecessarily high, recommend to Senior Manager and/or the individuals concerned, measures to reduce exposure.
20. Investigate and follow with appropriate recommendations to prevent reoccurrence, reports of over exposures to ionizing radiation, accidents involving nuclear substances, and losses of nuclear substances.
21. Report all incidents or accidents involving nuclear substances to the CNSC and other relevant authorities in accordance with legislation and the license.

22. Assess the adequacy of survey programs for measuring or managing radiation fields and radioactive contamination during licensed activities, such as during the use, storage and disposal of nuclear substances.
23. Ensure that the results of programs to reduce or remove radioactive contamination meet regulatory requirements.
24. Ensure that sealed radiation sources are leak tested in accordance with the institution's policies and regulatory requirements.
25. Consult with necessary safety committees and or personnel to ensure that the use of nuclear substances is conducted in a manner meeting institutional policies.
26. Prepare or review proposed or existing radiation safety procedures in cooperation with the Radiation Safety Committee.
27. Coordinate, or participate in, emergency responses to accidents involving nuclear substances.
28. Ensure that records and reports that are required of the institution by legislation and licenses are prepared, maintained or submitted as required.
29. Ensure that any nuclear substances that are to be transported are packaged in accordance with regulations.

1.4. INTERNAL PERMIT HOLDER RESPONSIBILITIES

The Permit Holder is designated as a Nuclear Energy Worker (NEW). In addition to the Nuclear Energy Worker's responsibilities, the Permit Holder must ensure that NEWs listed on the permit:

1. Attend all required safety training sessions, comply with the Nuclear Safety and Control Act (NSCA), CNSC regulations, CNSC licence conditions, internal permit conditions, and that safe laboratory practices are followed.
2. Are designated as nuclear energy workers to use nuclear substances and radiation devices.
3. Receive adequate radiation safety training from Western and have been informed of the risks associated with exposure to ionizing radiation. Permit Holder is also responsible for providing the specific hands-on training to all nuclear substance/radiation device users in his/her laboratories.
4. Perform weekly monitoring when radioisotopes are handled and maintain records.
5. Maintain radioisotope inventories, storage and waste disposal records. The Permit Holder must authorize and limit the release of nuclear substances only in the quantities specified in the regulations under guidance and approval of the Health & Safety Consultant (Nuclear, X-ray, Laser).
6. Report incidents of loss, theft, sabotage, illegal use or possession of any nuclear substance/radiation device immediately to the Health and Safety Consultant (Nuclear, X-ray, Laser);
7. Are provided with adequate facilities, equipment and supervision to ensure workers or students follow the rules and regulations set out by the CNSC and Western policies and procedures.
8. Must designate a responsible-trained individual to oversee radioisotope work during any absence (4 weeks), and a stand-in Permit Holder during extended absences (>4 weeks). The latter will be reported to the Health & Safety Consultant (Nuclear, X-ray, Laser) in advance of the extended leave.

1.5. NUCLEAR ENERGY WORKER'S RESPONSIBILITIES

Every Nuclear Energy Worker shall:

1. Be familiar with the Western Radiation Safety Manual, attend all required safety training sessions, comply with the Nuclear Safety and Control Act (NSCA), CNSC regulations, licence conditions and internal permit conditions.
2. Use equipment, devices, facilities and clothing for protecting the environment or health and safety of persons, or for determining doses of radiation, dose rates or concentrations of radioactive nuclear substances in accordance with the NSCA, CNSC regulations, permit and licence conditions.
3. Comply with the measures established by Western to protect the environment and health and safety of persons, maintain security, control of levels and doses of radiation, and control releases of radioactive nuclear substances and hazardous substances into the environment.
4. Inform the Permit Holder and/or the Health & Safety Consultant (Nuclear, X-ray, Laser) immediately of any situation involving the following: a risk environment or health and safety of persons, a threat of security or incident with respect to security, a failure to comply with the NSCA, CNSC regulations, CNSC licence, Western permit or Western Radiation Safety Manual, an act of sabotage, theft, loss, illegal use or possession of a nuclear substance/radiation device, a release of an authorized quantity of nuclear substance or hazardous substance.
5. Report the Permit Holder and/or the Health & Safety Consultant (Nuclear, X-ray, Laser) any incident involving known or suspected radiation exposure, personal contamination, any contamination or spill exceeding permissible limits prescribed in the Western Radiation Safety Manual.
6. Observe and obey all notices and warning signs posted by Western.
7. Take all reasonable precautions to ensure the worker's own safety, the safety of the other persons at the site of the licensed activity, the protection of the environment, the protection of the public and the maintenance of security.
8. Wear the required monitoring dosimeters and participate in the required bioassay programs.
9. Perform all regular contamination checks and clean up contamination.
10. A female worker is encouraged to inform her supervisor and/or the Health & Safety Consultant (Nuclear, X-ray, Laser) of her pregnancy as soon as she becomes aware of it.

SECTION 2: POLICIES & REGULATIONS

2.1. ALARA POLICY

All occupational exposures shall be limited in accordance with the ALARA principle and within the CNSC prescribed dose of the Radiation Protection Regulations. All work associated with nuclear substances shall be governed by considerations for the risk of radiation.

Western is committed to taking every reasonable precaution, as is practical, to maintain radiation exposures to staff, students and the public to ALARA (As Low As Reasonably Achievable). The Western University Radiation Safety Program is designed to keep exposures to ALARA by:

1. Management control over work practices

2. Personnel qualification and training
3. Control of occupational and public exposure to radiation
4. Planning for unusual situations

2.2. RADIATION PERMIT POLICY

The University is issued a Consolidated Licence by the CNSC in the name of the University. This licence authorizes the University to issue Internal Radioisotope Permits only to Western employees, for the use of radioisotopes on the campus. In this manual, the word "licence" refers to the authority granted by the CNSC; the word "permit" refers to the document issued internally by Western.

The Health & Safety Consultant (Nuclear, X-ray, Laser) and Radiation Safety Committee Chair review and approve all uses and operations involving radioisotopes on university property. The University issues an Internal Permit to the applicant who is then held responsible for ensuring that all CNSC Regulations and Western Policies and Procedures are in full compliance. Where the Regulations or Permit Conditions of Approval are violated and/or in non-compliance, the Health & Safety Consultant (Nuclear, X-ray, Laser) will recommend suspension, cancellation or disciplinary action on any Internal Permit.

2.3. NUCLEAR SUBSTANCE PURCHASE, SHIPPING, RECEIPT & INVENTORY POLICY

The purchase of all nuclear substances must be performed by authorized staff within the Western Purchasing Department, on behalf of the Internal Permit Holder. All purchases/acquisitions are reviewed and approved by the Health & Safety Consultant (Nuclear, X-ray, Laser) or OHS personnel authorized by the Consultant prior to receipt by the Internal Permit Holder. Nuclear substances must not be purchased via the University's Low Value Purchase Order procedures or by calling directly to any supplier. Acquisitions may include gifts, loans, purchases, transfers from external off-campus Licensees, and internal on-campus transfers. All acquisitions must be documented and traceable on the Western Inventory Record Form. Any work requiring the use of more than 10,000 exemption quantities of a nuclear substance at a single time must be approved by the CNSC.

All radioactive materials to be shipped must meet the current CNSC Packaging and Transportation of Nuclear Substances Regulations, International Atomic Energy Agency Regulations and other applicable regulations. No radioactive materials to be transported without consultation with the Health & Safety Consultant (Nuclear, X-ray, Laser) in Occupational Health and Safety.

All ordered nuclear substances must be delivered, and received at Loading Dock 11, Chemistry Building by ChemBioStores Staff. No other location is authorized for receiving of these materials unless it is authorized by the Health & Safety Consultant (Nuclear, X-ray, Laser). Only personnel listed on the permit, will be allowed to pick-up nuclear substances and bring the materials to the approved laboratory.

Each individual stock vial must be assigned a bar code number when received. Prepared aliquots of nuclear substances must be similarly numbered and recorded (for tracking purposes). A corresponding Inventory Report Form must be maintained and available in the laboratory, at all

times. Records shall be maintained in the Purple Binder provided by the Health & Safety Consultant (Nuclear, X-ray, Laser). Under no circumstances shall the inventory exceed the possession limits as defined in the Internal Permit.

An annual accounting of total inventory, waste disposal and other required records for the previous year must be submitted to the Health & Safety Consultant (Nuclear, X-ray, Laser) as requested.

2.4. NUCLEAR ENERGY WORKER POLICY

The University informs all those working with nuclear substances, radiation devices or Class II prescribed equipment as Nuclear Energy Workers including permit holders, faculty, staff, students, etc.

High school students are not allowed to handle nuclear substances, radiation devices or Class II prescribed equipment.

2.5. PERSONAL EXPOSURE POLICY

All occupational exposures shall be limited in accordance with the CNSC Radiation Protection Regulations (RPR), Effective Dose Limits and the ALARA principle. Nuclear Energy Workers will be monitored with TLD monitors from a CNSC approved agency. The nominal cost for this service is provided by the user's Department. All actual or suspected exposures must be reported to the Health & Safety Consultant (Nuclear, X-ray, Laser). Nuclear Energy Workers are also required to participate in a bioassay program, as specified in the conditions of the Internal Permit.

A pregnant worker is strongly recommended to inform in writing the Internal Permit Holder and the Health & Safety Consultant (Nuclear, X-ray, Laser) as soon as she is aware of her condition. On being informed by a worker, in writing, that she is pregnant, Western, in order to comply with Radiation Dose limits as per CNSC RPR, will make any accommodation that will not result in costs or business disruption constituting undue hardship to the institution.

On being informed by a female worker, in writing, that she is breastfeeding an infant, Western must, in order to limit intakes of nuclear substances by the worker, make any accommodation to the working conditions that will not result in costs or business disruption constituting undue hardship to the institution.

2.6. RADIOISOTOPE FACILITY POLICY

All rooms designed for the use of nuclear substances must approved by the Health & Safety Consultant (Nuclear, X-ray, Laser). Any area or enclosure where more than one exemption quantity of an unsealed nuclear substance is used at a single time must be classified as basic, intermediate, high or containment level according to RD-52 Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms. Except for the basic level classification, all other levels must be approved by the CNSC.

Nuclear substances or radiation devices may only be used in those laboratories/areas which are identified on the Internal Permit.

2.6.1. Radiation Warning Sign and Notice Policy

The use and posting of all types of radioactive warning labels and signs shall be in accordance with the CNSC Radiation Protection Regulations Section 20, 21, 22, 23. Radioactive warning signs shall NOT be posted in locations or on equipment where radiation is not present. Section 23 prohibits the frivolous posting of signs. All such signs and labels shall be removed.

2.6.2. Decommissioning Policy

The Department Chair is responsible for ensuring that all rooms, areas or enclosures that have been licenced for nuclear substance use, are decommissioned before being released for non-radioactive use or renovation.

The Internal Permit Holder is responsible for completing the Decommissioning Report prior to releasing his/her responsibility for the area. In the absence of the Internal Permit Holder, the Department Chair will assume these duties.

2.7. CONTAMINATION MONITORING AND LEAK TESTING POLICY

Regular monitoring by wipe test of radioisotope laboratories is required for the detection and then clean-up of contamination. Monitoring must be done on all normally accessible working surfaces in areas where unsealed nuclear substances are handled or stored. It must be completed (1) immediately after each use or at least weekly (2) after spills or incidents, (3) before equipment is released for non-radioactive use, and (4) before a decommissioned room is released for non-radioactive use. Values in excess of the regulatory quantity must be reported immediately to the Health & Safety Consultant (Nuclear, X-ray, Laser).

Each operating area must have ready access to an approved contamination meter for performing direct contamination monitoring after each use or at the end of the day (e.g., P-32, I-125).

Sealed sources must be monitored for leakage at the frequency identified in the Internal Permit. Leak testing must be done before using a sealed source that is returning to use after 12 months in storage. Leak testing must be done after an event that may have caused damage to the source.

Records *for the current year* of all survey and contamination test results must be maintained in a binder. *Previous year's records must be retained and available upon request.* The survey/contamination records are required to be maintained for 1 year following the expiry of the licence.

2.8. USE & MAINTENANCE OF RADIATION DETECTION INSTRUMENTS

All radiation detection instruments must be approved prior to purchasing registered and inventoried by the Health & Safety Consultant (Nuclear, X-ray, Laser).

2.9. ACCIDENT AND EMERGENCY POLICY

When damage to sealed sources and/or spillage of open-source isotopes occurs, the Internal Permit Holder is responsible for taking immediate action to contain the radiation, decontaminate personnel and equipment, and where necessary, to evacuate personnel from the affected area. The Health & Safety Consultant (Nuclear, X-ray, Laser) must be informed immediately of any such damage and of any spills. Afterhours: contact Western Special Constable Service at 911.

Those instances where any person is suspected of having been or is likely to be exposed to a dose exceeding maximum permissible levels, the Health & Safety Consultant (Nuclear, X-ray, Laser) must be informed immediately.

2.10. RADIOACTIVE WASTE DISPOSAL POLICY

Disposal of all radioactive wastes must be in accordance with regulations under the NSC Act. Waste must be handled and disposed of in a way that prevents unreasonable risk to the public or the environment. CNSC Regulations and Internal Permit Conditions require appropriate and specific disposal for each radio nuclide, and that records be retained for each method of disposal. Annual reporting of usage and waste disposal quantities is required. For specific waste procedures, refer to Section 3.9.

2.11. LOSS, THEFT & UNAUTHORIZED USE POLICY

Loss, theft or unauthorized use of any nuclear substances, prescribed equipment or prescribed information must be reported immediately to the Health & Safety Consultant (Nuclear, X-ray, Laser). Contact Western Special Constable Service at 911 afterhours.

2.12. RECORD KEEPING & REPORTS POLICY

All records and reports must be available for inspection at the site where the nuclear substance, radiation device or Class II prescribed equipment is used. Records and reports which are compulsory under *Section 27 of the NSC Act* and applicable regulations will be followed, maintained and provided at the request of the CNSC. All records must be maintained as required in the Nuclear Substances and Radiation Devices Regulations section 36 and General Nuclear Safety and Control Regulations section 28. The CNSC will be notified 90 days prior to the disposal of any documents kept for the licence.

2.13. RADIATION SAFETY TRAINING POLICY

All radiation users must be properly trained and informed of the hazards/risks associated with exposure to ionizing radiation and Transportation of Dangerous Goods (TDG), Class 7 before handling and working with nuclear substances, radiation devices or Class II prescribed equipment.

Radiation users including permit holders must complete the University radiation safety training session which includes TDG Class 7 training. The permit holder is responsible to provide hands-on training on any specific procedures or particular radiation sources to radiation users if required. Permit holder must ensure that all radiation users under the permit complete the University radiation safety training course before handling any nuclear substances, radiation devices or Class II prescribed equipment. The basic responsibility for the safe use of nuclear substances, radiation devices or Class II prescribed equipment rests with radiation users. Radiation users including permit holders are retrained every three years.

Any person (visitor, student, staff, etc.) who is in a radiation room and has not received radiation safety training must take the radiation safety awareness. A permit holder or an authorized radiation user needs to provide the radiation safety awareness to these people. A list of people who take the radiation safety awareness must be documented and kept in a logbook with other radiation documentation for verification by the Health & Safety Consultant (Nuclear, X-ray, Laser) and/or CNSC inspector.

2.13.1. Undergraduate Teaching Program Policy

All undergraduate students handling nuclear substances in group teaching laboratories must attend the radiation safety training session (or its equivalent) scheduled by the Department Course Coordinator and work under direct supervision at all times. Compliance is the responsibility of the Deans and Department Chairs.

2.14. LABORATORY INSPECTION/INTERNAL COMPLIANCE POLICY

Monitoring and inspection of laboratories is necessary to maintain the credibility and authority of an Internal Permit System. Internal Permit Holders are responsible for their own in-house inspections ensuring that licenced materials are being used in accordance with the Regulations, Licence Conditions and Internal Permit Conditions.

Health & Safety Consultant (Nuclear, X-ray, Laser) will inspect at least annually for each permit using the Western radiation safety inspection checklist posted on Human Resources website. An inspection can be announced or un-announced. In an announce inspection, the checklist will be sent to each permit for completion and the Health & Safety Consultant (Nuclear, X-ray, Laser) will perform the inspection after that. Any non-compliance items will be communicated for corrective actions. The inspection results for each permit will be recorded with graded A (exceeds requirements), B (meets requirements), C (below requirements), D (significantly below requirements) or E (Unacceptable). Operations which are considered unsafe will be suspended immediately.

All University personnel shall give CNSC inspector and/or Health & Safety Consultant (Nuclear, X-ray, Laser) all reasonable assistance to enable the inspector(s) to carry out his/ her duties and functions under the Nuclear Safety and Control Act and Regulations.

2.15. COMPLIANCE ENFORCEMENT POLICY

Western assumes the responsibility of ensuring to the CNSC that any use of nuclear substances and radiation devices will be used in strict compliance with the NSC Act & Regulations and the Conditions of the University's licences. To aid in determining the level of risk or immediate danger to safety and health, all compliance violations will be categorized as major or minor offences. This policy is intended as a means to categorize and give guidance for the anticipated response that is needed, when issues of non-compliance are identified by the Health & Safety Consultant (Nuclear, X-ray, Laser). All deficiencies must be corrected and reported in writing to the Health & Safety Consultant (Nuclear, X-ray, Laser). Any offence occurring twice in any 1-year period will be considered as a second offence and so on.

A major offence would result from violations which cause immediate risk or danger to safety, health, release to the environment of reportable quantities, doses of substantial amount to staff, or place the CNSC Licence in jeopardy. For example, a major offence would be one of the following deficiencies:

- Contamination above licence criteria
- Inadequate monitoring program (wipe test or contamination meter monitoring)
- Use or storage of food/drink or smoking in the laboratory
- Inadequate training of new staff
- Non-participation in the TLD or Bioassay Program

- Unauthorized possession/use of nuclear substances or radiation devices.
- Inadequate or unsafe storage areas for radioactive waste
- Records are inadequate or incomplete (usage, waste, monitoring)

A minor offence would be an infraction which poses no immediate risk or threat to safety, health, the environment or the Licence. Examples of a minor offense would be one of the following deficiencies:

- Inadequate signage
- Inadequate posting (permit, CNSC poster)
- Inappropriate use of radiation warning labels
- Inappropriate segregation and/or identification of radioactive waste for disposal/decay

Major Offence Actions:

- First Offence: A written notification will be sent to the Permit Holder and/or Permit Contact by the Health & Safety Consultant (Nuclear, X-ray, Laser). Immediate correction action of the violation is required, written reply in 7 days. If the written reply is not received after 7 days, the second notice will be copied to Department Chair, OHS Director, Radiation Safety Committee Chair and Dean of Faculty. A meeting will be arranged with the Permit Holder, Department Chair, OHS Director, Radiation Safety Committee Chair and Health & Safety Consultant (Nuclear, X-ray, Laser) if there is no response from the Permit Holder after 7 days of second notice.
- Second Offence: The Permit Holder will be notified in writing by the Health & Safety Consultant (Nuclear, X-ray, Laser) that the permit will be suspended until a meeting with the Radiation Safety Committee can be held.
- Third Offence: The Health & Safety Consultant (Nuclear, X-ray, Laser) will recommend permit cancellation to the Radiation Safety Committee.

Note: For the second and third occurrences, notification of the above actions will be copied to the Dean of Faculty, Department Chair, Director OHS and Radiation Committee Chair.

Minor Offence Actions:

- First Offence: A written notification will be sent to the Permit Holder and/or Permit Contact by the Health & Safety Consultant (Nuclear, X-ray, Laser). Corrective action of the violation is required, written reply in 21 days. If the written reply is not received after 21 days, the second notice will be copied to Department Chair, OHS Director, Radiation Safety Committee Chair. A meeting will be arranged with the Permit Holder, Department Chair, OHS Director, Radiation Safety Committee Chair and Health & Safety Consultant (Nuclear, X-ray, Laser) if there is no response after 14 days of second notice.
- Second Offence: A meeting will be arranged with the Permit Holder, Department Chair, OHS Director, Radiation Safety Committee Chair and Health & Safety Consultant (Nuclear, X-ray, Laser) to review the issues.
- Third Offence: The Permit Holder will be notified in writing by the Health & Safety Consultant (Nuclear, X-ray, Laser) that the permit will be suspended until a meeting with the Radiation Safety Committee can be held.

- Fourth Offence: The Health & Safety Consultant (Nuclear, X-ray, Laser) will recommend permit cancellation to the Radiation Safety Committee.

Note: For the second, third and fourth occurrences, notification of the above actions will be copied to the Dean of Faculty, Department Chair, OHS Director, and Radiation Committee Chair.

SECTION 3: STANDAR D OPERATING PROCEDURES

3.1. RADIATION PERMIT

3.1.1. New Permit

1. Complete in full the "Application for Radioisotope Internal Permit" and forward to: Health & Safety Consultant (Nuclear, X-ray, Laser). Application forms are available from Human Resources website.
2. The application is reviewed and approved by the Health & Safety Consultant (Nuclear, X-ray, Laser) and the Radiation Safety Committee Chair or thedesignate.
3. All projects requiring more than 10,000 EQ must be approved by the CNSC
4. Internal Permit Holders must be employees of Western University.
5. Internal Permits will not be issued to private companies renting or otherwise occupying space on University property.

Note: Strict adherence to the conditions of approval for each and every internal permit is critical. Failure to comply will not only result in cancellation of individual permits but will seriously jeopardize the continuance of the University's Licence.

3.1.2. Amendments

Any changes (personnel, rooms, radioisotope limits, etc.) are submitted to the Health & Safety Consultant (Nuclear, X-ray, Laser) by the Permit Holder or Permit Contact. A copy of the amended permit is mailed to the Permit Holder for posting in all approved locations.

3.1.3. Renewal of Permit

1. All radiation permits must be renewed according to the CNSC licence period.
2. Permit Holder may meet with the Health & Safety Consultant (Nuclear, X-ray, Laser) to review his/her current radioisotope projects, records and any outstanding compliance issues. All pertinent changes to the Regulations will be reviewed as well as any added responsibilities of the Permit Holder.
3. The Health & Safety Consultant (Nuclear, X-ray, Laser) will renew the permit.
4. A renewal permit will be sent to the Permit Holder.

3.1.4. Sabbatical/Extended Leave

Permit Holders leaving for an extended period of time (sabbatical or longer than a 4-week period) shall advise the Health & Safety Consultant (Nuclear, X-ray, Laser) in writing, prior to leaving. The Permit Holder must arrange for another Permit Holder to assume the permit responsibilities during his/her absence. The Health & Safety Consultant (Nuclear, X-ray, Laser) will confirm acceptance with the newly appointed Permit Holder *and his/her Departmental Chair.*

3.1.5. Permit Expiry/Termination

The Permit Holder *must* request termination of the Permit when his/her employment is terminated or when there are no further plans to continue with radioactive work. Notice must be given at least 4 weeks prior to leaving the University to ensure that the laboratories are decommissioned and all the records are released to the Health & Safety Consultant (Nuclear, X- ray, Laser). Records must be kept for a year after the expiry of the CNSC licence under which the Permit was issued. The Department Chair will be held responsible in the absence of the Internal Permit Holder.

3.1.6. Permit Suspension/Cancellation

An Internal Permit suspension or cancellation may result when the CNSC Regulations or Internal Permit conditions of approval are violated according to the "Compliance Enforcement Policy". *Suspension or cancellations will be at the discretion of the Health & Safety Consultant and Senior Manager in charge of the Radiation Safety Program. Appeals will be reviewed by the Radiation Safety Committee.*

3.1.7. Permit Records

Records in respect of any nuclear substance in the Permit Holder's possession shall be kept of the following:

1. The name, quantity, form and location of the nuclear substance,
2. Model, serial number of a sealed source or where the nuclear substance is contained in radiation device, model and serial number of a radiation device and location of the sealed source or radiation device,
3. The quantity of the nuclear substance used and the manner in which the nuclear substance was used,
4. A record of the name of each worker who uses or handles a nuclear substance,
5. A record of any transfer, receipt, disposal or abandonment of a nuclear substance, including
   - The date, name and address of the supplier or the recipient
   - The number of the licence of the recipient
   - The name, quantity and form of the nuclear substance where the nuclear substance is a sealed source, the model and serial number of the source and where the nuclear substance is contained in a radiation device, the model and serial number of the device
6. Records must be kept for a year after the expiry of the CNSC licence under which the Permit was issued.
7. Record of every inspection, measurement, test or servicing in accordance with the Act

Note: Records must be kept for 1 years after the expiry date of the last Internal Permit that was issued to the Permit Holder.

3.1.8. Use of Nuclear Substances in Animals

1. Animal housing containing a nuclear substance or room is used for administration of nuclear substances into animals is classified as a radiological laboratory. Access of the radiological laboratory is restricted to authorized users listed on the radiation permit or radiation safety trained persons authorized by the Health & Safety Consultant (Nuclear, X- ray, Laser).

2. Each radiological laboratory is posted at the entrance door with the radiation warning sign that indicates contact information of Radiation Permit Holder, Health & Safety Consultant (Nuclear, X- ray, Laser) and Campus Special Constables Service who can be contacted 24 hours a day.
3. Authorized users must wear all Personal Protective Equipment (PPE) including personal dosimeters and use shielding materials where required when handling a nuclear substance or treated animals with a nuclear substance. Animal is administered with a nuclear substance while in fume hood or bench which has been lined with protective absorbent pad and labelled as a radioactive use area. Once each animal is administered, it is returned to its cage. Each cage occupied by the treated animal has a durable and legible sign that bears the radiation warning symbol with the name of nuclear substance, activity per animal, date of administration and authorized user's name.
4. Once animals are euthanized, if the nuclear substance has a short half-life such as Tc99m, protective absorbent pad, feces and bedding that have been in contact with treated animals are kept for at least 10 half-lives until fully decayed to background level. Contact the Health & Safety Consultant (Nuclear, X- ray, Laser) before disposal. In an uncommon case, if the nuclear substance has a long half-life such as H-3, protective absorbent pad, feces, and cage bedding are collected from each cage and counted with scintillation fluid in a liquid scintillation counter to determine radioactive contamination. If radioactive contamination is detected, waste including bedding, feces and protective absorbent pad are disposed of as solid radioactive waste.
5. Once emptied of bedding, all cages are individually wiped tested to check for any contamination. If any cage is contaminated it will be cleaned with decontamination solution using absorbent pad and repeat the wipe test. The contaminated absorbent pad used for decontamination is disposed of as solid radioactive waste. Once the cages are free of contamination, the radiation warning signs are removed from the cages.
6. Radioactive animal carcasses and tissues must be placed in a durable plastic bag with radioactive waste label including nuclear substance, activity, date of activity, permit holder, permit number, type of waste, and stored in a radiation warning sign freezer in the radiological waste storage room or radiological laboratory. Once the activity is fully decayed to background level or below the CNSC regulatory limits for solid waste, they can be given to Western Hazardous Waste Contractor for disposal.
7. Perform wipe test for all areas indicated on the floor plan of the radiological room and record results in the contamination monitoring logbook. If contamination is detected, decontaminate the contaminated areas and re-monitor. Record results before and after the decontamination.
8. If you have any questions, please contact the Health & Safety Consultant (Nuclear, X- ray, Laser).

3.2. PURCHASING AND RECEIVING RADIOISOTOPES

3.2.1. Purchasing/Acquisitions

1. Nuclear substances and radiation devices orders must be placed through the University purchasing department using its online system and approved by the Health & Safety Consultant (Nuclear, X-ray, Laser) or OHS personnel authorized by the Consultant. The purchase requisition must be identified with name of Permit Holder, Permit Number, name and quantity of nuclear substance, chemical compound and the word "RADIOACTIVE"**.**

2. A University purchasing agent will send a copy of the purchase order to the Health & Safety Consultant (Nuclear, X-ray, Laser) and Chemistry Stores staff once it is generated.

3.2.2. Receiving Radioactive Shipments

1. Radioactive nuclear substance shipments entering the campus are delivered and received at Dock 11, Chemistry Stores in Chemistry Building by Chemistry Stores staff unless it is authorized by the Health & Safety Consultant (Nuclear, X-ray, Laser) to be delivered and received at a different location.
2. Shipping documents and purchase order numbers are verified and a visual inspection of the package for damage or tampering by the Receiving Agent is completed upon arrival. The Permit Holder or their designate is contacted immediately by phone/e-mail. Shipments must be picked up by the Permit Holder or a worker listed on the permit.
3. Each shipment will be issued a bar code number and a corresponding Inventory Record Form by Chemistry Stores staff.
4. Personnel picking up the shipment must be pre-authorized by the Health & Safety Consultant (Nuclear, X-ray, Laser). Personnel must present their Western ID card for identification at Chemistry Stores Receiving. The package must be taken on an uninterrupted route, directly to the approved nuclear substance room.
5. Shipments must be inspected as soon as possible upon arrival in the nuclear substance room using the guidance of CNSC poster INFO-0744 "Guidelines for Handling Packages Containing Nuclear Substances" The bar code number must be affixed to the stock vial when it is unpacked or the number hand-written onto the vial. The Inventory Form must be kept in the Radiation Record Binder.

Note: Report any anomalies (contamination, leakage, incorrect shipment) to the Permit Holder/Supervisor/Health & Safety Consultant (Nuclear, X-ray, Laser) immediately.

3.2.3. Transfers of Nuclear Substances

3.2.3.1. To/From Outside Institutions

No nuclear substances or radiation devices containing nuclear substances to be transferred to an institution or person outside the University, without written notice and approval from the Health & Safety Consultant (Nuclear, X-ray, Laser).

1. Contact the Health & Safety Consultant (Nuclear, X-ray, Laser) for permission to transfer. Provide the name, address, and CNSC Licence Number of the receiver. When approved for transfer the consignor must ensure that the goods are properly classified, packaged, labeled and documented according to *Transport Canada, CNSC, and International Regulations*, before they are shipped.

2. All exports of nuclear substance from the University require a permit from the Department of Foreign Affairs and International Trade. Allow a minimum of 3-5 weeks for processing the application. For additional information or assistance contact the Health & Safety Consultant (Nuclear, X-ray, Laser).

3.2.3.2. Transfers Within the University

1. Contact the Health & Safety Consultant (Nuclear, X-ray, Laser). The Health & Safety Consultant (Nuclear, X-ray, Laser) will verify that the "Borrower" is authorized to use the radioisotope and the quantity that is being requested.
2. Record the quantity, the name of the person "borrowing" and their Permit Number on your Inventory Record Form (see section 3.3).
3. Provide a new Inventory Record Form for the "borrower" with the bar code number of the stock vial. Label the borrowed sample with the bar code number, isotope and quantity.
4. The "borrower" must complete the new Inventory Record Form for their use and disposal of the borrowed nuclear substance. All inventory records must be retained in the Radiation Record Binder and available upon request.

3.3. INVENTORY/POSSESSION OF NUCLEAR SUBSTANCES

All nuclear substances and radiation devices are registered in the Radiation Enhanced Management System (REMS) database via purchasing and receiving control procedures to ensure they are within possession of permits' limits and CNSC limits.

3.3.1. Inventory Record Form

The Inventory Record Form authorizes the Internal Permit Holder to have the material in his/her possession and is a tracking record for both the use and disposal of the material. Possession of any nuclear substance is not allowed without a corresponding Inventory Record Form and a bar code number identifying the stock vial. The Inventory Form must be kept in the Radiation Record Binder and be available at all times for inspection purposes.

1. The Inventory Record Form is generated upon receipt of the material in Chemistry Stores. A unique bar code number is assigned to each stock vial when it is received. All receipt records are maintained in the Chemistry Store.
2. All subsequent aliquots that are created by the user from the stock vial must be identified by the bar code number and traceable to the original stock vial. Additional Inventory Forms may need to be created to record the use and disposal of all the aliquot material.
3. Final disposal must be dated and signed by the user on the Inventory Record Form.
4. All Internal Permit Holders must provide a written summary of all their radioisotope purchases, current year-end inventory and waste disposal data for the previous year.This information is essential for preparing the University's Annual Report to the CNSC. All inventory records must be retained for at least 1-year after the expiry of the licence.

3.3.2. Storage of Nuclear Substances

A radionuclide storage area or container is defined as that area within a licenced facility that provides appropriate shielding, ventilation and security for the materials. The area may be a lead or plexiglass, box, refrigerator, cupboard, or fume hood. Access is restricted to only those by the Permit Holder and persons on the permit. All storage areas or containers must be supervised by a Nuclear Energy Worker or otherwise secured from public areas.

The area/container must be labeled with the designated Western nuclear substance label. The dose rate at any occupied location outside the storage area, room or enclosure resulting from the substances or devices does not exceed 2.5 μSv/hr (0.25 mR/hr). All radionuclides (stock, aliquots, products, waste) must be stored in approved containers within approved areas/laboratories. All approved containers must be labeled with the date, type and quantity of radionuclide.

3.3.3. Security and Control Access of Nuclear Substances and/or Radiation Devices

All radiation rooms are restricted areas and must be kept secure and locked at all times when unattended. Only Permit Holder and authorized radiation users listed on the permit are allowed to be left alone in a radiation room with radioactive material that is not locked and stored away. All radiation rooms must meet the CNSC security requirements.

All visitors must be accompanied by Permit Holder or authorized radiation users listed on the permit and follow all applicable regulations, policies, guidelines and procedures.

3.3.4. Licence to Service Radiation Device & Prescribed Equipment

Permit Holder must ensure that a company or person who performs any maintenance of a device, including installation, repair or dismantling other than routine operating procedures as indicated in the manufacturer's operating manual for the device or Class II prescribed equipment has a CNSC servicing licence. Contact the Health & Safety Consultant (Nuclear, X-ray, Laser) if you have any questions with regard to the CNSC servicing licence.

3.4. NOTIFICATION & TRAINING OF NUCLEAR ENERGY WORKER

3.4.1. Nuclear Energy Worker (NEW)

Only Nuclear Energy Worker is authorized to handle nuclear substances, radiation devices or Class II prescribed equipment. A Nuclear Energy Worker will be required to attend a Radiation Safety Refresher every three years. The Health & Safety Consultant (Nuclear, X-ray, Laser) may direct any individual to re-train at any time. A Nuclear Energy Worker must:

1. Be familiar with, and practice safe laboratory handling techniques.
2. Have attended a formal Radiation Safety Training session at Western and be able to demonstrate an understanding of the following:
   - The hazards and risks associated with the uses of radionuclides and the particular chemical forms to be used and
   - General and specific safety procedures to be followed during the use, storage and disposal of all radioactive products to be used or generated.
3. Attend other safety courses as determined by Western safety training policies.
4. Provide given names, SIN, date of birth, country of birth, and previous dosimetry history if requested.
5. Sign the current NEW form.

3.4.2. Pregnant and Breastfeeding Nuclear Energy Worker

A pregnant worker is strongly recommended to inform in writing, her Internal Permit Holder and the Health & Safety Consultant (Nuclear, X-ray, Laser) as soon as she is aware of her condition.

A worker is strongly recommended to inform in writing, her Internal Permit Holder and the Health & Safety Consultant (Nuclear, X-ray, Laser) that she is breastfeeding an infant.

3.5. PERSONAL DOSIMETRY

3.5.1. Radiation Exposure Limits

Body Part	A person who is not a nuclear energy		Nuclear Energy Worker	
	Annual (mSv)	Pregnant (mSv)	Annual (mSv)	Pregnant**(mSv)
Whole Body	1	1	20*	4.0***
Hands and Feet	50	50	500	500
Lens of an Eye	15	15	50	50
Skin	50	50	500	500

* *One-year dosimetry period is 50 mSv and five-year dosimetry period is 100 mSv. The average annual in 5-year period is 20 mSv.*

** *Every female nuclear energy worker who becomes aware that she is pregnant is encouraged to immediately inform the Permit Holder and the Health & Safety Consultant (Nuclear, X-ray, Laser) in writing.*

*** *Balance of the pregnancy: the period from the moment the Permit Holder and the Health & Safety Consultant (Nuclear, X-ray, Laser) is informed, in writing, of the pregnancy to the end of the pregnancy.*

3.5.2. External Monitoring: TLD Badges

1. Dosimetry badges must be worn as designated by the conditions of the CNSC licence condition and/or Internal Permit condition.
2. Contact the Health & Safety Consultant (Nuclear, X-ray, Laser) for dosimetry service registration. The nominal cost for this service is provided by the user's Department or the Internal Permit Holder. Applicants must have received radiation safety training and be registered as a Nuclear Energy Worker.

Typical Badge Monitoring: Procedure Requirements

Isotope	Quantity/process	Whole body (Semi-Annual)	Ring (Semi-Annual)
H3, C14, S35 Ca45, Fe55	N/A	None required	None required
P32, Sr89, Y90 Sm153, Re186	≤50 MBq >50 MBq	Yes Yes	No Yes
Gamma Emitters	N/A	Yes	No

All records of dosimetry are reviewed and retained by the Health & Safety Consultant (Nuclear, X-ray, Laser) and a copy of each report is mailed to the Department's Dosimetry Coordinator. All actual or suspected exposures must be reported to the Health & Safety Consultant (Nuclear, X-ray, Laser).

Pregnant Nuclear Energy Workers will receive the same monitoring as a Nuclear Energy Worker or at the discretion of the Health & Safety Consultant (Nuclear, X-ray, Laser).

All NEWs are informed both in writing and electronically of their dose once a year by the Health & Safety Department.

3.5.3. Internal Monitoring: Bioassay

Surveys/Bioassays and/or Whole-Body Counter monitoring of individuals will be performed according to the conditions of the Internal Permit or at the discretion of the Health & Safety Consultant (Nuclear, X-ray, Laser).

3.5.3.1. Radio Iodine

Thyroid Monitoring

a. Every person who in any 24-hour period uses a total quantity of Iodine 124, Iodine-125 or Iodine-131 exceeding:
   (i) 2 MBq in an open room;
   (ii) 200 MBq in a fume hood;
   (iii) 20,000 MBq in a glove box; or
   (iv) any approved quantity in any room, area or enclosure authorized in writing by the CNSC shall undergo thyroid screening within a period more than 24 hours after the last use that resulted in any of the above limits being exceeded and less than 5 days after the limit was exceeded.
b. Every person who in any 24-hour period uses a total quantity of Iodine-123 exceeding:
   (i) 200 MBq in an open room;
   (ii) 20,000 MBq in a fume hood;
   (iii) 2,000,000 MBq in a glove box; or
   (iv) any approved quantity in any room, area or enclosure authorized in writing by the CNSC shall undergo thyroid screening within a period more than 8 hours after the last use that resulted in any of the above limits being exceeded and less than 48 hours after the limits was exceeded.
c. Every person who is involved in a spill greater than 2 MBq of Iodine-124, Iodine-125 or Iodine- 131 or on whom external contamination is detected, shall undergo thyroid screening within a period more than 24 hours after the spill and less than 5 days after the spill or contamination.
d. Every person who is involved in a spill greater than 200 MBq of Iodine -123 or on whom external contamination is detected, shall undergo thyroid screening within a period more than 8 hours after the spill and less than 48 hours after the spill or contamination.

Thyroid screening is performed in the Nuclear Medicine Department of University Hospital - London Health Sciences Centre (LHSC) during regular working hours. All results must be reported by e-mail to the Health & Safety Consultant (Nuclear, X-ray, Laser) on the same day and send a copy of the results by campus mail.

Validation of Screen Results

a. A direct measurement of the thyroid with an instrument that can detect 1 kBq of I-125 or I-131 or I-124 or 10 kBq of I-123; or a bioassay procedure approved by the CNSC or a person authorized by the CNSC.

b. If thyroid screening measurement results are greater than 1 kBq and less than 10 kBq of I-124, I-125 or I-131; or greater than 10 kBq and less than 100 kBq of I-123 the Health &Safety Consultant (Nuclear, X-ray, Laser) will follow appropriate steps in section 10.1 & 10.2 of the Regulatory Document (RD)-58 "Thyroid Screening of Radioiodine". If thyroid screening measurement results is greater than 10 kBq of I-124, I-125 or I-131; or greater than 100 kBq of I-123, the Health & Safety Consultant (Nuclear, X-ray, Laser) will follow appropriate steps in section 10.3 of the RD-58 and immediately inform the CNSC and have bioassay performed within 24 hours by a person approved by the CNSC to provide internal dosimetry.

3.5.4. Volatile Radioiodine Compounds

Volatile radioiodine compounds include such compounds as Sodium Iodide (NaI) and radioiodines in a disassociated form. The volatility of radioiodine compounds may increase as a result of acidifying or freezing.

Activities that may cause radioiodine to be released include opening stock reagent containers, opening packages containing capsules used for therapeutic or diagnostic purposes, and working with such open packages.

The addition of antioxidants, such as sodium thiosulfate, to either labelled or NaI solutions reduces both decomposition and volatility. Furthermore, maintaining radioiodine solutions at dilute concentrations minimizes radiolytic decomposition. It should also be noted that radioimmunoassay kits contain small quantities of I-125 in a non-volatile form.

3.5.5. Instrument Calibration

3.5.5.1. General

All equipment and instruments used for thyroid screening should be maintained in good operating condition and must be calibrated as per section 25 of the RPR. Calibration must be performed for the isotope of interest under conditions mimicking the thyroid in the neck. An example of a calibration procedure can be found in "Thyroid Monitoring Part III: A Basic Calibration Procedure for Thyroid Monitoring". Once set up, the measurement equipment must be calibrated if a quality control measurement is outside the control limits. In addition, the measurement equipment must be recalibrated prior to being put back into service if it has undergone any significant changes, such as repair or replacement that may have an adverse impact on the precision, accuracy or reliability of the measurements.

3.5.5.2. Detector Efficiency

To determine absolute detector efficiency, measure the activity of a traceable standard source of the isotope of interest and use the following formula:

$$E = \frac{(C - B)}{A}$$

Where:

E = the efficiency in counts per second (cps) per becquerel (Bq)
C = the measured counts per unit time of the standard source, in cps
B = the background count rate, in cps
A = the known activity of the standard source, traceable to a national standardizing laboratory within 5% (2σ, or standard deviation) accuracy, in Bq.

The licensee should ensure that if a short-lived standard source is used (e.g., I-131), the activity of the source is corrected for decay to the day on which the calibration is performed. Appropriate, longer-lived, surrogate standard sources include: Te-123m (for I-123), Cs-137 (for I-124), I-129 (for I-125) and Ba-133 (for I-131).

The instrument and measurement parameters used to determine counting efficiency should be the same as those used for routine screening. Placing the detector as close to the thyroid as possible achieves the greatest efficiency. However, because of variations in thyroid depth, size, shape and positioning, large uncertainties can be introduced into the activity estimate. Such errors can be reduced by increasing the distance between the neck and the detector. Each system has its own optimal compromise between high efficiency and error reduction, but generally a good neck-to-detector distance is 12 cm.

The licensee should ensure a long enough count time for both the standard source and the background count rate so that overall error (2σ) in the count is less than 5%. This means approximately 400 gross counts for the background measurement.

3.5.5.3. Minimum Detectable Activity

The licensee should conduct measurements to achieve a minimum detectable activity (MDA) that is less than 1 kBq. When the sample and background count times are equal, the MDA is calculated using this formula:

$$MDA = \frac{4.66\sqrt{B} + 2.71}{ET}$$

Where:

B = the total background counts collected during time T
E = the efficiency in cps/Bq
T = the time in seconds

When sample and background count times are not equal, the below equation should be used instead:

$$MDA = \frac{3 + 3.29\sqrt{B_b t_g \left(1 + \frac{t_g}{t_b}\right)}}{\varepsilon K t_g}$$

Where:

R_b = the background count rate
t_g = the gross count time (the sample or individual count time)
t_b = the background count time
ε = the counting efficiency
K = a correction factor

3.5.5.4. Sample MDA Calculation

If a system's MDA is not low enough, either because of a low efficiency or high background, it can be improved. This can be done by increasing the counting time used for the measurement, decreasing the background, or both.

As an example, consider I-125. Assuming that the efficiency is 0.0060 cps/Bq and the gross background count is 400 counts, a 300-second count time would result in the following MDA, using the equation in section 3.5.5.3:

$$\text{MDA} = \frac{4.66\sqrt{B}+2.71}{ET}$$

$$\text{MDA} = \frac{4.66\sqrt{400}+2.71}{(0{,}0060)(300)}$$

$$\text{MDA} = 53 \text{ Bq}$$

The resulting value, 53 Bq, is acceptable for I-125.

The counting time used to monitor personnel does not have to be as long as that used for calibration. In the example above, the background is 400 counts/300 seconds, or 1.3 cps. Assuming the background count rate is stable, a 60-second count time would result in approximately 80 counts. Substituting these new figures into the equation produces a new MDA value, as shown in the following formula:

$$\text{MDA} = \frac{4.66\sqrt{80}+2.71}{(0{,}0060)(60)}$$

$$\text{MDA} = 124 \text{ Bq}$$

3.5.5.5. Records

Accurate calibration and service records should be maintained for the measurement system. The records should contain the following information:

- calibration date
- reference method
- calibration source current activity
- background values (these should be compared with previous values to detect changes)
- MDA
- calculated efficiency
- authorization signature

3.5.6. Sample Thyroid Screening Log for Iodine-131

Investigation level: _____ net cps = 1 kBq of I-131

Reporting level: >_____ net cps = 10 kBq of I-131

Employee name: _____

Instrument used: _____

Date of measurement	Last use of radioiodine (date)	Background count rate (cps)	Gross counts	Count time (seconds)	Net count rate (cps)	Technician (initials)	Action Taken

3.5.7. Quality Control Charts

This section provides a method for recording background and standard source count rates for quality control verifications.

Prepare 2 control charts, one for each of the background and standard source quality control verifications described in section E.4.2 of the Regulatory document REGDOC-2.7.2 "Dosimetry, Volume I: Ascertaining Occupational Dose". Each control chart should show the date that measurements were taken and the corresponding count rates. After approximately 20 days of counting operations, there will be enough observations to estimate the standard deviations for the distributions. The standard deviation can be estimated in the following equation:

$$S = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (N_i - \bar{N})^2}$$

Where:

S = the standard deviation

n = the number of either background or standard source measurements

Ni = the count rate of each individual measurement

$\bar{N}$ = the average of n measurements of Ni

3.5.8. Other Bioassays

Use of any other radioisotopes in a quantity which would require a bioassay by the CNSC is forbidden without the express written permission of the Health & Safety Consultant (Nuclear, X-ray, Laser). Bioassay requirements are identified as a condition of use in the internal permit.

3.5.9. Whole Body Counter

The Health & Safety Consultant (Nuclear, X-ray, Laser) may require any Nuclear Energy Worker to have a whole-body count to determine internal or external contamination.

3.6. ALARA (AS LOW AS REASONABLY ACHIEVABLE)

ALARA is the acronym used in radiation protection for ensuring that every possible effort is used to keep radiation exposures as far below the regulated dose limit as practical. It is consistent with the purposes for which the licenced activity is undertaken, taking into account existing technology, the economics of improvements in relation to the benefits to the public health and safety, and other socioeconomic considerations. Western is committed to maintaining radiation exposures to staff, students and the public resulting from the use of radioisotopes and radiation emitting devices to ALARA.

1. All personnel are expected to practice ALARA in their work practices.
2. Each Permit Holder must establish, implement, and maintain procedures designed to reduce exposures of radiation to ALARA. These procedures will be required in the Internal Permit Application process.

3.6.1. General Laboratory Safe Handling Precautions

1. External exposures are minimized by reducing the TIME, increasing the DISTANCE, and using appropriate SHIELDING materials. TLD badge must be worn when provided.

2. Using appropriate shielding to protect eyes and the trunk of the body. Wearing polycarbonate plastic safety goggles when handling high energy beta emitters (>700 keV such as P-32). Avoid viewing or manipulating a radioactive source closer to the head than to the rest of the body.
3. Internal exposures are minimized by preventing Ingestion, Inhalation, and Absorption through the skin.
4. Eating, drinking or smoking in areas where nuclear substances are used or stored, is prohibited.
5. Never pipette radioactive solutions by mouth.
6. Volatile nuclear substances must be used in an approved ventilated area such as a non-recirculating fume hood.
7. Personal Protective Clothing must be worn to prevent exposure through skin contact. Laboratory coats must be worn in radiation work areas. Lab coats, disposable gloves and safety goggles must be worn when handling unsealed nuclear substances. Sandals or open-toed shoes are not permitted when handling unsealed nuclear substances.

3.6.2. Action Levels

Action level is defined as "a specific dose of radiation or other parameter that, if reached, may indicate a loss of control of part of a licensee's radiation protection program, and triggers a requirement for specific action to be taken". The primary goals of the action to be taken is to restore the effectiveness of the radiation safety program and to prevent a re-occurrence of the event. Action levels have been identified as required for the activities listed in the table below.

Table of Action Levels

Activity	**Initial Responsibility**	**Action Level**	**Action** Log occurrence and action taken (Attempt to prevent future occurrences)
Personnel Dosimetry Nuclear Energy Worker	Health & Safety Consultant	2 mSv/yr or 1 mSv/semi-annual (whole body)	- Conduct an investigation to establish the cause for reaching the action level, - Identify and take action to restore the effectiveness of the radiation protection program, - Notify the CNSC.
Thyroid Bioassay	Health & Safety Consultant	>1000 Bq	- Conduct an investigation to determine and correct the cause of the screening results, - Correct any deficiencies found by the investigation.
		>10,000 Bq	- A preliminary report shall be made immediately to the CNSC, - Have a bioassay performed on the worker within 24 hours by a person licensed by the CNSC, - Conduct an investigation to determine the magnitude of the dose and to establish the causes of the exposure, - Identify and take any action required to

			prevent the occurrence of a similar incident, - Report the findings to the CNSC, the Radiation Safety Committee and the worker.
Leak test for a sealed source (>50 MBq)	Health & Safety Consultant	>200 Bq	- Discontinue using the sealed source and/or radiation device, - Takes measures to limit the spread of radioactive contamination from the sealed source, - Notify the CNSC.
Package Receipt	Receiving Staff/ Health & Safety Consultant	Damaged Package or radiation level > than package designation.	- Reinforce CNSC Regulations and guidelines, • CNSC "Packaging and Transport of Nuclear Substances. Regulations" (SOR/2015-145). • CNSC INFO 0744 "Handling Packages Containing Nuclear Substances" - Investigate the incident and report to CNSC.
Contamination Levels	Nuclear Energy Worker	3 Bq/cm^2	Assess, decontaminate, re-monitor, record results.

3.7. DESIGNATING, POSTING & DECOMMISSIONING OF ROOMS

3.7.1. Room Designation for Nuclear Substances

All locations for the use and store of nuclear substances must be pre-approved by the Health & Safety Consultant (Nuclear, X-ray, Laser), identified and listed on the radiation internal permit. The area classification and room design for unsealed nuclear substances must follow the CNSC radioisotope laboratory classification (section 4.4) and the CNSC Regulatory Document GD-52 "Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms"

3.7.2. Posting

All approved designated nuclear substance rooms must be posted with an approved Radiation Warning Sign or in any area where the activity may exceed 100 EQ or exposure may exceed 25 μSv/hour or as required by the Health & Safety Consultant (Nuclear, X-ray, Laser). Required signs and labels are according to the following table.

Location	Type of Posting
All points of entry to a designated nuclear substance room including radioactive storage room	Radiation Warning Sign with Permit Holder name and office phone number, Health & Safety Consultant (Nuclear, X-ray, Laser) office phone number, and Western Special Constable Service 24-hour contact number
Inside a designated nuclear substance room, in a prominent location	Copy of the Internal Permit, CNSC safety poster which corresponds to the room classification, CNSC spill procedures poster, CNSC guidelines for handling packages containing nuclear substances
Specific storage location inside a designated nuclear substance room (i.e., fridge, freezer)	Radiation Warning Sign
Work area/bench/equipment	Radiation Warning Sign or radiation tape identifying the workstation

3.7.3. Decommissioning Radioisotope Areas/Laboratories

The Internal Permit Holder shall ensure that all areas/rooms identified on his/her Internal Permit are decommissioned upon the expiry or termination of the Permit or no longer used for radioactive work. Decommissioning would include, but not limited to, the following:

1. Transfer or removal of all nuclear substances or devices to an approved site
2. Appropriate disposal of all radioactive waste
3. Removal of all radioactive warning signs and labels
4. Monitor all areas and decontaminate to meet the Western contamination limit for decommissioning.
5. Complete Decommissioning Report and forward to Health & Safety Consultant (Nuclear, X-ray, Laser).
6. Update all records
7. Records will be retained for at least 1-year after the expiry of the licence in accordance with CNSC document GNSC 28(1)

CNSC Licence Contamination Criteria for Decommissioning

Classification*	Non-fixed Contamination Limit (Averaged over an area not to exceed 100 cm^2)
Class A	0.3 Bq per square centimeter
Class B	3.0 Bq per square centimeter
Class C	30 Bq per square centimeter

* *See Section 4.5 for Classification of Selected Radionuclides. Non-fixed contamination at Western prior to decommissioning does not exceed 0.3 Bq/cm^2 for all class A radionuclides and 3 Bq/cm^2 for all class B & C radionuclides.*

3.7.4. Frivolous Posting of RWS

Radioactive warning signs may not be used in a place where the radiation or nuclear substance is not present.

3.8. LABORATORY MONITORING

3.8.1. Radioactive Contamination & Control

All Internal Permits require regular monitoring for contamination. To ensure compliance, wipe testing or using a properly functioning contamination meter (for P-32 or I-125 only) must be performed once per week or when work is completed, in all active areas by a Nuclear Energy Worker. *Wipe testing or using contamination meter needs not be performed, if no nuclear substance was handled for any specific week.* A floor plan of the areas being tested must be used and records of wipe test measurements must be kept in the record binder. Inventory records indicating the date of use of a radioisotope, must correspond to the appropriate frequency or date of the wipe test records. The action level for non-fixed contamination limit of unsealed nuclear substances used or stored in a permitted laboratory at Western is 3.0 Bq/cm^2.

3.8.2. Measurement of Surface Contamination by Wipe Test

1. Select an absorbent grade of filter paper with a diameter of about 5 centimeters.
2. Hold the filter paper on the edge with thumb and index finger and rub lightly but firmly over the surface, using the pads of the other fingers to apply light pressure - try to obtain the contamination on centre of the paper. Estimate the area that you have smeared, usually 100 cm^2 with an S- shaped pattern.
3. Place wipe in a vial, add scintillation fluid, and cap the vial. Count 1 to 2 minutes on a liquid scintillation counter with a channel setting of wide-open window that detect all types of radiation.
4. Include a blank wipe to determine the net count-rate above background and standard with each set of wipes. Record the wipe test measurements and keep the printout from the counter in the record binder.
5. When using the wipe method of measurement, only a fraction of the contamination will be removed, assume a smear efficiency of 10% and the counter efficiency of 50% a conservative approach for most radioactive nuclear substances used. The net count rate equals to 3 Bq/cm^2 is 900 cpm.
6. Any wiped area has a net count rate greater than 900 cpm, decontaminate the area and re-wipe the area. Record the results before and after the decontamination including the printout in the record binder.

CNSC Licence Contamination Criteria:

Radionuclide*	Controlled Area Wipes: Bq/cm^2	Public Area Wipes: Bq/cm^2
Br-82	30	3
C-14	300	30
Ca-45	300	30
Co-57	300	30
Co-58	30	3
Co-60	3	0.3
Cr-51	300	30
F-18	30	3
Fe-59	30	3
Ga-67	30	3
H-3	300	30
I-123	300	30
I-125	300	30
I-131	30	3
In-111	30	3
Na-22	3	0.3
P-32	300	30
P-33	300	30
Ra-226	3	0.3
S-35	300	30
Sb-124	3	0.3
Sr-85	30	3
Tc-99m	300	30
Tl-201	300	30
Alpha emitter and their daughter isotopes	3	0.3

* *For radionuclide not listed above, contact the Health & Safety Consultant (Nuclear, X-ray, Laser)*

A wipe test result that exceeds the Western contamination criteria of 3 Bq/cm^2 must be cleaned/ decontaminated and re-wiped. The re-wipe results must be recorded as well.

The wipe test method is also preferable when background radiation is high in the area being checked or a portable radiation instrument is not suitable for the nuclides being used.

3.8.3. Maintenance & Use of Radiation Detection Instruments

All radiation monitoring instruments (portable and non-portable) must be registered with the Health & Safety Consultant (Nuclear, X-ray, Laser) and met the manufacturer's specifications.

1. All radiation monitoring instruments must be maintained to ensure they are properly functioning.
2. All portable meters will be inspected by the Health & Safety Consultant (Nuclear, X-ray, Laser) during a regular lab inspection. Any meter is not functioning properly must be removed from service until it is repaired.
3. A properly functioning portable contamination meters shall be available to workers at all times at the site of the licensed activity. Workers use high energy beta (e.g., P-32) or

gamma radiation (e.g., I-125) shall have a properly functioning contamination meter available while performing the work and monitor the workspace upon completion of the work.

4. A radiation survey meter shall be provided at all times where nuclear substances, except H-3 and Ni-63, are handled or stored. No person shall use, for the purpose of the Act, the regulations made under the Act or an order or a licence, a radiation survey meter that has not been calibrated within the 12 months preceding its use.

3.8.3.1. Measurement of Contamination Using Contamination Meter

1. Check the contamination meter sticker for detector efficiency, minimum detectable activity and net cpm or cps equal to 3 Bq/cm^2 and sticker date within one year.
2. Perform an operation check (i.e., battery, high voltage, response, etc.), measure and record the background count rate in the contamination monitoring record form. Background should be measured in an area well away from the surfaces to be monitored.
3. Hold the detector close to the surface to be monitored at the distance of 1 cm, taking care not to touch the surface, and move the detector slowly across the surface.
4. Record all results in the contamination monitoring record form.
5. Any location is greater than 3 Bq/cm^2 (see meter sticker for net count rate in cpm or cps equal to 3 Bq/cm^2), decontaminate the area and re-monitor. Record the results before and after decontamination.
6. If the reading is still higher than 3 Bq/cm^2 after repeated cleaning, then it is a fixed contamination. The level of contamination remaining shall be posted at the contaminated area with radiation tape and report to the Health and Safety Consultant (Nuclear, X-ray, Laser).

3.8.4. Efficiency Determination of Contamination Meters

1. Obtain desired radioactive standard.
2. Prepare a clean, flat surface which is free from all detectable radioactive contamination.
3. Place the radioactive standard on the clean surface with active side up (toward the detector).
4. Position the detector probe directly over the source at some reproducible distance (about 1 cm).
5. Observe and record the count rate on the meter.
6. Calculate the detection efficiency of the probe asfollows:

$$\text{Efficiency (4pi geometry)} = \frac{\text{Detector count rate} - \text{Background count rate}}{\text{Known activity of standard source}}$$

3.8.5. Leak Testing Sealed Sources by Wipe Test

3.8.5.1. Criteria for Leak Testing of Sealed Sources

Every sealed source containing 50 MBq or more of a nuclear substance or a nuclear substance as shielding must receive a wipe test as follows:

1. Every six months for a sealed source or shielding is not located in a radiation device.

2. Every 12 months for sealed source or shielding in a radiation device.
3. Every 24 months for sealed source or shielding in storage.
4. Immediately before using the sealed source or shielding after being stored for 12 months or more consecutive months.
5. Immediately after the event that have damaged the sealed sources or shielding.
6. Valid leak testing certificate must be accompanied with other TDG documentation during transportation.
7. All of leak testing sealed sources are reviewed by the Health & Safety Consultant (Nuclear, X-ray, Laser). Leak test results must be retained for at least 3 years.
8. If a sealed source is leaking (the measured activity on the wiped sample is greater than 200 Bq), follow the response actions described in section 3.6.2.
9. If the source is indeed leaking, the most likely resolution to the problem is to have the sealed source to be disposed of.

3.8.5.2. Exceptions

Subsection 3.8.5.1 does not apply in respect of a sealed source that is:

1. Gaseous;
2. Contained in a static eliminator that has been retained by the licensee for less than 15 months;
3. Exempted under section 5, 6, 8 or 8.1 of Nuclear Substances and Radiation Devices regulations or
4. Used or stored underwater in a nuclear facility that is equipped with a device capable of detecting waterborne contamination of 200 Bq or less of a nuclear substance.

3.8.5.3. Procedure

1. The wipe test should only be performed by a person who knows the source containment, and the requirements of the appropriate CNSC expectations and can recognize and minimize the potential contamination and radiation hazards associated with the source, source containment, sampling method and wipe sample.
2. The sampler should be wearing a personal dosimeter such as either film, TLD or PAD type during wipe procedures.
3. Wipes should not be handled with bare hands. Gloves and tongs should be worn and used during the wipe procedure. Only removed after sealed source sampling is complete.
4. Either filter papers (with a maximum diameter of 5 cm) or one-ended Q-tips must be used for sealed source leak testing purposes. The wipe should be dampened with alcohol before sampling to ensure that contamination will adhere to the swipe media.
5. For any one source or device, wipe samples should be taken at the exit port, transport system or any other accessory that may come in contact with the source.
6. Once the entire wipe is in contact with the surface to be swiped, sample the area using a back-and-forth movement while applying a constant, light but firm hand pressure. Pass over the sampling area only once. While the source containment can generally be vigorously wiped, care should be exercised in areas around fragile windows and protective covers.

7. The wipes should be placed in individual envelopes or plastic bags (1 sample per bag) and the envelope or sample bag sealed. The number of wipes should be indicated on the envelope or sample bag.
8. Analyze the collected samples using a calibrated Liquid Scintillation Counting LSC system. Record the results in a leak test certificate.

3.9. RADIOACTIVE WASTE DISPOSAL

Radioactive waste must be kept secured while in the laboratory (e.g., do not leave any container labeled as radioactive waste at the loading dock or any public area, unattended while waiting for pick-up). It is the responsibility of a Permit Holder to release all nuclear substances for disposal from his/her designated laboratories.

Determine the quantity of radioactivity used and disposed of according to experiment protocols. Record the quantity and method of disposal, date of disposal and the username on the Inventory & Waste Record Form. The Inventory & Waste Record Forms must be completed and kept current at all times. The Inventory & Waste Record Form must be signed and dated when disposal is complete. Waste container or pail must have radiation warning sign, nuclear substance name, activity and date of activity at all times.

Radioactive wastes (liquid scintillation vials, solids, liquids, etc.) are normally submitted to Environmental Safety Personnel in the radioactive waste pail for disposal through delay and decayed process or within the CNSC disposal limits in the licence or through a licensed waste disposal companies as authorized by the Health & Safety Consultant (Nuclear, X-ray, Laser). All wastes must not contain any viable bio-hazardous agents. Each radioactive waste pail contains only one nuclear substance and one type of waste and must have the following:

1. A completed Radioactive Waste Label Sticker on liquid waste container, solid waste bag or liquid scintillation vials bag. The radioactive labeled waste container or radioactive labeled bag must be contained in a radioactive waste pail. The radioactive waste pail must have the completed Radioactive Waste Label Sticker on it.
2. A radioactive pail must be checked for non-fixed contamination on surfaces (mainly outside) using a wipe test procedure then complete a Safe Transport of Radioactive Material Form.
3. A completed Material for Hazardous Waste Disposal Form.

Note: No radioactive waste shall be disposed to a sewer or regular garbage without consultation with the Health & Safety Consultant.

3.9.1. Liquid Scintillation Vials

Solvent liquid scintillation vials and environmental biodegradable scintillation vials must be collected separately in the laboratory. Vials must be placed in a clear plastic bag in the radioactive waste pail. Vials must have caps that are securely fastened. Vials must not be leaking or show evidence of leaking.

Non-contaminated vials from wipe test can be submitted to Environmental Safety Personnel as regular chemical waste. Environmentally safe biodegradable scintillation fluid is highly recommended for wipe test and experimental procedures, if possible. Vials are normally disposed of via commercial waste company by Health & Safety Consultant (Nuclear, X-ray, Laser).

3.9.2. Liquid Radioactive Waste

Aqueous (water soluble) liquid waste and organic solvent liquid waste must be collected separately in the laboratory. All liquid radioactive wastes must be collected in 4-liter plastic containers with Radioactive Waste Label on it. Close the cap tightly on the container when not being used and place it behind an appropriate shielding material, if required.

When close to full and/or prior to disposal, count an aliquot of the solution and determine the activity in mCi or MBq. The outside of containers must be free of any contamination before submitted to the Environmental Safety Personnel. The liquid waste container must be placed in the clear plastic bag inside the radioactive waste pail.

The wash water from the normal, daily, glassware may be disposed via the sewer. No liquid containing radioactive materials shall be discharged to the laboratory sanitary sewer.

3.9.3. Radioactive Stock Shipment Vials

All empty stock vials (no radioactivity) are submitted to the Environmental Safety Personnel as solid waste. Ensure that the bar code number is on the vial at the time of disposal. All shipment vial radioactive warning signs must be defaced or destroyed.

All vials with some residual activity must affix radioactive waste labels, indicating the date and the amount of activity remaining in the vial, and dispose of as liquid waste.

All environmentally hazardous materials such as lead, used in shielding containers should be disposed separately via Environmental Safety Personnel.

3.9.4. Solid Combustible Radioactive Waste

All solid combustible radioactive waste must be collected in a clear plastic bag and contained in a radioactive pail or behind an appropriate shielding material (if required).

Radioactive warning signs/labels must be destroyed or defaced before discarded into the clear plastic bag.

3.9.5. Radioactive Sharps (Needles and Syringes)

All sharps used for dispensing radioactive materials must be placed in a Western approved sharps container with a Radioactive Waste Label on it. The container must be monitored and shielded if necessary.

The outside of sharps containers must be free of any contamination before submitted to Environmental Safety Personnel.

3.9.6. Radioactive Glass

All radioactive glass waste (glass test tubes, glass pipettes, etc.) from radioactive experiments must be collected in a clear plastic bag and contained in a radioactive pail.

Radioactive warning signs/labels must be destroyed or defaced before discarded into the clear plastic bag.

3.9.7. Radioactive Animal Carcasses & Tissues

All radioactive contaminated animal carcasses and tissues must be frozen, held for the appropriate decay period and then incinerated. It is the responsibility of the researcher to provide freezer space for the animal material during this decay period. Animal materials may be incinerated when the activity is decayed to background level or below the CNSC regulatory limits for solid waste.

At disposal, the animal material must be double bagged in an opaque bag and labeled with the appropriate "Incinerator approved label". Bags must not weigh more than 20 kg each.

3.9.8. Sealed Sources

Contact the Health & Safety Consultant (Nuclear, X-ray, Laser) for the disposal of all sealed sources and radiation devices containing sealed sources. A sealed source that contains more than the exemption quantity must be transferred to a radioactive waste company licensed by the CNSC. A sealed source that contains less than the exemption quantity of a radioactive nuclear substance may be disposed as regular waste.

3.9.9. Smoke Detectors

Smoke detector may contain a small radioactive source. For more information, contact the Health & Safety Consultant (Nuclear, X-ray, Laser).

3.9.10. Mixed Biological/Radioactive Contaminated Waste

The biological hazard must be treated first. For additional information, please refer to the Biological Waste in Western Hazardous Materials Management Handbook. In some cases, contaminated biological/radioactive hazardous materials may be incinerated when the activity is decayed to background level or below the CNSC regulatory limits for solid waste. *Note: do not autoclave contaminated biological/radioactive waste.*

Waste Disposal Limits

Unsealed Nuclear Substance	Solids to Municipal Garbage System (MBq/kg)	Liquids (Water Soluble) to Municipal Sewer System (MBq/yr)	Gases to Atmosphere (kBq/m^3)
Calcium 45	0.37	10000	n/a
Carbon 14	3.7	10000	n/a
Chromium 51	3.7	100	n/a
Gold 198	0.1	100	n/a
Hydrogen-3	37	1000000	37
Indium 111	0.037	100	n/a
Iodine-123	3.7	1000	n/a
Iodine-125	0.037	100	n/a
Iron 55	3.7	10000	n/a
Phosphorus 32	0.37	1	n/a
Phosphorus-33	1	10	n/a
Scandium 46	0.1	0.1	n/a
Sulfur-35	0.37	1000	n/a
Technetium-99	0.37	10000	n/a
Technetium 99m	3.7	1000	n/a

Note: No radioactive waste shall be disposed to a sewer or regular garbage without consultation with the Health & Safety Consultant (Nuclear, X-ray, Laser).

3.10. ACCIDENTS AND EMERGENCIES

3.10.1. Open-Source Radioactive Spills

Minor Spills: typically, less than 100 exemption quantities (Schedule 1, Nuclear Substances and Radiation Devices Regulations) of a nuclear substance. Report the spill to the Permit Holder immediately or person in charge and, if necessary, to the Health & Safety Consultant (Nuclear, X-ray, Laser).

Major Spills: involve more than 100 exemption quantities, or contamination of personnel, or release of volatile material. Notify the Permit Holder or person in charge and the Health & Safety Consultant (Nuclear, X-ray, Laser) immediately.

Spill Procedures

1. Inform persons in the area and keep them away from the contaminated area.
2. Cover the spill with absorbent material to prevent the spread of contamination.
3. Clear the area. Persons do not involve in the spill should leave the immediate area. Limit the movement of all personnel who may be contaminated until they are monitored.
4. If the spill occurs in a laboratory, leave the fume hood running to minimize the release of any volatile nuclear substances to adjacent rooms and hallways.
5. Close off and secure the spill area to prevent entry. Post radiation warning sign(s).
6. Permit Holder or person in charge or the Health & Safety Consultant (Nuclear, X-ray, Laser) will direct personnel decontamination and will decide about decay or cleanup operations.
7. Persons who may have been contaminated should be monitored immediately with an appropriate contamination meter. Contaminated clothing should be removed and contaminated skin surfaces washed and re-surveyed. In general, decontamination personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap. For more information, please see Section 3.10.2 Personnel Contamination.
8. Wear protective clothing, disposal gloves and, if necessary, disposable foot covers during cleaning up of the spill.
9. Mark the location of the spill with a wax pencil or maker. Avoid spreading contamination.
10. Clean up the spill using absorbent paper and decontamination solution (i.e., soap and water). Work from the outside of the spill towards the centre. For more information, see Section 3.10.5 Decontamination Techniques.
11. Place contaminated clean-up materials in labeled plastic bags for transfer to a labeled waste container.
12. Following decontamination, wipe test the area, decontamination is complete when wiped samples are less than twice the background level.
13. Report details of spill and action taken to the Permit Holder and the Health & Safety Consultant (Nuclear, X-ray, Laser).
14. Record spill details and contamination monitoring results. Adjust inventory and waste records.

3.10.2. Personnel Contamination

1. If possible, locate contaminated area with an appropriate contamination meter.
2. If skin is intact, wet area and wash with a mild, non-abrasive soap. Rub gently into a lather for about three minutes and rinse thoroughly with lukewarm water. Repeat as necessary.
3. If skin is broken, wet swab the area taking care not to spread the activity into the wound. Use warm water. Encourage bleeding to flush the wound if appropriate.
4. If contamination persists, inform the Health & Safety Consultant (Nuclear, X-ray, Laser).
5. Take care not to spread the contamination over a larger area of skin.
6. Decontamination staff should wear disposable clothing to prevent personal contamination.
7. Place all contaminated clothing in materials in a plastic bag, seal and label
8. Inform the Internal Permit Holder, the Health & Safety Consultant (Nuclear, X-ray, Laser) and submit a Western Accident/Incident Report Form to the Department of Occupational Health & Safety.

3.10.3. Release of Airborne Contamination, Leakage of Sealed Sources, Explosions or Fire

1. If possible, cut off the release of radioactivity material from the source to the environment.
2. Close windows, shut off fans, air conditioners, close lab doors and any air outlets to other areas. Open fume hoods to the maximum.
3. Evacuate personnel and prevent further personnel access to radiation area by closing and locking doors. Emergency personnel responding to the scene should be advised that radioactive materials may be present.
4. Monitor all persons who may be contaminated and determine which persons may have been exposed to external radiation and/or inhalation of radionuclides and to what degree.
5. Perform simple decontamination and contact the Health & Safety Consultant (Nuclear, X-ray, Laser) immediately. *After hours call Western Special Constable Service at 911, ask to page the OHS person on call.*
6. The Internal Permit Holder will prepare a formal written report of the incident and forward to the Health & Safety Consultant (Nuclear, X-ray, Laser).

3.10.4. Decontamination of Areas and Equipment

Good working habits and good housekeeping will prevent most contamination incidents and circumvent the need for decontamination.

Steps to follow if contamination occurs:

1. Decontaminate using processes listed below.
2. Various chemicals may be used, but the initial approach should be scrubbing with small quantity of hot water containing suitable cleaning agent. Use no more liquid than necessary.
3. All waste chemicals, water, rags, etc. created as a result of decontamination are to be disposed of in accordance with the "Hazardous Waste Disposal Flowchart".
4. Discuss large scale decontamination with the Health & Safety Consultant (Nuclear, X-ray, Laser).

3.10.5. Decontamination Technique

METHOD	SURFACE	ACTION	TECHNIOUE	ADVANTAGES	DISADVANTAGES
High efficiency vacuum cleaning.	Dry Surface.	Removes Contaminated dust by suction.	Only use approved vacuum cleaner with a High Efficiency Filters.	Good on dry porous surface. Avoid water reactions.	All dust must be filtered out. Machine is contaminated.
Hot water and detergent.	All surfaces.	Dissolves and erodes.	For spills covering small areas Blot up liquid and rinse with hot water and detergent. May use on glass ware and clothing if immersed and agitated.	Extremely effective if done immeddilt1y after spill and on a nonporous surface.	Of little value for decontaminating large areas or long-standing contamination or porous surfaces.
Complexion agents i.e., Decon 75 Alconox.	Nonporous surfaces.	Forms soluble complexes with Contamination.	Make solution of 3% complexing agent with water. Sprays surface with solution. Keep moist for 30 min. Remove solution and rinse. Immerse Smaller objects in solution.	Keeps contamination in solution. Nontoxic and very effective.	Requires long soaking time (30min) and has little penetration power.
Organic solvents.	Nonporous surfaces.	Disso1ve organic material (oil, paint, etc.).	Immerse or apply solvent to surface. Blot up liquid and wipe clean.	Quick dissolving power.	Required good ventilation, flammable and toxic.
Inorganic acids.	Metal surfaces.	Dissolves metals.	Immerse smaller objects in a 1-2N acid solution. Flush surface with water. Scrub with detergent water mixture and rinse.	Corrosive action on metals and porous deposits	Possibility of excessive corrosion. Acids are corrosive to personnel.

3.10.6. Incident/Accident Reporting

Notify Permit Holder and Health & Safety Consultant (Nuclear, X-ray, Laser) immediately following:

- Lost or stolen of nuclear substance or radiation device
- Radiation device is damaged or sealed source is separated from radiation device
- Sealed source fails to return to shielded position inside radiation device
- Major radioactive spill (> 100 exemption quantity of a nuclear substance), contamination of personnel or release of volatile material.

The University shall notify CNSC Duty Officer at 613-995-0479 or 1-844-879-0805 immediately of the location and circumstances of the situation and of any action that the University has taken or proposes to take with respect to the above as required by the applicable CNSC regulations. A full report in regard to the above situations must be filed with the CNSC within 21 days.

3.10.7. Skin Contamination

Refer to CNSC Expectations for Response during Skin Contamination Event

3.10.8. Dose Reporting Procedure

When Western is aware that a dose of radiation received by or committed to a person or an organ or tissue may have exceeded an applicable dose limit prescribed by section 3.5.1, the Health & Safety Consultant (Nuclear, X-ray, Laser) must:

- Immediately notify the worker and the CNSC of the dose;
- Require the person to leave any work that is likely to add to the dose if the person may have or has received a dose that exceeds a dose limit for a nuclear energy worker;
- Conduct an investigation to determine the magnitude of the dose and to establish the causes of the exposure;
- Identify and take any action required to prevent the occurrence of a similar incident; and
- Within 21 days after becoming aware that the dose limit has been exceeded, report to the CNSC the results of the investigation or the progress that has been made in conducting it.
- Communicate the findings to the worker and the Radiation Safety Committee.

SECTION 4: APPENDICES

4.1. FORMS

Radioisotope Application Form

RADIATION PERMIT APPLICATION

Western Human Resources
Occupational Health & Safety

Please complete the information and send to:

Radiation Safety Office

Human Resources Occupational Health and Safety

Room 4159, Support Services Building

Please email RadSafety@uwo.ca or call ext. 84821, if you have any questions.

Applicant

Name (First and Last): _____

Department:_____

Faculty:_____

Office:_____Building: _____

Email:_____Staff ID: _____

Work Phone:_____Cell:_____

Home Phone:_____Fax:_____

Radiation Safety Training and Radiation Work Experience

1. Radiation safety training at Western: Yes or No (circle one)

2. Last date of radiation safety training at Western: _____

3. Attach a description of previous radiation safety training courses (date and location), radiation work experience, and a list of publications related to the use of nuclear substances, radiation devices and class II prescribed equipment.

Nuclear Substance, Radiation Device and Class II Prescribed Equipment Information

Nuclear Substance	Chemical Form	Maximum Possession Limit (mCi or MBq)	Maximum Order of Each Source/Vial (mCi or MBq)	Physical Form	Purpose	Make and Model of Radiation Device (if applicable)

Experimental Protocol

Describe in detail your experimental procedure for each nuclear substance, radiation device and Class II prescribed equipment and emphasize the aspects that pertain to safety issues, describe any special hazards, and include the following:

1. Brief description of purpose or objectives
2. Brief description of materials (indicate the types of equipment needed)
3. Brief description of methodology
4. Quantity of radioactivity used per experiment and the frequency
5. Names of personnel to handle this isotope
6. Laboratory(ies) where this procedure will be performed
7. Provide a waste disposal flow chart indicating approx. activities (mCi or MBq) for each type of waste (solid, liquid, liquid scintillation vials, etc.): Describe the types of waste that will be generated from each experimental protocol. Identify the volumes and activity amounts.
8. Will you be using animals? Y □ N □
9. Will you be receiving any nuclear substance that is not purchased directly from a commercial company? (e.g., borrowing/sharing from another permit holder, LHSC-UH)

Yes □ No □ If yes, please explain

_____

_____

_____

Locations of nuclear substances, radiation devices and class II prescribed equipment

Building	Room Number	Phone	Nuclear substance to be used or in the radiation device	Classification (to be determined by Health & Safety Consultant)

Diagram of Room

For each of the above-named locations, on a separate sheet, provide a diagram or floor plan as follows:

1. Include fume hood, waste storage area, radioactive-use sink, workstations, stock vial storage (fig, freezer, storage cupboard) student or staff work/study area, scintillation counter, personal hygiene sink, solvent storage area, biological containment cabinet, centrifuge, etc.
2. Identify where each radioactive workstation is located.
3. Identify where contamination monitoring locations are performed (both radioactive work area and non-radioactive work area)
4. Describe the storage facilities, security and access control including lockable storage fridge, cupboard or box of nuclear substances that will be stored and used.

_____

_____

_____

_____

Personal Protective Equipment

(1) Laboratory Coat- required

(2) Disposable gloves- required

(3) Safety glasses/goggles - required

(4) Shielding (indicate thickness and type): _____

(5) Remote handling tools(specify) _____

RADIATION DETECTION INSTRUMENTS

1. **Portable Radiation Survey Instrument**

Note: if you are sharing an instrument with someone else, or from your department, the following information may already be documented. Complete the serial number and owner only. Please complete multiples of this section if you use/own more than one portable survey instrument.

Meter

Manufacturer:_____ Model Number: _____

Serial Number:_____ Storage Location: _____

Owner:_____ Custodian: _____

Western ID Tag # _____

Probe

Type:_____ e.g., pancake Geiger-Mueller probe, NaI

probe Manufacturer: _____

Probe Model:_____ Serial Number: _____

Check Source (if applicable): Isotope: _____

Activity:_____ Date of Activity _____

Service Record

Purchased Date: _____

Last Calibration Date: _____

Last Service Date: _____

2. **Non-portable Counter (Liquid Scintillation, Sodium Iodide, etc.)**

Note: if you are sharing an instrument with someone else, or from your Department, the following information may already be documented. Complete the Serial Number and Owner only. Please complete multiples of this section if you use/own more than one counter.

Type: Alpha □ Beta □ Gama □ Western ID Tag # _____

Manufacturer:_____ Model Number: _____

Serial Number:_____ Room Location: _____

Owner:_____ Custodian:_____

Sealed Source(s) – Internal

Nuclear Substance	**Activity (mCi or MBq)**	**Date of Activity**

Sealed Source(s) – External

Nuclear Substance	**Activity (mCi or MBq)**	**Date of Activity**

Service Record

Purchase Date: _____

Purchase Cost: _____

Last Calibration Date: _____

Next Calibration Date: _____

Is there a service contract for this instrument? Yes ☐ No ☐

Name of servicing company _____

Is the servicing company licensed by the CNSC? Yes ☐ No ☐

Personnel

Identify the names of all persons who will handle or use nuclear substances, radiation devices or class II prescribed equipment in your radiation permit

Name	Email	Nuclear substance, radiation device and Class II prescribed equipment to be handled or used	Last date of Western Radiation Safety Training
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			

Attendance of the Western radiation safety training is mandatory before any of the above-named persons is authorized as a worker in your radiation permit. Personal dosimeter(s) including TLD badge(s) will be issued (if required) after radiation safety training is complete.

The applicant certifies that all submitted information is true and correct to the best of her/his knowledge. The applicant accepts the responsibilities as a Permit Holder and complies with the Nuclear Safety Control Act and Regulations, CNSC license conditions, Western policies, procedures and internal permit conditions.

Signed: Applicant Date

Signed: Department Chair Date

Signed: Health and Safety Consultant Date

Signed: Radiation Safety Committee Chair (AVP- Research) or Designate Date

Inventory Record & Waste Form

WESTERN UNIVERSITY

NUCLEAR SUBSTANCE INVENTORY & WASTE FORM

BAR CODE #_____ AUTHORIZED BY:_____

Permit Holder: _____ Permit #: _____

Nuclear Substance:_____ Chemical Form: _____

Purchase Order #:_____ Wipe test of shipping vial on receipt? Yes (circle)

Total Activity:_____ Total Volume: _____

Date of Activity: _____ Received Date: _____

Storage – Room/location: _____ Received By: _____

Date Used (m/d/y)	Name of User	Activity Used (e.g.: 100 μCi)	Activity Remaining	Disposal Method* and Measured Activity for Disposal (e.g.: LI = 50μCi, S1 = 50 μCi)	Date of Disposal (m/d/y)

Date of Shipping Vial Disposal (m/d/y): Name:_____ Signature:_____

LIQUID (L)	SOLIDS (S)
L1 Liquid to Environmental Safety Personnel	S1 Solid to Environmental Safety Personnel
L2 Liquid Scintillation Vials to Environmental Safety	R2 Return to Supplier (see note below)
L3 Transfer to another Research Unit (see note below)	S3 Transfer to another Research Unit (see note below)
L4 Storage until decayed to background level	S4 Storage until decayed to background level
L5 Return to Supplier (see note below)	S5 Store animals until decayed to background or below CNSC disposal limit (see note below)

NOTE: *No radioactive waste shall be disposed to the sewer, regular garbage, transfer or return without consultation with the Western Health and Safety Consultant.*

Nuclear Substance Room Decommissioning Form

The permit holder shall ensure that prior to decommissioning any area, room or enclosure where the permitted activity has been conducted: non-fixed contamination does not exceed 0.3 Bq/cm^2 for all class A radionuclides and 3 Bq/cm^2 for all class B & C radionuclides (see classification of selected radionuclides in the section 4.5 of Western radiation safety manual); averaged over an area not exceeding 100 cm^2. Any area, room, or enclosure containing fixed contamination must be reported to the Health & Safety Consultant.

Permit Holder:_____ Permit Number: _____

Room Number/Building _____

Performed By:_____ Signature:_____ Date: _____

	Completed		
1. *Removal of required Postings/Signs:*			
• Internal permit	Y	N	N/A
2. CNSC safety poster(s)	Y	N	N/A
3. Western waste label(s)	Y	N	N/A
4. CNSC licence (if applicable)	Y	N	N/A
5. Entry door warning sign	Y	N	N/A
2. *Other labels:*			
1. Refrigerator/freezer label	Y	N	N/A
2. Storage areas	Y	N	N/A
3. Tape surrounding workstation	Y	N	N/A
4. Pipettors	Y	N	N/A
5. Other lab equipment	Y	N	N/A
3. *Inventory: records completed, all stock vials, sources, aliquots etc. disposed*	Y	N	N/A
4. *Radioactive Waste:*			
1. Dispose of all remaining waste	Y	N	N/A
2. Check frig/freezer & dispose of all labeled contents	Y	N	N/A
3. Return pails to Environmental Safety Personnel	Y	N	N/A
5. Dosimetry: Inform the TLD badge coordinator to remove name(s) from radiation exposure monitoring list (if applicable)	Y	N	N/A

6. Radiation Measuring Instruments (e.g., Liquid Scintillation Counter): Will these be disposed or transferred to someone else (identify all)? Provide details below:

_____

_____

Contamination Monitoring Results

Provide a floor plan of the lab/area to be decommissioned. Indicate the locations of wipe test on the floor plan by a representative number and record results in the table below.
Radionuclides being sampled and monitored for:

Iodine 125	Carbon 14	Chromium 51
Hydrogen 3	Sulfur 35	Calcium 45
Phosphorous 32	Phosphorous 33	Other(s) _____

Measurement Method:
Counter (type, make and model): _____

Calibration Date:_____Background in cpm: _____

Minimum detector efficiency E: (for example 35% efficiency, E = 0.35) _____

Area sampled on the attached floor plan	Gross counts in cpm	Net count in cpm (Gross counts – Background counts)	Contamination level in Bq/cm^2 (Net counts in cpm)/(E x 600)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Please attach any additional area sampled on the floor plan if required
Potential fixed contamination is measured using an appropriate contamination meter at the above locations. Any measured location that is higher than the background level must be reported to the Health & Safety Consultant.
Potential radiation field is measured with calibrated dose rate meter. If the radiation field is above the background, the source of radiation must be removed until the radiation field is equal to the radiation background level.

Meter(s) used:

Reviewed by:_____Date:_____
Permit Holder's signature

Reviewed by:_____Date: _____
Health and Safety Consultant's signature

Please complete the necessary information and send to:
Radiation Safety (RadSafety@uwo.ca), Room 4159, OHS, Support Services Building

Unsealed Nuclear Substance Contamination Monitoring Form

Permit Holder:_____ **Room number(s):** _____

Indirect Monitoring (Wipe test using non-portable counter such as Liquid Scintillation Counter or NaI Counter)

Counter Type:_____ Make:_____ Model:_____

Contamination limit is 3 Bq/cm^2 or net count rate 900 cpm (assuming 10% collection efficiency, 100 cm^2 wiped area and 50% detector efficiency as a conservative approach for most unsealed nuclear substances used) or calculated net count rate (cpm) equal to 3 Bq/cm^2 if detector efficiency is less than 50%: _____

Record results in the table below accordingly and keep the printout from the counter in the binder.

Direct Monitoring (Using Western calibrated contamination meter(s) for P-32 and/or I-125)

Make and Model of Meter(s): _____

Net count rate in **cpm or cps** equal to 3 Bq/cm^2 for **P-32 (**from the calibration sticker) _____

Net count rate in **cpm or cps** equal to 3 Bq/cm^2 for **I-125** (from the calibration sticker) _____

Direct Monitoring can be used for weekly documented contamination monitoring if radioactive work only involved P-32 and/or I-125 during that week. Record results in the table below accordingly.

Note: If radioactive work is not conducted in any given week, contamination monitoring is not required. However, please indicate all non-radioactive work weeks with NR. DO NOT LEAVE ANY WEEK BLANK

Numbered areas to be monitored indicated on the room diagram

Year ( )	Name of Tester	Isotope used	Counted Unit	Back-ground	1	2	3	4	5	6	7	8	9	10
1 Wk Jan														
2 Wk Jan														
3 Wk Jan														
4 Wk Jan														
5 Wk Jan														
1 Wk Feb														
2 Wk Feb														
3 Wk Feb														
Year ( )	Name of Tester	Isotope Used	Counted Unit	Back-ground	1	2	3	4	5	6	7	8	9	10
4 Wk Feb														
5 Wk Feb														
1 Wk Mar														
2 Wk Mar														
3 Wk Mar														
4 Wk Mar														
5 Wk Mar														
1 Wk Apr														

2 Wk Apr														
3 Wk Apr														
4 Wk Apr														
5 Wk Apr														
1Wk May														
2 Wk May														
3 Wk May														
4 Wk May														
5 Wk May														
1 Wk Jun														
Year ( )	Name of Tester	Isotope used	Counted Unit	Back-ground	1	2	3	4	5	6	7	8	9	10
2 Wk Jun														
3 Wk Jun														
4 Wk Jun														
5 Wk Jun														
1 Wk Jul														
2 Wk Jul														
3 Wk Jul														

4 Wk Jul														
5 Wk Jul														
1 Wk Aug														
2 Wk Aug														
3 Wk Aug														
4 Wk Aug														
5 Wk Aug														
1 Wk Sep														
2 Wk Sep														
3 Wk Sep														
4 Wk Sep														
Year	Name of Tester	Isotope used	Counted Unit	Back-ground	1	2	3	4	5	6	7	8	9	10
5 Wk Sep														
1 Wk Oct														
2 Wk Oct														
3 Wk Oct														
4 Wk Oct														
5 Wk Oct														
1 Wk Nov														

2 Wk Nov														
3 Wk Nov														
4 Wk Nov														
5 Wk Nov														
1 Wk Dec														
2 Wk Dec														
3 Wk Dec														
4 Wk Dec														
5 Wk Dec														

CONTAMINATION LEVEL (Bq/cm^2) = $\frac{S-B}{E\ X\ A\ X\ T\ X\ F}$

Where:
S = Sample count rate (cpm or cps)
B = Background count rate (cpm or cps)
E = Detector efficiency (e.g., if 50% efficiency, E = 0.50)
A = Area wiped (100 cm^2) or detector area in cm^2
T = 60 sec/min if count rate in cpm
T = 1 if count rate in cps
F = 0.1 (e.g., 10%) is collection factor for area wiped (indirect monitoring or wipe test)

Net count rate (cpm or cps) = Sample count rate (cpm or cps) – Background count rate (cpm or cps)

Detector efficiency = Net count rate (cpm) /Known activity (dpm)
1 microcurie (μCi) = 2.2 x 10^6 disintegrations per minute (dpm)

Detector efficiency = Net count rate (cps)/Known activity (dps)
1 Becquerel (Bq) = 1 disintegration per second (dps)
1 microcurie (μCi) = 37 kilobecquerel (kBq) = 37000 becquerel (Bq)

Non-fixed contamination in all areas, rooms or enclosures where unsealed nuclear substances are used or stored does not exceed 3 Bq/cm^2.

Problem:

You have taken a swipe for unsealed H-3 and S-35 contamination in your designated radiation room. The liquid scintillation counter print out shows a sample count rate of 940 cpm for the swipe of the fume hood in 100 cm^2. The minimum detector efficiency is 50% and the background count rate is 40 cpm. What is the contamination level in Bq/cm^2?

Solution:

$$\text{Contamination level } (Bq/cm^2) = \frac{940 \text{ cpm} - 40 \text{ cpm}}{0.5 \times 100 \text{ cm}^2 \times 60 \text{ sec/min} \times 0.1}$$

Therefore, the contamination level is 3.0 Bq/cm^2.

Also, if you know the contamination limit in Bq/cm^2 and the counter print out shows in cpm then you can calculate a net count rate in cpm equal to the known contamination limit using the contamination level formula above. For example, the contamination limit is 3 Bq/cm^2, 10% collection efficiency, 100 cm^2 wiped area and 50% detector efficiency (as a conservative approach for most unsealed nuclear substances used.). Therefore, the calculated net count rate is 900 cpm.

Nuclear Energy Worker Form

Western University
Notification of Nuclear Energy Worker Status

Western University is committed to the health and safety of its employees. To this end, in the Radiation Safety program, the University informs all those working with nuclear materials including nuclear substances, radiation devices or Class II prescribed equipment as Nuclear Energy Workers (NEWS). In accordance with the Nuclear Safety and Control Act and Regulations of Canada, the University is required to inform such NEW status if there is a reasonable probability of an individual receiving a radiation dose (effective dose) greater than the dose limit for the general public (1 mSv per year for the whole body). The radiation dose is tracking by the National Dose Registry maintained by the Radiation Protection Bureau of Health Canada of each workers lifetime exposure to radioactive material.

Western is committed to taking every reasonable precaution, as is practical, to maintain the radiation exposure of all Nuclear Energy Workers, staff, students and the public to ALARA, (As Low As Reasonably Achievable).

As a Nuclear Energy Worker you must be aware of the following critical radiation levels:

- Natural background levels: 2.0 –3.0 mSv/year
- Typical occupational level: 0.2-1.0 mSv/year
- Effective dose limit: (a) One-year dosimetry period: 50 mSv (b) Five-year dosimetry period: 100 mSv. The average is 20 mSv/year in five-year period
- Action level of effective dose: 2.0 mSv/year (any value greater than this must be investigated and reported to the CNSC)

You must also be familiar with the following documents, which are provided to you:

1. The applicable dose limits as specified in the Radiation Protection Regulations by the Canadian Nuclear Safety Commission
2. Dose limits for pregnant Nuclear Energy Workers in section 13 of the Radiation Protection Regulations of the Canadian Nuclear Safety Commission
3. Radiation Risk in Perspective, a position statement of Health Physics Society
4. Risk Assessment, a position statement of Health Physics Society

i. The risks associated with the exposure of embryos and fetuses to radiation and the risks to breastfed infants from the intake of nuclear substances
ii. The importance of informing the licensee, as soon as feasible, in writing, that the female nuclear energy worker is pregnant or breastfeeding;
iii. Regarding their pregnancy and/or breastfeeding status, the worker's decision to advise the licensee is a personal one and will be informed by the risk information provided by the licensee. However once declared the regulatory requirements will apply.

I understand the risks, my obligations and the radiation dose limits and levels that are associated with being designated as a Nuclear Energy Worker.

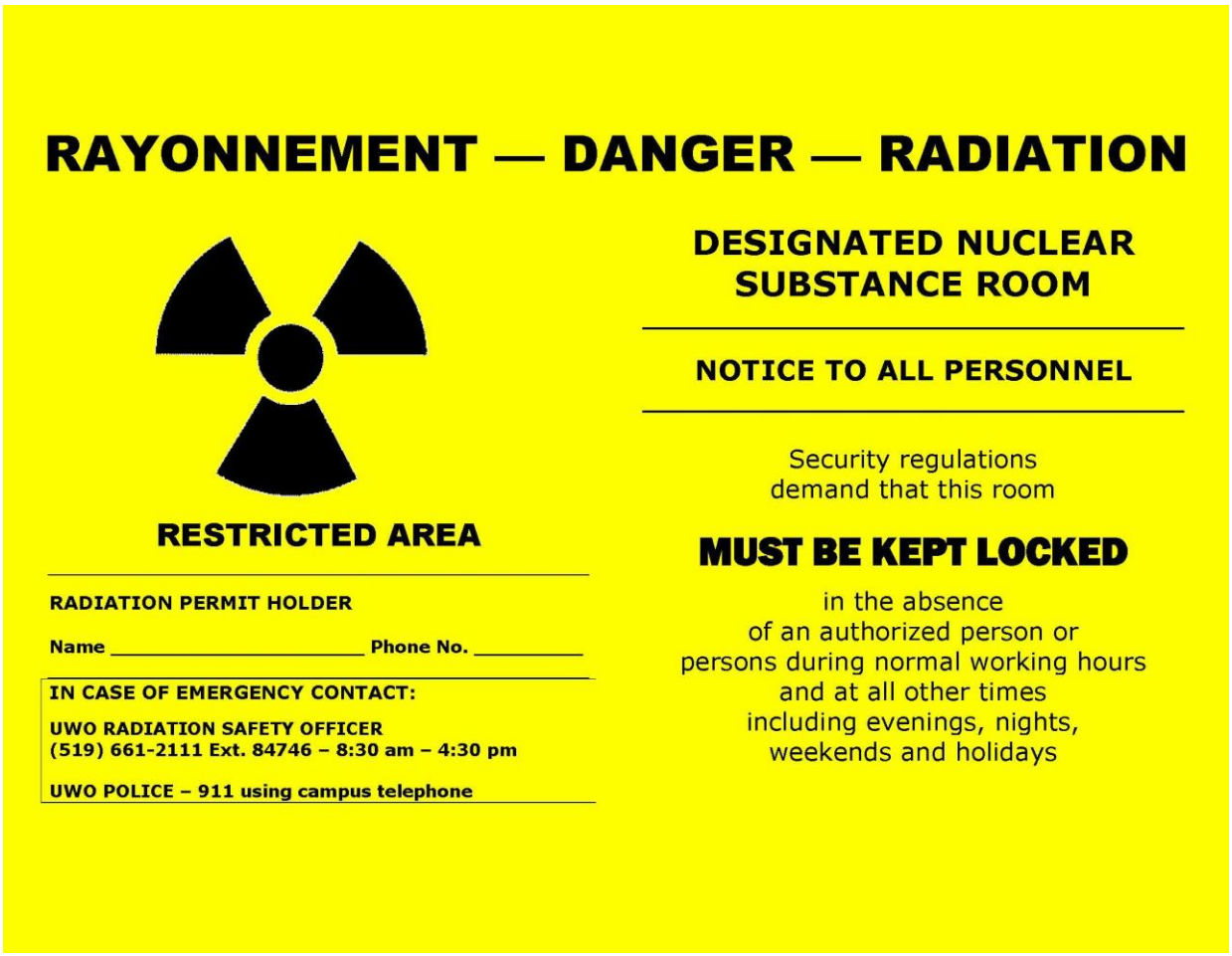
Name_____ Department_____

Signature_____ Date:_____

Signature of Radiation Safety Officer_____ Date:_____

4.2. POSTINGS & LABELS

4.2.1. Radiation Warning Signs



Specific Storage Location in Designated Nuclear Substance Room (i.e., Fridge, Freezer)

Canada's Nuclear Regulator

BASIC LEVEL
Use of Unsealed Nuclear Substances

This room has been classified as basic level for the use of unsealed nuclear substances in accordance with Canadian Nuclear Safety Commission requirements. Below is a list of safe work practices to be followed when working in this room.

24-hour emergency contact (name and phone number)

Room identification

- Do not eat, drink, store food, or smoke in this room.
- Use protective clothing and equipment when working with nuclear substances.
- Clearly identify work surfaces used for handling nuclear substances.
- Check all packages containing nuclear substances for damage upon receipt.
- Store nuclear substances in a locked room or enclosure when not in use.
- In case of a spill or incident involving a nuclear substance, inform others in the area, follow emergency procedures and notify the radiation safety officer immediately.

Notes

A room is classified as basic level for the use of unsealed nuclear substances where more than one exemption quantity is handled and where the largest quantity (in becquerels) of a nuclear substance handled by any worker does not exceed five times its corresponding annual limit of intake (in becquerels). Contact your radiation safety officer for a list of annual limits of intake.

For more information, contact:
Directorate of Nuclear Substance Regulation
Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
Ottawa, ON K1P 5S9
Telephone: 1-888-229-2672
Fax: 613-995-5086

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Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire

Canada

ISBN: 978-0-662-03915-0, Cat. No.: CC172-127/1-2016E-PDF

DECEMBER2016

Canada's Nuclear Regulator

HIGH LEVEL
Use of Unsealed Nuclear Substances

This room has been classified as high level for the use of unsealed nuclear substances in accordance with Canadian Nuclear Safety Commission requirements. The following is a list of safe work practices to be followed when working in this room.

24-hour emergency contact (name and phone number)

Room identification

- Restrict access to authorized workers only.
- Do not eat, drink, store food, or smoke in this room.
- Wear dosimetry as required by your radiation protection program.
- Wear appropriate protective clothing and equipment at all times.
- Clearly identify work surfaces used for handling nuclear substances.
- Work in a ventilated enclosure when required by the radiation safety officer or by your radiation protection program.
- Wash hands regularly and monitor them for contamination frequently.
- Monitor work area for contamination after working with nuclear substances.
- Check all packages containing nuclear substances for damage upon receipt.
- Store nuclear substances in a locked room or enclosure when not in use.
- In case of a spill or incident involving a nuclear substance, inform others in the area, follow emergency procedures and notify the radiation safety officer immediately.

Notes

A room is classified as high level for the use of unsealed nuclear substances where the largest quantity (in becquerels) of a nuclear substance handled by any worker does not exceed 500 times its corresponding annual limit of intake (in becquerels). Contact your radiation safety officer for a list of annual limits of intake.

For more information, contact:
Directorate of Nuclear Substance Regulation
Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
Ottawa, ON K1P 5S9
Telephone: 1-888-229-2672
Fax: 613-995-5086

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ISBN: 978-0-662-03923-5, Cat. No.: CC172-127/3-2016E-PDF

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Canada's Nuclear Regulator

INTERMEDIATE LEVEL
Use of Unsealed Nuclear Substances

This room has been classified as intermediate level for the use of unsealed nuclear substances in accordance with Canadian Nuclear Safety Commission requirements. The following is a list of safe work practices to be followed when working in this room.

24-hour emergency contact (name and phone number)

Room identification

- Do not eat, drink, store food, or smoke in this room.
- Wear dosimetry as required by your radiation protection program.
- Wear appropriate protective clothing and equipment when working with nuclear substances.
- Clearly identify work surfaces used for handling nuclear substances.
- Wash hands regularly and monitor them for contamination frequently.
- Monitor work area for contamination after working with nuclear substances.
- Check all packages containing nuclear substances for damage upon receipt.
- Store nuclear substances in a locked room or enclosure when not in use.
- In case of a spill or incident involving a nuclear substance, inform others in the area, follow emergency procedures and notify the radiation safety officer immediately.

Notes

A room is classified as intermediate level for the use of unsealed nuclear substances where the largest quantity (in becquerels) of a nuclear substance handled by any worker does not exceed 50 times its corresponding annual limit of intake (in becquerels). Contact your radiation safety officer for a list of annual limits of intake.

For more information, contact:
Directorate of Nuclear Substance Regulation
Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
Ottawa, ON K1P 5S9
Telephone: 1-888-229-2672
Fax: 613-995-5086

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ISBN: 978-0-662-03919-8, Cat. No.: CC172-127/2-2016E-PDF

DECEMBER2016

4.2.2. CNSC Guidelines for Handling Packages Containing Nuclear Substances Poster

Canadian Nuclear Safety Commission | Commission canadienne de sûreté nucléaire | INFO-0744

GUIDELINES FOR HANDLING PACKAGES CONTAINING NUCLEAR SUBSTANCES

Identifying Packages Containing Nuclear Substances

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

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

Category 1-WHITE
Does not exceed 5 µSv/h at any location on the external surface of the package

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

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

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

Upon receipt of a package containing nuclear substances, keep your distance. Examine the package for damage or leakage. If the package is damaged or leaking, contain and isolate it to minimize radiation exposure and contamination, and comply with Section 19 of the PTNS *Regulations*.

Opening Packages Containing Nuclear Substances

Radiation Safety Officer	**Phone Number**

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

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

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

For more information, contact: Directorate of Nuclear Substance Regulation, Canadian Nuclear Safety Commission, P.O. Box 1046, Station B, Ottawa, ON K1P 5S9. Telephone: 1-888-229-2672. Fax: (613) 995-5086.

Canada

4.2.3. Spill Procedures

SPILL PROCEDURES

Canada's Nuclear Regulator

Name and telephone number of the person responsible for enforcing safe work practices with nuclear substances in this work area:

Radiation safety officer	**Telephone number**

24-hour emergency contact	**Telephone number**

General precautions

1. Inform people in the area that a spill has occurred. Keep them away from the contaminated area.
2. Cover the spill with absorbent material to prevent the spread of contamination.

Minor spills (typically less than 100 exemption quantities of a nuclear substance)

1. Wear protective clothing and disposable gloves, clean up the spill using absorbent paper and place it in a plastic bag for transfer to a labelled waste container.
2. Avoid spreading contamination. Work from the outside of the spill towards the centre.
3. Wipe test or survey for residual contamination as appropriate. Repeat decontamination, if necessary, until contamination monitoring results meet the nuclear substances and radiation devices licence criteria.
4. Check hands, clothing, and shoes for contamination.
5. Report the spill and cleanup to the radiation safety officer or the person in charge.
6. Record spill details and contamination monitoring results. Adjust inventory and waste records appropriately.

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

Major spills (Major spills involve more than 100 exemption quantities, or significant contamination of personnel, or release of volatile material)

1. Clear the area. Persons not involved in the spill should leave the immediate area. Limit the movement of all personnel who may be contaminated until they are monitored.
2. If the spill occurs in a laboratory, leave the fume hood running to minimize the release of volatile nuclear substances to adjacent rooms and hallways.
3. Close off and secure the spill area to prevent entry. Post warning sign(s).
4. Notify the radiation safety officer or person in charge immediately.
5. The radiation safety officer or person in charge will direct personnel decontamination and will decide about decay or cleanup operations.
6. Decontaminate personnel by removing contaminated clothing and flushing contaminated skin with lukewarm water and mild soap.
7. Follow the procedures for minor spills or proceed in accordance with authorized procedure.
8. Record the names of all persons involved in the spill. Note the details of any personal contamination.
9. If required, the radiation safety officer or person in charge will arrange for any necessary bioassay measurements.
10. If required, submit a written report to the radiation safety officer or person in charge.
11. The radiation safety officer or person in charge must notify the CNSC immediately and submit a full report within 21 days.

If an exposure may have occurred that is in excess of applicable radiation dose limits, the CNSC shall be notified **immediately** as required by section 16 of the *Radiation Protection Regulations*.

For more information, contact:
Directorate of Nuclear Substance Regulation
Canadian Nuclear Safety Commission
P.O. Box 1046, Station B
Ottawa, ON K1P 5S9
Telephone: 1-888-229-2672
Fax: 613-995-5086

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4.3. RADIATION PROTECTION INFORMATION

4.3.1. Radiation Units

ROENTGEN (R): Describes the ionizing ability of Gamma and X-rays.

RAD OR GRAY (rad or Gy): The radiation absorbed dose is used to measure the energy deposited in a substance by any type of radiation. For x-ray and Gamma radiation 1 rad is equivalent to 1 roentgen.

REMS OR SIEVERT (rem or Sv): This unit takes into account the biological effects of different types of radiation. This is done by multiplying the dose by the Quality Factor (listed below).

QUALITY FACTOR (Radiation Weighting Factors)

Item	Type of Radiation and Energy Range	Weighting Factor
1.	Photons, all energies	1
2.	Electrons and muons, all energies[1]	1
3.	Neutrons[2] of energy < 10 keV	5
4.	Neutrons of energy 10 keV to 100 keV	10
5.	Neutrons of energy >100 keV to 2 MeV	20
6.	Neutrons of energy >2 MeV to 20 MeV	10
7.	Neutrons of energy >20 MeV	5
8.	Protons, other than recoil protons, of energy >2 MeV	5
9.	Alpha particles, fission fragments and heavy nuclei	20

[1] *Excluding Auger electrons emitted from nuclei bound to DNA.*

[2] *Radiation weighting factors for these neutrons may also be obtained by referring to the continuous curve shown in Figure 1 on page 7 of the 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, published in 1991.*

4.3.2. Conversion of Units

The rad (rad) is replaced by the gray (Gy)	
1 kilorad (krad) 1 rad (rad) 1 millirad (mrad) 1 microrad (μrad)	10 grays (Gy) 10 milligrays (mGy) 10 micrograys (μGy) 10 nanograys (nGy)
The gray (Gy) replaces the rad (rad)	
1 gray (Gy) 1 milligray (mGy) 1 microgray (μGy) 1 nanogray (nGy)	100 rad (rad) 100 millirad (mrad) 100 microrad (μrad) 100 nanorad (nrad)
The rem (rem) is replaced by the Sievert (Sv)	
1 kilorem (krem) 1 rem (rem) 1 millirem (mrem) 1 microrem (μrem)	10 sieverts (Sv) 10 millisieverts (mSv) 10 microsieverts (μSv) 10 nanosieverts (nSv)
The Sievert (Sv) replaces the rem (rem)	
1 sievert (Sv) 1 millisievert (mSv) 1 microsievert (μSv) 1 nanosievert (nSv)	100 rem (rem) 100 millirem (mrem) 100 microrem (μrem) 100 nanorem (nrem)
The curie (Ci) is replaced by the becquerel (Bq)	
1 kilocurie (kCi) 1 curie (Ci) 1 millicurie (mCi) 1 microcurie (μCi) 1 nanocurie (nCi)	37 terabecquerels (TBq) 37 gigabecquerels (GBq) 37 megabecquerels (MBq) 37 kilobecquerels (KBq) 37 becquerels (Bq)
The becquerel (Bq) * replaces the curie (Ci)	
1 terabecquerel (TBq) 1 gigabecquerel (GBq) 1 megabecquerel (MBq) 1 kilobecquerel (KBq) 1 becquerel (Bq)	27 curies (Ci) 27 millicuries (mCi) 27 microcuries (μCi) 27 nanocuries (nCi) 27 picocuries (pCi)

∗ *1Bq = 1 disintegration/second*

1 microcurie = 2.2 x 10^6 disintegration per minute
1 becquerel = 1 disintegration per second
disintegration per minute = count per minute/detector efficiency

4.3.3. Decay Rates

Radiation source activity at any time (t) can be calculated from the initial activity or activity at reference date using the following formula:

$A = A_0 (0.5)^{t/T_{1/2}}$

Where:

A = Final activity or activity at time (t)

A_0 = Initial activity or activity at reference date

t = The elapsed time between A and A_0

$T_{1/2}$ = Half-life of a radioactive isotope

4.3.4. Dose Rate from a Point Source of Photons

The point source approximation is applicable whenever the dose is calculated at a distance that is a least three times the largest source dimension. If we exclude the attenuation factor, we can write for the exposure rate or dose rate from a point source of gamma photons in expression of the following form:

$X = \Gamma \times A / r^2$

Where:
X = Exposure rate (R/h) or dose rate (rem/h) at distance r Γ = Specific gamma ray constant ($R.m^2/Ci.h$)
A = Activity of the source (Ci)
r = Distance from the point source (m)

Specific gamma ray constant of some radioisotopes	Γ
Radioisotope	$R \cdot m^2$
	$Ci \cdot h$
Antimony 122	0.24
Cesium 137	0.33
Chromium 51	0.016
Cobalt 60	1.32
Gold 198	0.23
Iodine 125	0.07
Iodine 131	0.22
Iridium 192	0.48
Mercury 203	0.13
Potassium 42	0.14
Radium 226	0.825
Sodium 22	1.20
Sodium 24	1.84
Zinc 65	0.27

If specific gamma ray constant Γ is not provided, gamma exposure rate or dose rate can be estimated from the properties of the source using the following relationship (+/- 20% of actual value of the gamma ray constant)

$\Gamma i = 0.5 \sum E_i Y_i$

Where:

Ei = Energy of the i^{th} gamma ray from the source (MeV)

Yi = Yield of the i^{th} gamma ray from the source

4.3.5. Basic External Radiation Protection

Radiation protection practice is a special aspect of the control of environmental health hazard by one or more of the following three techniques:

1. Minimizing exposure time
2. Maximizing distance from the radiation source
3. Shielding the radiation source

Time

Many biological effects of radiation are dependent on dose rate, it may be assumed, for environmental control, that the reciprocity relationship

Total dose = dose rate X exposure time

The more time workers spend in radiation areas, the more radiation dose they receive. Some effective methods of reducing exposure time are: job pre-planning, practicing the job on a mock-up outside the radiation area or in a low radiation area and ensuring that all required tools, equipment, materials and personnel are staged and ready to go before the radiation job starts.

Distance

The exposure rate from a gamma point source is inversely proportional to the square of the distance from the source. The Inverse Square Law can be expressed as follows

$X_1 (d_1)^2 = X_2 (d_2)^2$

Where:

X_1 = Exposure rate at distance d_1

X_2 = Exposure rate at distance d_2

Shielding

Negative beta particles: Shielding is required for high energy particles (0.5 MeV or higher) such as P-32, Y-90, Na-24, Bi-214, etc. The best materials to shield negative beta particles have low density and atomic number Z. High density materials will increase bremsstrahlung production. The most common material used to shield negative beta particles is plastic (Lucite).

Penetration Ability of Negative Beta Radiation

Energy (MeV)	Nuclear Substance	Maximum Range of Negative Beta Particle (cm) in Plastic (Lucite)
1.392	Na-24	0.5
1.51	Bi-214	0.6
1.71	P-32	0.7
2.273	Y-90	1

Gamma: Gamma photon absorption is an exponential process, which means that gamma photons are never completely stopped, regardless of the thickness of the absorber. Our goal is to reduce the gamma radiation to the acceptable levels for the work we need to do.

For quick shielding estimates, the half-value thickness concepts can be used. A half-value thickness (HVT) is the thickness of material that reduces the radiation intensity to one-half of its initial value.

$I = I_0 (0.5)^n$

Where:
I = Final intensity I_0 = Initial intensity
n = the number of HVTs = $\frac{\text{Thickness of shielding material}}{\text{HVT}}$

HVT for gamma and X-rays of various energies in three common shielding materials (cm)

Energy (MeV)	**Lead (11.35 g/cm^2)**	**Iron (7.86 g/cm^2)**	**Concrete (2.35 g/cm^2)**
0.3	0.160	0.845	2.7
0.4	0.278	0.9535	3.075
0.5	0.396	1.062	3.39
0.6	0.4584	1.1438	3.64
0.7	0.5478	1.2256	3.894
0.8	0.6372	1.3074	4.146
0.9	0.7266	1.3892	4.398
1.0	0.816	1.471	4.65
1.1	0.8876	1.5434	4.864
1.2	0.9592	1.6158	5.078
1.3	1.0308	1.6882	5.292
1.4	1.1024	1.7606	5.506
1.5	1.174	1.833	5.72
1.6	1.2108	1.8812	5.98
1.7	1.2476	1.9294	6.096
1.8	1.2844	1.9776	6.284
1.9	1.3212	2.0258	6.472
2.0	1.358	2.074	6.66
2.5	1.443	2.294	7.045
3.0	1.474	2.483	8.15

4.3.6. Selected Isotope Data Sheets

Phosphorus 32 (P-32)

P-32

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Part 1 – RADIONUCLIDE IDENTIFICATION			
Chemical symbol: P	Common name: Phosphorus	Atomic weight: 32	Atomic number: 15

Part 2 – RADIATION CHARACTERISTICS

Physical half-life: 14.263 days

Radiation type	Most abundant emissions (>10 keV, >0.01%)	Most energetic emissions (>10 keV, >0.01%)	Shielding information (mm)
Gamma & X-ray	None	None	Not an external radiation hazard
Beta(-), Beta(+), electrons	1710.4 keV (100%)	1710.4 keV (100%)	Practical range in glass: 3.4 Practical range in plastic: 6.3

Part 3 – DOSE RATE CONSTANTS AND COEFFICIENTS

External dose

Dose rate to skin from direct contamination: 1.9 mSv/h per kBq/cm^2
Gamma ray effective dose rate at 1 m: not applicable

Internal dose

	Ingestion	Inhalation
Worker dose coefficient	2.4E-09 Sv/Bq	2.9E-09 Sv/Bq

Part 4 – CLEARANCE AND EXEMPTION			
CNSC exemption quantity:	1 kBq/g or 100 kBq	**CNSC classification:**	Class C
CNSC unconditional clearance level:	1 kBq/g	**Surface contamination free-release criterion:**	100 Bq/cm^2 (fixed + removable)

Part 5 – DETECTION AND MEASUREMENT

Method of detection (dose rate):
Not applicable

Method of detection (contamination):

1. Hand-held: thick ZnS scintillator with proprietary discrimination, gas-flow proportional, sealed-gas proportional, plastic scintillator, halogen quenched thin window Geiger-Mueller
1. Non-portable: liquid scintillation counter, gas-flow proportional counter

Dosimetry
External: Gamma/beta
Internal: Urinalysis

Part 6 – SAFETY PRECAUTIONS

For emergency procedures, please refer to appendix B. For

general safety precautions, please refer to appendix C.

C-14

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Part 1 – RADIONUCLIDE IDENTIFICATION

Chemical symbol: C	Common name: Carbon	Atomic weight: 14	Atomic number: 6

Part 2 – RADIATION CHARACTERISTICS

Physical half-life: 5.73E+03 years

Radiation type	Most abundant emissions (>10 keV, >0.01%)	Most energetic emissions (>10 keV, >0.01%)	Shielding information (mm)
Gamma & X-ray	None	None	Not an external radiation hazard
Beta(-), Beta(+), electrons	156.5 keV (100%)	156.5 keV (100%)	Practical range in glass: 0.2 Practical range in plastic: 0.3

Part 3 – DOSE RATE CONSTANTS AND COEFFICIENTS

External dose

Dose rate to skin from direct contamination: 0.32 mSv/h per kBq/cm^2
Gamma ray effective dose rate at 1 m: Not applicable

Internal dose

	Ingestion	Inhalation
Worker dose coefficient	5.8E-10 Sv/Bq	2.0E-11 Sv/Bq *

Part 4 – CLEARANCE AND EXEMPTION

CNSC exemption quantity:	10 kBq/g or 10 MBq	**CNSC classification:**	Class C
CNSC unconditional clearance level:	1 Bq/g	**Surface contamination free-release criterion:**	1 Bq/cm^2 (fixed + removable)

Part 5 – DETECTION AND MEASUREMENT

Method of detection (dose rate):
Not applicable

Method of detection (contamination):

1. Hand-held: thick ZnS scintillator with proprietary discrimination, gas-flow proportional, sealed-gas proportional, plastic scintillator, halogen quenched thin window Geiger-Mueller
1. Non-portable: liquid scintillation counter, gas-flow proportional counter

Dosimetry
External: Not applicable Internal:
Urinalysis, lung, feces

Part 6 – SAFETY PRECAUTIONS

For emergency procedures, please refer to appendix B.
For general safety precautions, please refer to appendix C and apply if necessary.
Note: C-14 is primarily an internal hazard.

*Revised $^{14}CO_2$ dose coefficient from Leggett, R.W., Radiation Protection Dosimetry Vol. 208, pp. 203-213 (2004).

Iodine 125 (I-125)

I-125

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Part 1 – RADIONUCLIDE IDENTIFICATION

Chemical symbol: I	Common name: Iodine	Atomic weight: 125	Atomic number: 53

Part 2 – RADIATION CHARACTERISTICS

Physical half-life: 59.4 days

Radiation type	Most abundant emissions (>10 keV, >0.01%)	Most energetic emissions (>10 keV, >0.01%)	Shielding information (mm)
Gamma & X-ray	27.47 keV (74.4%) 27.20 keV (39.9%) 31.00 keV (25.8%)	35.49 keV (6.7%) 31.00 keV (25.8%) 27.47 keV (74.4%)	Lead: 1st HVL = 0.02, 2nd HVL = 0.02, 1st TVL = 0.06, 2nd TVL = 0.04 Steel: 1st HVL = 0.09, 2nd HVL = 0.1, 1st TVL = 0.3, 2nd TVL = 0.3 Concrete: 1st HVL = 3.1, 2nd HVL = 2.8, 1st TVL = 9.5, 2nd TVL = 9.7
Beta(-), Beta(+), electrons	22.70 keV (20.0%) 30.55 keV (10.7%) 34.49 keV (2.13%)	34.49 keV (2.1%) 30.55 keV (10.7%) 22.70 keV (20.0%)	Practical range in glass: <0.1 Practical range in plastic: <0.1

Part 3 – DOSE RATE CONSTANTS AND COEFFICIENTS

External dose

Dose rate to skin from direct contamination: 0.021 mSv/h per kBq/cm^2
Gamma ray effective dose rate at 1 m: 1.449E-05 mSv/h per MBq

Internal dose

	Ingestion	Inhalation
Worker dose coefficient	1.5E-08 Sv/Bq	1.4E-08 Sv/Bq (vapor)

Part 4 – CLEARANCE AND EXEMPTION

CNSC exemption quantity:	1 kBq/g or 1 MBq	**CNSC classification:**	Class C
CNSC unconditional clearance level:	100 Bq/g	**Surface contamination free-release criterion:**	100 Bq/cm^2 (fixed + removable)

Part 5 – DETECTION AND MEASUREMENT

Method of detection (dose rate):

1. Specialized equipment may be required

Method of detection (contamination):

1. Hand-held: NaI scintillator, thick ZnS scintillator with proprietary discrimination
2. Hand-held: halogen quenched thin window Geiger Mueller, gas-flow proportional, sealed-gas proportional, plastic scintillator
1. Non-portable: liquid scintillation counter, NaI well counter

Dosimetry

External: Gamma/beta
Internal: Whole body counting, Thyroid counting, urinalysis

Part 6 – SAFETY PRECAUTIONS

For emergency procedures, please refer to appendix B. For

general safety precautions, please refer to appendix C.

I-131

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Part 1 – RADIONUCLIDE IDENTIFICATION

Chemical symbol: I	Common name: Iodine	Atomic weight: 131	Atomic number: 53

Part 2 – RADIATION CHARACTERISTICS

Physical half-life: 8.03 days
Radioactive progeny: Xe-131 (half-life = 11.84 days, 1%)

Radiation type	Most abundant emissions (>10 keV, >0.01%)	Most energetic emissions (>10 keV, >0.01%)	Shielding information (mm)
Gamma & X-ray	364.49 keV (81.2%) 636.99 keV (7.3%) 284.3 keV (6.1%)	722.91 keV (1.8%) 642.7 keV (0.22%) 636.99 keV (7.3%)	Lead: 1st HVL = 3.9, 2nd HVL = 3.1, 1st TVL = 12, 2nd TVL = 17 Steel: 1st HVL = 32, 2nd HVL = 14, 1st TVL = 64, 2nd TVL = 42 Concrete: 1st HVL = 118, 2nd HVL = 50, 1st TVL = 226, 2nd TVL = 134
Beta(-), Beta(+), electrons	606.31 keV (89.4%) 333.81 keV (7.36%) 45.62 keV (3.5%)	806.87 keV (0.40%) 629.65 keV (0.05%) 606.31 keV (89.4%)	Practical range in glass: 0.9 Practical range in plastic: 1.6

Part 3 – DOSE RATE CONSTANTS AND COEFFICIENTS

External dose

Dose rate to skin from direct contamination: 1.6 mSv/h per kBq/cm^2
Gamma ray effective dose rate at 1 m: 5.471E-05 mSv/h per MBq

Internal dose

	Ingestion	Inhalation
Worker dose coefficient	2.2E-08 Sv/Bq	2.0E-08 Sv/Bq (vapor)

Part 4 – CLEARANCE AND EXEMPTION

CNSC exemption quantity:	100 Bq/g or 1 MBq	**CNSC classification:**	Class B
CNSC unconditional clearance level:	10 Bq/g	**Surface contamination free-release criterion:**	10 Bq/cm^2 (fixed + removable)

Part 5 – DETECTION AND MEASUREMENT

Method of detection (dose rate):

1. Plastic scintillator, ion chamber, ion chamber with window, energy compensated NaI, energy compensated Geiger-Mueller

Method of detection (contamination):

1. Hand-held: thick ZnS scintillator with proprietary discrimination, gas-flow proportional, sealed-gas proportional, NaI scintillator, plastic scintillator, halogen quenched thin window Geiger-Mueller
1. Non-portable: liquid scintillation counter, gas-flow proportional counter, NaI well counter

Dosimetry

External: Gamma/beta
Internal: Whole body counting, thyroid counting, urinalysis

Part 6 – SAFETY PRECAUTIONS

For emergency procedures, please refer to appendix B. For general safety precautions, please refer to appendix C.

Sulphur 35 (S-35)

S-35

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Part 1 – RADIONUCLIDE IDENTIFICATION

Chemical symbol: S	Common name: Sulphur	Atomic weight: 35	Atomic number: 16

Part 2 – RADIATION CHARACTERISTICS

Physical half-life: 87.51 days

Radiation type	Most abundant emissions (>10 keV, >0.01%)	Most energetic emissions (>10 keV, >0.01%)	Shielding information (mm)
Gamma & X-ray	None	None	Not an external radiation hazard
Beta(-), Beta(+), electrons	167.14 keV (100%)	167.14 keV (100%)	Practical range in glass: 0.2 Practical range in plastic: 0.3

Part 3 – DOSE RATE CONSTANTS AND COEFFICIENTS

External dose

Dose rate to skin from direct contamination: 0.35 mSv/h per kBq/cm^2
Gamma ray effective dose rate at 1 m: not applicable

Internal dose

	Ingestion	Inhalation
Worker dose coefficient	7.7E-10 Sv/Bq (organic)	1.2E-10 Sv/Bq (organic)
Worker dose coefficient	1.9E-10 Sv/Bq (inorganic)	1.1E-09 Sv/Bq (inorganic)

Part 4 – CLEARANCE AND EXEMPTION

CNSC exemption quantity:	100 kBq/g or 100 MBq	**CNSC classification:**	Class C
CNSC unconditional clearance level:	100 Bq/g	**Surface contamination free-release criterion:**	100 Bq/cm^2 (fixed + removable)

Part 5 – DETECTION AND MEASUREMENT

Method of detection (dose rate):
Not applicable

Method of detection (contamination):

1. Hand-held: thick ZnS scintillator with proprietary discrimination, gas-flow proportional, sealed-gas proportional, plastic scintillator, halogen quenched thin window Geiger-Mueller
1. Non-portable: liquid scintillation counter, gas-flow proportional counter

Dosimetry
External: Not applicable
Internal: Urinalysis

Part 6 – SAFETY PRECAUTIONS

For emergency procedures, please refer to appendix B. For

general safety precautions, please refer to appendix C.

H-3

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Part 1 – RADIONUCLIDE IDENTIFICATION

Chemical symbol: H	Common name: Tritium	Atomic weight: 3	Atomic number: 1

Part 2 – RADIATION CHARACTERISTICS

Physical half-life: 12.32 years

Radiation type	Most abundant emissions (>10 keV, >0.01%)	Most energetic emissions (>10 keV, >0.01%)	Shielding information (mm)
Gamma & X-ray	None	None	Not applicable
Beta(-), Beta(+), electrons	18.6 keV (100%)	18.6 keV (100%)	Not applicable

Part 3 – DOSE RATE CONSTANTS AND COEFFICIENTS

External dose

Tritium is not an external radiation hazard.

Internal dose

Dose coefficients for tritium were obtained from the CNSC's *Health Effects, Dosimetry and Radiological Protection of Tritium* INFO- 0799, April 2010.

	Ingestion	Inhalation	
Compound type	Unspecified compounds	Tritiated water	Elemental tritium gas
Worker dose coefficient	2.0E-11 Sv/Bq	2.0E-11 Sv/Bq	2.0E-15 Sv/Bq

Part 4 – CLEARANCE AND EXEMPTION

CNSC exemption quantity:	1 MBq/g or 1 GBq	**CNSC classification:**	Class C
CNSC unconditional Clearance level:	100 Bq/g	**Surface contamination Free-release criterion:**	100 Bq/cm^2 (fixed + removable)

Part 5 – DETECTION AND MEASUREMENT

Method of detection (dose rate):
Not applicable

Method of detection (contamination):

1. Hand-held: windowless gas-flow proportional
1. Non-portable: liquid scintillation counter

Dosimetry
External: Not applicable
Internal: Urinalysis

Part 6 – SAFETY PRECAUTIONS

For emergency procedures, please refer to appendix B.

For general safety precautions, please refer to appendix C and apply if necessary.
Note: Tritium is an internal hazard only and cannot generally be detected with handheld equipment. Tritium can also migrate through conventional latex/nitrile gloves and plastic bottles. Tritium can be absorbed through the skin.

4.4. UNSEALED NUCLEAR SUBSTANCE LABORATORY CLASSIFICATION

The licensee shall classify each room, area or enclosure where more than one exemption quantity of an unsealed nuclear substance is used at a single time as:

a) Basic-level if the quantity does not exceed 5 ALI
b) Intermediate-level if the quantity does not exceed 50 ALI
c) High-level if the quantity does not exceed 500 ALI, or
d) Containment-level if the quantity exceeds 500 ALI, or
e) Special purpose if approved in writing by the Commission or a person authorized by the Commission

Except for basic-level classification, the licensee shall not use unsealed nuclear substances in these rooms, areas or enclosures without written approval of the Commission or a person authorized by the Commission.

Nuclear Substance	EQ	ALI	ALI	Basic Level		Intermediate Level		High Level	
	(MBq)	(Inhale)	(Ingest)	(MBq)		(MBq)		(MBq)	
		MBq/yr	MBq/yr	Inhale	Ingest	Inhale	Ingest	Inhale	Ingest
Cadmium 109	1	2.1E+00	1.0E+01	10.50	50.00	105.00	500.00	1050.00	5000.00
Calcium 45	10	8.7E+00	2.6E+01	43.50	130.00	435.00	1300.00	4350.00	13000.00
Carbon 14	10	1.0E+03	3.4E+01	5000.00	170.00	50000.00	1700.00	500000.00	17000.00
Chromium 51	10	5.6E+02	5.3E+02	2800.00	2650.00	28000.00	26500.00	280000.00	265000.00
Cobalt 57	1	3.3E+01	9.5E+01	165.00	475.00	1650.00	4750.00	16500.00	47500.00
Fluorine 18	1	2.2E+02	4.1E+02	1100.00	2050.00	11000.00	20500.00	110000.00	205000.00
Hydrogen 3 (HT)	1000	1.0E+07	-	50000000.00	-	500000000.00	-	5000000000.00	-
Hydrogen 3 (HTO)	1000	1.0E+03	1.0E+03	5000.00	5000.00	50000.00	50000.00	500000.00	500000.00
Hydrogen 3 (OBT)	1000	4.9E+02	4.8E+02	2450.00	2400.00	24500.00	24000.00	245000.00	240000.00
Indium 111	1	6.5E+01	6.9E+01	325.00	345.00	3250.00	3450.00	32500.00	34500.00
Iodine 123	10	9.5E+01	9.5E+01	475.00	475.00	4750.00	4750.00	47500.00	47500.00
Iodine 125	1	1.4E+00	1.3E+00	7.00	6.50	70.00	65.00	700.00	650.00
Iodine 131	1	1.0E+00	9.1E-01	5.00	4.55	50.00	45.50	500.00	455.00
Iron 55	1	2.2E+01	6.1E+01	110.00	305.00	1100.00	3050.00	11000.00	30500.00
Phosphorus 32	0.1	6.9E+00	8.3E+00	34.50	41.50	345.00	415.00	3450.00	4150.00
Phosphorus 33	100	1.5E+01	8.3E+01	75.00	415.00	750.00	4150.00	7500.00	41500.00
Plutonium 239	0.01	6.3E-04	8.0E-02	0.00315	0.40000	0.03150	4.00000	0.31500	40.00000
Sulfur 35 (inorganic)	100	1.8E+01	1.1E+02	90.00	550.00	900.00	5500.00	9000.00	55000.00
Sulfur 35 (organic)	100	1.7E+02	2.6E+01	850.00	130.00	8500.00	1300.00	85000.00	13000.00
Technetium 99m	10	6.9E+02	9.1E+02	3450.00	4550.00	34500.00	45500.00	345000.00	455000.00
Scandium 46	1	4.2E+00	1.3E+01	21.00	65.00	210.00	650.00	2100.00	6500.00
Uranium (Depleted)	0	3.4E-03	1.9E+00	0.017	9.500	0.170	95.000	1.700	950.000
Uranium (Enriched)	0.01	3.3E-03	4.3E-01	0.017	2.150	0.165	21.500	1.650	215.000
Uranium (Natural)	0	3.2E-03	2.1E+00	0.016	10.500	0.160	105.000	1.600	1050.000

GD-52 Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms published by the Canadian Nuclear Safety Commission in May 2010

Note that the appropriate ALI value is the one that best represents the risks associated with the nuclear substance. If it cannot be determined whether the greater risk is related to inhalation or ingestion of the substance, then the most restrictive value should be used.

4.5. CLASSIFICATION OF SELECTED RADIONUCLIDES

CLASS	RADIONUCLIDE				
CLASS A	all alpha emitters and their daughter isotopes				
	Ag-110m	Bi-210	Co-56	Co-60	Cs-134
	Cs-137	I-124	Lu-177m	Mn-52	Na-22
	Po-210	Pu-238	Pu-239	Pu-240	Sb-124
	Sc-46	Sr-82	U-234	U-235	U-238
	V-48	Zn-65			
CLASS B	Au-198	Ba-133	Br-82	Ce-143	Co-58
	Cu-67	Fe-59	Hg-194	Hg-203	1-131
	Ir-I92	La-140	Mo-99	Nb-95	Pa-233
	Ra-223	Re-186	Re-188	Ru-103	Sb-122
	Sm-153	Sr-90	Xe-127	Y-86	Y-90
	Yb-169	Zr-89	Zr-95		
CLASS C	C-11	C-14	Ca-45	Cd-109	Ce-141
	Cl-36	Co-57	Cr-51	Cu-60	Cu-61
	Cu-64	F-18	Fe-55	Ga-67	Ga-68
	Ge-68	H-3	1-123	I-125	ln-111
	In-113m	In-114	K-42	Kr-85	Lu-177
	Mn-52m	Mn-56	N-13	Na-24	Nb-98
	Ni-63	O-15	P-32	P-33	Pd-103
	Pr-144	Pu-241	Rh-106	S-35	Sc-44
	Sn-113	Sr-89	Tc-94m	Tc-99	Tc-99m
	Te-127	Tl-201	V-49	W-181	W-188
	Xe-133	Zn-63			

When using more than one radionuclide in a room, the radionuclide with the lowest contamination limit must be used to determine the limit, Class A, Class B or Class C that applies to the room.

If a radionuclide is not listed in the table, contact the CNSC at 1-888-229-2672.

4.6. LIST OF FEDERAL ACT AND SELECTED CNSC REGULATIONS

The following Federal Act, selected CNSC regulations and documents have been identified relevant to the CNSC licences issued to Western and available on-line at: http://nuclearsafety.gc.ca/eng/acts-and-regulations/acts/index.cfm

- Nuclear Safety and Control Act
- General Nuclear Safety and Control Regulations
- Nuclear Substances and Radiation Devices Regulations
- Radiation Protection Regulations
- Packaging and Transport of Nuclear Substances
- Class II Nuclear Facilities and Prescribed Equipment Regulations
- GD-52 Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms
- G-121 Radiation Safety in Educational, Medical and Research Institutions
- G-129 Keeping Radiation Exposures and Doses "As Low As Reasonably Achievable (ALARA)"
- RD-58 Thyroid Screening for Radioiodine

4.7. LIQUID SCINTILLATION FLUIDS/COCKTAILS/VIALS APPROVED FOR DISPOSAL

- Ecoscint A
- Ecoscint
- Ecoscint H
- Ecoscint O
- Betamax ES
- Cytoscint ES
- Ecolite
- Ecolume
- Bio-Safe II
- Bio-Safe NA
- Econosafe
- Mono Flow 5
- Scintiverse BD Cocktail
- Optifluor
- Microscint 20
- Microscint PS
- Ultima Gold
- OrganicSolv 3
- Envirosafe
- Betaplate Scint
- Ready Safe
- ScintSafe Econo 1
- ScintSafe Econo 2
- Scinti-Safe Plus 50%
- BSC Scintillation Cocktail

4.8. CNSC AUTHORIZED LIST OF SUPPLIERS/SHIPPERS FOR IMPORTING TRITIUM (H-3)

MP Biochemical
29525 Fountain Parkway
Solon, Ohio, 44139 United States of America

Moravek Biochemicals Inc. 577 Mercury Lane
Brea, California, 92821 United States of America

American Radiolabeled Chemicals Inc. 101 Arc Drive
St. Louis, Missouri, 63146 United States of America

Valeant Pharmaceuticals International (formerly ICN) Corporate Headquarters
One Enterprise
Aliso Viejo, California, 92656 United States of America

PerkinElmer Inc. 120 East Dedham St.
Boston, Massachusetts, 02118 United States of America

GE Healthcare Limited 800 Centennial Ave.
Piscataway Township, New Jersey, 08855-1327 United States of America

Please note that Tritium (H-3) ordered from Mandel Scientific and Amersham in the past is now order through Perkin Elmer and GE HealthCare, respectively.

4.9. CNSC EXPECTATIONS FOR RESPONSE DURING SKIN CONTAMINATION EVENT

Canadian Nuclear Safety Commission
Commission canadienne de sûreté nucléaire

DNSR article – CNSC Expectations for Licensee Response During Skin Contamination Events

This article describes the Directorate of Nuclear Substance Regulation's (DNSR) expectations for licensee response to skin contamination incidents. Experience gained over the past several years has shown that most skin contamination incidents, if detected promptly, actually result in relatively low extremity doses. Consequently, continued reporting of incidents which do not result in a significant dose would be unnecessarily burdensome for both licensees and the regulator. As a result, the DNSR is implementing a revised reporting scheme: only incidents in which the dose exceeds 10 percent of the corresponding dose limit must be reported to the licensing officer. In addition, this article provides a standardized method for evaluating skin dose, including detection screening levels to assist licensees in evaluating whether or not a particular incident must be reported.

Irrespective of the requirement to report, all licensees are required to document, record and investigate every skin contamination event to ensure work practices are optimized and to minimize the probability of repeat occurrences.

Response to skin contamination events can be divided into three parts:

- Phase 1 – Measuring the contamination and decontaminating the skin
- Phase 2 – Calculating the skin dose
- Phase 3 – Reporting to the CNSC, if necessary

Reporting skin contamination events to the CNSC is only required for the following circumstances:

1. If a nuclear energy worker (NEW) was calculated to have received an extremity (skin) dose above 50 mSv.
2. If a Non-NEW was calculated to have received an extremity (skin) dose above 5 mSv.

The flow diagrams and appendices on the following pages provide step-by-step instructions on how to respond to skin contamination events.

Please contact your licensing officer if you have any questions regarding your regulatory requirements for event response and event reporting.

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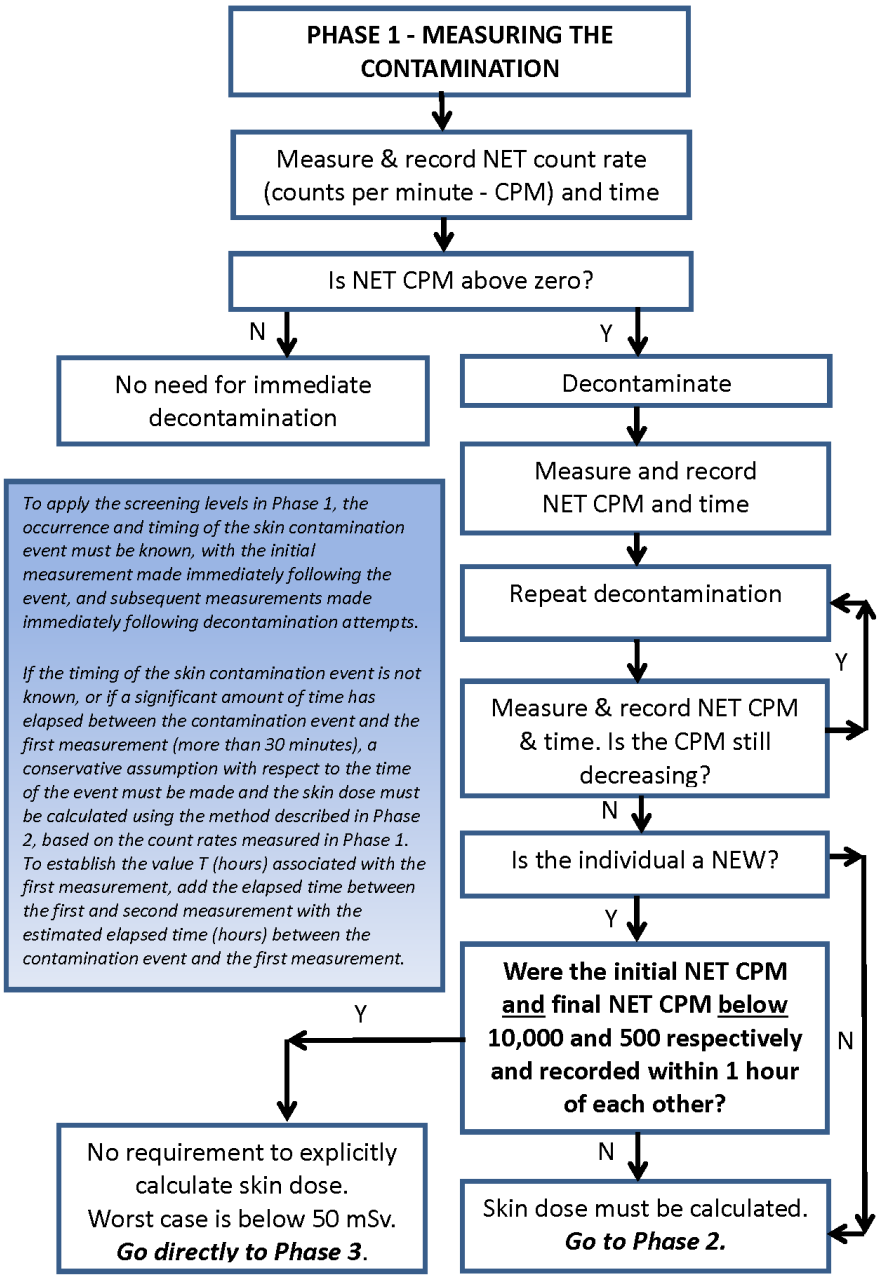
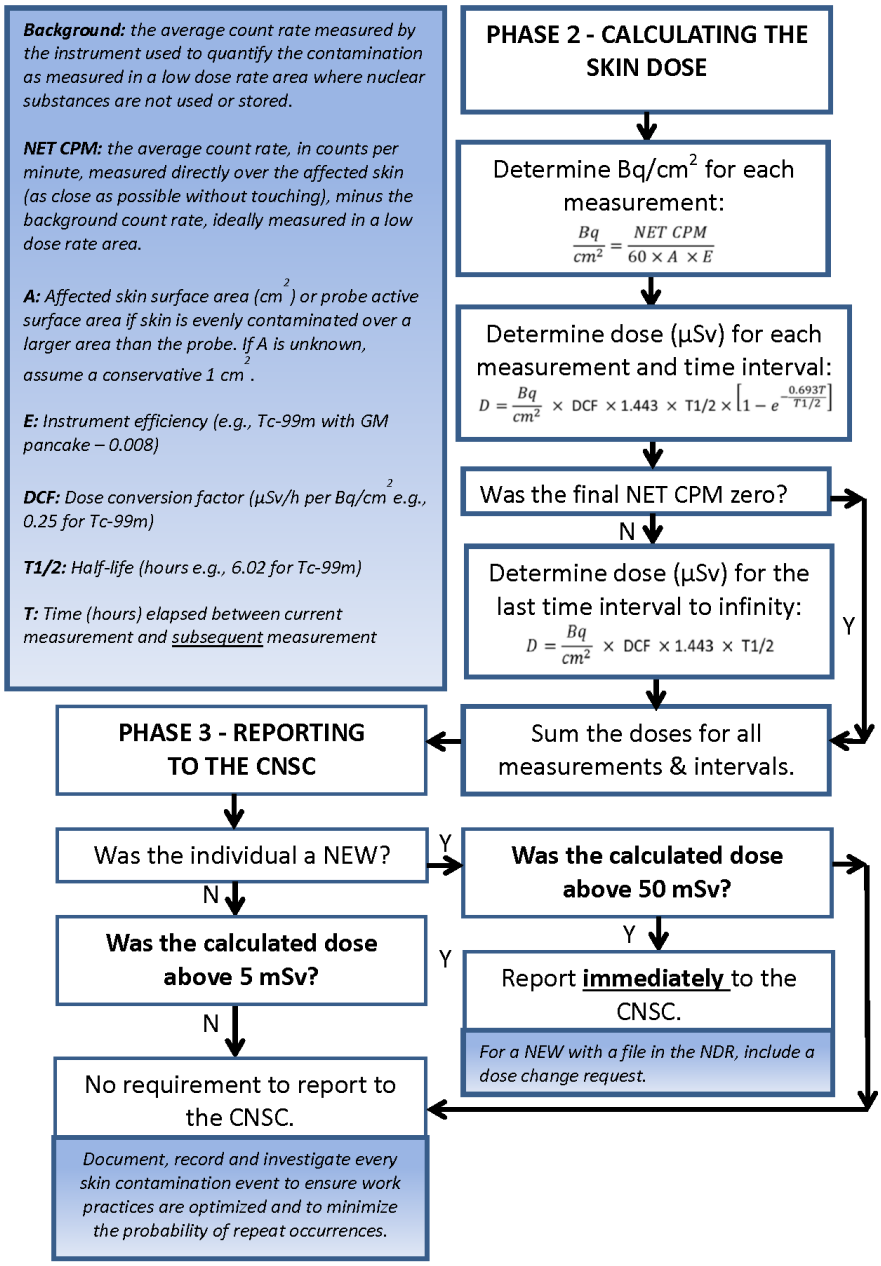

PHASE 1 - MEASURING THE CONTAMINATION
Measure & record NET count rate (counts per minute - CPM) and time
Is NET CPM above zero?
N
Y
No need for immediate decontamination
Decontaminate
Measure and record NET CPM and time
Repeat decontamination
Y
Measure & record NET CPM & time. Is the CPM still decreasing?
N
Is the individual a NEW?
Y
Were the initial NET CPM and final NET CPM below 10,000 and 500 respectively and recorded within 1 hour of each other?
Y
N
N
No requirement to explicitly calculate skin dose. Worst case is below 50 mSv. Go directly to Phase 3.
Skin dose must be calculated. Go to Phase 2.
To apply the screening levels in Phase 1, the occurrence and timing of the skin contamination event must be known, with the initial measurement made immediately following the event, and subsequent measurements made immediately following decontamination attempts.
If the timing of the skin contamination event is not known, or if a significant amount of time has elapsed between the contamination event and the first measurement (more than 30 minutes), a conservative assumption with respect to the time of the event must be made and the skin dose must be calculated using the method described in Phase 2, based on the count rates measured in Phase 1. To establish the value T (hours) associated with the first measurement, add the elapsed time between the first and second measurement with the estimated elapsed time (hours) between the contamination event and the first measurement.


Background: the average count rate measured by the instrument used to quantify the contamination as measured in a low dose rate area where nuclear substances are not used or stored.
NET CPM: the average count rate, in counts per minute, measured directly over the affected skin (as close as possible without touching), minus the background count rate, ideally measured in a low dose rate area.
A: Affected skin surface area (cm²) or probe active surface area if skin is evenly contaminated over a larger area than the probe. If A is unknown, assume a conservative 1 cm².
E: Instrument efficiency (e.g., Tc-99m with GM pancake – 0.008)
DCF: Dose conversion factor (µSv/h per Bq/cm² e.g., 0.25 for Tc-99m)
T1/2: Half-life (hours e.g., 6.02 for Tc-99m)
T: Time (hours) elapsed between current measurement and subsequent measurement
PHASE 2 - CALCULATING THE SKIN DOSE
Determine Bq/cm² for each measurement:
$\frac{Bq}{cm^2} = \frac{NET\ CPM}{60 \times A \times E}$
Determine dose (µSv) for each measurement and time interval:
$D = \frac{Bq}{cm^2} \times DCF \times 1.443 \times T1/2 \times \left[1 - e^{-\frac{0.693T}{T1/2}}\right]$
Was the final NET CPM zero?
N
Y
Determine dose (µSv) for the last time interval to infinity:
$D = \frac{Bq}{cm^2} \times DCF \times 1.443 \times T1/2$
Sum the doses for all measurements & intervals.
PHASE 3 - REPORTING TO THE CNSC
Was the individual a NEW?
Y
N
Was the calculated dose above 50 mSv?
Y
Report immediately to the CNSC.
For a NEW with a file in the NDR, include a dose change request.
Was the calculated dose above 5 mSv?
Y
N
No requirement to report to the CNSC.
Document, record and investigate every skin contamination event to ensure work practices are optimized and to minimize the probability of repeat occurrences.

Appendix 1 – Flow diagram assumptions

1. Any measurement of contamination on the skin should be immediately washed.
2. The skin dose **must** be calculated whenever the incident involves a non-NEW.
3. The calculated skin dose threshold above which immediate reporting to the CNSC is required is **50 mSv** for a NEW and **5 mSv** for a non-NEW.
4. The worst case skin dose resulting from a 10,000 CPM NET measurement followed by a 500 CPM NET measurement after decontamination within one hour is approximately 48.3 mSv (Ga-67 measured with a pancake meter over 1 cm^2, skin decontamination unsuccessful beyond the 500 CPM, and a 27-day exposure). Consequently, the default screening level(s) for which the ascertaining of dose for a NEW is not required is:
    - **Less than 10 000 CPM NET (167 CPS)** on the initial measurement **AND 500 CPM NET (8.3 CPS)** on the subsequent measurement after decontamination efforts when both measurements are taken **within one hour** of each other
      OR
    - **Less than 500 CPM NET (8.3 CPS)** if only one measurement is taken
5. These default values were established based on a worst case combination of isotope and detector. Note that, as illustrated in appendix 2, at these count rates, the dose incurred from isotopes other than Ga-67 would be much less than 50 mSv.
6. Licensees may choose to establish their own screening thresholds for reporting based on the isotopes they use and detection efficiency of their contamination monitors for those isotopes. In general, this would be expected to increase the count rates, at which reporting is required. Licensees who wish to adopt this approach must submit their evaluation of the screening levels to the CNSC for review prior to implementation.

***Note**: Equivalent skin doses that have been ascertained to be above **50 mSv** should result in the licensee submitting a dose change request to the CNSC on behalf of the affected individual to facilitate the addition of the equivalent dose to the skin to their dose of record in the National Dose Registry.*

Appendix 2 – Skin dose calculations

Skin dose conversion coefficients (μSv/h per Bq/cm^2):

C-14	F-18	P-32	Ga-67	Y-90	Tc-99m	In-111	I-123	I-125	I-131	Tl-201
0.32	1.9	1.9	0.35	2.0	0.25	0.38	0.38	0.021	1.6	0.27

Reference: IAEA-TECDOC-1162

10 000 CPM NET - Doses after 1 hour				
Tc-99m	**Ga-67**	**I-131**	**F-18**	**P-32**
4.9 mSv	7.3 mSv	1.8 mSv	1.3 mSv	1.3 mSv
500 CPM NET - Doses after 27 days				
Tc-99m	**Ga-67**	**I-131**	**F-18**	**P-32**
2.3 mSv	41.0 mSv	22.3 mSv	0.2 mSv	22.8 mSv
Total Doses				
Tc-99m	**Ga-67**	**I-131**	**F-18**	**P-32**
7.2 mSv	48.3 mSv	24.1 mSv	1.5 mSv	24.1 mSv

Assumptions used in skin dose calculations

- Instrument used: pancake (Background 50 CPM)
- Measurement efficiencies: Tc-99m 0.8%, Ga-67 0.8%, I-131 15%, F-18 20%, P-32 25%
- Contaminated skin surface area: 1 cm^2