Radiation Safety for Nuclear Substances
Refresher Training
Refresher Training Instructions

The following refresher training is intended for nuclear substance workers who have previously attended the full day Radiation Safety training workshop and is not intended to substitute for the full training session.

This course is also intended to provide Radiation Safety awareness training for anyone required to only use sealed sources of radiation.

Refresher training is required every **three** years to maintain a valid nuclear substance worker status.

Refresher training will be documented by reviewing this power point and submitting the associated quiz to the Environmental Health & Safety Office.

If you are required to receive radioactive packages, you will also need to complete the TDG Class 7 Receiving refresher training.

If you are required to ship radioactive packages you must complete an external course. For more information contact the Radiation Safety Officer.
Course Outline

This refresher course will review the following topics:

• The Basics of Radiation
• Nuclear Substance Regulators
• Responsibilities
• Nuclear Substance Worker Classifications
• Radiation Hazards
• Purchasing & Transferring Nuclear Substances
• Laboratory Requirements
• Laboratory Signage
The Basics of Radiation
Types of Radiation

Radiation is energy in the form of waves or particles. There are two types of radiation:

- **Non-Ionizing Radiation** (low energy) – which *does not* have sufficient energy to dislodge orbital electrons. Ex: heat, visible light, microwaves

- **Ionizing Radiation** (high energy) – which *does* have sufficient energy to dislodge orbital electrons. Ex: alpha and beta particles, gamma and x-rays
## Types of Ionizing Radiation

Understanding different types of ionizing radiation and the corresponding details in the chart below is an important part of working with nuclear substances. You should know the information presented below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Type of Radiation</th>
<th>Approx. Energy</th>
<th>Range in Air</th>
<th>Shielding Materials</th>
<th>Associated Hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha</td>
<td>Particle</td>
<td>High 2-8 (MeV)</td>
<td>A few centimetres</td>
<td>Paper, skin, clothing</td>
<td>Internal – ingested/inhaled</td>
</tr>
<tr>
<td>Beta</td>
<td>Particle</td>
<td>keV to 5 MeV</td>
<td>A few metres</td>
<td>Plastic, glass, plexiglass</td>
<td>Internal – ingested/inhaled, External – eyes/skin</td>
</tr>
<tr>
<td>Gamma</td>
<td>Electromagnetic</td>
<td>keV to 6 MeV</td>
<td>Very long range</td>
<td>Dense metals i.e. lead, concrete</td>
<td>Internal &amp; External – whole body</td>
</tr>
<tr>
<td>Neutrons</td>
<td>Particle - emitted upon fissioning of some heavy nuclides or light nuclei bombarded by alpha particles or gamma rays</td>
<td>Variable – depending on kinetic energy</td>
<td>Variable – depending on kinetic energy</td>
<td>Water, concrete, oil</td>
<td>Internal &amp; External – whole body</td>
</tr>
</tbody>
</table>
**Radiation Units of Measurement**

**Absorbed Dose** – The amount of energy deposited by ionizing radiation to a suitably small volume of matter divided by the mass of that volume. The unit of measurement of absorbed dose is the gray (Gy).

**Activity** – The rate at which nuclear disintegrations occur in radioactive material and is used to measure the amount of a radionuclide present. The unit of measurement of activity is the becquerel (Bq).

**Effective Dose** – A measure of dose designed to reflect the amount of radiation detriment, obtained by multiplying the equivalent dose of each tissue by an appropriate tissue weighting factor. The unit of measurement is the sievert (Sv).

**Equivalent Dose** – The risk adjusted absorbed dose. Absorbed dose is weighted by radiation type and tissue susceptibility to biological damage. The unit of measurement is the Sievert (Sv).

**Exposure** – The amount of charge produced per unit mass of air from x-rays and gamma rays. The unit of measurement is C/kg.
Half-Life or $T_{1/2}$

The decay of radioactive elements occurs at a fixed rate, with each radioisotope having its own unique rate at which it decays.

**Half-life or $T_{1/2}$** is the amount of time required for the activity of a radioisotope to decrease by half the original value.

A new source will have an intensity of 100%. At one half-life, the intensity will be reduced by 50% of the original intensity. At two half lives, it will have an intensity of 25%.

After 10 half-lives, less than $1000^{th}$ of the original activity will remain. At this point it is no longer considered “radioactive”. 

![Radioactive Half-life Graph](image-url)
### Commonly Used Isotopes and their Half-Lives

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Symbol</th>
<th>Half-Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-14</td>
<td>$^{14}\text{C}$</td>
<td>5 730 years</td>
</tr>
<tr>
<td>Fluorine-18</td>
<td>$^{18}\text{F}$</td>
<td>110 minutes</td>
</tr>
<tr>
<td>Iodine-123</td>
<td>$^{123}\text{I}$</td>
<td>13.2 hours</td>
</tr>
<tr>
<td>Nickel-63</td>
<td>$^{63}\text{Ni}$</td>
<td>96 years</td>
</tr>
<tr>
<td>Phosphorus-32</td>
<td>$^{32}\text{P}$</td>
<td>14.3 days</td>
</tr>
<tr>
<td>Sulfur-35</td>
<td>$^{35}\text{S}$</td>
<td>87.5 days</td>
</tr>
<tr>
<td>Technetium-99m</td>
<td>$^{99}\text{mTc}$</td>
<td>6 hours</td>
</tr>
<tr>
<td>Tritium</td>
<td>$^{3}\text{H}$</td>
<td>12.3 years</td>
</tr>
<tr>
<td>Uranium-238</td>
<td>$^{238}\text{U}$</td>
<td>4.5 billion years</td>
</tr>
</tbody>
</table>
Forms of Radioisotopes

Research techniques used at Dalhousie involve the use of nuclear substances in the following forms:

1. *Open Source*
   - A radioactive material that is not encapsulated, nor contained, and is easily spread
   - If adequate controls are not in place there is a risk of environmental contamination and personal contamination from external and internal routes
   - Typically in liquid form, but may also be in powder or gaseous form

2. *Sealed Source*
   - A radioactive material that is fully encapsulated and contained, and with normal use cannot be dispersed
   - Eliminates potential spread of contamination
   - Typically powders encapsulated in metal, plastic, epoxy resin, etc.
   - May be used alone as a teaching or calibration source or may be incorporated into a piece of equipment
Natural Background Radiation

Radiation is always present and is all around us in many natural forms. There are four major sources of natural radiation:

1. **Cosmic radiation** – ionizing radiation penetrating the earth’s atmosphere mainly from the sun and other celestial events
2. **Terrestrial radiation** – radiation found in the ground, rocks and soil, and therefore also found in some building materials
3. **Intakes of naturally occurring radionuclides through inhalation** – radioactive gases such as Radon found in buildings
4. **Intakes of naturally occurring radionuclides through ingestion** – many common foods including red meats, white potatoes, carrots, bananas, lima beans and Brazil nuts have been found to contain Potassium-40. Trace amounts of radioisotopes such as polonium-210, carbon-14 and potassium-40 have been found to occur naturally within the human body.

Natural background radiation accounts for approximately 60% of a person’s annual average effective dose.

Natural background radiation is approximately 1.8 mSv in Canada, 2.5 mSv in Halifax and 2.4 mSv worldwide.
Artificial Sources of Radiation Exposure

Artificial sources of radiation exposure come from commercial and industrial activities such as diagnostic and therapeutic medical procedures, smoking, and smoke detectors.

X-rays and other diagnostic and therapeutic medical procedures have been found to account for approximately 1.2 mSv a year of a person’s average annual dose.

Medical procedures and other sources of artificial radiation account for roughly 40% of our annual dose.

There is no difference between the effects caused by natural or man-made radiation.
Biological Effects of Radiation

Radiation can cause harm by damaging the DNA or other critical components of cells. There are three distinct responses that may result from radiation exposure:

1. **Proper DNA repair** – cell repairs itself and continues to function normally

2. **Deterministic Effects** – occur after a high dose of radiation to the DNA or cell, in a short period of time
   - The cell may die or be damaged beyond repair
   - The severity of the effects is related to the dose received

3. **Stochastic Effects** – occur after DNA has been damaged and the cell survives, however it no longer functions properly and may affect other cells
   - There is a statistical probability that the effects of exposure will occur
   - The probability of occurrence increases proportionally to the radiation dose received, however the timing of the effects or their severity does not depend on the dose
RADIATION EFFECTS

Measurements in millisieverts (mSv). Exposure is cumulative.

- Potentially fatal radiation sickness.
  Much higher risk of cancer later in life.
  10,000 mSv: Fatal within days.
  5,000 mSv: Would kill half of those exposed within one month.
  2,000 mSv: Acute radiation sickness.

- No immediate symptoms. Increased risk of serious illness later in life.
  1,000 mSv: 5% higher chance of cancer.
  400 mSv: Highest hourly radiation recorded at Fukushima. Four hour exposure would cause radiation sickness.
  100 mSv: Level at which higher risk of cancer is first noticeable

- No symptoms. No detectable increased risk of cancer.
  20 mSv: Yearly limit for nuclear workers.
  10 mSv: Average dose from a full body CT scan
  9 mSv: Yearly dose for airline crews.
  3 mSv: Single mammogram
  2 mSv: Average yearly background radiation dose in UK
  0.1 mSv: Single chest x-ray

EYES High doses can trigger cataracts months later.

THYROID Hormone glands vulnerable to cancer. Radioactive iodine builds up in thyroid. Children most at risk.

LUNGS Vulnerable to DNA damage when radioactive material is breathed in.

STOMACH Vulnerable if radioactive material is swallowed.

REPRODUCTIVE ORGANS High doses can cause sterility.

SKIN High doses cause redness and burning.

BONE MARROW Produces red and white blood cells. Radiation can lead to leukaemia and other immune system diseases.
Nuclear Substance Regulators
Regulators

The **Canadian Nuclear Safety Commission** (CNSC) is the governing body for nuclear substances in Canada. The **Nuclear Safety and Control Act** provides the CNSC with the authority to regulate the production and use of nuclear energy and materials to protect the environment, health, and safety of Canadians. The CNSC ensures that Canada is contributing to the international commitment of peacefully using nuclear energy.

The CNSC is responsible for communicating regulations and requirements to licensees, inspecting licensees for compliance, and intervening in the event of non-compliance.
Regulators

The International Atomic Energy Agency (IAEA) works with the CNSC to oversee the possession of safe guarded nuclear substances within Canada. The IAEA establishes and administers safeguards to promote the safe and secure use of nuclear substances. The IAEA is also responsible for setting forth regulations around the safe transport of nuclear substances.

The Nova Scotia Department of Labour and Advanced Education provincially regulates the use of hazardous materials, including nuclear substances, through the Occupational Health & Safety Act.

Transport Canada is responsible for transportation policies and programs. They promote safe, secure, efficient, and environmentally responsible transportation including the transportation of dangerous goods (TDG), under the Transportation of Goods Act 1992 and the Transportation of Dangerous Good Regulations, which have been adopted by all provinces and territories.
Responsibilities
Radiation Safety Officer

The **Radiation Safety Officer** (RSO) manages and maintains Dalhousie’s Radiation Safety Program. The RSO has many responsibilities including, but not limited to:

- Creating and implementing radiation policies and procedures
- Advising personnel of new and proposed legislation
- Acting as a liaison with regulatory agencies such as the CNSC, IAEA, and Department of Labor and Advanced Education
- Issuing Nuclear Substance User Permits
- Providing safety training and awareness sessions
- Conducting audits of labs spaces, records, personnel exposure doses, inventory, etc.
- Assuming control in emergency situations involving radiation hazards
The **Radiation Safety Committee** (RSC) acts as a resource body for Dalhousie University and is comprised of individuals from various departments across the different campuses. The committee helps develop policies and procedures for the safe use of nuclear substances and advises personnel on radiation safety requirements relating to research. The following positions are included as members of the committee:

- Chair
- RSO
- Applicant Authority
- Radiation Safety Technician
- Principle Investigators
- Building Managers
- Lab Managers
A **Principal Investigator** (PI) is an individual who oversees and is responsible for all research activities within a lab space. A nuclear substance PI must follow the conditions of the Radiation Safety Program including, but not limited to:

- Applying for and maintaining a permit to possess and conduct research with nuclear substances
- Ensuring that lab facilities, equipment, and PPE are functioning in accordance with Dalhousie University’s radiation protection policies and procedures
- Reporting all nuclear substance incidents to the RSO
- Maintaining appropriate records of inventory, waste, training, etc. on the electronic EHS Assistant and in the Yellow Radiation Safety Binder as required
- Ensuring that all workers under their supervision have taken the required Radiation Safety Training and are aware of the potential hazards associated with the use of nuclear substances prior to beginning their work in the lab
- Ensuring proper security is maintained at all times
- Complying with all license and permit conditions
A **Nuclear Substance Worker** is an individual who works with nuclear substances or radiation emitting devices to conduct research experiments. Workers must follow the conditions of the Radiation Safety Program including, but not limited to:

- Following all Dalhousie policies and procedures
- Completing and maintaining radiation safety training
- Performing and documenting contamination surveys as required
- Wearing the proper PPE, including a personal dosimeter, when required
- Ensuring that the security of the lab, and the nuclear substances within the lab space, is maintained
- Reporting any unusual incidents or breach of security, non-compliances, contamination to personnel, and shipment irregularities to the RSO
Nuclear Substance Worker Classifications
Nuclear Substance Worker Classifications

There are two major classifications of nuclear substance workers:

1. **Nuclear Energy Workers (NEW)**
   - A Nuclear Energy Worker as defined by the Nuclear Safety and Control Act, is a person who is required, in the course of their business or occupation, in connection with a nuclear substance or nuclear facility, to perform duties in such circumstances that there is a reasonable probability that the person may receive a dose of radiation that is greater than the prescribed limit for the general public
   - The RSO will determine which workers should be classified as a NEW
   - Declared NEW’s are required to sign a declaration accepting the risks associated with this designation, once they have been informed of these risks
   - NEW’s have a maximum allowable dose of **20 mSv/year for a 5 year period**.

2. **Non-Nuclear Energy Workers (non-NEW)**
   - Any other person who is not a nuclear energy worker, as defined above
   - Have a maximum allowable dose of **1 mSv/year**
Dose Limits Based on Worker Classification

The following are the prescribed allowable dose limits set by the CNSC for nuclear substance workers, NEW and non-NEW:

<table>
<thead>
<tr>
<th>Person</th>
<th>Organ or Tissue</th>
<th>Period</th>
<th>CNSC Dose Limits (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nuclear Energy Worker (NEW)</strong></td>
<td>Whole body</td>
<td>One-year dosimetry period</td>
<td>Effective Dose 50</td>
</tr>
<tr>
<td></td>
<td>Whole body</td>
<td>Five-year dosimetry period</td>
<td>Effective Dose 100 *Average 20 per year</td>
</tr>
<tr>
<td></td>
<td>Skin</td>
<td>One-year dosimetry period</td>
<td>Equivalent Dose 500</td>
</tr>
<tr>
<td></td>
<td>Hands and feet</td>
<td>One-year dosimetry period</td>
<td>Equivalent Dose 500</td>
</tr>
<tr>
<td><strong>Anyone who is not a Nuclear Energy Worker (non-NEW)</strong></td>
<td>Whole body</td>
<td>One calendar year</td>
<td>Effective Dose 1</td>
</tr>
<tr>
<td></td>
<td>Skin</td>
<td>One calendar year</td>
<td>Equivalent Dose 50</td>
</tr>
<tr>
<td></td>
<td>Hands and feet</td>
<td>One calendar year</td>
<td>Equivalent Dose 50</td>
</tr>
</tbody>
</table>
Pregnant Nuclear Substance Workers

If a nuclear substance worker becomes pregnant, they must advise the RSO as soon as possible to ensure safety measures are put in place to lower the dose that is received by the worker and the embryo/fetus. A declaration of pregnancy form must be completed and signed by the worker and the RSO.

This information will remain confidential between the worker and the RSO. It is not necessary to disclose this information to any other party.

The following are the prescribed allowable dose limits set by the CNSC for pregnant nuclear energy workers:

<table>
<thead>
<tr>
<th>Person</th>
<th>Organ or Tissue</th>
<th>Period</th>
<th>CNSC Dose Limit (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pregnant nuclear energy worker</td>
<td>Whole body</td>
<td>Balance of pregnancy</td>
<td>Effective Dose 4</td>
</tr>
</tbody>
</table>
Radiation Hazards
ALARA

There are several hazards when working with radiation. All radiation exposures shall be kept As Low As Reasonably Achievable (ALARA), economical and social factors being taken into account. In order to maintain ALARA in the work environment we utilize the following principles:

• **Time** – Spending less time around a radioactive source will decrease the radiation exposure that is received.

• **Distance** – The greater the distance between you and a radioactive source, the less the radiation exposure you will receive. Tongs or other tools may be used to reduce exposure to your fingers and hands.

• **Shielding** – Choose appropriate shielding to decrease radiation exposure. Plexiglass is used for high energy beta emitters and lead for x-rays or gamma emitters. Remember that incorrect shielding may increase radiation exposure.
Internal Exposure

**Internal Exposure** occurs from a source that has inadvertently been deposited into the body and decays. The radiation exposure will continue until it decays or has been excreted. It may enter the body through:

- Inhalation
- Ingestion
- Absorption

In order to reduce the chance of internal exposure you can:

- Use a fume hood when working with volatile isotopes or heating solutions
- Cover wounds with waterproof bandages
- Double glove and change often
- Do not eat or drink in any radiation designated area
- Wash and monitor hands
- Maintain a clean work area
- Perform contamination monitoring and wipe testing
External Exposure

External Exposure occurs when our body is partly or completely exposed to a source of radiation. This type of radiation exposure can occur if you are not properly shielded while working with nuclear substances.

In order to reduce external radiation exposure
• Use ALARA principles
• Wash and monitor hands
• Maintain a clean work area
• Perform contamination monitoring and wipe testing
**Personal Contamination**

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

If a person is not injured, but is contaminated, they should remove contaminated clothing and wash appropriately, using the emergency shower or eyewash as needed.

If an injured person is contaminated, do not delay medical attention by trying to decontaminate.

The RSO should be notified immediately in the event that an individual becomes contaminated.
Area Contamination

Most spills will involve only a minor quantity of isotope and can be handled appropriately by the trained radiation workers.

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

- A spill involving a nuclear substance of **very high radiotoxicity**
- A spill involving contamination of inaccessible areas
- A spill involving more than **100 exemption quantities (EQ’s)** of activity
- A spill involving the release of volatile material
- A spill involving the contamination of personnel
- When reasonable efforts to decontaminate are not successful in reducing activity to less than twice background

When there is any doubt concerning appropriate decontamination procedures, refer to the CNSC “Spill Procedures” poster in your lab to perform decontamination processes, contact the PI or the RSO.
Contamination Detection

There are two methods for detecting contamination:

• **Direct Method** – which detects both fixed (non-removable) and loose (removable) contamination with the use of a contamination meter (pancake probe)

• **Indirect Method** – which detects loose (removable) contamination only, with the use of wipe testing that is counted using a Liquid Scintillation Counter (LSC)
Contamination Detection Requirements

**Daily** contamination monitoring should be completed at the end of each day of use:
- For all isotopes detectable with contamination meter
- During use periods only
- Maintain records of survey
- Use contamination meter (pancake)

Wipe tests should be completed on **weekly** basis:
- Within 7 days of use
- During use periods only
- Maintain all records of wipes
- Use Liquid scintillation counter
Radionuclide Classes for Contamination Limits

CNSC groups the most commonly licenced radioisotopes into 3 Classes, A, B and C, based on their radiological properties. When using more than one radionuclide in a room, the radionuclide with the lowest contamination limit must be used to determine the limit that applies to the entire room.

<table>
<thead>
<tr>
<th>Class</th>
<th>Radionuclides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>Ag-110m, Bi-210, Co-56, Co-60, Cs-134, Cs-137, I-124, Lu-177m, Mn-52, Na-22, Po-210, Pu-238, Pu-239, Pu-240, Sb-124, Sc-46, Sr-82, U-234, U-235, U-238, V-48, Zn-65</td>
</tr>
<tr>
<td></td>
<td>All alpha emitters and their daughter isotopes</td>
</tr>
<tr>
<td>Class C</td>
<td>C-11, <strong>C-14</strong>*, <strong>Ca-45</strong>*, Cd-109, Ce-141, Cl-36, Co-57, <strong>Cr-51</strong>*, Cu-60, Cu-61, Cu-64, <strong>F-18</strong>*, Fe-55, Ga-67, Ga-68, Ge-68, <strong>H-3</strong>*, <strong>I-123</strong>*, <strong>I-125</strong>*, <strong>In-111</strong>*, In-113m, In-114, K-42, Kr-85, Lu-177, Mn-52m, Mn-56, N-13, Na-24, Nb-98, Ni-63, O-15, <strong>P-32</strong>*, <strong>P-33</strong>*, Pd-103, Pr-144, Pu-241, Rh-106, <strong>S-35</strong>*, Sc-44, Sn-113, Sr-89, Tc-94m, Tc-99, <strong>Tc-99m</strong>*, Te-127, Ti-201, V-49, W-181, W-188, Xe-133, Zn-63</td>
</tr>
</tbody>
</table>
Prescribed Contamination Limits

Ensure you know what classification your radionuclides fall under to determine the contamination limits for the lab space in which you are working. Most of the licenced isotopes at Dalhousie fall under Class C. The contamination limits set for Dalhousie will align with the **Public Area Limit**, for all radionuclide classes, as set forth by the CNSC. These low levels of contamination are more than attainable. **The Dalhousie Limit must be used to determine your contamination limit.**

<table>
<thead>
<tr>
<th>Class of Radionuclide</th>
<th>Control Area Limit (CNSC)</th>
<th>Public Area/Decommissioning Limit (CNSC)</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>
Conversion of Bq/cm$^2$ to CPM

Results from Liquid Scintillation Counters (LSC) are typically displayed in CPM (counts per minute). To determine the contamination value in Bq/cm$^2$, the following equation can be used.

$$\text{Bq/cm}^2 = \frac{(\text{Cpm} - \text{Bkg})}{(\text{Ec} \times \text{Ew} \times 60 \times A)}$$

- Where Cpm = counts per minute
- Bkg = counts per minute of the background (assume 15cpm)
- Ec = scintillation counter efficiency (refer to Appendix 1, Table, or the product manual)
- Ew = wipe efficiency, assume 10% (input 0.1)
- A = area wiped in cm$^2$, assume 100cm$^2$. 
Contamination and Radiation Spill Kits

Each Nuclear Substance Lab must have a radiation spill response kit or decontamination kit available in case of an accidental spill. Kits should be easily accessible to the work area in the event of an urgent situation.

Spill kits should be checked every six months to ensure all necessary supplies are available and in good condition to promote clean up and decrease contamination (no expired items). The kit should contain a form to document the six month inspection.
Recommended Spill Kit Contents

- Radioactive warning sign (1)
- Tape (1)
- Disposable gloves (1 box)
- Plastic bags (4 of each): small, medium, and large
- Masking tape (1)
- Grease pencil (1)
- Forceps (2)
- Tongs (1)
- Gauze sponges (1 package)
- Detergent (1 bottle)
- Scouring powder (1)

- Identification tags (6)
- Scissors (1 pair)
- Filter paper wipes or cotton applications (20 in total)
- Absorbent pads (6)
- Floor plan for your work area-made in advance
- Nail brush or test tube brush
- Bar soap or dermabrasive cleaner (1)
- Tissues (1 box)
- Paper towel (1 roll)
- Disposable plastic aprons (4)
- Spare batteries for contamination meter (2)
Emergency Response Summary

In the event of an emergency involving nuclear substances, the immediate objectives are to:

• Prevent or reduce the chance of personnel contamination
• Contain and prevent dispersal of the contamination
• Attend to the needs of the injured person before containing decontamination (if necessary)

Know who to call in the event of an emergency:

• Security 902-494-4109
• PI
• RSO

In the event of a fire follow standard fire instructions, but make sure to notify emergency personnel of the presence of isotopes.
Purchasing and Transferring Nuclear Substances
Purchasing Nuclear Substances

All **purchases** of nuclear substances must be approved by the RSO.

Purchase requisitions must be submitted in completion to the RSO prior to the purchase of any nuclear substances.

The PI of the permit should sign the purchase requisition, providing authorization of the isotope purchase.

No purchases can be acquired using a Dalhousie p-card.
Transferring Nuclear Substances

**Internal transfers** – transfers of isotopes that take place within the Dalhousie licenced locations.

**External transfers** – transfers of isotopes between two different licensees.

**Transfer Process:**

- One transfer form must be completed by both parties of the transfer, which then needs to be submitted to the RSO.
- Once the RSO has approved the transfer and returned the form to both parties, the physical transfer of the isotope can be completed.
- The RSO will also complete the transfer of inventory in the EHS Assistant upon approval.
- There should be NO transfer of a Nuclear Substance without the authorization of the RSO.
- All transfers must comply with TDG Class 7 regulations.
Receiving Shipments of Nuclear Substances

**Only** those who have successfully completed and maintained their TDG Class 7 Receiving training are permitted to receive packages containing nuclear substances.

Workers are responsible for following proper receiving and documentation procedures.

*Is your TDG Class 7 Receiving training up-to-date?*

See slide 65 for the CNSC Guidelines for Handling Packages Containing Nuclear Substances sign.
Lab Requirements
Security

All nuclear substances must be secured against unauthorized removal.

Ensure that stock solutions are locked away whenever they are not in use. The lock that is used to secure nuclear substances must be approved by the RSO prior to being used.

The lab space must be locked when unoccupied to prohibit the entrance of unauthorized personnel.

Radiation workers and/or PIs must immediately report missing nuclear substances to the RSO, breach or attempted breach of security.
Audits and Inspections

All nuclear substances labs and sealed sources will be audited on an annual basis by EHS staff.

All nuclear substance labs are required to complete a semi-annual laboratory audit.

Random inspections of nuclear substance labs may be performed by the CNSC and the IAEA.

Sealed sources meeting the requirements for leak testing must have leak testing completed as per the regulations. The RSO will manage and arrange to complete the leak testing of required sealed sources.
Tips for CNSC Inspections

Evidence of Food/Drink – Waste containers located within the lab must not contain food or drink remnants; the inspector will interpret this as evidence of eating and drinking in the lab.

Dosimeter(s) – If dosimeters are not readily available when the inspector arrives they will assume it is lost.

Meters Available/Operational – Anyone using nuclear substances must have access to and be able to properly operate a contamination meter and a survey meter, if it is appropriate for the isotopes in the lab.

Security – The inspector will look for open locks on fridges, vacant labs with doors open, and unattended isotopes.

Record Keeping – The inspector will go through all records to ensure compliance with internal policy – every record must be accounted for.
Personal Protective Equipment

Workers must wear the required PPE while working with nuclear substances. These include safety glasses, proper lab attire, and personal dosimeters.

Safety glasses are required for all isotope work with high energy beta (β) emitters. Nonetheless, safety glasses should be worn whenever there is a risk of splashing while using any chemical substance – which includes the use of any/all radioisotopes.

Proper lab attire includes lab coat, gloves, closed toed shoes, and clothing to avoid exposed skin to decrease the chance of contamination.
Personal Dosimetry (Badges)

To detect the amount of radiation exposure to an individual’s body, a radiation detector (dosimeter) must be worn. Dosimeters (badges) are required when working with open sources of high energy beta and gamma emitters such as $^{18}\text{F}$, $^{32}\text{P}$, $^{123}\text{I}$, $^{99m}\text{Tc}$, etc. Badges may also be required when working with particular sealed sources.

Whole body badges are called Thermoluminescent Dosimeters (TLD) and are worn on the torso (between the waist and the neck), in a location where they are likely to receive the highest exposure, such as on the pocket of a lab coat.

Ring dosimeters are worn underneath disposable gloves, on the individual’s dominant hand, with the chip facing outwards toward the source.

Dosimeters must be stored in a safe place away from sunlight, heat, and sources of radiation. Personal dosimetry records are maintained at the EHS Office, and workers are invited to contact the RSO at any time to access/review their records. Radiation workers are asked to review their records at minimum, on an annual basis.

To request a dosimeter, a Worker Registration Form must be completed and submitted to the RSO for processing. If you are in doubt whether you require a dosimeter, contact the RSO for further guidance.
Record Requirements

Records of the following must be kept:

• Inventory – on the electronic EHS Assistant
• Direct monitoring results (if applicable)
• Weekly wipe test results
• Leak test records for sealed sources (if applicable)
• Accident/incident reports
• Personal exposure records (maintained by RSO)
• Use and non-use periods
• Routine hand/personnel monitoring
• Survey meter calibration records
• Self-inspection results
• Isotope transfer documents
• Packing slips and all documents associated with the purchase, shipping, and receiving of nuclear substances
• Radiation worker training certificates
Record Keeping - EHS Assistant

The Environmental Health and Safety Assistant (EHS Assistant or EHSA) is an online database that Principal Investigators are required to use to maintain and update records associated with their Nuclear Substance User Permit.

The following functions, among others, can be carried out on the EHSA:

• Creation of Nuclear Substance User Permits
• Applications, renewals, and amendments of Nuclear Substance User Permits
• Maintenance of worker list
• Maintenance of isotope inventory and usage
• Maintenance of radiation emitting devices inventory
• Maintenance of waste disposal records
• Maintenance of training records

Training for this system is provided by the EHS office upon request.
Any work involving nuclear substances that could generate an airborne hazard must be confined to a fume hood. This includes:

- Any work with known volatile isotopes or powders
- Any manipulation of the compound that will cause the release of particles, aerosols, or gasses:
  - Including pipetting
  - Heating the compound
  - Forcefully discharging a syringe
- Examples of volatile isotopes include $^{35}\text{S}$, $^{123}\text{I}$, $^{125}\text{I}$, $^{131}\text{I}$, and tritiated water.
Radioactive Waste Procedures

Working with nuclear substances generates contaminated waste, and although the material is no longer being used for research procedures, radioactive waste must be tracked and controlled.

There are three* main types of radioactive waste:

- **Solid** – to be packaged in a labelled radioactive materials box
- **Liquid** – to be packaged in a 4L chemical waste container
- **Sharps** – to be packaged in a verified sharps container

Completed waste disposal tags **must** be attached to solid and liquid waste. Please contact the RSO for waste disposal tags and instructions on how to use them.

The Radiation Safety Team provides a monthly radioactive waste collection service in which PIs and/or Radiation Workers are responsible for collecting, packaging, labeling, and transporting their radioactive waste to be controlled and decayed by the RSO.

*Biological waste and chemical waste must undergo separate processes prior to being disposed. For further information, contact the RSO.
Cleanliness

Maintaining a clean work environment is an important part of controlling radiation hazards.

Good personal work practices can also help to reduce the risk of contamination, including:

• Maintaining good housekeeping practices
• Maintaining good personal hygiene
• **Must:** wash hands after every radiation use
• **Must:** monitor hands, lab coat and footwear after every use or when exiting the lab, to decrease spread of contamination.

Eating and/or drinking is **NEVER** permitted in a nuclear substance lab.
Lab Signage
Radiation Warning Symbol

A trefoil is the international symbol of radiation. **Radiation warning signs** are used to identify areas where radioactive material is used/stored, and where exposure to radiation is possible.

Radiation warning signs are presented in two contrasting colors – often a yellow background with a magenta or black trefoil.

Caution wording must be written in English and French.

The 24-hour emergency contact should be listed as Dal Security at 902-494-4109.
Radiation Signage

The CNSC deems any inappropriate use or over use of radiation warning signs as “frivolous use of signage”

Examples of frivolous behaviour include:

• Jokes on fellow workers
• Labeling something as radioactive when it is not
• Using an excessive number of warning signs
Radiation Work Area

At Dalhousie, purple dots and thatched tape are used to identify nuclear substance equipment and work areas, respectively, to avoid frivolous use of signage.
Hazard Identification Sign

Nuclear substance labs are classified as Exempt, Basic, Intermediate, or Sealed Source. Lab classification is based on the isotopes, their form and possession limits stated on the nuclear substance user permit, that corresponds to the lab space.

Exempt Level Lab                Basic Level Lab             Intermediate Level Lab          Sealed Source Lab

Exempt Quantities Radiation     Radiation                        Radiation                        Sealed Source Radiation

The correct lab classification must be chosen on the EHSA placard developer and displayed on the Hazard Identification Sign.
Hazard Identification Sign

Custodial services are only permitted **with an escort** in all nuclear substance labs. This must be indicated on the Hazard Identification Sign that is posted on the door to the lab space. Only one Custodial Access symbol should be selected.
Basic and Intermediate level labs must have the appropriate Lab Classification sign, containing safety precautions and emergency contact numbers, posted in the lab space.
Nuclear Substance User Permit

A copy of an up to date, signed, Nuclear Substance User Permit and all of the attachments, including the “Schedule of Conditions” must be posted in the lab space.
CNSC Signage

All nuclear substance labs must have a copy of the CNSC Spill Procedures, Guidelines for Handling Packages Containing Nuclear Substances, and Personal Dosimetry signs (if applicable), posted in the lab space.
Q: I have to work late in the lab tonight, can a friend drop by to visit me?
A: With approval from your supervisor, you may have a friend drop by, provided that any unsecured nuclear substances are under constant supervision.

Q: Is it okay to eat in my office?
A: Food and drink are permitted in adjacent offices provided that the area is separated from the lab by walls and a door.

Q: Will the CNSC inspect my lab?
A: The CNSC may inspect any licensed location at any time. However, they typically prefer to inspect higher risk labs, often inspecting Intermediate levels lab first, followed by Basic level labs.
Summary of Refresher Course

This course was intended to review the basics of Radiation Safety and the required processes to be compliant with CNSC regulations and the Dalhousie Radiation Safety program for Nuclear Substances.

If there is an area in radiation safety that you require more guidance or clarification, please contact the Radiation Safety Officer, or the Radiation Safety Technician for further information.

To complete the course, the associated quiz must be submitted via email to jrobertson@dal.ca or bertha.louis@dal.ca, fax to 902-423- 5242 or through interdepartmental mail to the Environmental Health & Safety Office at 1435 Seymour St. Halifax, NS.
Additional Resources

• CNSC: https://nuclearsafety.gc.ca/eng
  • Nuclear Safety & Control Act

• DOL:
  • Occupational Health & Safety Act

• IAEA: https://www.iaea.org/

• Transport Canada: https://tc.canada.ca/en

• EHS website https://www.dal.ca/dept/safety.html
  • Dalhousie Radiation Safety Manual