Radiation Safety Manual

Issued by the

Radiation Safety Office

http://safety.dal.ca

Revised July 2011
Radiation Safety Manual

All new staff is expected to become familiar with the material in this document. Please review, date and sign to confirm that you have read the material.

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Telephone Contact Information

1. **Radiation Incidents**

   Radiation Safety Officer: Melissa Michaud  
   494-1938 (office)  
   403-3063 (cell)

   Director of EH&S: Raymond Ilson  
   494-2495/1241

   After hours Security:  
   494-6400

2. **Emergency numbers**

   **EMERGENCIES**: 4109
   Dalhousie Security: 494-6400
   Dalhousie Health Service: 494-2171
   Poison Control: 428-8161

3. **Members of the Radiation Safety Committee (2011)**

   Dr. A. Chatt: 494-2474
   Dr. S. Cameron: 494-3759
   Dr. R. Dunlap: 494-2394
   Dr. K. Hall: 494-2679
   Dr. K. Hewitt: 494-7109
   Dr. D. Hoskin (Chair): 494-6509
   Raymond Ilson: 494-2495/1241
   Melissa Michaud (Secretary): 494-1938
   Ms. K. Murphy: 494-8001
   Dr. N. Ridgway: 494-7133
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GLOSSARY
A. Introduction

The teaching and research activities at Dalhousie University employ numerous and varied sources of radiation in the form of nuclear substances and radiation emitting devices. The policies and procedures described herein are designed to provide a reasonable and practical standard of safety for the use of nuclear substances in the university and to assist in compliance with all applicable regulations and codes as well as the ALARA principle.

This manual is intended to provide a reference to current regulations and to serve as a guide to acceptable methods of practice. It is not intended to serve as an introduction in radiation protection. Workers new to the field are required to register with the Radiation Safety Office, read the Radiation Safety Training Manual, the Radiation Safety Manual and attend the first Radiation Safety Training session offered after beginning work unless otherwise exempted. These Radiation Safety Training sessions are typically held in August/September, December and May. Dates of training sessions for the coming academic year will be posted on the Environmental Health & Safety web site at http://safety.dal.ca. Worker re-training is required every five years. Re-training will be in the form of a Power-Point presentation found on the web site followed by a short quiz, which is submitted to the Radiation Safety Office. Only workers with current training will be listed on approved worker lists.

No set of rules can cover all possible eventualities and workers must exercise sound judgment in all their work.

This manual covers the use of nuclear substances only, although some sections (e.g. radiation exposure limits) will apply to the use of other sources of radiation. Amendments may be made from time to time to reflect changes in the Radiation Safety Program.
B. Regulations

In Canada there are several bodies which have jurisdiction over aspects of the use of ionizing radiation. Under the **Nuclear Safety and Control Act**, the **Canadian Nuclear Safety Commission (hereafter the CNSC)** licenses the acquisition and use of all nuclear substances and certain radiation emitting equipment such as nuclear reactors and accelerators. The **Health Protection Branch** of **Health Canada** and in particular the **Radiation Protection Bureau** formulates regulations relating to the standard of functioning of new radiation equipment under the aegis of the **Radiation Emitting Devices Act**. This group also prepares certain “Safety Codes” to provide for some national guidelines. Many provinces also have their own regulations regarding the use of radiation emitting equipment. In general the recommendations of the **International Commission on Radiological Protection (ICRP)** are used to formulate the rules and conditions under which radiation-emitting devices or nuclear substances are used.
C. Program Organization & Administration

C.1 Administration:

The policies, regulations and procedures of the Radiation Safety program shall apply to all activities involving the use, storage, transportation and disposal of nuclear substances in or on the buildings and grounds of Dalhousie University.

The organization to administer the Radiation Safety Program includes the following:

1. Radiation Safety Committee
2. Radiation Safety Officer
3. Director of Environmental Health & Safety
4. Project Directors (Principal Investigators)
5. Radiation Users

C.2 Policy Statement:

The Radiation Safety Officer is responsible for the day to day operations of the radiation safety program. He/she reports to the Radiation Safety Committee which has the authority to implement and enforce the radiation safety program encompassing the use, handling, storage and disposal of sources of ionizing and non-ionizing radiation in accordance with regulatory requirements of the Canadian Nuclear Safety Commission and provincial and federal standards for the safe use of x-ray emitting devices and lasers.

The Radiation Safety Committee is appointed by and accountable to the Vice-President, Academic and Research.

All faculty, staff and students are expected to take individual responsibility for safe work practices and procedures so as to safeguard their own individual health and well being as well as that of their colleagues.

Committee Membership:

The Committee shall consist of a minimum of four voting members drawn from those engaged in work involving the use of nuclear substances or radiation emitting devices and a minimum of one voting member engaged in work involving the use of Class 3B or Class 4 lasers. Facilities Management and Security will be invited to each appoint a member. In addition, the following shall be non-voting members:

- Radiation Safety Officer (Secretary)
- Director of Environmental Health & Safety
- Building Services Manager, Sir Charles Tupper Medical Building

Committee members are appointed by the Vice-President – Research.
Terms of Reference:

1. Establish and regularly review policies and procedures for the safe use and control of nuclear substances, radiation emitting devices, lasers, and other sources of non-ionizing radiation throughout the university.

2. Assist the Radiation Safety Officer, where necessary, with the preparation and submission of CNSC applications and Annual Compliance Reports.

3. Establish and review worker training programs on an annual basis.

4. Advise the Radiation Safety Officer, if necessary, on the processing of internal permit applications and approval of space and facilities to be used for projects involving those items listed in item (1).

5. Receive reports of any incidents or accidents involving sources of ionizing or non-ionizing radiation, arrange for investigations where warranted and assist the Radiation Safety Officer with the required reporting to appropriate bodies.

6. Monitor necessary action on any action item or directive from regulatory agencies.

7. Order appropriate corrective action in accordance with the university’s Compliance Enforcement Policy.

8. Advise senior management of the need for additional resources to improve the Radiation, X-ray and Laser Safety programs.

9. Conduct an annual audit of the university ALARA program.

10. Maintain written records of meetings, actions, incidents and unusual occurrences along with recommendations.

Reporting Structure:

The Radiation Safety Committee is accountable to the Vice-President. Dalhousie University’s Environmental Health and Safety Committee shall be advised of the Radiation Safety Committee’s proceedings, and in turn may refer matters to the Radiation Safety Committee for consideration or action.

Membership Term:

Committee members will normally be appointed for a three year term. Members may be reappointed to serve subsequent terms.

Chairperson:

The Chairperson shall serve a three year term. The Chairperson will be elected by the voting members.
Meetings:

The Radiation Safety Committee may meet four times yearly – September, December, March and June. Special meetings, however, may be called at any time. The schedule for the year will be established at the September meeting.

Agenda:

Any member may place items on the agenda for discussion. Items for inclusion on the agenda should be received by the Radiation Safety Office at least one week prior to the scheduled meeting to allow time for distribution of relevant documents to committee members.

Conduct of Meetings:

Meetings will be conducted by the Chairperson. In the absence of the Chairperson, voting members in attendance will select a member as acting Chairperson.

Quorum:

At all meetings, a quorum will be one half of the voting Committee membership.

Voting:

The Committee will normally seek to operate by consensus without the need for formal votes. When a member requests a formal vote, a motion will be carried when supported by a simple majority of the voting members.

C.3 Radiation Safety Officer

The Radiation Safety Officer (RSO) is a technically qualified officer of the university experienced in the nature and use of radiation. The RSO is responsible for the daily operations of the Radiation Safety Office. This office performs the executive functions of the Radiation Safety Committee and carries out the following responsibilities:

1. Over-all administration of the university Radiation Safety Program,

2. implementation of approved policies and procedures forming part of the universities Radiation Safety Program, including training and dispersal of information,

3. maintenance of current awareness of developments in the field of radiation protection in order to make appropriate recommendations for modification of the Radiation Safety Program for the university,

4. liaison with the municipal, provincial, and federal authorities concerned with radiation safety, and with RSO’s at other institutions,

5. review all applications for permits to use nuclear substances and other radiation sources prior to submission to the Radiation Safety Committee,
6. arrange periodic surveys of laboratories, facilities and work places for radiation levels and contamination. **The RSO has the authority to suspend operations which are considered unsafe,**

7. maintain records, including inventories, permits, personal exposures, purchases and disposition of nuclear substances and radiation emitting devices, an up to date list of all rooms where nuclear substances are used or stored, an inventory of all sealed sources, an inventory of all portable monitoring devices and a list of all personnel using/handling nuclear substances or radiation emitting devices,

8. advise and consult with members of the university community in matters of radiation safety when required,

9. any other function assigned by the Radiation Safety Committee, the VP-Academic & Research, or the President.

C.4 **Director of Environmental Health & Safety (EH&S):**

The Director of EH&S has a general responsibility for safety related matters on campus. The specific responsibility for radiation safety, however, rests with the RSO, who may call on the Director of EH&S for assistance, as is often the case when potential radiation hazards occur in combination with other hazards such as biological or chemical hazards. The RSO will inform the Director of EH&S of any incident or emergency involving radiation and may request assistance with its management.

C.5 **Project Directors (Principal Investigators):**

Project Directors are those holding permits or licences for the use of nuclear substances or radiation emitting devices in their work. **They are responsible to the university for the safe use of such materials or devices by all persons under their supervision and for ensuring that these persons under their supervision receive adequate instruction in radiation safety as approved by the Radiation Safety Committee.**

**Responsibilities:**

1. Ensure that conditions of the permit are fulfilled and that safe laboratory practices are followed.

2. Ensure that all staff using nuclear substances have been authorized to use nuclear substances and are listed as approved workers on the Nuclear Substance User permit.

3. Ensure that all staff using nuclear substances has been issued (if required), and use, a TLD and participate in bioassay programs as required.

4. Ensure that required personal protective equipment (PPE) is provided and used. PPE includes lab coats and disposable gloves and may also include (if indicated) whole body TLD’s, extremity TLD’s, and eye protection.
5. Designate specific work and storage areas for nuclear substances and ensure that these areas are kept **clean, properly labeled, ventilated, adequately shielded and secure from unauthorized removal of nuclear substances.**

6. Ensure that **all** staff using nuclear substances receives required radiation safety training from the institution and have been informed of the risks associated with exposure to ionizing radiation. Female staff **shall** be advised of the university’s **Prenatal Exposure Policy.**

7. Ensure that functional survey instrumentation is available to monitor both for exposure and contamination and that survey meters are calibrated annually as required by the CNSC under regulatory documents.

8. Maintain all required records as outlined in Dalhousie University’s **Record Keeping Requirements** policy in the binder provided by the Radiation Safety Office unless otherwise exempted by the RSO. Records must be maintained for a minimum of six (6) years. Prior to disposal authorization must be received from both the RSO and the CNSC.

9. Report all radiation incidents to the RSO,

10. Ensure that a responsible **designated alternate,** approved by the RSO, is available to oversee nuclear substance work during your short or extended absences.

### C.6 Nuclear Substance Users:

Nuclear substance users are all persons whose work involves the use of nuclear substances or radiation emitting devices, whether or not they are project directors, are trained to carry out licensed activities, and are listed on the approved worker list as generated by the Radiation Safety Office.

#### Responsibilities

1. Become familiar with and comply with the University’s and any local lab safety regulations.

2. Work in such a manner as to minimize exposure to yourself and your fellow workers.

3. Follow the three (3) basic radiation safety principles, **time, distance, shielding.**

4. Practice **ALARA.**

5. Report to your supervisor any incident involving a known or suspected radiation exposure, personal contamination or a spill exceeding permissible limits.

6. Carry out required weekly contamination checks, and decontaminate if necessary.

7. A female worker **shall** inform her supervisor and/or the RSO in writing of her pregnancy as soon as she becomes aware of it.
D. Radiation Safety Policies

D1. ALARA Statement

ALARA is an acronym for As Low As Reasonably Achievable, means making every reasonable effort to maintain exposures as far below the regulated dose limits as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licence material in the public interest.

The current system of radiological protection reflected in the International Commission on Radiological Protection (ICRP) Publication 60 "1990 Recommendations of the International Commission on Radiological Protection" and the National Council on Radiological Protection (NCRP) Publication 116, "Limitation of Exposure to Ionizing Radiation" is based on three general criteria:

I. Justification, the need to justify any activity which involves radiation exposure on the basis that the expected benefits to society exceed the overall societal detriments.

II. Optimization, the need to ensure that the benefits of such justifiable activities or practices is maximized for the minimum associated societal detriment, economic and societal factors being taken into account.

III. Dose and Risk Limitation, the need to apply dose limits to ensure that individuals or groups of individuals do not exceed acceptable levels of risk.

Dalhousie University is committed to maintaining radiation exposures to staff, students, and the public, resulting from the use of nuclear substances and radiation emitting devices in diagnostic, therapeutic and research procedures, as low as is reasonably achievable, ALARA. The Radiation Safety Committee and the Radiation Safety Officer will advise and assist in all matters of radiation safety. The Committee will recommend to University administration through the Radiation Safety Office, policies and procedures to be required for maintaining radiation exposures ALARA through safe handling, storage, use, transport and disposal of radiation sources and will assist in the interpretation of the Nuclear Safety & Control Act, Regulations and Licence conditions.

Sources of radiation include materials or equipment which are capable of emitting ionizing radiation. Ionizing radiation sources include nuclear substances, nuclear reactors, particle accelerators, x-ray machines and electron microscopes. Policies and procedures are delineated in the Dalhousie University, Radiation Safety manual.
Introduction:

ALARA an acronym for As Low As Reasonably Achievable, means making every reasonable effort to maintain exposures as far below the regulated dose limits as practical consistent with the purpose for which the licenced activity is undertaken, taking into account the state of technology, the economics of improvements in relation to the state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licenced materials in the public interest.

The current system of radiological protection reflected in the International Commission on Radiological Protection (ICRP) Publication 60 “1990 Recommendations of the International Commission on Radiological Protection” and the National Council on Radiological Protection (NCRP) Publication 116 “Limitation of Exposure to Ionizing Radiation” is based on three criteria.

I. **Justification** - the need to justify any activity which involves radiation exposure on the basis that the expected benefits to society exceed the overall societal detriments

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III. **Dose and Risk Limitation** - the need to apply dose limits to ensure that individuals or groups of individuals do not exceed acceptable levels of risk

Administration Commitment:

a) The administration of Dalhousie University is committed to the program described herein for keeping individual and collective doses as low as reasonably achievable. In accord with this commitment we hereby describe an administrative organization for radiation protection and will develop policies, procedures and instructions to foster the ALARA concept. The organization will be comprised of a Radiation Safety Committee and a Radiation Safety Officer (RSO).
b) An annual review of the radiation safety program will be performed. This review will include operating procedures, past personnel dose records, inspections, laboratory self-audits, training and consultation with the RSO.

c) Modifications to operating, maintenance, and experimental procedures as well as changes in equipment and facilities will be made if they will reduce exposures unless the cost, in our judgement, is considered unjustified. If modifications have been recommended but not implemented, we will be prepared to justify the reasons for not implementing them.

d) The Radiation Safety Committee will meet quarterly to review the **ALARA** program with a formal written annual report submitted no later than one month after the end of the calendar year.

**Obligations of Licensees**

a) Ensure the presence of a sufficient number of qualified workers to carry on the licensed activity safely and in accordance with the **Nuclear Safety and Control Act** (the Act), the regulations made under the Act and the **Nuclear Substances and Radiation Devices Licence**

b) Train workers to carry on the licensed activity in accordance with the Act and regulations

c) Take all reasonable precautions to protect the environment and the health and safety of persons and to maintain security

d) Provide the devices required by the Act and regulations and maintain them within the manufacturer's specifications

e) Require that every person at the site of the licensed activity uses equipment, devices, clothing and procedures in accordance with the Act and regulations

f) Take all reasonable precautions to control the release of radioactive nuclear substances or hazardous substances within the site of the licensed activity and into the environment as a result of the licensed activity

g) Implement measures for alerting the licensee to the illegal use or removal of a nuclear substance, prescribed equipment or prescribed information, or the illegal use of a nuclear facility

h) Implement measures for alerting the licensee to acts of sabotage or attempted sabotage anywhere at the site of the licensed activity

i) Instruct the workers on the physical security program at the site of the licensed activity and to their obligations under that program

j) Keep a copy of the Act and the regulations made under the Act that apply to the licensed activity readily available for consultation by the workers
These obligations are tasked to the Radiation Safety Committee to be carried out by the Radiation Safety Officer.

**Obligations of Workers:**

a) Use equipment, devices, facilities and clothing for protecting the environment or the health and safety of persons, or for determining doses of radiation, dose rates or concentrations of radioactive nuclear substances, in a responsible manner and in accordance with the Act, the regulations made under the Act and the Nuclear Substance User Permit (permit).

b) Comply with the measures established by the licensee to protect the environment and the health and safety of persons, maintain security, control the levels and doses of radiation, and control releases of radioactive nuclear substances and hazardous substances into the environment.

c) Promptly inform the licensee or the worker’s supervisor of any situation in which the worker believes there may be:

- A significant increase in the risk to the environment or the health and safety of persons
- A threat to the maintenance of security or a incident with respect to security
- A failure to comply with the Act, the regulations made under the Act or the permit
- An act of sabotage, theft, loss or illegal use or possession of a nuclear substance, prescribed information, or
- A release into the environment of a quantity of a radioactive nuclear substance or hazardous substance that has not been authorized by the licensee
- Observe and obey all notices and warning signs posted by the licensee in accordance with the *Radiation Protection Regulations*, and
- 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.


ALARA Procedures:

The Radiation Safety Committee will delegate authority to the RSO for enforcement of these procedures. The Radiation Safety Committee will support the RSO when necessary in asserting his/her authority. If the Radiation Safety Committee overrules the RSO, it will record the basis for its action in the minutes of the quarterly meeting.

All occupationally exposed workers will be provided with a copy of the ALARA policy. It will be made available to each research group as part of the Radiation Safety Policies and will be available for review on the EH&S web site at http://safety.dal.ca/

All new occupationally exposed workers will participate in the first available Radiation Safety Training course available after joining a research group, unless otherwise exempted by the RSO. The Radiation Safety Training course is held three times annually, typically in May, September and December.

The RSO will thoroughly review the qualifications of each principal investigator with respect to the types and quantities of nuclear substance requested, methods of use, suitability of laboratory space, availability of required shielding, dosimetry, and monitoring equipment.

The RSO will thoroughly review all planned laboratory construction and renovation prior to submission of plans to the Canadian Nuclear Safety Commission (CNSC) to ensure that the requirements of CNSC’s Regulatory Document GD-52 “Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms” are met.

The RSO will review quarterly the occupational radiation exposures of all monitored workers. Dalhousie University sets exposure limits action level of one third the maximum limit in any quarter is set. If an action level is exceeded the RSO will conduct an investigation and decide if action is warranted. These limits apply to combined external and internal exposures.
Licence conditions require that removable contamination does not exceed nuclear substance-specific limits on accessible surfaces in occupational and public areas. Nuclear substances are assigned classifications as follows:

- **Class A** - typically long lived and emit alpha radiation
- **Class B** - typically long lived and emit beta or gamma radiation
- **Class C** - typically short lived and emit beta and gamma radiation

At Dalhousie University Class B & C nuclear substances are typically used. In keeping with an ALARA policy contamination limits are set at regulatory limits, however every effort should be made to maintain contamination levels below the **2-3 times background** “rule of thumb”. Contamination limits are based on activity per square centimetre.

<table>
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<tr>
<th>Class</th>
<th>Control Area Limit</th>
<th>Public Area/Decommissioning Limit</th>
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<tr>
<td>A</td>
<td>3 Bq/cm²</td>
<td>0.3 Bq/cm²</td>
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<td>B</td>
<td>30 Bq/cm²</td>
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<tr>
<td>C</td>
<td>300 Bq/cm²</td>
<td>30 Bq/cm²</td>
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Apply the **Compliance Enforcement Policy** as required

Each research group will be required to conduct a nuclear substance laboratory self-audit on a twice yearly basis, in May and November. These audits will be reviewed by the RSO and appropriate corrective action taken within one week of receipt of audit. The Radiation Safety Officer shall conduct a series of verification inspections twice annually to comply with Dalhousie University’s Quality Assurance Policy.
The status of all Nuclear Substance User Permits will be reviewed annually. If no work with nuclear substances has been performed and no inventory is on hand the Principal Investigator will be given the option of:

a) Decommissioning the laboratory by following the procedure as set out in Dalhousie University’s "Policy for the Termination of Nuclear Substance Use - Renovations, Remodels, Moves, and Terminations".

b) Placing their permit as "inactive". To do so would require that the most recent wipe test result be submitted to the Radiation Safety Office and all signage be removed.

If no work with nuclear substances has been performed and inventory is on hand the P.I. will be required to change their permit to a "storage only" status. To do so would require that the most recent wipe test result be submitted to the Radiation Safety Office.
Title: Transfer/shipment of nuclear substances and/or radiation devices

Number: RSP - 004

Date: December 7, 2005

Transfers of nuclear substances and/or radiation devices are permitted. Transfers from one permit holder to another within the same department is permitted by making the appropriate notations on respective inventory control sheets. A transfer form is not required. Transfers from one permit holder to another in different departments or different physical locations on campus are permitted provided the material falls under the category "excepted radioactive material, limited activity". In this case a transfer form is required along with the appropriate notations on respective inventory control sheets.

Transfers of nuclear substances and/or radiation devices that do not fall into the above category but will remain on campus must be coordinated by the Radiation Safety Officer. The RSO will have the required TDG training.

Transfers of nuclear substances and/or radiation devices to another licensee must be coordinated by the RSO. The RSO will determine through contact with the RSO at the receiving institution whether the shipment can be transported to and received by the licensee.

Prior to any transfer of nuclear substances and/or radiation devices to Dalhousie University from another licensee approval to receive must be granted by the RSO.
Title: Thyroid Screening/Bioassay Policy

Number: RSP - 006

Date: December 1983

The CNSC requires:

1. Under condition 2046-11 of our licence
   
   Every person shall undergo thyroid screening within five days who:
   
   (a) uses in a 24-hour period a quantity of 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;
   (iv) any other quantity in other containment approved in writing by the Commission or a person authorized by the Commission; or

   (b) is involved in a spill of greater than 2 MBq of Iodine-125 or Iodine-131; or

   (c) on whom Iodine-125 or Iodine-131 external contamination is detected

2. Under condition 2600-3 of our licence

   Screening for internal iodine-125 and iodine-131 shall be performed using:

   (a) direct measurement of the thyroid with an instrument that can detect 1 kBq of iodine-125 or iodine-131; or

   (b) a bioassay procedure approved by the Commission or a person authorized by the Commission.

3. Under condition 2601-6 of our licence

   If thyroid screening detects more than 10 kBq of iodine-125 or iodine-131 in the thyroid, the licensee shall immediately make a preliminary report to the Commission or a person authorized by the commission and have bioassay performed within 24 hours by a person licensed by the Commission to provide internal dosimetry.
Procedure:

1. The Radiation Safety Office shall be notified 24 hours in advance of a radioiodination.

2. Items b, c, d, and e of the Nuclear Substance User permit “Special Conditions” shall be strictly adhered to.

3. Personnel shall report to the Radiation Safety Office with 48 hours of the radio-iodination for routine thyroid screening. If amounts of iodine-125 or iodine-131 meet or exceed those limits as referenced in condition 2601-6 of the university consolidated licence a thyroid bioassay must be performed within 24 hours by a person licensed by the Commission to provide internal dosimetry.

4. Personnel must report any spill or external personal contamination to the Radiation Safety Office immediately.
Title: Compliance Enforcement Policy

Number: RSP - 007

Date: 2000, reviewed 12/05, revised 08/07

Introduction:

Dalhousie University is issued a Nuclear Substances and Radiation Devices Licence by the Canadian Nuclear Safety Commission (CNSC) for the possession, use and importation of nuclear substances or devices containing nuclear substances.

The Nuclear Substances and Radiation Devices Licence is a single broad-scope licence issued by the CNSC to an institution having many users of nuclear substances who are primarily in one location. The application for and issuance of a consolidated licence to an institution rather than to each individual nuclear substance user emphasizes to the institution its responsibility for a radiation safety program.

Upon issue of this licence the university assumes the responsibility to ensure that any use of nuclear substances on campus complies with the Nuclear Safety & Control Act and regulations made under the Act, IAEA regulations (Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), being Safety Standards Series No. TS-R-1 (ST-1, Revised), as well as conditions that apply to the licence.

The CNSC requires the following three components are in place:

1. Radiation Safety Committee
2. Radiation Safety Officer

Although the Radiation Safety Officer is responsible for the day to day operations of the radiation safety program he/she reports to the Radiation Safety Committee which has the authority to implement and enforce the radiation safety program encompassing the use, handling, storage and disposal of nuclear substances. The Radiation Safety Committee is appointed by and accountable to the Vice-President, Academic and Research.

The institution is visited annually by compliance inspectors from the CNSC to ensure that the above regulations and conditions are being met by nuclear substance users. The CNSC has the ultimate authority to withdraw nuclear substance user privileges if serious violations are observed. A serious violation by one user could affect all those who use nuclear substances under Dalhousie University’s licence.
COMPLIANCE AUDIT POLICY

The Radiation Safety Officer will visit each lab to which a nuclear substance user permit is issued, at a minimum annually. The visit will be unannounced. In keeping with the university Quality Assurance policy a minimum of 50% of all labs will undergo a comprehensive verification check of their submitted self-audits in May and November. Violations will be categorized as either major or minor offences.

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 Nuclear Substances and Radiation Devices Licence in jeopardy. Examples of a major offence would include:

a) contamination above licence criteria  
b) inadequate monitoring program  
c) use or storage of food or drink in the laboratory  
d) inadequate training of new staff  
e) non-participation in required bioassay programs  
f) refusal to wear required PPE (personal protective equipment)  
g) inadequate security measures to safeguard nuclear substances

A minor offence would be an infraction which poses no immediate risk or threat to health, safety, the environment or the licence. Examples of a minor offence would include:

a) inadequate signage  
b) inadequate posting (permit, Dalhousie posters)  
c) inadequate inventory record  
d) frivolous use of signage  
e) failure to wear required PPE
MAJOR OFFENCE ACTIONS

1. On the **first** occurrence written notification will be sent to the permit holder, with a copy to the department head, outlining the nature of the offence. Immediate attention to and correction of the violation is required.

2. On a **second** occurrence within a twelve month period the permit holder will be notified in writing that the permit will be revoked until a meeting can be held with the Radiation Safety Committee. The permit holder may attend the meeting to explain why his/her permit should be renewed.

3. On a **third** occurrence within a twelve month period the permit will be cancelled and all inventory disposed of by the Radiation Safety Office.

   For the second or third occurrences notification of the above actions will be copied to the department head and the Dean.

MINOR OFFENCE ACTIONS

1. On the **first** occurrence, the permit holder will be notified verbally by the Radiation Safety Officer of the violation observed.

2. On a **second** occurrence within a twelve month period the Radiation Safety Officer will send written notification of the observed violation to the permit holder, with copies to the department head and the Radiation Safety Committee.

3. On a **third** occurrence, within a twelve month period the Radiation Safety Officer will arrange to have the permit transferred to the Head of the department in which the permit holder does the majority of his/her work. If the department head agrees to assume responsibility all work will be under his/her direct control. The department head’s signature **must** appear on all purchase requisitions. Written notification of the above action will be sent to the Dean of the faculty.

4. On a **fourth** occurrence within a twelve month period the permit will be revoked. A meeting may be requested by the permit holder with the Radiation Safety Committee at which time the permit holder may argue as to why the permit should be renewed.

   Minor offences must be corrected within seven (7) calendar days.
Introduction:

Every pregnant woman and her developing fetus are exposed to some risks affecting their well being. These risks may be voluntary or involuntary and avoidable or unavoidable on the part of the mother. They include the ingestion of alcohol, tobacco smoke, prescription and non-prescription drugs, dietary and environmental agents and exposure to ionizing radiation from non-medical sources.

In utero radiation exposure of the embryo causes intense anxiety among parents and the public in general. Too often, pregnant women and their families are frightened by careless statements made with little or no regard of the actual facts.

Those of you who work in or visit areas where nuclear substances are used need to understand the biological risks radiation presents to your unborn child.

The fetus passes through three relatively clear cut phases. In each of which the type and magnitude of an effect that can be produced by radiation will differ. They are:

**Preimplantation**

This period begins with fertilization and ends with implantation in the uterus. this stage is complete at 10 days. There are few epidemiologic data available for this period of gestation. During preimplantation, irradiation of animals appears to lead to “all or none” effects. X-ray doses of 2 Gy in mice result in a high incidence of embryonic death; however, those that survive appear to be normal. It is possible that spontaneous abortions increase slightly during this early time period; however, this increase has been too small to quantitate accurately. The “normal” incidence of spontaneous abortion in humans may be as high as 30-50%.

**Organogenesis**

The period of organogenesis is usually divided into early and late portions. The early organogenesis period is 15-28 days after conception, whereas late organogenesis refers to the time 29-50 days after conception. During early organogenesis, the embryo is sensitive to lethal, teratogenic and growth-retarding effects because of the criticality of cellular activities and the high proportion of radiosensitive cells. Irradiation at this time may lead to severe developmental defects. Effects in animals can be seen down to 100 mSv. Human embryos exposed to similar doses at Hiroshima and Nagasaki, however, did not exhibit any increase in frequency of developmental defects.
**Fetal Stage**

Animal experiments suggest that irradiation is less likely to lead to developmental anomalies after the first two months of gestation. The only human data available are drawn from pregnant survivors of Hiroshima and Nagasaki, where reduced head size and mental retardation were the developmental abnormalities noted after whole body exposures exceeding 500 mSv. There is also thought to be an increased risk of childhood cancer. The “natural” incidence of childhood cancer including leukemia, up to the age of ten years is 6 per 10,000. The added risk of cancer including leukemia from exposure during pregnancy is 2-6 per 10,000 per 10 mSv over the first ten years of life. The best estimate of risks associated with prenatal exposure to radiation suggests that the overall risk lies in the range of 0-1 cases per 1000 irradiated by 10 mSv in utero, which is at least 30 times lower than the natural level of occurrence of serious handicaps in average pregnancies.

The vast majority of occupationally exposed radiation workers at Dalhousie University receive annual whole body exposures of less than 1 mSv.

**Fetal Exposure and the Nuclear Safety and Control Act:**

The International Commission on Radiological Protection (ICRP) regularly reviews the biological evidence of the detrimental effects of ionizing radiation and publishes appropriate recommendations regarding acceptably safe practices for the exposure of occupational workers, patients undergoing treatment/diagnosis and for members of the public. In Canada these recommendations have been incorporated into law in the *Nuclear Safety and Control Act*. The law is administered by the *Canadian Nuclear Safety Commission* and enforced locally by the Dalhousie University Radiation Safety Committee. The *Nuclear Safety and Control Act* requires that the dose to the pregnant Nuclear Energy Worker after the licensee is informed of the pregnancy of that worker shall not exceed 4 mSv. The vast majority of occupationally exposed radiation workers at this institution receive annual whole body exposures of less than 1 mSv. Thus a pregnant worker exposed to the levels of radiation which would normally be encountered at Dalhousie is well within the levels of radiation exposure as defined in the *Nuclear Safety and Control Act* and the probability of harm occurring to the fetus is considered to be extremely small in comparison to the incidence of “spontaneous” genetic and developmental abnormalities.

**RESPONSIBILITIES OF FEMALE RADIATION WORKERS:**

1. Where a pregnant nuclear energy worker becomes aware of her pregnancy, she shall immediately inform Dalhousie University in writing of her pregnancy.

**RESPONSIBILITIES OF DALHOUSIE RADIATION SAFETY COMMITTEE:**

1. An assessment of the work situation shall be done to ensure that radiation safety principles are being adhered to and that radiation dose limits are not exceeded and remain as low as reasonably achievable (ALARA).

2. Radiation exposures of pregnant Nuclear Energy workers shall be monitored to ensure that the dose limit of 4 mSv for the balance of the pregnancy is not exceeded in accordance with the Nuclear Safety and Control Act.
**DECLARATION OF PREGNANCY FORM**

I declare that I am pregnant, for the purposes of lowering the dose received by me and/or my embryo/fetus. I understand and agree that additional monitoring may be required of me during the balance of my pregnancy to ensure that the dose limit of 4 mSv is not exceeded.

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Title: Purchasing Policy  
Number: RSP - 009  
Date: October 1997, reviewed 12/05

Introduction

Following two incidents in which radioactive materials were fraudulently obtained and informal licensee reports of weaknesses in the control of the purchase and receipt of radioactive materials, staff of the Materials Regulation Division (MRD) of the Atomic Energy Control Board convened a small workshop with an invited group of knowledgeable and experienced licensees.

Although there are regulatory principles and licence conditions governing this issue, there is no common standard. Consequently, each licensee has developed their own approach. Some have developed and implemented comprehensive processes while others have kept the process very simple. This leads to institutional procedures which are highly variable in their design and operation and, to some degree, in their effectiveness.

Purchase Procedure:

1. Purchase requisitions for radioisotope purchases will be issued by the Radiation Safety Office.

2. All orders for radioactive materials will be placed by the Purchasing department.

3. Requests for radioactive materials must be faxed to the Radiation Safety Office for approval prior to the order being placed. To ensure same day ordering the fax must reach the Radiation Safety Office (fax 494-2996) no later than 3:00 pm. It will be necessary to include on the requisition, information including product number, nuclear substance ordered and activity required. **Orders for a nuclear substance not listed on an individual permit will not be processed.**

4. Approved radioisotope purchase requisitions will be faxed to Purchasing for processing completion.
Introduction:

Dalhousie University uses nuclear substances under conditions set down by a licence issued by the Canadian Nuclear Safety Commission. Waste disposal is among the many facets of nuclear substance use governed by this licence. Failure to observe the disposal procedures set out below risks harming people or the environment, licence cancellation and even prosecution.

Categories of Radioactive Waste:

1. **Dry Waste**
   
   Includes dry solid materials, dehydrated biological materials, and contaminated papers, glassware, gloves or apparel.

2. **Liquid Waste**
   
   Includes liquid nuclear substances, solutions, contaminated rinses, and liquid scintillation cocktail. Liquid wastes are further categorized as *aqueous* and *non-aqueous*.

   Aqueous wastes are those considered readily soluble in water.

   Non-aqueous wastes are those liquids which are not readily soluble in water. These liquids include organic based liquid scintillation fluids.

3. **Biological Waste**
   
   Includes animal carcasses, bedding, solid excreta, tissue, organs, blood, etc...

4. **Sharps**
   
   Includes contaminated broken glass, needles, razor blades, scalpels, etc...
**Disposal and Packaging Procedures:**

**Dry (solid) Waste**

Solid waste containing nuclear substances **shall** be packaged in the radioactive waste storage boxes available through Tupper stores. These boxes are provided with a two part transfer form which must be completed. Copy 1 remains as the laboratory record of disposal. Copy 2 accompanies the box to storage. Boxes must be lined with a **clear** garbage bag. Arrangements are made with the Radiation Safety Officer to transport the waste to the appropriate decay room in either Tupper or the Life Sciences Centre. Transfer form accompanying the box must contain the following information:

i) lab of origin  
ii) permit #  
iii) date of transfer  
iv) nuclear substance(s) contained  
v) approximate activity  
vi) name of individual who packaged box  

Every effort should be made to segregate wastes by nuclear substance, though provisions may be made to mix **short lived** waste (T ½ of less than 90 days). Boxes found to be packaged incorrectly will be returned to the lab of origin for re-packaging.

* Labs with sufficient storage space may opt to store waste for decay in their own laboratory. Prior approval must be granted by the RSO and the P.I. must demonstrate that prior to any decayed waste being released a survey is completed to ensure decay to background. All radiation trefoils must be removed prior to release.

Arrangements may also be made to transfer empty “pigs” to the storage rooms.

**Liquid Waste**

I. **Aqueous Liquid Waste**

Aqueous liquid waste containing nuclear substances must be decanted to the color-coded 1 gallon bottles provided by the Radiation Safety Office. Bottles will be color coded as such:

- Short lived nuclear substances  
  T ½ < 30 days - MAGENTA  
- Medium lived nuclear substances  
  T ½ 30 days to 90 days - GREEN  
- Long lived nuclear substances  
  T ½ > 90 days - YELLOW

When full, arrangements must be made with the Radiation Safety Officer to transport the aqueous liquid waste to the appropriate decay room. The outside of the bottle must be clean and free of wet or dried liquids.

All information must be included on the bottle tag provided.
II Non-aqueous Liquid Waste

Liquid scintillation cocktails need not be drained from their counting vials, but rather placed intact in a plastic bag lined cardboard box. The box must be appropriately labeled as to contents including the following information:

- a) lab of origin
- b) nuclear substance
- c) solvent
- d) estimated activity
- e) name of person packaging waste

Arrangements should be made with either the Radiation Safety Office or the Environmental Health and Safety Office for collection. Boxes found to contain materials other than counting vials and their contents will be returned to the lab of origin for repackaging.

Biological Waste

Arrangements for disposal of radioactive contaminated biological waste should be made through the Radiation Safety Office and the Animal Care Facility. As all biological waste must be shipped for incineration, provisions should be made for refrigerator or freezer storage until arrangements can be made for shipment. Prior to shipment it must be demonstrated that the activity present meets regulatory requirements.

Sharps

Sharps as defined earlier must be packaged in an approved sharps container for collection and subsequent disposal.

RESPONSIBILITIES:

Principal Investigators

In accordance with this procedure and permit conditions the principal investigators are responsible for the collection of all radioactive waste arising from activities under their direction:

- a) Determining the waste activity and for separating waste by category
- b) Assuring that the radioactive contents do not exceed the indicated quantity.
- c) Ensuring that all packaging and disposal procedures are accurately followed. Waste found inappropriately packaged will be the responsibility of the lab of origin to re-package.
- d) Maintaining accurate records of disposal routes for all nuclear substances purchased against their Nuclear Substance User Permit.
Radiation Safety Officer

The Radiation Safety Officer is responsible for:

a) Developing policy and procedures for the safe storage, collection, and processing of radioactive waste.

b) Managing waste disposal program in accordance with the terms and conditions of the university’s Nuclear Substances and Radiation Devices Licence as issued by the CNSC.
INTRODUCTION:

It is the policy of Dalhousie University to generate and maintain radiation protection records; to use these records to protect individuals from unnecessary exposure; and to make these records available to the Canadian Nuclear Safety Commission.

Other uses of these records may include:

a) evaluation of the effectiveness of the radiation protection program;

b) demonstration of compliance with regulations and requirements of both the CNSC and Dalhousie University Radiation Protection Program;

c) other purposes as may be required

Dalhousie University requires that all applicable areas conduct a functional program for the generation and administration of occupational radiation protection program records and supporting information for their employees. Timely reporting of appropriate data is also required.

As a minimum, an acceptable radiation protection records program is one that:

a) has well documented policies and procedures for record and report generation and administration;

b) demonstrates timely record and report generation and retrieval capability;

c) includes a documented quality assurance plan for assuring accuracy and completeness;

d) maintains documents that are traceable, trackable, verifiable, and retrievable.
RECORDS TO BE MAINTAINED BY INDIVIDUAL WORK AREAS:

1. Personal radiation exposure records (including fetal exposure)
2. Personnel bioassay records
3. Receipt of nuclear substance records
4. Inventory Records (accounting for stock, in use, disposal)
5. Daily direct monitoring records
6. Weekly wipe test records
7. Leak test records done on sealed sources
8. Incident reports

The above records shall be maintained in a format approved by the Radiation Safety Committee and filed in yellow binders provided by your Radiation Safety Officer. These records must be up to date and available for inspection by radiation safety personnel and officers of the CNSC at any time. Personal exposure records are normally kept for fifty years, other records for a minimum of six years.

RECORDS TO BE MAINTAINED IN THE RADIATION SAFETY OFFICE:

1. File of all occupationally exposed workers at Dalhousie University
2. Personal radiation exposure records of all occupationally exposed workers
3. Copies of all active Nuclear Substances and Radiation Devices Licences and Nuclear Substance User permits
4. Listing of all rooms where nuclear substances are used or stored
5. Listing of all radiation survey meters and dose rate meters with their required calibration dates
6. Verification of instrument calibration form
7. Listing of all sealed sources with their required frequency for leak testing
8. Leak test records on all sealed sources
9. Annual inventory records from each licenced area
10. Minutes from Radiation Safety Committee meetings
11. Incident reports
12. ”Declaration of Pregnancy” forms
13. Staff training records

The above records shall be kept **up to date** and available for inspection by officers of the University and the CNSC at any time.

The CNSC requires

1. *Every person who is required to keep a record by the Act, the regulations made under the Act or a licence shall retain the record for the period specified in the applicable regulations made under the Act or, if no period is specified in the regulations, for the period ending one year after the expiry of the licence that authorizes the activity in respect of which the records are kept.*

2. *No person shall dispose of a record referred to in the Act, the regulations made under the Act or a licence unless the person*

   a) *is no longer required to keep the record by the Act, the regulations made under the Act or the licence; and*

   b) *has notified the Commission of the date of disposal and of the nature of the record at least 90 days before the date of disposal*
Title: Policy for the Security of Nuclear Substances
Number: RSP - 012
Date: 2004, reviewed 12/05

Introduction:

Ensuring the security of nuclear substances consists of two components:

a) accountability

b) physical security

Your accountability program has important security ramifications as well as being both a CNSC licence condition as well as a Dalhousie University "Nuclear Substance User Permit" condition. You must keep an accurate record of your inventory in order to know what is missing, should theft or loss occur. Physical security means ensuring that a mechanism is in place either by a locked laboratory door or a locked storage area to ensure that unauthorized removal of unattended nuclear substances does not occur.

The Canadian Nuclear Safety Commission requires, under its "Radioisotope Safety - Intermediate Laboratories" poster that:

a) General Safety -
   1. Keep unauthorized persons out of this laboratory. Keep locked when unoccupied.

b) Usage, Storage and Disposal -
   17. Store radioisotopes in a locked room or enclosure.
   18. Supervise radioisotopes at all times when in use.
   20. Maintain up-to-date inventory, usage and disposal records for all radioisotopes.

The Canadian Nuclear Safety Commission further requires under its "General Nuclear Safety and Control Regulations" that:

a) Section 12: Obligations of Licensees

   g) implement measures for altering the licensee to the illegal use or removal of a nuclear substance, prescribed substance, prescribed equipment or prescribed information, or the illegal use of a nuclear facility

   h) implement measures for alerting the licensee to acts of sabotage or attempted sabotage anywhere at the site of the licenced activity;
j) instruct workers on the physical security program at the site of the licenced activity and on their obligations under that program;

b) Section 17: Obligations of Workers

i) promptly inform the licensee or the worker’s supervisor of any situation in which the worker believes there may be

ii) a threat to the maintenance of security or an incident with respect to security

iv) an act of sabotage, theft, loss or illegal use or possession of a nuclear substance, prescribed equipment or prescribed information,

Requirements:

Nuclear Substances In Use:

a) Constant surveillance and control must be maintained for nuclear substances in use. This means that an individual who has received training, as approved by Dalhousie University’s Radiation Safety Committee, in the safe use of radioactive material must be present in the laboratory or the laboratory must be locked if the material is left unsecured in the laboratory.

Nuclear Substances In Storage:

a) All nuclear substances in storage such as stock or stock dilutions must be secured from unauthorized removal or access. The laboratory must be equipped with a lock as well as the storage container within the lab. The storage container must be equipped with a locking mechanism approved by the Radiation Safety Office.

b) When a room containing nuclear substances is unoccupied for periods such as lunch, evenings, meetings etc. the room must be locked. The nuclear substance must also be secured by placing the material in a locked storage container such as a refrigerator or a lock box within the refrigerator provided that it is secured within the unit.

c) The storage of nuclear substances in hallways is not permitted. Any exceptions to this policy must be approved by the Radiation Safety Committee.

d) Radioactive waste containers must be secure from unauthorized removal.

e) Counting rooms must be secured if nuclear substances are present.
Responsibilities:

a) It is the responsibility of the Permit Holder to secure nuclear substances in their possession that are in storage from unauthorized access or removal.

b) It is the responsibility of the Permit Holder or his/her designate to maintain surveillance over nuclear substances in their inventory that are not in storage.

c) If constant surveillance cannot be maintained, the materials must be secured.

d) Nuclear substances must be secured in such a manner that an individual with authorized access to the area, but who is not authorized to use or possess the materials, cannot gain control of the materials.

e) The Permit Holder or his/her designate must contact the RSO immediately if any actual or suspected loss or theft of a nuclear substance.
Introduction:

A principal investigator (PI) is the individual in whose name a **Nuclear Substance User Permit** is issued for the use of nuclear substances or radiation emitting devices in their work. The principal investigator is responsible to the university for the safe use of such materials or devices by all persons under their supervision. Further, the principal investigator is responsible for the security of these materials from the time they enter the laboratory until they are safely and properly disposed of.

It is the responsibility of the principal investigator to ensure that the Radiation Safety Office receives advance notification when:

a) there is a planned move to new laboratory space

b) there is expansion of current laboratory space (renovation)

c) there are changes to current laboratory space (renovation/remodel)

d) work with nuclear substances ceases

e) the principal investigator leaves the university

Procedures:

a) Notify the Radiation Safety Office prior to any of the above listed changes or moves, giving the following information

   I. Principal Investigator, department, phone number

   II. Time and date of projected change or move

   III. Location of laboratory

b) Collect all radioactive waste and dispose of it in an appropriate manner as outlined in Dalhousie University’s **Management of Radioactive Waste** policy
c) Consolidate all unwanted lead/plastic items (pigs, shields etc.,) into one area for removal by Radiation Safety

d) Nuclear substances not designated as waste must be disposed of in one of the following ways:

I. An inventory **transfer within the same department**

II. An inventory **transfer within the university**

III. An inventory **transfer to another institution.** In case of such a transfer only individuals with full TDG training will be permitted to ship. This task is normally carried out by the RSO. Documentation from the receiving institution must be forwarded to the Radiation Safety Office verifying that the receiving institution is licenced to receive the material and that the RSO has approved the transfer.

e) A wipe test survey must be done on all items that are in current use or had **previously been used** with nuclear substances. These results must be recorded in your **Radiation Safety Records** manual. Items found to be contaminated must be cleaned and re-surveyed until removable contamination is below those limits as set out in Dalhousie University’s **ALARA Program.** Wipe test results must also be submitted to the Radiation Safety Office.

f) A thorough lab survey **must** be conducted using both the direct survey method (if appropriate) and an indirect survey (wipe test). Areas surveyed **must include,** at the very least:

I. Laboratory benches
II. Fume hoods
III. Sinks
IV. Floor areas
V. Refrigerator/freezer (exterior and interior)
VI. Door knobs
VII. Telephone receivers
VIII. On/off switches

These results must be recorded in your **Radiation Safety Records** manual. Areas found to be contaminated must be cleaned and re-surveyed until removable contamination is below those limits as set out in Dalhousie University’s **ALARA Program.** Monitoring results must also be submitted to the Radiation Safety Office.

Once the monitoring results have been reviewed by the RSO, all radiation warning signs **must be removed.** This would include warning signs on doors, storage areas, sinks etc., The RSO will visit the lab to give final certification that the lab has been decommissioned. The lab will then be removed from the list of approved locations for work with nuclear substances.
Any piece of heavy/bulky equipment transferred outside your laboratory must be certified “clear” by the RSO prior to removal by either Facilities Management or “outside” professional movers.

Be aware that the RSO must be consulted prior to the disposal of some pieces of equipment, such as liquid scintillation counters, as they often contain a radioactive source.

Plans to clean, paint or renovate a vacated or occupied lab must be submitted to the Radiation Safety Officer. Prior to any work beginning, the RSO must review the most current wipe test results for the area and grant official clearance for the work to begin.

*The procedures listed above have been completed. The laboratory has been decommissioned and prepared for vacating/renovation.*

________________________________________  ____________________________
Principal Investigator                                      Date

________________________________________  ____________________________
Department Head/Chair                                      Date

________________________________________  ____________________________
Radiation Safety Officer                                  Date
Introduction:

Section 12 (1)(b) of the CNSC *General Nuclear Safety and Control Regulations* require that every licensee shall:

"train the workers to carry on the licensed activity in accordance with the Act, the regulations made under the Act and the licence.

Item 4 of the Dalhousie University, *Nuclear Substance User Permit - Schedule of Conditions* states:

"Principal Investigators (permit holders) are responsible for registering all persons under their supervision with the Radiation Safety Office and ensuring that these persons are enrolled in the first available Radiation Safety Training Course offered by the university after that individual joins the lab."

Radiation Safety Training sessions will be scheduled three times annually, typically in May, August and December.

Training Procedure:

1. New workers who will be designated as a *"Worker Approved To Use/Handle Nuclear Substances"* shall be registered with the Radiation Safety Office within seven days of joining the research group.

2. The Principal Investigator or his/her designate shall ensure that all new workers read the laboratory copy of the *Radiation Safety Training Manual* and sign that they have done so prior to any work with nuclear substances.

3. The Principal Investigator shall ensure that all new workers register for the first available Radiation Safety Training course available after the worker has joined the research group. Schedules of available training sessions, as well as registration forms are posted annually to the EH&S web site at [safety.dal.ca](http://safety.dal.ca).

4. New workers may be exempted from participating in the training session if they are able to demonstrate by means of a training certificate that they have attended a training session held at another Canadian institution with the past twenty-four (24) months.

5. Worker re-training is required every 5 years. The refresher Power Point training session is posted on the EH&S website. Workers who are required to re-train must complete the on-line session and complete a short quiz with a minimum 80% pass rate. Workers who do not complete the re-training and successfully pass the quiz will be removed from the authorized worker list.
Introduction:

The radiation dose received by any person from external or internal exposure to ionizing radiation must be kept to the lowest possible value consistent with effective use of the following procedures and must never exceed the legally maximum permissible dose limits.

Control of radiation exposure is based on the assumption that any exposure involves some risk. However, occupational exposures within accepted limits represent a risk, very small compared to the other risks voluntarily encountered in other work environments.

The policy at Dalhousie University is to maintain occupational exposures as low as reasonably achievable (ALARA). ALARA is a part of the normal work process involving people working with ionizing radiation. Management at all levels and in all areas, as well as each individual worker, must take an active role in minimizing radiation exposure.

RADIATION USE PROTOCOL:

All individuals using nuclear substances in live animals under the control of Dalhousie University “Nuclear Substances and Radiation Devices Licence” are to be advised of the following policy. This policy has been developed to reduce the risk and/or severity of unnecessary radiation exposure to staff. Animal users are to notify the Animal Care supervisor one week prior to beginning the use of nuclear substances.

Housing Within the Animal Care Centre:

1. Animals to be used in any study involving in vivo use of nuclear substances are to be housed in a separate room specifically designated for that purpose by the Animal care supervisor in consult with the Radiation Safety Officer. This room will contain a decontamination kit in the event of a radioactive spill.

2. Appropriate signs must be posted on the door where nuclear substances are used. The posted information must include the name, department, and phone number of the responsible person (principal investigator), the nuclear substance used and its activity and the RSO’s name and phone number.

3. In addition an appropriate warning sign must be posted on the cage in which the animal is housed.

4. Prior to the start of nuclear substance work it is the responsibility of the user to confirm and adhere to the “Conditions for Use” printed on the Nuclear Substance User Permit. In addition, to these conditions the user, after consultation with the Animal care supervisor,
is responsible for care of the animals labeled with nuclear substances. This responsibility includes proper care, feeding and cleaning of the animals and cages, as well as approved handling of all animal wastes, bedding and cages. Suitable plastic bags and appropriately marked boxes are available from Central Stores. All animal waste (excrement and bedding) is to be treated as radioactive waste and disposed of in double plastic bags in the radiation disposal boxes kept in the animal room to avoid tracking contaminated waste throughout the facility.

5. Animal handlers are to double glove at all times when working in rooms with radiation hazard sign posting. Shoe covers shall be worn in all cases when the animal housed is a rabbit or large animal. Dosimeters are to be worn at all times if required by the permit. Gloves and shoe covers must be removed and disposed of before exiting the room.

6. Upon completion of the project, or as required, the properly packaged radioactive waste must be disposed of as per university guidelines.

7. Prior to sending out any used cages, racks or boxes for cleaning, rooms and cages must be monitored and wipe tested for any residual radioactivity. The required wipe test procedure/form will be provided by the Animal care supervisor. Results will be recorded on the form provided. These results will then be forwarded to the RSO for interpretation. Once results have been checked and an independent audit done by the RSO, if necessary, the room will be opened for use. Cages etc, will be forwarded to cage wash for sanitation.

Transportation of Animals Off Site:

1. If the animal is to be transported to another area within the Tupper building, the cage shall be moved by cart via the service elevators to the designated area.

2. If the animal is to be transported off site, along with Animal Care personnel the RSO must be notified. The animal must be transported in an appropriately marked cage via a university vehicle. Appropriate care must be taken to ensure that any urine produced in transit can be contained to avoid unnecessary contamination of the vehicle. The animal must be accompanied by a member of the research group. Larger animals such as dogs must have a radiation warning sticker attached to their collar.

3. A “Transfer of Radioactive Material” form must be completed prior to the transfer.

4. If animals are transferred to an off site location not covered by the Dalhousie University license prior approval must be received by the Director of Animal Care as well as the RSO. Since the move involves a transfer of radioisotope we must ensure that the receiving institution is licensed to use both the radioisotope in question as well as in vivo use in animals.

After transfer of the animal back to the Animal Care facility appropriate contamination checks must be done at the off site location.

____________________  ____________________
Melissa Michaud       Dr. Sylvia Craig
Radiation Safety Officer  University Veterinarian
Dalhousie University    Dalhousie University
Each research group will be required to conduct a nuclear substance laboratory self-audit (attached) on a twice yearly basis, in May and November. These audits will be reviewed by the RSO and appropriate corrective action taken within one week of receipt of the audit.

Twice yearly to correspond with research group self-audits, the RSO will verify the results of a minimum of 50% of the audits from active laboratories. Research groups to be audited will be selected randomly.
The Nuclear Safety & Control Act and accompanying Regulations dictate several conditions where a licensee must notify the CNSC of changes. The applicable legislation includes:

- Nuclear Safety & Control Act
- General Nuclear Safety & Control Regulations
- Radiation Protection Regulations

It is the responsibility of the Radiation Safety Officer, or in his/her absence the Director of Environmental Health & Safety, to notify the CNSC within the required time frame. CNSC may be contacted by calling 1-800-668-5284.

<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>The commissioning of a licenced activity for a period of &gt; 90 days</td>
<td>Within 7 days of the commencement of the activity</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>The decommissioning of a licenced activity</td>
<td>Within 7 days of the decommissioning</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid screening of personnel detects activity &gt; 10 kBq</td>
<td>An immediate preliminary report must be made followed by thyroid bioassay within 24 hours of detection.</td>
</tr>
</tbody>
</table>
The Nuclear Safety & Control Act and accompanying Regulations dictate several conditions where a licensee must notify the CNSC of changes or occurrences. The applicable legislation includes:

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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>The licensee is required to submit an ACR annually</td>
<td>The report must be received by CNSC by April 30th of each year.</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exceeding of licensees action levels</td>
<td>Immediate notification</td>
</tr>
</tbody>
</table>

### Personal Dose Limits

<table>
<thead>
<tr>
<th>Person</th>
<th>Period</th>
<th>Effective Dose (mSv)</th>
<th>Action Level (mSv/quarter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Energy Worker (NEW)</td>
<td>1 calendar year</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>a person who is not a NEW</td>
<td>1 calendar year</td>
<td>1</td>
<td>0.3</td>
</tr>
<tr>
<td>a person who is not a NEW - lens of an eye</td>
<td>1 calendar year</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>a person who is not a NEW - skin</td>
<td>1 calendar year</td>
<td>50</td>
<td>16</td>
</tr>
<tr>
<td>a person who is not a NEW - hands &amp; feet</td>
<td>1 calendar year</td>
<td>50</td>
<td>16</td>
</tr>
</tbody>
</table>

### Contamination Levels

<table>
<thead>
<tr>
<th>Class</th>
<th>Control Area Limit</th>
<th>Public Area/ Decommissioning Limit</th>
<th>Dalhousie Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3 Bq/cm²</td>
<td>0.3 Bq/cm²</td>
<td>0.3 Bq/cm²</td>
</tr>
<tr>
<td>B</td>
<td>30 Bq/cm²</td>
<td>3 Bq/cm²</td>
<td>3 Bq/cm²</td>
</tr>
<tr>
<td>C</td>
<td>300 Bq/cm²</td>
<td>30 Bq/cm²</td>
<td>30 Bq/cm²</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exceeding of personal dose limits</td>
<td>Immediate notification followed by a written investigation report within 21 days.</td>
</tr>
</tbody>
</table>

### Personal Dose Limits

<table>
<thead>
<tr>
<th>Person</th>
<th>Period</th>
<th>Effective Dose (mSv)</th>
<th>Action Level (mSv/quarter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear Energy Worker (NEW)</td>
<td>1 calendar year</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>a person who is not a NEW</td>
<td>1 calendar year</td>
<td>1</td>
<td>0.3</td>
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<tr>
<td>a person who is not a NEW - lens of an eye</td>
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<td>16</td>
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<td>16</td>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes to representatives of applicants and licensees</td>
<td>The change must be reported to the CNSC within 15 days</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retention and disposal of records</td>
<td>CNSC must be notified a minimum of 90 days prior to the proposed disposal date.</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss or theft of nuclear substances, prescribed equipment or prescribed</td>
<td>An immediate preliminary report must be made to CNSC followed by a full</td>
</tr>
<tr>
<td>information</td>
<td>written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contravention of the Act in relation to an activity</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occurrence likely to result in exposure exceeding applicable dose limits</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unauthorized release of radioactivity to the environment</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation or event requiring implementation of a contingency plan</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breach of security or act of sabotage – actual or attempted</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual, threatened or planned work disruption</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death of a person at a nuclear facility</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankruptcy</td>
<td>An immediate preliminary report must be made to CNSC followed by a full written report within 21 days of occurrence</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficiencies in records</td>
<td>A report must be submitted to the CNSC within 21 days of becoming aware of the deficiency</td>
</tr>
</tbody>
</table>
Title: Failed leak test – CNSC Reporting Requirements
Number: RSP – 036
Date: March 1, 2008
Approved by: Radiation Safety Committee

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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive leak test – activity measured in excess of 200 Bq</td>
<td>A report must be submitted to CNSC immediately after becoming aware of failed test – source must be immediately removed from service and any contamination remediated</td>
</tr>
</tbody>
</table>
Title: Loss or damage to an exposure device or sealed source – CNSC Reporting Requirements

Number: RSP – 037

Date: March 1, 2008

Approved by: Radiation Safety Committee

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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss or damage to an exposure device or sealed source</td>
<td>A report must be submitted to CNSC immediately with a full written report within 21 days</td>
</tr>
</tbody>
</table>
The Nuclear Safety & Control Act and accompanying Regulations dictate several conditions where a licensee must notify the CNSC of changes or occurrences. The applicable legislation includes:

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- Radiation Protection Regulations
- Packaging and Transport of Nuclear Substances Regulations

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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation – dangerous as defined in Section 19 of the &quot;Packaging and Transport of Nuclear Substances Regulations&quot;</td>
<td>An immediate preliminary report must be made to CNSC</td>
</tr>
</tbody>
</table>
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- Radiation Protection Regulations
- Packaging and Transport of Nuclear Substances Regulations

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<table>
<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation – damaged shipment</td>
<td>A report must be submitted to the CNSC and the Consignor within 21 days</td>
</tr>
</tbody>
</table>
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- Radiation Protection Regulations
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation – tampered with package</td>
<td>An immediate preliminary report must be submitted followed by a full written report within 21 days</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation – undeliverable consignments</td>
<td>An immediate report must be submitted</td>
</tr>
</tbody>
</table>
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<thead>
<tr>
<th>Occurrence</th>
<th>Reporting Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of more than 2 GBq for tracer studies</td>
<td>A request must be submitted to CNSC prior to intended use followed by a report to CNSC within 60 days of completion of the study</td>
</tr>
</tbody>
</table>
E.1 Nuclear Substances

The purchase, use and disposal of nuclear substances is strictly controlled by the Canadian Nuclear Safety Commission. Permission to use nuclear substances must be licenced accordingly. The requirements are dealt with in the following sections, as well as regulations, procedures and guides to good practice.

E.1.1 Licence Requirements & Permits

Dalhousie University is issued a Consolidated Nuclear Substances and Radiation Licence by the Canadian Nuclear Safety Commission. The licence authorizes the university to issue Nuclear Substance User Permits for the use of nuclear substances and radiation emitting devices on campus. In this manual the word “licence” refers to authority granted by the CNSC; the word “permit” refers to a document issued by the Radiation Safety Committee.

E.1.2 Nuclear Substance User Permits

Individuals who plan to use nuclear substances shall complete a permit application form and forward two copies to the Radiation Safety Office.

Application forms as illustrated in Section G, may be obtained either from the Radiation Safety Office or from the Environmental Health & Safety web site at safety.dal.ca. The Radiation Safety Officer may request other relevant details prior to approval. Typically permits are processed by the Radiation Safety Officer, however, there may be instances where an application will be reviewed by the Radiation Safety Committee prior to approval.

Permit holders shall comply with all conditions forming part of the permit.

E.1.3 Nuclear Substance Purchase

Once an individual has received a Nuclear Substance User Permit the purchase procedure as outlined in Section D shall be followed. A block of stamped requisitions will be issued to the permit holder by the Radiation Safety Officer. No more than two persons from any research group shall have signing authority for nuclear substance purchases – typically the principal investigator and one other senior staff member. In preparing purchase requisitions for nuclear substances either separately or with other items, the following information must appear on the requisition:

- consolidated licence number
- nuclear substance permit number
- personal signature of the permit holder (or his/her alternate)

Purchases of nuclear substances cannot be processed using a credit card, as each purchase must be verified by the RSO prior to processing.
E.1.4 Import Permits

The consolidated **Nuclear Substances and Radiation Devices Licence** serves as an import permit with the following restrictions. "The licence does not authorize the licensee to import in any calendar year more than:

a) 37 TBq of tritium  
b) 1 GBq of plutonium  
c) 2 MBq of thorium 228 or 232  
d) 200 MBq of enriched uranium 233  
e) 37 kBq of enriched uranium 235  
f) 6 MBq of natural uranium; or  
g) 6 MBq of depleted uranium except when incorporated as shielding in a radiation device – Licence condition (2402-3)

E.1.5 Inventory

It is the responsibility of every permit holder to maintain up-to-date and accurate records of all nuclear substances purchased as well as the use and disposition of that material. Records **shall** be maintained in the computerized inventory tracking program. Under no circumstances shall the inventory exceed the possession limits as defined on the Nuclear Substance User Permit. Any loss or theft of a nuclear substance **shall be reported immediately** to the Radiation Safety Office.

E.1.6 Permit Amendments

There will be occasions when it is necessary to add or delete items from a permit, or vary the purpose for which the permit was approved. Permit holders desiring amendments must complete an [Application for Nuclear Substance Permit Amendment](#), see Section G or our website at [safety.dal.ca](http://safety.dal.ca) Forward two signed copies to the Radiation Safety Office.

E.1.7 Permit Renewals

Routinely **Nuclear Substance User Permits** are issued for two years. Renewal of an existing permit should be requested at least two weeks in advance of its expiry to allow time for processing. More time may be necessary if changes are requested. In either case, the permit holder should forward two signed copies of the **Nuclear Substance Permit Renewal** form, see Section G or our website at [safety.dal.ca](http://safety.dal.ca) to the Radiation Safety Office.

E.1.8 Decommissioning of Nuclear Substance Laboratories

If a project director vacates a lab, or work with nuclear substances ceases it is necessary to decommission the laboratory. Laboratory decommissioning requires:

1. notification of intent to decommission to the RSO  
2. wipe test survey of the area to ensure contamination levels are below licence criteria  
3. remedial decontamination if necessary  
4. transfer or disposal of all inventory of nuclear substances under the supervision of the RSO  
5. removal/defacing of all radiation warning signs  
6. written clearance by the RSO

See Section D for Dalhousie University’s [Policy for the Termination of Nuclear Substance Use - Renovations, Remodels, and Moves & Terminations](#).
E.2 Unsealed Nuclear Substances

The use of unsealed sources of nuclear substances is customary in many research projects for a variety of reasons. As well as a potential hazard from external radiation exposure, these materials present a potential internal radiation exposure hazard. The most common routes of entry into the body are ingestion, inhalation, absorption through open wounds, and absorption through intact skin.

Hazards

There are three main hazards in handling unsealed sources of nuclear substances. These are:

1. skin contamination and/or deposition into the body
2. spread of contamination
3. external beta (β) and gamma (γ) radiation exposure

The important characteristics of the most commonly used nuclear substances are shown in Section H “Nuclear Substance Data Sheets”. For nuclear substances not listed please consult with the RSO.

E.2.1 Nuclear Substance Laboratory Facilities

Laboratory classification will depend on several factors including - the amount of nuclear substance used, the type of operation performed, and the radiotoxicity of the nuclear substance. Facilities must be approved by the RSO prior to any work beginning with nuclear substances. Renovations or new facilities shall meet CNSC’s requirements in Regulatory Guide RD-52, “Design Guide for Nuclear Substance Laboratories and Nuclear Medicine Rooms”. New or renovated Intermediate Laboratories must have prior approval by the CNSC. The approval process will be coordinated through the Radiation Safety Office.

Work areas to be designated as nuclear substance laboratories shall meet the requirements set out below, which refer to features related to radiation safety. Requirements have been separated to show essential requirements as distinct from those which are recommended. The latter group ought to receive appropriate consideration with a view to possible upgrading of the facilities.
E.3 Precautions For Handling Unsealed Nuclear Substances

The following precautions are given for the handling of unsealed nuclear substances. These guidelines are provided for the protection of personnel working with nuclear substances as well as to avoid contamination of other workers, adjacent work areas and sensitive equipment.

The protection of individuals from external radiation hazards is a relatively simple matter. It is achieved by the control of time work and/or working distances from the source, in conjunction with the use of appropriate shielding materials - **Time, Distance, Shielding**. Protection from internal radiation hazards is best achieved by the prevention of bodily contamination. **Ingestion, inhalation** and **absorption** are the principle routes of entry into the body. Preventative measures include, adequate ventilation, containment, PPE, and immaculate hygiene. With the exception of accidents, poor laboratory technique and poor radiation hygiene are the chief causes of internal contamination among workers.

The following rules **shall** be observed when working with unsealed nuclear substances. More thorough training is **required** by all workers handling nuclear substances. This **shall** be achieved by attending a Radiation Safety Training workshop conducted through the Radiation Safety Office by reading the **Radiation Safety Manual** and the **Radiation Safety Training Manual**, available in each research group and participation in mandatory re-training every five years.

- Confine experiments to trays lined with disposable absorbent liners; use bench liners on workbenches wherever practical.
- Confine operations to a fume hood wherever practical.
- **Do not pipette radioactive solutions by mouth.**
- **Do not eat, drink, smoke, store food or apply cosmetics in a nuclear substance laboratory.**
  - Avoid direct contact with nuclear substances, wear all necessary/required PPE.
  - Do not remove PPE from the laboratory unless it is known to be free from contamination.
  - Do not work with nuclear substances if you have open cuts or abrasions on the hands.
  - Always monitor hands, clothing and shoes for contamination before leaving the laboratory.
- **Always wash hands** prior to leaving the laboratory.
  - Conduct required weekly contamination surveys of work areas and general laboratory areas and keep records in the binder provided by the Radiation Safety Office (unless otherwise exempted). Non-use periods must be noted.
  - Always use a fume hood if the nuclear substance in use is volatile, or when the procedures generate gases, aerosols, vapors or dust.
Use a glove box for work with dry radioactive powders.

Segregate contaminated glassware and equipment from clean.

Identify all equipment used with nuclear substances.

Have a radiation monitor (if required) available and turned on when working with nuclear substances, remembering that these instruments are insensitive to radiation produced by weak beta emitters for which special monitoring (LS counting) is required.

No person shall work with nuclear substances until they are registered with the Radiation Safety Office and have received some basic training in radiation safety as approved by the Radiation Safety Committee and have come to appreciate the hazards involved, and their name appears on the approved worker list which is an appendix of the Nuclear Substance User permit.

E.4 Contamination Surveys

Regular surveys of nuclear substance laboratories are required for the detection and clean up of small amounts of loose contamination which may be present in spite of scrupulous care in technique and which would otherwise go unnoticed. It is a condition of the Nuclear Substance User Permit that contamination surveys be conducted on a weekly basis during periods when work with nuclear substances is being conducted, however, every permit holder is required to maintain a weekly record to indicate periods of both use and non-use. Contamination of laboratory furnishings and equipment presents both a potential health hazard to staff and a source of significant error in sensitive experiments. Routine procedures are set out below, the management of spills is outlined in Section F of this manual.

By using a portable contamination monitor, it is possible to detect the presence of most gamma emitters and the more energetic beta emitters. Quantitative estimates of the amount of loose activity and the amount of activity per unit are not easily obtainable in this way and readings due to contamination may be masked by the background from nearby radiation sources. The sensitivity of these instruments for the detection of beta emitters is insufficient or poor for beta emitters such as $^3$H, $^{14}$C, $^{35}$S, $^{33}$P and gamma emitters such as $^{125}$I and $^{51}$Cr. Advice should be sought from the RSO regarding appropriate instrumentation for monitoring these materials. Subject to these limitations, the use of a contamination monitor may be suitable and adequate to monitor for contamination in some laboratories.

Loose transportable contamination on surfaces (which carries the potential hazard for internal exposure to personnel and for the spread of contamination) may be detected by wipe testing. Wipe testing is required on a weekly basis in laboratories where nuclear substances are regularly used. Where use is infrequent, wipe test at the conclusion of each week's experiment. To provide a continuous ongoing record of use/non use periods documentation of non use periods is required. Records of surveys must be maintained in the binder provided by the Radiation Safety Office. A wipe test program shall contain the following elements:
1. Sketch a floor plan of the laboratory
2. Mark test locations and number them on the floor plan. In addition to the obvious areas of use, include such things as door handles, telephone receivers, taps, on/off switches on equipment, computer keyboards, etc.
3. Use filter paper or cotton swabs moistened with a suitable solvent and wipe a representative (often defined as 100 cm$^2$) in each location. Cotton swabs are not appropriate if your wipes will be counted by the direct survey method.
4. Let wipes air dry before counting.
5. Measure the radioactivity on each wipe using suitable detection devices for the nuclear substance used in the laboratory – contact the RSO if in doubt as to which type of counting would be most appropriate.
6. Obtain background counts using a clean wipe.
7. Dalhousie University’s ALARA program requires that levels of loose contamination on all accessible areas not exceed 3 Bq/cm$^2$ and 30 Bq/cm$^2$ respectively for Class B & C radionuclides.

**Formula For Determining Loose Contamination:**

\[
\text{Bq/cm}^2 = \frac{\text{CPM net}}{[\text{C.E.} \times 60 \times 100 \times W_{eff}]}
\]

where:

- Bq/cm$^2$ = Becquerel per centimeter squared
- C.E. = counting efficiency
- 60 = 60 seconds
- 100 = area of 100 cm$^2$ wiped
- W$_{eff}$ = wipe efficiency (10% for a wet wipe; 1% for a dry wipe)

A wipe efficiency of 10% is assumed for a wet wipe, 1% efficiency is assumed for a dry wipe, since only a fraction of contamination will be removed by this method. Notwithstanding the limits as defined above, it is expected that contamination levels shall be kept to as low as reasonably achievable (ALARA).

- If contamination is detected above ALARA criteria the location shall be cleaned with a suitable agent taking care not to spread the contamination over a larger area.
- Repeat wipe testing of the area in question and continue decontamination efforts until background levels are achieved or it has been determined that the contamination is fixed.
- Maintain records of such tests in the binder provided by the Radiation Safety Office – these records must be available for inspection by the RSO or an agent of the CNSC at all times.
- Should there be an occasion where the weekly wipe test cannot be performed (e.g. equipment breakdown), this must be recorded in the record book.
E.5 Regulatory Limits and Action Levels

Licence conditions require that removable contamination does not exceed radionuclide-specific limits on accessible surfaces in occupational and public areas. Radionuclides are assigned classifications as follows:

- **Class A** - typically long lived and emit alpha radiation
- **Class B** - typically long lived and emit beta and gamma radiation
- **Class C** - typically short lived and emit beta and gamma radiation

**Classification of Selected Radionuclides**

<table>
<thead>
<tr>
<th>Class</th>
<th>Radionuclide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>Na-22, Na-24, Co-60, Ir-192, Sb-124, Ta-182, Zn-65 All alpha emitters and their daughter isotopes</td>
</tr>
<tr>
<td>Class B</td>
<td>As-74, Au-198, Br-82, Co-58, F-18, Fe-59, Ga-67, Gd-153 Hg-203, I-131*, In-111*, In-114m, Nb-95, Rb-84, Rb-86, Sc-46 Se-75, Sm-153, Sn-113, Sn-123, Sr-85, Sr-90</td>
</tr>
</tbody>
</table>

* These radionuclides are commonly used at Dalhousie University.

At Dalhousie University Class B and Class C radionuclides are typically used. In keeping with an ALARA policy contamination limits are set at regulatory limits for public areas and decommissioning limits, however, every effort should be made to maintain contamination levels to the 2-3 times background “Rule of Thumb”. Contamination limits are based on activity per square centimeter.

<table>
<thead>
<tr>
<th>Class</th>
<th>Control Area Limit</th>
<th>Public Area/Decommissioning Limit</th>
<th>Dalhousie Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3 Bq/cm²</td>
<td>0.3 Bq/cm²</td>
<td>0.3 Bq/cm²</td>
</tr>
<tr>
<td>B</td>
<td>30 Bq/cm²</td>
<td>3 Bq/cm²</td>
<td>3 Bq/cm²</td>
</tr>
<tr>
<td>C</td>
<td>300 Bq/cm²</td>
<td>30 Bq/cm²</td>
<td>30 Bq/cm²</td>
</tr>
</tbody>
</table>

**Dalhousie University Action Levels**

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Counting Method</th>
<th>Nominal Efficiency</th>
<th>Net Count Rate for 3 Bq/cm²</th>
<th>Net Count Rate for 30 Bq/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-14</td>
<td>LSC</td>
<td>50%</td>
<td>900 cpm</td>
<td>9000 cpm</td>
</tr>
<tr>
<td>H-3</td>
<td>LSC</td>
<td>30%</td>
<td>540 cpm</td>
<td>5400 cpm</td>
</tr>
<tr>
<td>P-32</td>
<td>LSC</td>
<td>50%</td>
<td>900 cpm</td>
<td>9000 cpm</td>
</tr>
<tr>
<td></td>
<td>Direct (pancake)</td>
<td>20%</td>
<td>506 cpm</td>
<td>9000 cpm</td>
</tr>
<tr>
<td>P-33</td>
<td>LSC</td>
<td>50%</td>
<td>900 cpm</td>
<td>9000 cpm</td>
</tr>
<tr>
<td>S-35</td>
<td>LSC</td>
<td>50%</td>
<td>900 cpm</td>
<td>9000 cpm</td>
</tr>
</tbody>
</table>

For LSC, the nominal efficiency is assumed to be 50% of the counter efficiency for an unquenched sample. This is generally conservative and takes into consideration that wipes collected from lab surfaces may have higher quench than normal laboratory samples.

Wipes are all assumed to be 100 cm² with a collection efficiency of 10% for a wet wipe and 1% efficient for a dry wipe.
E.6 SEALED SOURCES

E.6.1 INTRODUCTION

A sealed source is radioactive material contained in a sealed capsule, sealed between layers of non-radioactive material, or firmly fixed to a non-radioactive surface by electroplating or other means. The confining barrier prevents dispersion of the radioactive material under normal and most accidental conditions related to the use of the source. In a general laboratory a sealed source can be a calibration source, check source, internal standards, plated sources or irradiators. They are generally gamma emitters. Some plated sources, however, are beta emitters such as $^{63}$Ni used in gas chromatography.

The inventory and leak testing of sealed sources is regulated under the conditions of Dalhousie University’s consolidated licence issued by the CNSC. The process begins and the paper trail begins when the source is requested for purchase. Once the source has been received a source identification number will be assigned by the Radiation Safety Officer and added to the university’s sealed source inventory.

E.6.2 GENERAL HAZARD

Sealed sources are primarily an external hazard. They present an exposure potential to individuals close to the source. Sealed sources are used to check portable survey meters, liquid scintillation counters as well as in research applications such as gas chromatography studies and Mossbauer studies.

Sealed sources should be handled as if they are contaminated (i.e. gloves and remote handling tools). The basic principles of radiation protection applied to the use of sealed sources are:

- **TIME**
- **DISTANCE**
- **SHIELDING**
- **SOURCE REDUCTION**

E.6.3 SEALED SOURCE ACCOUNTABILITY

Each lab in possession of sealed sources must maintain an inventory of these sources. The inventory process should include:

- source location
- labeling and RSO identification
- isotope
- activity
- assay date
E.6.4 LEAK TESTING OF SEALED SOURCES

Leak testing of sealed sources is conducted in accordance with the CNSC regulations.

The CNSC requires:

Every licensee who possesses, uses or produces either a sealed source containing 50 MBq or more of a nuclear substance or a nuclear substance as shielding shall, at the following times, conduct leak tests on the sealed source or shielding using instruments and procedures that enable the licensee to detect a leakage of 200 Bq or less of the nuclear substance:

- where the sealed source or shielding is used after being stored for 12 or more consecutive months, immediately before using it;
- where the sealed source or shielding is being stored, every 24 months;
- where an event that may have damaged the sealed source or shielding has occurred, immediately after the event; and
- in all other cases,
  - where the sealed source or shielding is located in a radiation device, every 12 months, and
  - where the sealed source or shielding is not located in a radiation device, every six months.

Sealed source leak testing shall be completed to manufacturers specifications.
E.7 GAMMACELL IRRADIATORS

Gammacell irradiators are designed to provide a large uniform gamma field for the irradiation of samples.

For radiation protection purposes, external dose is the primary concern to the operator when using the unit.

DOSE RATES ASSOCIATED WITH GAMMACELL IRRADIATORS

Gammacell irradiators provide a large gamma dose to samples. The most commonly used radioisotopes in these irradiators are $^{60}$Co or $^{137}$Cs. The sources are sealed sources, normally comprised of stainless steel encapsulation.

Sources are commonly provided as a line source, similar in shape to a pencil. Within a sample chamber, this shape enables the exposure to be provided as a uniform dose over a larger distance. A point source projects the dose differently, as radiation coming from a single small point. When the distance from a line source is increased (about three times the length of the source) the line source acts as a point source. The exposure to the operator would be considered a point source due to the distance from the source itself.

The containment vessel of the system is normally heavily shielded, typically with lead. The dose rates on the outside of most systems, approximately one foot from the source, are normally < 0.025 mSv/hr when the source is in the expose position. This is the highest potential for an exposure to the operator. When the source is in the safe position, the source is more heavily shielded. When the system is in the expose position, the level of exposure to the operator, one foot from the source calculated for a working year would be:

$$0.025 \text{ mSv/hr} \times 40 \text{ hour/week} \times 50 \text{ weeks/year} = 50 \text{ mSv}$$

Routinely, the operator is only at this location for a few minutes at any one time. The systems are designed with interlocks and other safety features to minimize any potential exposure to operators. These are designed to move the source into the safe position if the chamber is opened or other situations arise. Administrative controls are established to make sure the area is clear and ensure that the operators have the appropriate training. This control normally includes control of the key to the system. Workers using the system must be monitored for whole body gamma exposures.

SYSTEM OPERATION

Verify that the source is in the “OFF” position before attempting to open the chamber door. After placing the sample into the chamber, check the interlocks before placing the source in the active position.

After using the irradiator, document use in the log book.

The operator should stay outside the room when the unit has the source in the active position. If the sample will be left in the irradiator for an extended period of time while the operator is not attending the system, the area must be locked.

In the event of a problem with the system, the RSO should be contacted.
EMERGENCY PROCEDURES

In the event of malfunction during loading or unloading of the irradiator, the unit is to be taken out of service immediately. Evidence of malfunction includes binding or moving parts, the presence of metal shavings or chips etc..

a. Log and describe any abnormal occurrences in the use log book

b. Should the “Release Source” fail, leave/secure the room immediately and contact the RSO

c. If at any time it is possible to open the cavity door without pressing the door release button, the interlock assembly is malfunctioning. **Do not use the unit!** Leave/secure the room and contact the RSO.

d. If at any time it is impossible to raise the source with the door closed or to open the door with the source in the “OFF” position, either the interlock switches or interlock solenoids are malfunctioning. **Do not use the unit!** Leave/secure the room and contact the RSO.

RESPONSIBILITIES:

The Principal Investigator must

a. maintain the irradiator in a clean and mechanically functional condition

b. ensure that designated users receive training as required

c. ensure that designated users wear whole body dosimeters when operating the unit

d. list and certify designated users

e. ensure physical security of the key to the unit and prevent unauthorized use of the irradiator

f. notify the RSO immediately of any malfunctions or problems with the irradiator

g. arrange for repairs or maintenance of the unit by appropriate persons

Designated users must

a. operate the unit in accordance with the established procedures at all times

b. wear a whole body dosimeter when operating the irradiator

c. notify the principal investigator and the RSO of any malfunctions or problems with the irradiator

d. ensure that the key is returned to secure storage following irradiation
Radiation Safety personnel must

a. maintain the licence/permit issued to the facility by CNSC/Dalhousie for operation of the irradiator

b. conduct leak tests annually

c. provide appropriate training

Change of Principal Investigator

If transfer of responsibility for the irradiator is contemplated, the new applicant must apply for authorization.

Individuals who may wish to use the Gammacell Irradiator must be registered with the Radiation Safety Office and receive specific training in the safe use and operation of the unit. This training is provided by the laboratory manager in charge of the Gammacell Irradiator.

E.8 Nuclear Substance Disposal

General responsibility for policies regarding the disposal of nuclear substances rests with the Radiation Safety Committee and the Radiation Safety Office. The control, safe packaging, and identification of radioactive waste, transportation, and any costs involved are the responsibility of the individual user. It is important that radioactive waste produced at the university be disposed of in compliance with Dalhousie University’s “Management of Radioactive Waste” policy. See Section D.

In some circumstances waste materials may be returnable to the supplier. More commonly, disposal will take place by direct discharge to the environment, storage for decay, or shipment to an approved waste management site. The choice of disposal method requires consideration of the type of nuclear substance, its level of activity and its physical and chemical form. Consideration must also be given to any hazards arising from regulations applicable to non-radioactive components of waste.

*Good judgment is important. In case of any doubt concerning proper disposal procedures, the RSO should be consulted.*

One of the conditions of the Nuclear Substance User Permit is that inventory records be maintained. Such records shall include the location and methods of disposal for all radioactive wastes. The sample inventory and disposal form is shown in Section G. Compliance with this requirement will be audited from time to time.

*Nuclear Substance shipping vials and “pigs” must be monitored for residual activity prior to disposal. If not contaminated or in the case of the shipping vial itself it has either been rinsed to remove residual activity or allowed to decay to background levels, the radiation trefoil must be removed or defaced prior to disposal. Failure to do so may result in substantial fines levied by the Halifax Regional Municipality.*
### E.9 Exposure To Personnel

#### Personal Dosimeters

Personal monitoring devices are worn to record cumulative dose received as a result of occupational exposures to external radiation. Most applications are to obtain an approximation of whole body dose, but dosimeter units are available to measure localized areas (e.g. fingers). Information obtained when the dosimeters are read is useful for evaluating the effectiveness of protective measures and the necessity of appropriate action (especially if overexposure is indicated). The most common device is the thermoluminescent dosimeter (TLD).

TLD’s have inherent limitations which must be recognized. Most apparent is that they must be processed in order to obtain a reading of accumulated dose. The use of direct reading dosimeters (DRD’s) may be warranted if immediate indication of exposure is required. Personal monitoring devices are **insensitive to weak beta radiation** such as that from $^3$H, $^{14}$C, $^{35}$S and $^{33}$P. Information and advice concerning the choice of dosimeters and readout services are the responsibility of the user or the users department. In any work for which dosimeters are required by the permit they are considered part of the personal safety equipment and must be worn at all times when working with radiation.

Dosimeter services are available at nominal costs from various vendors. These services include the supply of dosimeters and standardized readout of exposures at regular intervals. For information on various vendors approved by the CNSC, contact the Radiation Safety Office.

Reports of personnel exposures from the vendor are sent first to the Radiation Safety Office for review and then forwarded to the department or lab. Workers wishing to review their dosimetry records should contact their departmental administrator.

The RSO will investigate any **unusual exposure** after consultation with the worker in question and advise corrective action where indicated for the health and safety of personnel. The RSO is **required** to investigate and report to the CNSC on the circumstances of any exposure report exceeding maximum permissible dose limits as stipulated in the **Nuclear Safety & Control Regulations**.

#### E.9.1 Radiation Exposure Limits

Occupationally exposed workers at Dalhousie University are normally considered to be persons working in controlled areas for which effective dose limits apply as they do for "**A person who is not a nuclear energy worker**". The majority of occupationally exposed workers at Dalhousie receive effective doses far below these limits, as set out in the following table. The limits given are for radiation doses due to **occupational** exposure only and do not include doses received as a result of medical or dental procedures performed by a qualified practitioner. In special circumstances, the RSO may designate individual workers as **Nuclear Energy Workers** as defined by the **Nuclear Safety & Control Act**.

It should be noted that the setting of a dose limit is equivalent to specifying a maximum acceptable level of risk. Nevertheless, it is not acceptable to be exposed to the full extent of the limit if a lower dose can be reasonably achieved (**ALARA**).
Effective Dose Limits

<table>
<thead>
<tr>
<th>Item</th>
<th>Person/Organ or Tissue</th>
<th>Period</th>
<th>Effective Dose (mSV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NEW’s including pregnant NEW</td>
<td>One year dosimetry period</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Five year dosimetry period</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Pregnant NEW</td>
<td>Balance of pregnancy</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>A person who is not a NEW</td>
<td>One calendar year</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Lens of the eye: NEW</td>
<td>One year dosimetry period</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Any other person</td>
<td>One Calendar year</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Skin: Nuclear energy worker</td>
<td>One year dosimetry period</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Any other person</td>
<td>One calendar year</td>
<td>50</td>
</tr>
<tr>
<td>6</td>
<td>Hans &amp; feet: NEW</td>
<td>One year dosimetry period</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td>Any other person</td>
<td>One calendar year</td>
<td>50</td>
</tr>
</tbody>
</table>

NEW – Nuclear Energy Worker

E.9.2 Bioassay Programs

Safe working procedures will minimize the likelihood of ingesting, inhaling, or absorbing nuclear substances into the body. For some types of work, however, routine bioassay is a regulatory requirement. Routine bioassay in these cases will give warning if working conditions or procedures require improvement or are potentially unsafe. Bioassay programs seek to detect internal contamination by measurement of radioactivity in biological samples such as blood or urine or by direct in vivo measurements (external thyroid counting). Bioassay requirements at Dalhousie University are contained in Section D.

E.10 Radiation Warning Signs & Notices

a) CNSC requires that appropriate warning signs with required wording be posted where there is a radioactive nuclear substance in a quantity greater than 100 times its exemption quantity and/or where there is reasonable probability that a person might be exposed to an effective dose rate of greater than 25 µSv/h. The Dalhousie University Radiation Safety Committee requires that ALL laboratories in which nuclear substances or radiation emitting devices are present shall have posted at each entrance to the lab, a Dalhousie University Hazard Identification sign posted with the radiation trefoil bearing the words “Caution, Radioactive Materials”.

b) A copy of the Dalhousie University poster "Basic Level Laboratory - Nuclear Substance Safety" or “Intermediate Level Laboratory - Nuclear Substance Safety” must be posted in each laboratory where nuclear substances are used or stored. The poster shall include names as well as twenty four hour contact information to be used in case of an emergency.
c) The **Nuclear Substance User Permit** with all attachments, including the approved worker list must be posted in any room where nuclear substances are used or stored.

d) Cupboards, cabinets, refrigerators, and other containers used to store nuclear substances must be identified with a radiation warning label and 24 hour emergency contact information. These areas **shall** be secured against unauthorized access with a locking system approved by the Radiation Safety Office.

e) Primary storage containers must be identified with a radiation warning symbol and information respecting the nature, quantity and date of assay of the nuclear substance contained within.

### E.11 Nuclear Substances in Teaching Programs

This section applies to those instances where students at Dalhousie University (usually undergraduate) may have occasion to handle nuclear substances as part of classroom or laboratory exercises connected with the classes in which they are enrolled. Such activities must be undertaken with the utmost concern for the safety of the students involved and the following conditions must be observed:

a) All nuclear substances used for teaching purposes must be covered by a current Nuclear Substance User Permit. It is not necessary that a unique permit be obtained specifically for teaching purposes, nor that the permit holder be the instructor for the exercises in question, although this may be convenient. The permit holder, must however, be fully conversant with the work done and assume full responsibility for the use of nuclear substances and the safety precaution to be taken.

b) The instructor must be qualified in the safety aspects of procedures to be performed so as to provide adequate supervision and advice to students. Further, instructors must know proper procedures to follow in event of spills, accidents and emergencies and to be prepared to give competent leadership to students as required.

c) Special care must be taken to ensure that the possibility of exposure to the participants and observers to external exposure or contamination is kept **as low as reasonably achievable (ALARA)**.

d) Before undertaking any project requiring the handling of nuclear substances, students must be given clear and complete instruction in the radiation safety aspects of the procedures.

e) Adequate protective clothing for the procedures at hand **must be available and worn** by all students participating.

f) For the mutual protection of both students and the University, class instructors **are required** to complete "**Teaching Laboratory Enrollment Form**" available from the Radiation Safety Office or on the EH&S website at [http://www.dal.ca/safety](http://www.dal.ca/safety). Students **are required** to read the attached form "**Safe Handling of Nuclear Substances**". Copies of this form should be filed with the Radiation Safety Office as soon as possible after classroom memberships are established.

g) The RSO must be notified immediately of any incident involving loss of a nuclear substance, injury or personal contamination, however minor.
Section F - Emergencies

F.1 Radioactive Contamination

Any work with unsealed nuclear substances involves the possibility of radioactive contamination, with consequent risk to personnel of subsequent ingestion and of interference with accurate measurements. Good operating methods as described in previous sections together with careful cleaning will normally keep contamination to an acceptably low level. However, regular monitoring of work and adjacent areas must be conducted on a minimum weekly basis. Procedures and supplies for dealing with an accidental spill must be provided. It is desirable that loose contamination be kept as near background levels as possible.

F.1.1 Radioactive Spills

Spills are the most likely type of incident to occur in a laboratory operation involving the use of open source nuclear substances. Most of these spills will involve only minor quantities of radioactivity and can be dealt with at the time by laboratory personnel.

The Radiation Safety Office must be consulted for advice in any of the following situations:

i. a spill involving a nuclear substance of very high radiotoxicity

ii. a spill involving contamination of inaccessible areas

iii. a spill involving more than 100 exemption quantities (EQ’s) of activity

iv. a spill involving the release of volatile material

v. a spill involving the contamination of personnel

vi. when reasonable efforts to decontaminate are not successful in reducing activity to less than twice background

vii. when there is any doubt concerning appropriate decontamination procedures

F.1.2 Spill Clean-Up Procedure

The spill clean-up procedure is detailed in Section- C, Policies and CNSC poster INFO-0743 “Spill Procedures”.

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F.1.3 Decontamination of Personnel

If contamination of personnel is suspected have a colleague identify contaminated areas of the body with a suitable survey meter or other suitable detection method. By having a colleague perform the survey, contamination of the survey instrument is avoided.

**If skin is intact**

Flush the area with copious amounts of tepid water

Wet area and apply a mild soap

Work up a good lather, keep lather wet

Work lather into the contaminated area by rubbing gently to avoid damaging the intact skin. This process should be continued for three minutes, applying water frequently

Rinse thoroughly with tepid water

Repeat above procedures twice, if necessary

If residual activity remains after three attempts to decontaminate, obtain assistance from the RSO

**If minor cuts, abrasions or open wounds** which do not warrant treatment at the hospital are observed
Dry clean the affected area with suction and swabs

Using wet swabs, work away from the area of open wounds taking care not to spread activity over the body or into the wound

Obtain advice from the RSO

*If ingestion of the nuclear substance has occurred, dial 4109 immediately. Security will notify the RSO.*
F.2 Accidents

Even in the best run laboratories accidents occasionally occur. Those involved must be fully conversant with emergency procedures to be followed in the event of an accident involving a nuclear substance.

In any incident of an emergency nature (including all which involve significant personal injury) security must be contacted immediately at 4109, they will in turn contact the RSO who will assist in the further management of the emergency. No person shall resume work at the site of an emergency until authorized to do so by the RSO.

Any radiation incident which qualifies as an emergency must be followed by a formal report (see Section G) submitted to the Radiation Safety Committee through the Radiation Safety Office. The RSO may request reports of non-emergency incidents as well, and it is important to keep notes of all incidents, however minor, for future reference.

No set of guidelines can anticipate all potential emergency situations. The need for good judgement and prompt correct action is crucial. It follows, that specific procedures for meeting emergencies should be worked out in advance for the particular circumstances in each laboratory project. These must be known and understood by all workers involved.

In the event of personal injury, the treatment of the injury must take precedence, even with contaminated personnel. It may, however, be possible to "contain" any contamination by confining all such persons to the same area and immediately notifying Security at 4109, who will in turn notify the RSO. Standard (universal) precautions should be incorporated.

Minor injuries, should be treated at, or near, the scene of the incident. Wash any wound under tap water with copious amounts of tepid water and encourage bleeding. If the wound is on the face take care not to contaminate the eyes, mouth or nostrils. Wash the wound with soap and tepid water and apply a clean first aid dressing. The injured area should be monitored to establish the level of residual activity, if any.

The treatment of serious injuries must take precedence over all other considerations. The injured person, if moveable, should be transported under escort to the Emergency Department of the Queen Elizabeth II Health Sciences Center. The Emergency Department (9-473-2043) should be warned of the patient’s arrival and given the following information:

1. name(s) of patient(s)
2. nuclear substance involved
3. total activity involved
4. physical form of nuclear substance (powder, liquid)
5. chemical form of nuclear substance
6. extent of contamination (skin, inhalation, ingestion)
7. nature of injuries

Inform Security (4109, who will in turn contact the RSO)
F.3 Fire

In the event of fire, personnel must follow Dalhousie University’s fire procedures for the area. Laboratory personnel should see that the door to the radiation area is closed and take all reasonable steps to prevent the combustion of nuclear substances. Security should be contacted immediately at 4109 who will in turn notify the RSO.
APPLICATION FOR NUCLEAR SUBSTANCE USER PERMIT

1. a) Principal Investigator: ________________________
   b) Department: ________________________________
   c) Phone #: _________________________________
   d) E-Mail: __________________________________

2. Previous experience in nuclear substance work by applicant: ________________________________

3. List all rooms where nuclear substances will be used or stored: ______________________________

4. Description of nuclear substances required:

   **Unsealed sources:**

<table>
<thead>
<tr>
<th>Nuclear Substance</th>
<th>Maximum amount to be used or stored at any time (SI units)</th>
<th>Anticipated annual use (SI units)</th>
</tr>
</thead>
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</table>

   **Sealed sources:**

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<thead>
<tr>
<th>Nuclear Substance</th>
<th>Activity (SI units)</th>
<th>Serial #</th>
<th>Model</th>
</tr>
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</table>

5. Primary use of nuclear substances:

   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________

6. Instrumentation (include survey meters, LS counters, (counters)
7. List of nuclear substance workers (attach separate sheet if necessary)

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Previous Radiation Safety Training (note institution and date)</th>
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8. Name another qualified person who will assume responsibility for your permit during any leave of more than 14 days that you might take. You are required to advise the Radiation Safety Office when taking an extended or sabbatical leave:

______________________________________

9. The applicant warrants the statements contained herein and agrees that the nuclear substances supplied against this application **shall** only be used for the purpose and in the manner authorized by the Dalhousie University Radiation Safety Committee.

Signature: ______________________    Date: ______________________

Department Head: ________________________
NUCLEAR SUBSTANCE USER PERMIT
PRINCIPAL INVESTIGATOR RESPONSIBILITIES

An authorized principal investigator is a professional staff member who has been authorized by the Radiation Safety Committee to use nuclear substances and to supervise the use of these materials by others, specifically graduate students, grant paid employees and university paid employees. The authorized principal investigator is responsible for ensuring that individual user responsibilities are discharged by those using nuclear substances under his/her direction and that such users have been apprised of the risks associated with the use of nuclear substances.

THE PRINCIPAL INVESTIGATOR SHALL DO THE FOLLOWING:

1. Assure compliance with the following Dalhousie University policies:
   a) ALARA policy
   b) Bioassay policy
   c) Compliance Enforcement policy
   d) Handling Animals Injected with a Nuclear Substance policy
   e) Prenatal Radiation Exposure policy
   f) Purchasing policy
   g) Radioactive Waste Disposal policy
   h) Record Keeping policy
   i) Security policy
   j) Termination of Use policy
   k) Training policy

2. Determine the type and amount of a nuclear substance to be used and develop appropriate safety procedures in consultation with the Radiation Safety Officer.

3. Instruct individual users under his/her supervision in practices for safely working with nuclear substances and ensure that individual users under his/her supervision who will be working in areas where nuclear substances are used or stored attend appropriate Radiation Safety Training sessions.
4. Promptly inform the Radiation Safety Officer of any personnel changes, procedural changes or equipment alterations that might affect radiation control or personnel exposures.

5. Ensure that service personnel are not permitted to work on equipment, fume hoods, or sinks in areas where nuclear substances are used or stored without clearance from the Radiation Safety Office.

6. Comply with all conditions of the Nuclear Substance User Permit issued in his/her name.

7. Comply with the terms of Dalhousie University’s ‘Radiation Safety Program, Policy and Procedure Manual’.

8. Comply with the Canadian Nuclear Safety Commission’s poster INFO - 0142 - 1 Rev.3, "Radioisotope Safety, Basic Laboratories"

I have read, understand and agree to comply with the above.

_________________________________________  _________________________
Signature of Principal Investigator              Date

Date received by Radiation Safety Office: ______________________

Date approved as Principal Investigator: ______________________

Date                  Initials (RSO)
APPLICATION FOR NUCLEAR SUBSTANCE USER PERMIT AMENDMENT

With reference to Nuclear Substance User permit #:  

Number ___________________ Expiring ___________________

Project Director ___________________ Department ___________________

The following changes are proposed:

1. Change possession limits ____________________________

2. New nuclear substance (specify and attach a statement of use)  
   ___________________________________________________

3. Deletion of nuclear substance (specify)  
   ___________________________________________________

4. Change Project Director to  
   ___________________________________________________

5. Change location to  
   ___________________________________________________

6. Change designated alternate to  
   ___________________________________________________

7. Other (specify)  
   ___________________________________________________

Date: ___________________ Signature: ___________________

Approved by: ___________________ (Radiation Safety Committee)

Date: ___________________

Form#: RS-002
APPLICATION FOR RENEWAL OF NUCLEAR SUBSTANCE USER PERMIT

With reference to Nuclear Substance User Permit #:

Number ______________________ Expiring ______________________

Project Director ________________ Department ______________________

________________________________________________________________

Approval is requested for renewal of the above permit (check one)

__________ under the same conditions as specified in the original application

__________ with changes as requested on the attached application for amendment

Please append to this application a current list of workers who will use/handle nuclear substances under your supervision. This list will form part of your renewed permit.

Date: ________________________ Signature: _________________________

Approved by: _________________________ (Radiation Safety Committee)

Date: ________________________

Form#: RS-003
Record of Disposition of Radioactive Material

WITH REFERENCE TO NUCLEAR SUBSTANCE USER PERMIT #:

Number ___________________________ Expiring __________________

Project Director ____________________________

Department _______________________________

_________________________________________________________________

This is to certify that:

It is not my intention to renew the referenced Nuclear Substance User Permit

and that:

_______  1. No radioactive material is currently in my possession

_______  2. All radioactive material obtained on the above permit has been disposed of as per Dalhousie University guidelines.

_______  3. All radioactive material obtained and/or possessed by the above permit holder has been transferred to ____________________ whose permit number is ____________________ .

_______  4. Other (Please specify)

Date ________________ Signature ______________________

Received By _______________________ (RSO)

Date ________________
TRANSFER OF RADIOISOTOPE

Identified as "excepted radioactive material, limited activity"

PRINCIPAL INVESTIGATOR: ________________________________

PERMIT #: __________________________

NUCLEAR SUBSTANCE: __________________________

QUANTITY (activity & volume):________________________

FORM: Solid _____  Liquid _____  Gas _____

FROM: Room # _____  Building __________

TO: Room # _____  Building __________

_____________________________________________  ________________________
Signature ( Principal Investigator )  Date

Distribution: 1 copy - Radiation Safety Office
1 copy - Recipient
1 copy - Supplier
RADIATION WORKER REGISTRATION FORM

Personal Information:
Name: ________________________  Department: ________________________
Supervisor: ____________________  Phone #: _________________________
Start Date: _____________________

Previous Radiation Safety Training:
Type of training: ___________________ where trained: ______________________
Date of training: ___________________ Certificate _______(yes) _________ (no)
Previous experience handling radioactive materials: ________________________________
________________________________________________________
________________________________________________________

Radioisotopes handled:
________________________________________________________

I agree to attend the first available Radiation Safety Training Course offered by Dalhousie University. In the interim I acknowledge that I have read, understand and will comply with the policies as outlined in the Radiation Safety Manual and the Radiation Safety Policies. This material is available on our website at http://www.dal.ca/safety.

Signature:_________________________ Date:______________________________
RSO: _____________________________ Date:______________________________

*Training Waived: _____ RSO Signature:________________________________

*Training may be waived if you are able to demonstrate that appropriate training has been received at another institution.
DECLARATION OF PREGNANCY FORM

I declare that I am pregnant, for the purposes of lowering the dose received by me and/or my embryo/fetus. I understand and agree that additional monitoring may be required of me during the balance of my pregnancy to ensure that the dose limit of 1 mSv is not exceeded.

<table>
<thead>
<tr>
<th>Worker Name (please print)</th>
<th>Telephone Number</th>
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Estimated Date of Birth ________________________________

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<th>Signature of Worker</th>
<th>Date</th>
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<th>Signature of Supervisor</th>
<th>Date</th>
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<tr>
<th>Signature of Radiation Safety Officer</th>
<th>Date</th>
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</table>
1. Permit Holder: ________________________  Permit #: ________________________

2. Instructor: ___________________________  Department: ______________________

3. Phone Number: ______________________

4. Class Title:
__________________________________________________________________________

5. Dates of sessions in which Nuclear Substances will be used:
__________________________________________________________________________

6. Rooms where above sessions will be held: _________________________________

7. Nature of work that students will undertake:
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

8. List Nuclear Substances and activity of each that a student will handle:
__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

9. List of students (complete page two)

   Date: __________________________  Signature: __________________________

   Department Chair/Head ______________________________

Form#: RS-004
The instructor and permit holder shall be responsible for the safe use of nuclear substances by all involved.
SAFE HANDLING OF NUCLEAR SUBSTANCES

There are three main hazards involved when working with open sources of nuclear substances. These are:

**Skin contamination and/or deposition of nuclear substances in the body**

**Spread of contamination**

**External radiation**

In teaching laboratories students handle very small quantities of nuclear substances, so generally, the hazard from external radiation is minimal. The main hazards are spread of contamination and internal deposition of the nuclear substance.

Spread of contamination is controlled by:

1. **Containment**
   a) use of spill trays (double containment)
   b) use of absorbent pads

2. **Cleanliness**
   a) good housekeeping
   b) regular weekly wipe testing
   c) good personal hygiene

Nuclear substances can be internally deposited by the following routes of entry into the body:

1. Direct **inhalation** of airborne contamination (volatility, droplets, particulates)
2. **Ingestion**, that is entry through the mouth
3. **Absorption** through intact skin or a contaminated wound

Once nuclear substances are inside the body they may be selectively concentrated in one or more organs referred to as **critical or target organs**. These target areas will continue to be irradiated until the nuclear substance has decayed or the body has biologically eliminated the substance.

To avoid the possibility of internal deposition of the nuclear substance the following laboratory rules **shall be strictly enforced.**

1. Do not bring unnecessary personal items into the laboratory
2. Wear proper protective clothing (lab coats, disposable gloves)
3. **Do not eat drink, smoke, apply cosmetics or store food where nuclear substances are used.**
4. Do not pipette by mouth.
5. Line work benches with disposable absorbent pads.

6. Label anything likely to become contaminated before the experiment begins.

7. Define an area on the lined workbench where contaminated items are to be laid down.

8. Radioactive waste is to be disposed of only in the containers provided.

9. If a nuclear substance is spilled, immediately cover the area with absorbent paper and call for assistance from the demonstrator. If you become contaminated, stay at your work area to avoid spread of the contamination and immediately call for assistance from the demonstrator.

10. **Hands must be thoroughly washed with soap and lukewarm water at the completion of your operation.**

*I have read, understand and agree to comply with the above instructions:*

NAME: (please print) __________________________________________

CLASS TITLE:____________________  INSTRUCTOR:____________________

DATE: _____________SIGNATURE:________________________________

Detach form and return to the Radiation Safety Office. This form must be on file in the Radiation Safety Office in order to participate in the class.

RS 011
RADIATION INCIDENT REPORT

To: Radiation Safety Office

From: __________________________  P.I. Signature __________________________

Date: __________________________

Location Of Incident:  Bldg ___________________  Room # ___________________

Nuclear Substance(s) Involved: _______________  Estimated Activity: __________

Date/Time Of Incident:  Date: ___________________  Time: _______________

Name Of Person Making Report: __________________________

Instrument Used To Check For Contamination: __________________________

6. Give a brief description of the incident:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

7. Name of individual(s) present:

________________________________________________________________________

8. Injuries sustained: ______ (yes)  __________ (no)

9. Personnel contamination: _______ (yes, describe)  ______ (no)

________________________________________________________________________

10. Action Taken: (see attached report)

11. Statement Of The Cause(s):

________________________________________________________________________

12. Any Remedial Action Taken:

________________________________________________________________________

13. Additional Comments:
RADIOACTIVE SPILL CONTAMINATION/CLEAN UP SURVEY

Decontamination completed at ____:____ on ____-____-____

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-Clean cpm/dpm</th>
<th>Post clean cpm/dpm</th>
<th>Activity Present</th>
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Name: __________________________________________
### SAFETY DATA SHEET

**HYDROGEN-3 (TRITIUM)**

#### PHYSICAL DATA:

<table>
<thead>
<tr>
<th>Radiation:</th>
<th>Beta ($\beta$) 100 % abundance</th>
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<tbody>
<tr>
<td>Energy:</td>
<td>Max: 18.6 keV; Avg. 5.7 keV</td>
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<tr>
<td>Half Life ($T_{1/2}$)</td>
<td>Physical - 12.3</td>
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<tr>
<td></td>
<td>Biological - 10-12d</td>
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<tr>
<td></td>
<td>Effective - 10-12d</td>
</tr>
<tr>
<td>Specific Activity</td>
<td>$3.59 \times 10^9$ Bq</td>
</tr>
<tr>
<td>Beta Range:</td>
<td>Air - 6 mm</td>
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<tr>
<td></td>
<td>Water - 0.006 mm</td>
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#### RADIOLOGICAL DATA:

<table>
<thead>
<tr>
<th>Exemption Quantity</th>
<th>$1 \times 10^9$ Bq</th>
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<tbody>
<tr>
<td>Radiotoxicity</td>
<td>Slight</td>
</tr>
<tr>
<td>Critical organ</td>
<td>Whole body (water &amp; tissue)</td>
</tr>
<tr>
<td>Exposure routes</td>
<td>Ingestion, inhalation, absorption</td>
</tr>
<tr>
<td>Radiological hazard</td>
<td>External - not a radiological concern</td>
</tr>
<tr>
<td></td>
<td>Internal - primary concern</td>
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</table>

#### SHIELDING:
None required

#### DOSIMETRY REQUIREMENTS:
External dosimetry not required; urine bioassay for suspected intake

#### DETECTION:
Liquid scintillation counting

#### PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS:
Lab coats, double gloves

#### SPECIAL PRECAUTIONS
Avoid skin contamination by double gloving (change outer pair ~ every 20 minutes)

---

### $^3$H Handling Procedures

1. Designate an area for handling $^3$H and label clearly
2. Do not consume food and/or drink in the laboratory
3. Do not pipette by mouth
4. Cover work surfaces with absorbent liners
5. Use transfer pipettes and spill trays to confine contamination
6. Promptly return stock solutions to storage areas
7. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
8. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
9. Maintain cleanliness and good housekeeping in the work area
10. Supervise nuclear substances at all times when in use
11. Keep laboratory locked when unattended
### SAFETY DATA SHEET

**CARBON-14**

**14C**

#### PHYSICAL DATA:
- **Radiation:** Beta (β) - 100% abundance
- **Energy:** Max: 156 keV; Avg: 49 keV
- **Half Life (T ½):**
  - Physical - 5730 yrs
  - Biological - 12 d
  - Effective - 12 d (bound); 40 d (unbound)
- **Specific Activity:** 1.65E + 11 Bq·g⁻¹
- **Beta Range:**
  - Air: 24 cm.
  - Water/Tissue: 0.28 mm
  - Plexiglas: 0.3 mm

#### RADIOLOGICAL DATA:
- **Exemption Quantity:** 1 x 10⁸ Bq
- **Radiotoxicity:** Moderate
- **Critical organ:** Fat tissue
- **Exposure routes:** Ingestion, inhalation, absorption
- **Radiological hazard:**
  - External - dose to skin from contamination in mSv·h⁻¹ = 3.24E⁻¹/kBq·cm²
  - Internal - primary concern

#### SHIELDING:
- 0.75 - 3 mm Plexiglas

#### DOSIMETRY REQUIREMENTS
- External dosimetry not required; urine bioassay for suspected intake

#### DETECTION
- Liquid scintillation counting
- Pancake GM detector - 3.75% efficiency @ cm (2.25% probe protected with saran wrap; 0.06% protected with parafilm)

#### PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS:
- Lab coats, double gloving

#### SPECIAL PRECAUTIONS
- Avoid skin contamination by double gloving (change outer pair ~ every 30 minutes), use remote handling devices where possible

#### 14C Handling Procedures:
1. Designate an area for handling 14C and label clearly
2. Do not consume food and/or drink in the laboratory
3. Do not pipette by mouth
4. Cover work surfaces with absorbent liners
5. Use transfer pipettes and spill trays to confine contamination
6. Promptly return stock solutions to storage areas
7. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
8. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
9. Maintain cleanliness and good housekeeping in the work area
10. Supervise nuclear substances at all times when in use
11. Keep laboratory locked when unattended
## SAFETY DATA SHEET
### IODINE -125

### PHYSICAL DATA:
- **Radiation:**
  - Gamma (γ) - 35.5 keV (7 % abundance)
  - X-ray - 27 keV (113 % abundance)
- **Specific γ ray constant:** 0.27 - 7.0 μSv/hr/37 MBq @ 1 m
- **Half Life (T₁/₂):**
  - Physical - 60.1 d
  - Biological - 120-138 d
  - Effective - 42 d
- **Specific Activity:** $6.45 \times 10^{14}$ Bq.g⁻¹

### RADIOLOGICAL DATA:
- **Exemption Quantity:** $1 \times 10^6$ Bq
- **Radiotoxicity:** High
- **Critical organ:** Thyroid
- **Exposure routes:** Inhalation, ingestion, absorption
- **Radiological hazard:**
  - External - 1.56 - 2.75 mSv/hr @ 1 cm
  - Internal - primary concern

### SHIELDING:
- **Half Value Layer (HVL) - Lead:** < 1 mm
- **Tenth Value Layer (TVL) - Lead:** < 1 mm

### DOSIMETRY REQUIREMENTS
- Whole body TLD’s, bioassay requirement if handling < 50 MBq in a fume hood

### DETECTION:
- Low energy NaI detector or Wipe test - LS or γ counting

### PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS
- Lab coat, double gloves, foot covers (iodination procedures)

### SPECIAL PRECAUTIONS
- Avoid skin contamination by double gloving (change outer pair ~ every 30 minutes); use remote handling devices where possible. Avoid making low pH solutions containing $^{125}$I to avoid volatilization. Confine as many manipulations as possible to a fume hood that draws at a minimum of 0.5 - 1.0 m/sec

### $^{125}$I Handling Precautions
1. Designate an area for handling $^{125}$I and label clearly
2. Avoid making low pH solutions containing $^{125}$I to avoid volatilization.
3. Confine manipulations to a fume hood that draws at a min of 0.5 - 1.0 m/sec
4. Do not consume food and/or drink in the laboratory
5. Do not pipette by mouth
6. Cover work surfaces with absorbent liners
7. Use transfer pipettes and spill trays to confine contamination
8. Promptly return stock solutions to storage areas
9. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
10. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
11. Maintain cleanliness and good housekeeping in the work area
12. Supervise nuclear substances at all times when in use
13. Keep laboratory locked when unattended
SAFETY DATA SHEET
PHOSPHORUS-32

PHYSICAL DATA:
Radiation: Beta (β) 100 % abundance
Energy: Max: 1.709 MeV; Avg: 0.690 MeV
Half Life (T 1/2): Physical - 14.3d
Biological - 257d
Effective - 14.1d
Specific Activity: 1.06E + 16 Bq.g⁻¹
Beta Range: Air - 610 cm
Water/tissue - 0.76 cm
Plexiglass - 0.61 cm

RADIOLOGICAL DATA:
Exemption Quantity: 1 x 10⁴ Bq
Radiotoxicity: Moderate
Critical organ: Bone
Exposure routes: Ingestion, inhalation, absorption
Radiological hazard:
External (skin contamination) 87-92 mSv/37 MBq/cm²
External (exposure) 7.8 Sv/hr @ surface of 37 MBq sol
Internal - bone receives ~ 20% of internal dose

SHIELDING:
Shield with 2 cm Plexiglas; apply thin lead sheeting to absorb bremsstrahlung if necessary

DOSIMETRY REQUIREMENTS:
Whole body and ring TLD’s required

DETECTION:
Pancake GM probe - 22.4% efficient or Liquid scintillation counting

PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS
Lab coats, double gloving (outer pair changed ~ every 30 minutes), eye protection

SPECIAL PRECAUTIONS
Avoid skin contamination by double gloving and using remote handling tools
Store ³²P waste behind Plexiglas shielding
Always have a portable survey meter present and turned on (including audio) during handling

³²P Handling Procedures
1. Designate an area for handling ³²P and label clearly
2. Place a whole body Plexiglas shield on the work area
3. Ensure both whole body and ring TLD dosimeters are worn at all times when handling ³²P
4. Ensure that a functioning survey meter is available and in the “ON” position during the entire procedure. The audio must also be turned on
5. Do not consume food and/or drink in the laboratory
6. Cover work surfaces with absorbent liners
7. Use transfer pipettes and spill trays to confine contamination
8. Promptly return stock solutions to storage areas
9. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
10. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
11. Water soluble waste may be disposed to the sanitary sewer provided that the dilution criteria as defined by the CNSC is met
12. Maintain cleanliness and good housekeeping in the work area
13. Supervise nuclear substances at all times when in use
14. Keep laboratory locked when unattended
SAFETY DATA SHEET
PHOSPHORUS -33

PHYSICAL DATA:
Radiation: Beta (β') 100 % abundance
Energy: Max: 249 keV; Avg: 85 keV
Half Life (T ½ )
  Physical - 25.4 d
  Biological - 257 d
  Effective - 24.9 d
Specific Activity: 5.72E + 15 Bq.g⁻¹
Beta Range:
  Air - 50 cm
  Water/tissue - 0.06 cm
  Plexiglass - 0.05 cm

RADIOLOGICAL DATA:
Exemption Quantity: 1 x 10⁶ Bq
Radiotoxicity: Moderate
Critical organ: Bone marrow
Exposure routes: Inhalation, ingestion, absorption
Radiological hazard: External - dose from skin contamination in mSv.h⁻¹ = 8.65E⁻¹/kBq.cm³

SHIELDING: 32 mm Plexiglas for stock solutions

DOSIMETRY REQUIREMENTS: None required. Contact RSO for suspected intake

DETECTION
Liquid scintillation counting
Pancake GM probe - ~ 8% efficiency @ 1 cm (7.2% efficient (saran wrap covered); 1.95% efficient (parafilm covered))

PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS
Lab coats, double gloving

SPECIAL PRECAUTIONS
Avoid skin contamination by double gloving (change outer pair ~ every 30 minutes), use remote handling devices

³³P Handling Procedures

1. Designate an area for handling ³³P and label clearly
2. Do not consume food and/or drink in the laboratory
3. Do not pipette by mouth
4. Cover work surfaces with absorbent liners
5. Use transfer pipettes and spill trays to confine contamination
6. Promptly return stock solutions to storage areas
7. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
8. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
9. Maintain cleanliness and good housekeeping in the work area
10. Supervise nuclear substances at all times when in use
11. Keep laboratory locked when unattended
### SAFETY DATA SHEET
**SULPHUR-35**

#### 35S

<table>
<thead>
<tr>
<th><strong>PHYSICAL DATA:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation:</td>
<td>Beta (β) - 100 % abundance</td>
</tr>
<tr>
<td>Energy:</td>
<td>Max: 167 keV; Avg: 53 keV</td>
</tr>
<tr>
<td>Half Life (T ½ )</td>
<td>Physical - 87.4 d</td>
</tr>
<tr>
<td></td>
<td>Biological - 623 d</td>
</tr>
<tr>
<td></td>
<td>Effective - 44 - 76 d</td>
</tr>
<tr>
<td>Specific Activity</td>
<td>1.58E + 15 Bq.g⁻¹</td>
</tr>
<tr>
<td>Beta Range:</td>
<td>Air - 26 cm</td>
</tr>
<tr>
<td></td>
<td>Water/tissue - 0.32 mm</td>
</tr>
<tr>
<td></td>
<td>Plexiglass - 0.25 mm</td>
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</table>

<table>
<thead>
<tr>
<th><strong>RADIOLOGICAL DATA:</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exemption Quantity</td>
<td>1 x 10⁸ Bq</td>
</tr>
<tr>
<td>Radiotoxicity</td>
<td>Moderate</td>
</tr>
<tr>
<td>Critical organ</td>
<td>Whole body, testes</td>
</tr>
<tr>
<td>Exposure routes</td>
<td>Inhalation, ingestion, absorption</td>
</tr>
<tr>
<td>Radiological hazard</td>
<td>External – negligible</td>
</tr>
<tr>
<td></td>
<td>Internal - primary concern</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SHIELDING:</strong></th>
<th>3 mm Plexiglas for stock solutions</th>
</tr>
</thead>
</table>

**DOSIMETRY REQUIREMENTS:** None required. Contact RSO for suspected uptake

**DETECTION:** Liquid scintillation counting or Pancake GM probe - 4-6 % efficiency @ 1cm

**PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS:** Lab coats, double gloving

### SPECIAL PRECAUTIONS
Avoid skin contamination by double gloving (change outer pair ~ every 30 minutes). Use remote handling devices where possible.
Many 35S compounds are slightly volatile. This can occur when 35S amino acids are thawed, and when added to cell culture media and incubated.

**35S Handling Procedures**

1. Designate an area for handling 35S and label clearly
2. Do not consume food and/or drink in the laboratory
3. Do not pipette by mouth
4. Cover work surfaces with absorbent liners
5. Use transfer pipettes and spill trays to confine contamination
6. Handle potentially volatile compounds (particularly 35S methionine and cysteine) in ventilated enclosures
7. Vent 35S amino acid stock vials with an open ended charcoal filled disposable syringe
8. Incubators used with 35S should have an activated charcoal trap placed inside
9. Promptly return stock solutions to storage areas
10. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
11. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
12. Maintain cleanliness and good housekeeping in the work area
13. Supervise nuclear substances at all times when in use
14. Keep laboratory locked when unattended
SAFETY DATA SHEET  
CHROMIUM-51  
$^{51}\text{Cr}$

### PHYSICAL DATA:
- **Radiation:**
  - Gamma (γ) 320 keV (9.8 % abundance)
  - X-ray - 5 keV (22 % abundance)
- **Specific γ ray constant:** 0.17 μSv/37 MBq @ 1 m
- **Half Life (T½):**
  - Physical - 27.8 d
  - Biological - 616 d
  - Effective - 26.6 d
- **Specific Activity:** 3.42E + 15 Bq.g$^{-1}$

### RADIOLOGICAL DATA:
- **Exemption Quantity:** 1 x 10$^6$ Bq
- **Radiotoxicity:** Moderate
- **Critical organ:** Lower large intestine (LLI)
- **Exposure routes:** Ingestion, inhalation, absorption
- **Radiological hazard:**
  - External - 16 mSv/hr/37 MBq @ 1 cm
  - Internal - concern

### SHIELDING:

<table>
<thead>
<tr>
<th>Material</th>
<th>Half Value Layer (HVL)</th>
<th>Tenth Value Layer (TVL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>2mm</td>
<td>7 mm</td>
</tr>
<tr>
<td>Concrete</td>
<td>2.8 cm</td>
<td>9.3 cm</td>
</tr>
<tr>
<td>Steel</td>
<td>21 cm</td>
<td>50 cm</td>
</tr>
</tbody>
</table>

* The accessible dose rate should not exceed 2.5 μSv/hr

### DOSIMETRY REQUIREMENTS:
- Whole body TLD’s

### DETECTION:
- Survey meter equipped with a NaI detector

### PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS:
- Lab coats, double gloving

### SPECIAL PRECAUTIONS
- Avoid skin contamination by double gloving (change outer pair ~ every 30 minutes), use remote handling devices where possible
- Store $^{51}\text{Cr}$ waste behind lead shielding sufficient to reduce dose rate to < 2.5 μSv/h

### $^{51}\text{Cr}$ Handling Procedures:

1. Designate an area for handling $^{51}\text{Cr}$ and label clearly
2. Do not consume food and/or drink in the laboratory
3. Do not pipette by mouth
4. Cover work surfaces with absorbent liners
5. Use transfer pipettes and spill trays to confine contamination
6. Promptly return stock solutions to storage areas
7. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
8. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
9. Maintain cleanliness and good housekeeping in the work area
10. Supervise nuclear substances at all times when in use
11. Keep laboratory locked when unattended
SAFETY DATA SHEET
INDIUM - 111

**PHYSICAL DATA:**
Radiation: Gamma (γ) 245 keV (94% abundance); 171 keV (90% abundance); 23 keV (69% abundance)
Specific γ ray constant 9.9E-4 @ 30 cm from 1 MBq
Half Life (T½) Physical - 2.80 d
Specific Activity 1.55E + 16 Bq⁻¹

**RADIOLOGICAL DATA:**
Exemption Quantity 1 x 10⁶ Bq
Radiotoxicity Moderate
Critical organ Lower large intestine (LLI)
Exposure routes Ingestion, inhalation, absorption
Radiological hazard External - contamination skin dose in mSv.h⁻¹ = 3.78E-1/kBq/cm²

**SHIELDING:**
<table>
<thead>
<tr>
<th>Material</th>
<th>Half Value Layer (HVL)</th>
<th>Tenth Value Layer (TVL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>&lt; 1 mm</td>
<td>3 mm</td>
</tr>
<tr>
<td>Steel</td>
<td>9 mm</td>
<td>31 mm</td>
</tr>
</tbody>
</table>

* The accessible dose rate should not exceed 2.5 μSv/hr

**DOSIMETRY REQUIREMENTS:** Whole body TLD’s required

**DETECTION:** Pancake GM detector

**PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS:** Lab coats, double gloving

**SPECIAL PRECAUTIONS**
Avoid skin contamination by double gloving (change outer pair ~ every 30 minutes); use remote handling devices where possible. Store ¹¹¹In waste behind sufficient lead shielding to reduce exposure rates to < 2.5 μSv/hr.

**¹¹¹In Handling Procedures**

1. Designate an area for handling ¹¹¹In and label clearly
2. Do not consume food and/or drink in the laboratory
3. Do not pipette by mouth
4. Cover work surfaces with absorbent liners
5. Use transfer pipettes and spill trays to confine contamination
6. Promptly return stock solutions to storage areas
7. Maintain contamination control by regularly monitoring and promptly cleaning contaminated areas
8. Isolate waste in clearly labelled containers and arrange for disposal with the RSO
9. Maintain cleanliness and good housekeeping in the work area
10. Supervise nuclear substances at all times when in use
11. Keep laboratory locked when unattended
RADIATION SAFETY MANUAL - GLOSSARY

Absorbed Dose

The amount of energy imparted to matter by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the Gray (Gy)

Activity

The number of nuclear disintegrations occurring in a given quantity of material per unit time

Activity, specific

The activity per unit of mass or volume of a given sample

ALARA

Acronym for As Low As Reasonably Achievable- making every reasonable effort to maintain exposures to radiation as far below the dose limits as is practical consistent with the purpose for which the licensed activity is undertaken, taking into account technology, the economics of improvements in relation to benefits to the public health and safety, and other socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

Alpha Particle

A strongly ionizing particle emitted from the nucleus during radioactive decay, having a mass and charge equal in magnitude to a helium nucleus, consisting of two protons and two neutrons with a double negative charge

Annual Limit of Intake (ALI)

The derived limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by reference man that would result in a committed effective dose equivalent of 50 mSv or a committed dose equivalent of 500 mSv to any individual organ or tissue.

Background Radiation

Ionizing radiation arising from radioactive material other than the one directly under consideration. Background radiation due to cosmic rays and natural radioactivity is always present

Becquerel

The international (SI) unit of radioactivity in which the number of disintegrations is equal to one disintegration per second
**Beta Particle**

Charged particle emitted from the nucleus of an atom during radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

**Bioassay**

The determination of kinds, quantities or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement (in vivo) or by analysis and evaluation of materials excreted or removed from the human body.

**Bremsstrahlung**

Photon radiation produced by deceleration of charged particles (usually electrons) passing through matter.

**Calibration**

Determination of variation from standard, or accuracy, of a measuring instrument to ascertain necessary correction factors. The check or correction of the accuracy of a measuring instrument to assure proper operational characteristics.

**Contamination, radioactive**

Deposition of radioactive material in any place where it is not desired, and particularly in any place where its presence may be harmful.

**Critical Organ**

The organ or tissue, the irradiation of which will result in the greatest hazard to the health of the individual.

**Decay, radioactive**

Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.

**Declared Pregnant Worker**

A woman who has voluntarily informed her employer, in writing, of her pregnancy and the estimated date of conception.

**Decontamination**

The reduction or removal of contaminating radioactive material from a structure, area, object, or person. Decontamination may be accomplished by (1) treating the surface to remove or decrease contamination, (2) letting the material stand so that radioactivity is decreased as a result of natural decay, and (3) covering the contamination to shield or attenuate the radiation emitted.
**Dose Equivalent**

The product of the absorbed dose in tissue, quality factor, and all other necessary modifying factors at the location of interest.

**Dose Rate**

The radiation dose delivered per unit of time

**Dosimeter**

A portable instrument for measuring and registering the total accumulated exposure to ionizing radiation

**Efficiency (radiation detection instrument)**

A measure of the probability that a count will be recorded when radiation is incident on a detector

**Electron Volt**

A unit of energy equivalent to the amount of energy gained by an electron in passing through a potential difference of 1 volt, abbreviated eV

**External Dose**

That portion of the dose equivalent received from radiation sources outside the body

**Gamma Ray**

Very penetrating electromagnetic radiation frequently emitted from the nucleus of an atom during radioactive decay

**Geiger-Mueller (G-M) Counter**

A radiation detection and measuring instrument consisting of a gas filled tube containing electrodes, between which there is electrical voltage but no current flowing. When ionizing radiation passes through the tube, a short, intense pulse of current passes from the negative electrode to the positive electrode and is measured or counted

**Gray**

The international (SI) unit of absorbed dose in which the energy is equal to one Joule per kilogram

**Half-Life, Biological**

Time required to eliminate 50% of a dose of any substance by the regular processes of elimination
**Half-Life, Effective**

Time required for a radioactive nuclide in a system to be diminished by 50% as a result of the combined action of radioactive decay and biological elimination

**Half-Life, Radioactive**

Time required for a radioactive substance to lose 50% of its activity by decay. Each radioisotope has a unique half-life

**Half Value Layer**

The thickness of any specified material necessary to reduce the intensity of an x-ray or gamma ray beam to one-half its original value

**Inverse Square Law**

The intensity of radiation at any distance from a point source varies inversely as the square of that distance

**Ionization**

The process by which a neutral atom or molecule acquires a positive or negative charge

**Ionizing Radiation**

Any radiation capable of displacing electrons from atoms or molecules, thus producing ions

**Isotopes**

Nuclides having the same number of protons in their nuclei, and hence having the same atomic number, but differing in the number of neutrons, and therefore in the mass number

**Monitoring**

The measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of the results of these measurements to evaluate potential exposures and doses

**Neutron**

Elementary particle with a mass approximately the same as that of a hydrogen atom and electrically neutral

**NORM**

Naturally occurring radioactive materials
Occupational Radiation Dose

The dose received by an individual in the course of employment in which the individual’s assigned duties involve exposure to radiation and to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the general public.

Photon

A quantum of energy emitted in the form of electromagnetic radiation. Gamma rays and x-rays are examples of photons.

Principal Investigator (P.I.)

A faculty member appointed by the licensee, who has been approved through the Radiation Safety Committee for the purchase and use of radioactive materials.

Proton

An elementary nuclear particle with a positive electric charge located in the nucleus of an atom.

Quality Factor

A modifying factor that is used to derive dose equivalent from absorbed dose. It corrects for varying risk potential due to the type of radiation.

Radioisotope

A nuclide with an unstable ratio of neutrons to protons placing the nucleus in a state of stress. In an attempt to reorganize to a more stable state, it may undergo various types of rearrangement that involve the release of radiation.

Radiosensitivity

The relative susceptibility of cells, tissues, organs, organisms, or other substances to the injurious action of radiation.

Radiotoxicity

Term referring to the potential of an isotope to cause damage to living tissue by absorption of energy from the disintegration of the radioactive material introduced into the body.

Scintillation Counter

A counter in which light flashes produced in a scintillator by ionizing radiation are converted into electrical pulses by a photomultiplier tube.
**Sealed Source**

Radioactive material that is permanently bonded or fixed in a capsule or matrix designed to prevent release and dispersal of the radioactive material under the most severe conditions which are likely to be encountered in normal use and handling.

**Sievert**

The international (SI) of dose equivalent.

**Thermoluminescent Dosimeter (TLD)**

Crystalline materials that emit light if they are heated after they have been exposed to radiation.