Okanagan University College

RADIATION POLICY & PROCEDURES

for

RADIOISOTOPE USAGE AND RADIATION SAFETY

JUNE 1998

DESIGNATED RADIOISOTOPE LABORATORIES: OUC Science, North Kelowna campus

Sci 137 - Fish Holding

Sci 138 - Wet Laboratory

Sci 140D - Environmental Chambers area

Sci 147 - Project Laboratory

Sci 351 - Cryogenics

as of July 1996 Licence Numbers 09-04278-99B
and 09-04278-99C

AECB contact number: 1-888-229-2672

IMPORTANT TELEPHONE NUMBERS:

Radiation Safety Officer: .... Dr. Scott D. Reid 7561
.... home 765-7412

Assistant RSO: .... Dr. Mary Forrest.. 7560

Biohazard Officer: Dr. Mary Forrest.... 7560

Health and Safety Coordinator: .... Catherine Williams 4573

First Aid.. 6699
Chemical Spills 6699
Other Emergencies 6699

Campus Security: .... Days:... 4262
.... Evenings:..763-7322

Police.. 9-911
Fire.. 9-911
Ambulance: 9-911

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A. Radiation Safety Officer (RSO)

The Radiation Safety Officer (RSO) is that person appointed by the Administration of the University College, who by reason of education, training and experience is qualified to:

- advise others on radiation safety
- supervise and implement the radiation safety program on campus

1. The responsibilities of the RSO shall be:
2. To approve rules and policies regarding activities and procedures which involve personal exposure to radiation or the release of radioactive substances into the environment and to implement such procedures and policies.
3. Act in a supervisory capacity in all aspects of OUC's radiation protection program such as personal monitoring, survey methods, waste disposal and other radiological safety practices.
4. To ensure methods of use, storage and disposal of radioactive materials meet the conditions of the radioisotope license issued by the Atomic Energy Control Board to OUC.
5. To control acquisition, transportation, storage, use and disposal of radioactive materials.
6. To maintain records of personal exposure and an inventory of radioisotope purchases and disposals.
7. To carry out regular inspections of facilities where radioisotopes are used and stored.
8. To suspend any operation causing excessive personal exposure to radiation or release of radioactive substances into the environment.
9. To investigate promptly any accident or spill.
10. To be available to consult with all users of radioisotopes at OUC and give advice and training on radiological safety procedures.
11. When absent from the OUC, to designate a qualified individual to act as interim RSO.

B. Authorized Users:

An authorized user is a person who by virtue of training and experience is approved by the RSO to use radioactive material. The authorized user must be an employee of OUC.

1. The responsibilities of an authorized user shall be:
2. Being familiar with and obeying the safety regulations listed in the OUC Radiation Safety Manual.
3. Keeping personal radiation exposure and exposure of those working under the user's supervision to the lowest level which is reasonably achieved. No individual shall be permitted to receive a radiation dose in excess of any allowable dose specified in Table 1.
4. Adequate planning of all experiments, including the type and amount of radioactive material to be used, shielding or other protective measures required and disposal of materials at the completion of the experiment.
5. Limiting the release of radioactive material to concentrations less than those specified in Table 3.

6. Wearing monitoring equipment such as film badges as prescribed by the RSO and ensuring that designated users wear such equipment.

7. Limiting the use of radioisotopes to the locations specified in the permit.

8. Maintaining accurate up-to-date records of inventory, usage and disposal of all radioisotopes received.

9. Supplying the RSO with information concerning designated workers and their activities. Female Users must notify the RSO if they or their designated workers become pregnant as special precautions or adjustment of working conditions may have to be made.

10. Informing the RSO of any changes in approved projects.

11. Being aware of the Federal Atomic Energy Control Regulations and the Provincial Radiation Health and Safety Act.

C. Designated Workers:

A designated worker is a person sponsored by an authorized user and approved by the RSO to use radioactive material under supervision of an authorized user. This category is intended for students and technicians. A designated worker shall be at least 18 years of age.

All designated workers shall be aware of and comply with the regulations for radiation safety as listed in the OUC Radiation Safety Manual. Individual responsibilities shall include:

1. Wearing appropriate personal protective equipment and monitoring equipment when working with radioisotopes.

2. Keeping personal radiation exposure to the lowest level which is reasonably achieved.

3. Limiting the use of radioisotopes to the locations specified in the permit.

4. Limiting the release **of** radioactive material to concentrations less than those specified in Table 3.

5. Maintaining an accurate record of all use and disposal of radioactive substances.

II. RADIATION EXPOSURE

A. Permissible Doses:

All unnecessary exposure to ionizing radiation is undesirable and exposure to such radiation fields should be limited to the lowest level reasonably achievable.

Table I gives the maximum permissible doses of ionizing radiation for individuals as established by the Atomic Energy Control Board of Canada. Individuals employed by OUC are not considered Atomic Radiation Workers; therefore permissable doses for members of the general public shall apply.

On the recommendation of a medical advisor and in the interest of an individuals's health and safety, the AECB or designate may prescribe a lower permissible dose to that individual. If a female user becomes pregnant she must notify the RSO so that appropriate precautions may be taken to minimize radiation exposure.

In general, minimizing exposure to radiation may be accomplished **by** following a few basic rules.

- Maximize the **distance** between you and the source.
- Minimize the **time** spent in the radiation field.
- Use appropriate **shielding.**
- Avoid any **ingestion, inhalation** or **absorption** of radioactive material through the skin. While small quantities of radioactive material may present an insignificant external hazard, once absorbed into the body they may collect selectively in one or more organs and present a much greater risk.

TABLE 1. Maximum Permissible Doses of Radiation*

Organ or Tissue	OUC Personnel or General Public msvlyear (rem/year)	Atomic Radiation Workers mSv/year (rems/year)
Whole body, gonads, bone marrow	5 (0.5)	50 (5)
Bone-, skin, thyroid**	30 (3)	300 (30)
Any tissue of hands, forearms, feet and ankles	75 (7.5)	750 (75)
Other single organs or tissues	15 (1.5)	150 (15)
Abdomen of pregnant-woman	0.6 (0.06)/2 weeks	0.6 (0.06)/2 weeks

Note: In determining the dose, the contribution from sources of ionizing radiation both inside and outside the body shall be included.

* The maximum permissible doses specified in the table do not apply to ionizing radiation that has been received by:

a a patient in the course of medical treatment by a qualified medical practitioner;
b by a person carrying out emergency procedures undertaken to avert danger to human life.

* * The dose to the thyroid of persons under the age of 1 6 shall not exceed I 5mSv/year.

B. Personnel Monitoring:

All users who in the course of their work are likely to receive a radiation dose in excess of 25% of the maximum permissible dose shall wear appropriate personal monitoring devices. Film badges or thermolumineseent dosimeters (TLDS) are supplied and evaluated by the Radiation Protection Bureau, Ottawa. Permanent records of finds from the Radiation Protection Bureau are maintained by the National Dose Registry in Ottawa. Records of exposures of OUC employees shall also be maintained by the RSO.

Personal monitoring devices should be worn at chest or waist height while working in the radioisotope lab. When not in use, these devices should be stored in areas where they will be protected from radiation and heat. A box will be provided outside the radioisotope lab.

TLD's are excellent dosimeters for x-rays, gamma radiation and bremsstrahlung from high energy beta emitters such as ^{32}P, but do not detect radiation from low energy beta emitters such as tritium, ^{14}C or ^{35}S.

Individuals using ^{125}I are required to undergo a thyroid scan quarterly and within three days following the experimental iodization of compounds.

Personal monitoring devices must not be exposed to sources of radiation unless being worn by the workers to which they have been issued, and should not be worn during non- occupational exposures such as during medical examinations.

See Appendix 2 for explanation of units of radiation exposure.

C. **<u>Minimizing exposure</u>:**

The rnaximum allowable radiation field for any working area is 2.5 ⫤ Sv per hour (0.25mR/h).

The radiation dose received by an individual is a function of:

a) the length of time spent in the radiation field. **Minimize exposure tim**e;
b) the distance from the source. **Maximize the distance between you and the source**;
c) the energy of the radiation emitted. **Use appropriate shielding**.

1. **Time.** The radiation dose an individual receives is directly proportional to the length of time spent in the radiation field. If possible, practice any new protocol with a non- radioactive blank. This should make you aware of any technical difficulties which would otherwise contribute to delays in handling. Familiarity with the procedure should also reduce the possibility of accidents.

2. **Distance.** Distance is a very effective way to reduce the intensity of radiation incident on the body. Keep as much distance as possible between you and the radiation source. Use forceps or tongs to minimize radiation exposure to the hands when using stock vials which produce a significant radiation field.

   The relationship between radiation dose and distance follows the inverse square law for point emission sources:

$$\frac{I_1}{I_2} = \frac{(D_2)^2}{(D_1)^2}$$

   where **I_1**, is the intensity of radiation at distance D_l from the source and **I_2**. is the intensity at distance D_2 from the source.

3. **Shielding.** When it is not possible during the course of a procedure to minimize the time and distance between the user and the radiation source, use of adequate shielding is necessary. Depending on the type and energy of the radioisotope in use, different shielding materials are recommended. Table 2 shows the types of radiation produced by some commonly used isotopes and the appropriate shielding to use.

TABLE 2. Radiation Produced by Some Isotopes and Appropriate Shielding

Isotope	Emission Energy (keV)		Minimum Shielding
	Beta (maximum)	Gamma or X-rays	
^{3}H	18		glass stock via[
^{14}C	156		glass stock vial; 3mm plexiglass for activities >37 MBq (1 mci)
^{35}S	167		glass stock vial; 1 cm plexiglass for activities >37 MBq (1 mci)
^{32}P	1710		1.2 cm plexiglass for activities <37 MBq(I mCi)
^{125}I		35	0.04 mm lead
^{131}I	806	364;637	6.0 cm lead
^{86}Rb	1780	1078	10 cm (4") lead - 2 layers 2" lead bricks

Tritium (^{3}H) produces very weak beta particles which travel only a short distance in matter and are not able to penetrate the outer epidermis of the skin. Their range in air is about 4.7 mm and **a glass stock vial or test tube** provides complete shielding.

Carbon-14 and Sulphur-35 For use of kilobecquerel amounts (> 1 ╡Ci), a **glass container** will provide adequate shielding. If tens of megabequerels (> 1 mCi) are being handled, **3 mm thick plexiglass**, lucite or glass shielding is recommended.

Phosphorus-32 is a high energy beta emitter and most operations require shielding. Thick plexiglass (1.2 cm) is recommended. **N.B**. Lead or other metals are not recommended as shielding materials for high energy beta emitters because of high energy secondary X-rays (bremsstrahlung) which are produced by the interaction of energetic beta particles and nuclei of high atomic number.

lodine-1 25 When performing iodinations it is essential to shield the separation column. All use of '251 must be performed in the fume hood.

Rubidium-86 produces both beta and gamma radiation and shielding is always required**. Thick lead sheeting** or bricks should be used and the effectiveness of the shielding should always be checked with a suitable survey meter. We also suggest using plexiglass shield between the source and the lead shielding to minimize bremsstahlung.

III. SAFETY RULES AND PROCEDURES FOR WORKING WITH RADIOISOTOPES

A. General Rules:

1. Keep the laboratory locked when not in use and keep unauthorized persons out **of** the laboratory.

2. Do not eat, drink, smoke or apply cosmetics in the laboratory.

3. Always wear appropriate personal protective equipment and avoid direct contact with radioactive materials. Never pipet solutions by mouth.

4. Effectively contain radioactive materials at all stages of handling and use fume hood whenever possible for work with open sources. Always use fume hood for work with boiling or evaporating sources.

5. Use appropriate shielding when working with radioactive materials.

6. Do not use refrigerators or freezers designated for storage of radioisotopes for food storage. Glassware and other equipment used for radioactive work must not be used for other purposes.

7. Clearly mark containers of radioactive materials with warning symbols indicating the nature and amount of radioactivity. Mark all other equipment that has been contaminated with radioisotopes and store in appropriately shielded locations in the radioisotope lab. This equipment must not be removed from the lab.

8. Store radioactive waste and sources in a safe and secure place. Use shielding to ensure that the surface radiation does not exceed 2.5 /iSv/h (0.25 mR/h).

9. When work is complete, clean and/or isolate contaminated supplies and equipment; monitor and decontaminate trays and working surfaces. Floors and working surfaces should be wipe checked daily when the lab is in use.

10. Wash hands, monitor clothes, shoes and hands before leaving the laboratory.

B. The Radioisotope Laboratory:

1. Open source radioactive materials may be used and stored only in licensed locations (ie SCI 147). This room must be locked at all times when not in use and only authorized personnel will be permitted entry. The room will be labelled with signs: "Caution - Radiation Area" and "In case of Emergency Call..." All storage areas, contaminated sites and decay cupboards etc. must be labelled 'Caution - Radioactive Materials." The room must also display the "No Eating, Drinking or Smoking' and 'Rules for Working with Radioisotopes" signs.

2. When radioisotopes are being used, all personnel in the radiation area should be informed and precautions taken that the maximum allowable working field of 2.5 ╡Sv/h in any direction from the source is not exceeded.

3. Working surfaces should be covered with an absorbent covering, such as plasticized paper or incontinence pads, to prevent contamination.

4. Label all material used for radioactive work with radiation stickers. Signs and labels should be removed when the equipment has been shown to be free of contamination and will no longer be used for isotope work.

5. The sink should be clearly labelled with a radiation sign.

6. If there is a possibility of producing airborne radioactivity (aerosols, dust, vapours) work should be performed in an absorbent paper-lined fume hood. The hood should be labelled clearly with a radioactive sign. All work with 1-125 must be performed in the fume hood. If the fume hood stops working, report it to the RSO immediately.

7. Store open source radioisotopes in the refrigerator marked with a radiation sign. On a routine basis the refrigerators should be defrosted, cleaned and wipe tested. Food or beverages **must not** be stored in the same refrigerator with radioisotopes.

C. **<u>Personal Protective Equipment</u>:**

1. **Gloves.** Disposable gloves must be worn when working with open radioactive sources. Gloves should be checked frequently during the experiment to detect small punctures that may have developed, especially at the fingertips. Disposable gloves must never be worn outside the laboratory. For work with iodine, a minimum of two pairs of gloves is recommended, with the outer pair being changed frequently.

2. **Lab coats** must be worn when working with radioactive materials. Button completely, with sleeves rolled down fully and the cuffs sealed with gloves. Lab coats should not be worn outside the lab and **never** in areas where food is consumed. Coat hooks are provided in the lab for storage of your lab coat.

3. **Clothing:** It is recommended that long pants be worn to provide splash protection for the lower legs. Do not wear rings when working with open sources as contamination can become trapped under the band. It may be impossible to decontaminate a piece of jewellery, in which case it could never be worn again.

4. **Shoes:** Shoes that cover the entire foot are required. Sandals or thongs do not provide adequate coverage in the event of a spill, nor do they provide protection from failing objects.

5. **Eye Protection:** Safety glasses, goggles or face guards should be worn, especially if there is any hazard of splashing material in the eyes. It is also good practice to wear glasses as shielding when working with high energy beta emitters to reduce the external radiation dose to the eyes.

6. **Remote handling devices,** such as forceps or tongs, should be used when handling stock solution vials or other sources that produce a significant radiation field. **A** glove box should be used when working with dry radioactive powders.

7. In most cases it is preferable to **shield the source** of radiation rather than the individuals in the laboratory. In any case where reduction of the radiation field below the 2.5 ╡Sv/h limit cannot be achieved, a lead apron that provides whole body coverage must be worn.

D. **<u>Receiving Radioisotope Sources</u>:**

It is necessary to monitor packages in which radioisotopes have been shipped as these can be contaminated both internally and/or externally. Regular procedures for unpacking radioisotopes should include:

- Wear disposable gloves and a lab coat and eye protection.
- Place the package in the fume hood and wipe test the exterior.
- Remove packing slip and open outer package.
- Verify that the contents agree with the packing slip and check the activity.
- Measure radiation emitted by the inner container and shield as required.
- Check for damage, broken seals, loss of liquid, change in color etc.
- Wipe test the inner container

- Remove or deface the radiation symbol on the shipping label and if the package is free of contamination dispose as regular garbage.
- Notify the RSO of any irregularities.

E. Contamination Control:

Following the use of radioisotopes, monitoring of all work surfaces that may have become contaminated must be performed. The method used to check for contamination depends on the radioisotope in question. A combination of wipe testing and direct reading provides the best margin of safety. Wipe tests are useful for the detection of loose contamination but will not give any indication of fixed or embedded contamination. On the other hand, the poor counting efficiency of survey meters results in underestimation of the level of contamination, especially if the levels are low or if the contaminant is a low energy beta emitter. **Floors and working surfaces must be wipe checked daily** when the lab is in use.

a) **Wipe Testing.** This is the only effective method for detecting low energy beta particles such as those emitted by ^{3}H, ^{14}C or ^{35}S. Wet a disc of filter paper with ethanol, rub it over the surface to be checked and count in the liquid scintillation counter.

b) **Direct Reading.** To supplement wipe testing, portable detectors or survey meters are used to detect high energy beta particles, X-rays or gamma radiation. Hold the detector approximately two centimetres above the surface to be monitored and move slowly over the area in a grid-like fashion.

Performance checks of survey meters should be performed on a regular basis. Before each use:

- check for signs of damage to the instrument - indications that it may have been dropped, breakage in the probe cable, excessive bounding of the needle when the meter is moved.
- turn the meter to the battery check position to see if the batteries are still working.
- turn the range selection knob gently to the highest scale and let the needle stabilize. Continue turning to more sensitive scales until a response is obtained; the needle will fluctuate more on the lower scales because of the random nature of the detected events.
- check the reproducibility of the meter response to a known radiation source. The readings obtained should not deviate from the mean value by more than 10%.
- have instruments calibrated annually.

IV. MANAGEMENT OF RADIOACTIVE WASTE

Unlike other hazardous materials, radioisotopes are invulnerable to degradation by external chemical or physical processes. Dilution of these atoms into the air, landfill or bodies of water simply moves them from one location to another. The only mechanism whereby radioisotopes can be eliminated from the environment is by radioactive decay.

To minimize the environmental impact of radioisotope disposal, the following guidelines must be strictly followed. These guidelines are enforced by law and are administered by the Atomic Energy Control Board (AECB). **Detailed accounting of all disposal of radioisotopes is required.** Each radioisotope poses a unique degree of risk to people and the environment. Therefore the AECB has set out isotope disposal limits that vary with the associated degree of hazard. These limits are defined as **'Scheduled Quantities'** (SQ) as defined in Table 3 and Appendix 3 for various isotopes.

TABLE 3. Maximum Activities for Disposal of Some Radioisotopes

Isotope	Scheduled Quantity (SQ)		Disposal Limits					
	(kBq)	╡Ci/kg	Solid (0.1 SQ/kg)		Liquid (0.01 SQ/0.1)		Air (0.001 SQ/m^3)	
			KBq/kg	╡Ci/kg	kBq/L	╡Ci/L	kBq/m^3	╡Ci/m^3
^{3}H	37000	1000	3700	100	370	10	37	1
^{14}C	3700	370	370	10	37	1	3.7	0.1
^{35}S	100	10	37	1	3.7	0.1	0.37	0.01
^{32}P	370	10	37	I	3.7	0.1	0.37	0.01
^{86}Rb	370	10	37	1	3.7	0.1	0.37	0.01
^{125}I	37	1	3.7	0.1	0.37	0.01	0.037	0.001

A. Classification of Waste:

1. Solid waste includes:

   a) non-hazardous items such as gloves, tissues, pipette tips, bottles, bench paper etc. Solid waste bound for landfill may not contain bi6hazardous or toxic material.

   b) biohazardous or animal waste including whole or parts of dead animals contaminated with radioisotopes. Animal waste or biohazardous waste must be incinerated.

2. Liquid waste includes:

   a) Aqueous:water-soluble, non-toxic chemicals

   b) Organic: non-soluble and/or flammable and toxic materials. Liquid scintillation fluid falls under this category.

   c) Corrosive materials.

3. Gaseous waste includes radioactive gases such as tritium or carbon dioxide released during an experiment.

4. Other - any unusual waste not listed above.

   All radioactive waste is considered part of the radioisotope inventory and consequently it is necessary to keep a permanent record of disposal for each isotope. **Isotope disposal record sheets** shall include the date, isotope, activity, and user's name. All users must fill out the appropriate sheets when disposing of radioactive waste.

B. **Methods of Disposal:**

There are 6 basic ways to dispose of radioactive waste:

1. Storage until the activity has decayed.
2. Landfill for non-toxic, non-biohazardous solid garbage. Limits: **0.1 SQ per kilogram solid** garbage.
3. Sewer for water soluble waste. Limits: **0.01 SQ per litre after dilution.**
4. Storage and appropriate disposal of organic and corrosive liquids. Limits: **0.01 SQ per litre after dilution.**
5. Gaseous waste to the environment. Limits: **0.001 SQ per cubic meter of air**.
6. Shipment to controlled burial areas for high activity radioactive waste.

1. **. Storage of waste for decay:**

Isotopes with a half life of less than 90 days (^{32}P,^{35}S) may be held for decay until acceptable disposal guidelines are met. As a general rule, holding for ten half lives will ensure that all the isotope has decayed to an acceptable level. Aqueous liquid waste containing short-lived isotopes should be held for decay rather than immediately diluting into the sewer system.

Radioactive waste will be held in the isotope laboratory in appropriately shielded containers such that exposure of workers to the radiation field is **less than 2.5 µSv per hour (0.25 mR/hr).** Each container must be labelled with the initial holding date, the isotope and activity, the user's name and the anticipated disposal date. Once the isotope has decayed to the acceptable level the waste may be treated as ordinary solid or liquid (aqueous, organic or corrosive) waste and disposed of accordingly. The disposal sheet should then be placed in the isotope log book.

2. **Solid waste:**

Solid waste containing non-toxic materials and low levels of radioactivity shall be sent to landfill. Solid waste includes such items as gloves, tissues, syringes, bottles, bench covering etc. Use a cardboard box double lined with plastic bags. **Sharp objects** such as syringes, glass pipettes etc. should be packaged in an appropriate sized can or pail before disposal in the box. **The weight of the filled box should not exceed 5 kg.**

Solid waste must contain less than or equal to 0.1 SQ per kilogram and emit less than 2.5 µSv per hour (0.25 mR/hr) at the surface of the container. By ensuring the disposal guidelines are met, the radiation in the box does not pose a health hazard to any individual who may be required to handle it. It may therefore be disposed of as regular garbage. There should be no markings, tape or labelling indicating that the box contains very low levels of radioactivity. Boxes containing glass waste should be appropriately labelled as "GLASS WASTE'.

The isotope disposal sheet should then be placed in the radioisotope log book. It is essential to ensure that there is full and complete documentation of all quantities of radioactivity disposed of as solid waste.

Biohazardous or radioactively contaminated animal parts must be incinerated. Do not autoclave waste that has been radioactively contaminated.

3. Liquid Wastes:

The disposal limit for radioactive liquid waste is 0.01 SQ per litre.

a) **Aqueous**: If possible, aqueous waste should be held in sealed containers until the radioactivity has decayed. For large volumes or long-lived isotopes, disposal of aqueous solutions via the sanitary sewer is permissable. In these cases the liquid disposal limit is **less than 0.01 SQ per litre of water**. To ensure that no radioactive waste remains in the building plumbing, continue the flow of water for several hours after the meeting the dilution criteria.

b) **Organic and corrosive materials**: All waste organic solvents and corrosive liquids, contaminated or not, shall be collected in corrosion resistant containers of volumes not to exceed 5 litres. Glass or other breakable containers should **not** be used. Chlorinated organic compounds should be kept in separate containers. Liquid waste containers should be placed in a tray with an absorbent pad to control accidental spillage.

Each container should be labelled with the type of organic or corrosive waste, the isotope and the activity present in the container. A running tally of radioisotope added to the container should be kept and when full, the total activity in the container should be verified by counting a sample:

Total activity in waste = Net CPM of sample X total volume of waste X 10^{-6},╡ Ci / Efficiency of counter X volume of sample X 2.2

or in **Si units** Net CPM of sample X total volume of waste X 1 Bq / Efficiency of counter X volume of sample X.60

Liquid scintillation vials must be emptied into appropriately labelled corrosion resistant containers. An estimate of the activity present may be obtained by keeping track of the net CPM for each vial as counted during your experiment.

Total activity in the waste (Sample CPM-background CPM) = Net CPM in all vials X 10^{-6} uCi / Efficiency of the counter X 2.2

Liquid scintillation fluid will be treated as organic waste and, provided the disposal limit of 0.01 SQ/L is maintained, can be disposed of as non-radioactive waste. Keep scintillation fluid containing short-lived isotopes (^{32}P and ^{35}S) separate and in an appropriately shielded location, and allow them to decay before disposal.

The vials themselves, when empty, may be disposed of as solid waste, as long as the disposal guidelines for radioactive solid waste (0.1 SQ/kg) are met.

4. Gases and Aerosols:

Procedures for which there is a potential to emit radioactive gases, aerosols or dust shall be performed in an absorbent paper-lined fume hood. For radioactive material that may be discharged to the atmosphere via fume hoods, the disposal limit is **0.001 SQ per cubic meter of air** at the point of discharge, averaged over a one week period.

5. **<u>High Activity Waste</u>:**

In situations where the activity to be disposed of exceeds the solid waste disposal guidelines and the half-life of the isotope precludes holding the material for decay, the material may be sent for burial in Chalk River, Ontario. The appropriate containers for this are new, empty 1 gallon paint cans, available from most commercial paint stores. Minimize the volume of waste placed in cans ... the shipping is very costly. Cans should be used for items such as stock solution vials containing unused radioisotope, columns and heavily contaminated glassware from iodination procedures and "hot spots" only cut out of heavily contaminated bench paper. The activity of all isotope waste placed in the can must be documented.

V. RECORD KEEPING

The Atomic Energy Control Board requires that each licensed laboratory maintain accurate and up-to-date records **of** all radioactive sources.

Purchasing: The acquisition of radioisotopes is strictly regulated by laws which require the possession of a license prior to obtaining any radioisotopes. At OUC the RSO will maintain a central record of all radioisotopes purchased or donated and in what quantities. Authorized Users must place their isotope requests with the RSO. A copy of the invoice will be forwarded to the users to keep in the Isotope Usage log book.

Usage: For every stock vial of isotope purchased, a usage record must be maintained. Every time you remove an aliquot from the stock vial you must record your name, the date and the activity removed on the 'Isotope Usage Sheet" for that vial. These sheets will be kept in a special log book in the lab. At the end of your experiment, you must account for all of the isotope removed in terms of amounts disposed of into liquid, solid and gaseous waste, or held for decay.

Disposal: All radioactive waste is considered part of the radioisotope inventory and consequently it is necessary to keep a permanent record of disposal for each isotope. An **isotope disposal record sheet** shall be kept near the decay area, sink, fume hood or approved disposal containers and shall include the date, isotope, activity, and user's name. All users must fill out the appropriate sheet when disposing of radioactive waste.

Contamination Control: Monitoring for contamination by wipe testing and direct reading (if appropriate) must be performed at the end of each working day in which radioactive materials were used. The results of these tests must be kept in the log book, even if no contamination is found. Records must be kept for a period of three years for inspection by the AECB.

VI. EMERGENCY PROCEDURES:

Proper adherence to safety procedures while using radioisotopes should minimize the chance of accidents. However occasional emergencies in the isotope laboratory may occur. These may range from minor spills involving relatively no personal hazard, to major incidents and spills which may involve personal injury. As each case will differ, set rules and emergency procedures cannot be made to cover all possible situations. However, the **primary concern** must always be:

1. **protection of personnel** from radiation hazard and
2. **confinement of contamination** to the local area of the incident.

General guidelines to follow in the case of emergencies are listed below.

A. Minor spills involving no radiation hazard to personnel:

1. Notify all other persons in the room immediately and advise them to leave if necessary. Notify the Radiation Safety Officer.

2. Remove any contaminated clothing and assess if any areas of the body have been contaminated. If the individual is contaminated, follow procedures outlined in C.

3. Confine the contamination. Put on protective clothing - a minimum of a lab coat and disposable rubber gloves are required. Turn off any device, instrument or machine that could enhance the spill.

   a) Liquid spills: Drop absorbent pads on the spill.

   b) Dry spills: Place dampened absorbent material over the spill. Do not spray with water as this may spread the material.

4. Mark off the contaminated area with masking tape.

5. Clean up the spill using a 2-5% solution of decontamination detergent, taking care not to spread the spill. If the contamination persists, increase the concentration of detergent. Place contaminated clean-up materials in the Solid Waste.

6. Monitor the area carefully, using the appropriate detector, to ensure all splatters have been dealt with. If contamination persists, outline the area with tape and label with the date, type of isotope and approximate activity. Use appropriate shielding to protect workers from unnecessary exposure.

B. Major spills involving radiation hazard:

1. Notify all persons to leave the room immediately.

2. If spill is on skin, flush thoroughly with water. If spill is on clothes, remove and discard in plastic bag.

3. Confine the contamination but do not attempt clean-up.

4. Notify the Radiation Safety Officer. Vacate the room and prohibit entry until approved by the Radiation Safety Officer. Post appropriate signs.

C. Decontamination of Personnel:

1. External Contamination:

   a) Remove all contaminated clothing.

   b) Flush the contaminated area with copious amounts of water for several minutes. Wash with mild soap, gently lathering for three minutes. Rinse thoroughly. (**DO NOT use harsh decontamination detergents**).

   c) Monitor the contaminated area with the most appropriate detector and repeat b as necessary.

   d) If contamination persists, use cold cream or baby oil to clean skin.

e) Monitor, and if contamination persists, DO NOTHING MORE. Do not use abrasives or caustic detergents. Any further manipulation may result in injury to the tissue and internal contamination.

f) Notify the Radiation Safety Officer.

2. Internal Contamination:

a) If an individual has ingested or been accidentally injected with radioisotope, contact the Radiation Safety officer immediately.

b) If the ingested radioactive material is chemically toxic, treat the chemical toxicity first. If the individual is conscious, dilution of stomach contents by drinking copious amounts of water, immediately followed by medical attention is the best response. Refer to the Material Safety Data Sheet for First Aid Information.

c) For minor cuts or injections, allow the wound to bleed freely under a stream of water.

D. Accidents involving personal iniurv-

Treatment of the injury must take precedence, even if the individual is contaminated. Where possible, contamination should be "contained" by confining the injured person to a restricted area.

All accidents involving personal injury, no matter how minor in appearance, must be reported to the RSO and the First Aid Office within 24 hours.

1. Minor iniury :

a) Treat minor injuries at or near the scene of the accident.

b) Rinse contaminated wounds under a tap with copious quantities of water and encourage bleeding. If the wound is on the face, take care not to contaminate eyes, nose or mouth.

c) Wash the wound with mild soap and water.

d) Apply a first aid dressing. The injured areas should be monitored to establish the residual level of radioactivity.

e) Immediately notify the Radiation Safety Officer and the First Aid Attendant (Dial 6699).

2. Serious injuries:

a) In situations where there is serious bodily harm, call the First Aid Attendant immediately (6699) and the RSO. Advise emergency personnel of the contamination, nature of the injuries and isotope handling procedures.

b) Ensure that the radioactive material does not further contaminate the victim or others in the area. Isolate contaminated body parts as much as possible using available shielding.

E. Loss or theft of radioactive material

The Atomic Energy Control Board requires immediate reporting of these incidents. Any situation involving the disappearance of radioactive material **must** be reported immediately to the Radiation Safety Officer.

Appendix 1

Radioactive Decay

Radioactivity can be defined as spontaneous nuclear events that result in the transformation of one element into a different stable element. Upon decay, various types of subatomic particles and energy will be released. Half-life describes the time in which one half of the original radioactivity of a sample has decayed. Table 4 gives the half-lives and types of radiation produced by various radioisotopes.

Alpha particles are massive, highly energetic fragments emitted from the nucleus of a radioactive atom when the neutron to proton ratio is too low. It is positively charged helium nucleus, consisting of two protons and two neutrons. Gamma rays (energy of very short wavelength) are also released in this type of atomic disintegration. Alpha particles, due to their size, have a very limited ability to penetrate matter, including clothing and skin. Exposure to alpha radiation from external sources poses a minimal radiation hazard. However alpha particles may cause severe damage to cells when deposited internally and therefore ingestion, injection or inhalation is extremely hazardous.

Beta particles are electrons ejected from beta-unstable radioactive atoms. The particle has a single negative electrical charge (- 1.6×10^{19} C) and a very small mass (5.5×10^{-4} amu). Beta decay occurs in those isotopes that have a surplus of neutrons and are emitted when neutrons disintegrate into protons. Beta particles do not penetrate the body core but can produce significant radiation damage to the skin and eyes.

Gamma rays are electromagnetic radiations that are emitted from the nuclei of excited atoms following radioactive transformations. Following alpha or beta decay processes, gamma emission is the mechanism by which a nucleus loses energy in going from a high energy excited state to a low energy stable state. X-rays are electromagnetic radiations generated outside the atomic nucleus. Both X-rays and gamma rays are highly penetrating and can produce whole body radiation doses.

Bremsstrahlung ("breaking radiation") is radiation produced by the rapid deceleration of high energy beta particles when they interact with the electric fields surrounding atomic nuclei. The energy of the resulting X-rays is related to the energy of the incident beta particles as well as the electric field strength, which is greater in nuclei of high atomic number. For this reason lead is not an appropriate shielding material for beta emitting isotopes. Plexiglass shielding, composed of atoms with low atomic number, minimizes the energy and intensity of the bremsstrahlung.

TABLE 4. Half-lives and Radiation Produced by Sorne Isotopes

Isotope	Half-life	Emission Energy (maximum)kev		Specific gamma-ray constant
		Beta (maximum)	Gamma or X-rays	
^{3}H	12.3 years	18		
^{14}C	5730 years	156		
^{35}S	87.9 days	167		
^{32}P	14.3 days	1710		
^{125}I	60.2 days		35	.19
^{131}I	8.05 days	806	364;637	.14
^{86}Rb	18.7 days	1780	1078	.56
^{99} mTc	6 hours		140	.19

Holding material for decay:

The equation to use for calculating the amount of activity of a given radioactive substance left after a given length of time is as follows:

$$N = N_0 e^{-0.693 \infty t / T_{1/2}}$$

Where:

N = the activity left: at time t
N_0 = the activity at time 0
t = the time elapsed since time 0
$T_{l/2}$ = the half life of the isotope

As a general rule of thumb, the time necessary for holding material so that it falls within the scheduled quantities for disposal is 10 half-lives.

Appendix 2

Units of Radiation

Units of Activity:

Bq (becquerel): SI unit defined as the quantity of radioactive material in which one atom is transformed per second, or one disintegration per second (1 dps).

Ci (curie): Older unit defined as the activity of radioactive material in which the nuclei of 3.7 x 10^{10} atoms disintegrate per second (dps) or 2.2 x 10^{12} disintegrations per minute (dpm).

1 becquerel (Bq) = 1 dps = 27 pCi
1 kilobq (kBq) = **I** x 10^{3} dps = 27 nCi
1 megabq (MBq) = 1 x 10^{6} dps = 27 ╡Ci
1 gigabq (GBq) = 1 x 10^{9} dps = 27 mCi
1 terabq (TBq) = 1 x 10^{12} dps = 27 Ci

1 millicurie (mCi) = 2.2 x 10^{9} dpm = 37 MBq
1 microCi (╡Ci) = 2.2 x 10^{6} dpm = 37 kBq
1 nanoCi (nCi) = 2.2 x 10^{3} dpm = 37 Bq
1 picoCi (pCi) = 220 dpm = 37 mBq

Units of Radiation Exposure:

The **coulomb/kilogram (C/kg)** is the SI unit used to measure the radiation-induced ionizations created in a unit mass.

The **roentgen (R)** is the old unit defined as the quantity of radiation that produces ions carrying one statcoulomb of charge per cubic centimetre of air at O_C and 760 mm Hg. The milliroentgen (mR) is a commonly used unit for the display or readout on survey meters and portable detection units.

1 R =	258 microcoulomb (╡C)/kg
1 mR =	0.258 ╡C/kg
1 C/kg =	3876 R

Units of Absorbed Dose:

The **gray (Gy)** is the SI unit used to measure the energy imparted to irradiated matter and is defined as the absorbed radiation dose of one joule (J) per kg.

The rad (Radiation Absorbed Dose) is the old, but still commonly used unit, defined as an absorbed dose of 100 ergs/g or 0.01 J/kg.

1 gray (Gy) = **I** J/kg = 100 rads

Units of Relative Biological Effectiveness (RBE):

The **Sievert (SV)** is the SI unit that takes into account the biological effects of the particular radiation emission into the absorbed dose. It is defined as the absorbed dose in grays multiplied by the appropriate **quality factor (QF)**. The quality factor is based on the collision stopping power of the incident particle and is a measure of the potential biological injury of a particular type of radiation. For gamma and X-rays the quality factor is 1. The Sievert replaces the **rem (rad equivalent in man)**.

1 Sv = 1 Gy x QF
1 rem = 1 rad x QF

1 SV = 100 rems
1 mSv = 100 mrems = 0.1 rems
1 ╡Sv = 100 ╡rems

Appendix 3 Scheduled Quantities and Toxicities of Some Isotopes

S.Q= Scheduled Quantities

S =	Slight	H = High		M =	Moderate	VH =	Very High
h =	hours	d = days		y =	years	╡Ci =	Microcuries

Isotope	S. Q. (╡Ci)	Toxicity	Half Life	Isotope	S.Q. (╡Ci)	Toxicity	Half Life
Actinium 227 Antimoney 124 Arsenic 74 Barium 140 Beryllium 7 Bismuth 207 Bismuth 210 Bromine 82 Cadmium 109 Calcium 45 Calcium 47 Carbon 14 Cerium 144 Cesium 134 Cesium 137 Chlorine 36 Chromium 51 Cobalt 58 Cobalt 57 Cobalt 60 Copper 64 Gold 198 Hydrogen 3 Iodine 125 Iodine 131 Iodine 132 Indium 114m Iridium 192 Iron 55 Iron 59 Krypton 85	0.1 10 10 10 100 10 1 10 10 10 10 100 1 10 10 10 100 10 10 10 100 10 1000 1 1 10 10 10 100 10 100	VH H M H M H H M M H M M H H H H M M M H M M S M H M H H M M S	21.2 y 60 d 18 d 12.8 d 53 d 30 y 5 d 36 h 1.3 y 165 d 4.5 d 5730 d 285 d □ 1 1y 30 y 3 x 10^5 y 27.8 d 71 d 267 d 5.3 y 12.9 h 64.8 h 12.3 y 57 d 8 d 1 1h 50 d 74 d 2.7 y 45 d 10.4 y	Lanthanum 140 Lead 210 Manganese 54 Manganese 56 Mercury 197 Mercury 203 Molybdenum 99 Nickel 63 Phosphorus 32 Polonium 210 Potassium 42 Promethium 147 Radium 226 Rubidium 86 Scandium 46 Selenium 75 Silver 110m Sodium 22 Sodium 24 Strontium 85 Strontium 89 Strontium 90 Sulphur 35 Technetium 99 Technetium 99m Tin 113 Thallium 204 Xenon 133 Xenon 135 Yitrium 90 Zinc 65	10 0.1 10 10 100 10 10 10 10 0.1 10 10 0.1 10 10 10 10 10 10 10 10 0.1 10 10 100 10 10 100 100 10 10	M VH H M M M M M M VH M M VH M H M H H M M H H M M S M H S M M M	40.2 h 21 y 314 d 2.6 h 65 h 47 d 66 h 92 y 14.3d 138 d 12.4h 2.5 y 1620 y 18.7 d 84 d 120 d 249 d 2.6 y 15 h 64 d 50 d 28 y 87 d 2.1x10^5 y 6 h 118 d 3.8 y 5.3 d 9.2 h 64.2 h 245 d

Except as otherwise specified by the AECB the scheduled quantity of:
Isotopes of elements of atomic number greater than 89 - 0.1 ╡Ci
Other isotopes not referred to in above table - 1 ╡Ci

Two or More Isotopes:
The scheduled quantity shall be determined by the equation:

$$\frac{A_1}{M_1} + \frac{A_2}{M_2} + \frac{A_3}{M_3} + \cdots\cdots = 1$$

where A_1, A_2, A_3, etc., are the quantities of the isotopes involved and M_1, M_2, M_3, etc., are the scheduled quantities of such isotopes.

<u>References</u>

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